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區塊鏈數位生態系統設計之關鍵多數實現程度評量

Estimate the Fulfillment of Critical Mass within Blockchain-Based Digital Ecosystem Design

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隨著研究論文完成，畢業的腳步一步步逼近，意味著二十三年的求學生涯即將畫上句點。隻身北上與教授會面的回憶歷歷在目，這兩年最要感謝的是願意成為我指導教授的苑老師，感謝老師接納與包容不懂服務科學，憑著一股熱情便逕自投入服科研究的我；碩一開始藉由 paper reading、修習相關課程，扎實有條理地帶領我們用不同角度了解服科；在研究的過程中，老師給予我們很大的發揮空間，透過不斷地耐心地討論讓我們自己思考問題的解答，在老師的循循善誘以及專業的帶領下，我才得以完成今日的學業。能進入 SSRC 成為老師退休前最後一批指導的學生，我覺得自己真的很幸運，也感到非常榮幸。

其次要感謝在課程中合作、在生活中互相扶持，一同創造兩年美好回憶的同學們，特別是 SSRC 的每個成員都在研究專案中扮演重要的角色；柏緯的負責與細心讓我們在遇到困難與意見相左時，能以較理性的方式找到平衡點，除了技術上的支援，更帶領我們持續推動專案進行與扮演組內溝通的重要角色，也謝謝柏緯在研究與生活中都給予我許多協助，成為我研究所這兩年最重要的好夥伴；閎中於技術面的專業與開朗的個性，不僅在專案中扮演重要的開發人員，也時常與我討論研究相關問題，更是在高壓環境下幫我們排憂解悶的好幫手；建佑則是個心細的人，謝謝他讓 BlockFarm 有個可愛舒適的介面，並幫我們處理了許多行政上的瑣碎事物；另外要特別感謝惟棣在問卷分析與研究統計方面給予我許多的幫助；和時常鼓勵我，陪我聊天解悶的惠宸，在我遇到挫折與衝突的當下給我建議和支持；以及所有協助我們完成研究的受測者和同學們，謝謝大家包容我們尚不成熟的系統，用心地給予我們許多建議及回饋，讓我們得以瞭解不足並予以改進，在專案中學習到非常多難得且寶貴的經驗。

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摘要

區塊鏈是一種高可行性的基礎建設技術，不僅能提高效率、降低建設成本，其交易透明化和避免篡改等特性更使之得以被廣泛應用。由於資訊科技蓬勃發展，互聯網革命伴隨著客戶主導邏輯的興起，平台思維對於服務設計而言早已不敷使用。因此，區塊鏈數位生態系統將成為下一代服務設計的解決方案，強調生態系統中利益相關者的價值共創欲目標追求。

以現況而言，仍有許多服務無法在現實中發展或得以維持，網路效應的影響在數位環境中是極為強大且不容忽視的。我們的研究旨在由此出發衡量區塊鏈數位生態系統的成敗。我們提出的方法能使設計師基於理解關鍵多數的實現和網絡效應水平的大小，來瞭解其設計的可適應性與競爭力，這是一個數位生態系統能否突破真空的關鍵。此方法還提供如何提升設計的指南，使服務設計能更有機會地進入網路效應的爆炸階段。

關鍵字：數位生態系統、關鍵多數、網路效應、區塊鏈、服務設計

Abstract

Blockchain is an infrastructure technology not only restricted to the financial industry, but also feasible and affordable to facilitating the operation of service provision with efficiency, lower construction cost, information transparency and non-falsified characteristics. By virtue of the information technology booms swiftly, the revolution which Internet brings about, accompanies with the rise of customer-dominant logic, platform thinking is no longer sufficient for the service design. Consequently, blockchain-based digital ecosystem becomes a solution of the next generation's service design aspect which stresses on value co-creation among all the stakeholders of the ecosystem and proceeds to the same proposition. However, there are many service provisions unable to launch or sustain in reality.

The network externality of the Internet is the most powerful, indispensable and un-negligible effect in the digital environment. Our study aims to estimate and measure the success or failure of blockchain-based digital ecosystems from this perspective. We proposes a method which enables blockchain-based digital ecosystem designers to comprehend with the adaptability and competitiveness of the fulfillment of the critical mass and the examination of network effect level. They are crucial to pass through the vacuum stage of ecosystem lifetime. The method also provides guides about how to improve the designs in order to have a greater opportunity to get into the explosion stage of ecosystem lifetime.

Keywords: Digital Ecosystem, Critical Mass, Network Effect, Blockchain, Destination

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Chapter 1 INTRODUCTION

1.1 Background and Motivation

In the last decade we still talked about building a platform for your service, however, platform thinking is not completed enough to sustain the novel service nowadays. Digital disruption, which been come up with in 2015, is a process as the business world is rapidly digitizing, breaking down industry barriers and creating new opportunities while destroying long-successful business models (Weill & Woerner, 2015). For instance, Uber, Airbnb, FordPass, they all created its new digital business models and subverted the value exchange that we have been impressed for a long time ago. With the flourishing of technology, it becomes a trend that is irreversible. And we believe this kind of transformation can happen in every industry based on the ecosystem thinking.

Ecosystem, which is component of living organisms and also the nonliving constituents of environment, has its own interacting mechanism and is also a self-sustainable system. The concept of ecosystem highly catches the public's attention not only in the biological community, but also the commercial community. Digital ecosystems transcend the traditional, rigorously defined, collaborative environments from centralized, distributed or hybrid models into an open, flexible, domain cluster, demand-driven, interactive environment (Boley & Chang, 2007). At present, there are some businesses designing or already provided service like a digital ecosystem, such as Apple, Amazon, Google, Microsoft, and Ford. With the spectacular service ecosystems and the new service options created by those business, it is time for every business to think about the trend of building a digital ecosystem.

While having a concept of designing a service digital ecosystem is not enough to launch successfully and become a gorgeous business that is able to be considered as a destination. Destinations are regarded as well-defined geographical areas before; nevertheless, the concept of destination is also seen as the perceptual notions that can be interpreted by the participants subjectively (Buhalis, 2000). The same as the digital ecosystem, participants share the common consensus of the ecosystem and identify it with most of the other would become a destination.

Due to platform businesses add value by facilitating interaction of various sorts between customers who are attracted to the platform at least in part by network externalities (Evans & Schmalensee, 2010). The reason why to reach the critical mass is owing to what previous research had mentioned. If the costs vary little with group size, larger groups should exhibit more collective action than smaller ones because larger groups have more resources and are more likely to have a critical mass of highly interested and resourceful actors (Oliver & Marwell, 1988). Reaching the critical mass, which means to have the ability to cause the network effects, is the basic requirement of being a destination of digital ecosystem.

1.2 Research Question

Collective action usually depends on a "critical mass" that behaves differently from typical group members. Sometimes the critical mass provides some level of the good for others who do nothing, while at other times the critical mass pays the start-up costs and induces widespread collective action (Oliver, Marwell & Teixeira, 1985). From the point of view, we believe that critical mass is an end point of a phase equilibrium curve, that can be viewed as a critical point going to explode an exponential growth of the participants.

The fulfillment of critical mass is correlation to the probability of reaching exploded stage of the designed ecosystem. To realize the measurement of critical mass, we consider the destination of digital ecosystem design based on the Customer-Domain Logic and the de-centralized concept of blockchain, which can provide a cheaper, less preparation, and efficient infrastructure to build the digital ecosystem. Then, we put forward a research model constructed with three dimensions: Operant, Operation, and Empowerment, that are related to the design thinking of digital ecosystem. (Figure 1.1)

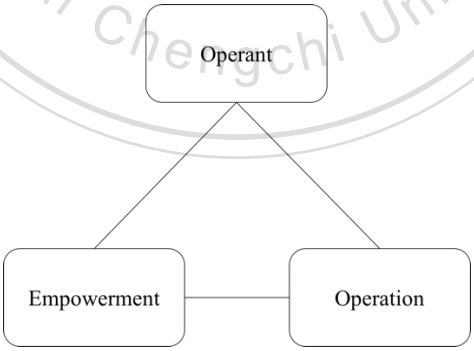

Figure 1.1 Design Thinking of Digital Ecosystem

- Operant: Measure the share of voice in each domain to inspire service designers to sketch out the stakeholders of digital ecosystem.
- Empowerment: To enhance the motivation of participants co-creating in the digital

ecosystem, enhance the feasibility of empowerment strategies, and make sure all operants are beneficial and necessary.

- Operation: Confirm the digital ecosystem design provide a smooth, unhindered, effortless service procedure by designing a linkware towards flow experience.

As each dimension that has be mentioned above, we have come up with our research questions as below:

1. *"What are the meanings of the score of each dimension, can they lead to the critical mass?"*

The first research question is for connecting three dimensions and the critical mass, also defining how the information can help service designers to do their digital ecosystem design. The dimension of operant is the first step for designing a digital ecosystem that is performed by the blockchain technology. Besides, empowerment is fundamentally a motivational process by which an individual experiences a sense of enablement (Yagil, 2006). And flow research provides an understanding of experiences during which individuals are fully involved in the present moment, that constitutes a good life (Nakamura & Csikszentmihalyi, 2014). On account of those concepts above and the Customer-Domain Logic, differ from Service-Domain Logic, user's willingness to be the participant of digital ecosystem is somehow interconnected to the empowerment degree and the flow experience. The connection between critical mass and those dimensions is what our research is going to find out.

2. *"What are the relationship between fulfillment of three dimensions and the critical mass of the digital ecosystem?"*

In the time with the widespread Internet, which is developed by the telecommunication, the power of effect it caused is so immense that we even can not neglect it. According to the literature, telecommunication services are distinctive in that their adoptions are influenced by network effect resulting in the late take-off phenomenon and the critical mass problem (Lim, Choi & Park, 2003). We believe that it is able to cause the network effect in the world of the Internet while the digital ecosystem reaches the critical mass. Furthermore, that is the foundation of our second research question, which is going to talk the problem of relations between those dimensions and the network effect over. Based on our research, digital ecosystem designers can take the network effect into account without complicated computing as well.

1.3 Research Method

As we have known, there are only few of businesses have the sense of building a destination of digital ecosystem. For the purpose of filling up the gap between the supply and demand, we intend to propose an ecosystem design assistance system, which is based on the blockchain technology, aims at achieving a better world of stabilize supply-demand equilibrium. Our value proposition will be realized in building a service design system, which is called D^3 Accelerator which D^3 represent the Destination of De-centralized Digital ecosystem, and develop a useful, thoughtful, and valuable system.

Our system is constructed with four major modules, which is Operant Module, Empowerment Module, Operation Module, and Verification Module. First of all, the Operant Module analyze the value supplier's share of voice based on the value proposition and inspire ecosystem designers to do the value design. Then to weight the completeness of the designed ecosystem by measuring the service desirability, service disruption, and smart contract consistence.

Next is the Empowerment Module, this module examines the operants and entities of the designed ecosystem by the proposed AIA model and its sub-modules: Service Operant Evaluation Module and Service Operant Analysis Module. The examinations can help designers to come up with an appropriate empowerment strategy rely on the assay of operant ability, operant intention, and resource availability.

The third one, the Operation Module, provides an implement which named as Flow Experience Maximization System for designers to optimize their service procedure and the user experience. Realized by four sub-modules: Measurement Module, Linkware Design Module, Resource and Pattern Management Module, and Aided Design Module, in order to achieve the goal of maximum flow experience of the designed ecosystem.

The last but not least, the Fulfillment Testing Module, which high level the vision to arrange the network effect caused by other module with the concept of Nash Equilibrium. In addition, to testify that the outcome of the system is qualified to reach the critical mass and grow into a prosperous, and self-sustainable ecosystem. That would help designers recognize the gap between design and reality, and to accomplish the prospect desired as well.

1.4 Purpose and Contribution

Digital ecosystem designers can devise a service ecosystem that is corresponds to the demand of the market and is sustainable in reality through our D^3 Accelerator system. This research will be concentrated on the Verification Module that has be mentioned above. Without the Verification Module, designers can not be sure whether their design is qualified to realize or to survive, whether the situation in each dimension is sufficient or not, whether the design has the opportunity to become the killer application. The following shows the contribution of this research:

1. *Shorten the gap between the design and the reality.*
2. *Make sure the variations of each dimension will not cause any negative effect in the digital ecosystem design.*
3. *Fulfill the digital ecosystem design pattern implemented by blockchain into a factual service architecture.*

In order to make the digital ecosystem design more feasible to be launched, the Verification Module consider the Nash Equilibrium of economics, putting the concept of cost and effect in the module. We expect to provide a concise, effortless guideline for service designers to make use of, for the entrepreneurs to reorganize their business, and for all service can gaining ground as well.

1.5 Content Organization

First of all, we will talk about the concept of digital ecosystem and the briefly elaborate the decentralized blockchain value in Chapter one. The importance of the customer-domain logic and why our research will base on it. Besides, our research motivations, research inquiries, research methods, research intentions, research contributions, and the content organization will all be described in this chapter as well.

Next in the literature review of Chapter two, we are going to introduce the previous research, that is related to the concept of destination of digital ecosystem and the decentralized blockchain value. Also, the architecture of destination of digital ecosystem, and the measurement of being a destination. The principles and the construction of our research are developed and based on those literatures.

The third comes to Chapter three, in this chapter, we will display the whole framework of our system, D^3 Accelerator. Show the system architecture and the using procedure, briefly introduce the modules of our system.

The forth is Chapter four, the complete system portray will be illustrated in this chapter, including conceptual framework, system architecture, system modules, and algorithms. The entire mechanism of our system will be described as well.

The fifth in Chapter five, we simply give an application scenario to show how our system works, in order to make readers more comprehensive to our system and to provide our system's value to them.

The sixth in Chapter six, we illustrate the implementation and questionnaire result of our project, so as to verify the proposed theory of our research.

The last in Chapter seven, we conclude our research and simply summarize the ambition and contribution of our research.

Chapter 2 LITERATURE REVIEW

Unlike products or services that are managed, the evolution of ecosystems and their myriad participants must be orchestrated through a thoughtful alignment of architecture and governance (Tiwana, 2013). Therefore, we proposed a governance mechanism with measurements for designing a destination of decentralized digital ecosystem based on the blockchain architecture. The followings are the relevant literatures.

2.1 Blockchain Technology

Blockchain is an innovative technology that is popular discussed in recent years (illustrated in Figure 2.1) and regarded as a blueprint for new economies. It is first proposed by Satoshi Nakamoto in January 2009 and accompanied with two untested concepts: bitcoin and proof-of-work (Buterin, 2014). The former can be seen as an application of blockchain technology, and the latter is a fundamental of blockchain technology fulfillment. Blockchain technology is affordable of all creations and applications of decentralized currencies, smart contracts which are built-in self-executing digital contracts, and smart properties that are intelligent assets controlled over the Internet (Wright & De Filippi, 2015).

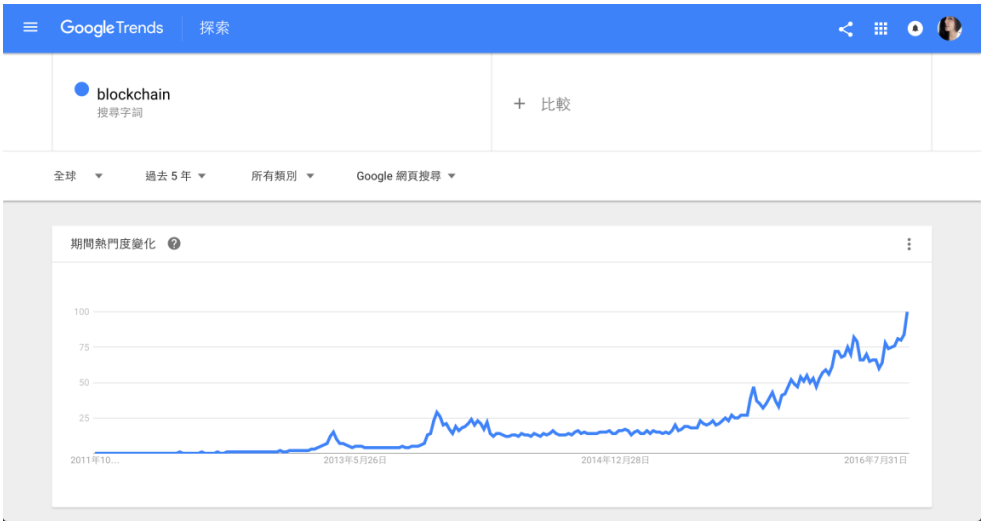

Figure 2.1 Searching trends of keyword 'Blockchain' on Google Trends.

Referring to the *Blockchain: Blueprint for a new economy* written by Swan (2015), blochchain ecosystem features decentralized storage, communication, and computation. It is worth mentioning that storage can be either centralized like Google Drive or decentralized like blockchain. The blockchain transaction registers smart assets providing a pointer and an access method for user to choose whether to privilege for the off-chain stored file or not. The attributes of blochchain are not only decentralized and distributed, but also immutable and transparent (Fecher, 2016), as briefed below:

- Decentralization guarantees that there will no longer have single point of failure.
- Distributed secures the data and its copy to be stored in different devices.
- Immutability safeguards all information on blockchain from falsification.
- Transparency pledges every transaction and peer are provable to the external.

By virtue of decentralized and the concept of smart contract, blockchain envisioned the more complicated deployment of expansion, such as decentralized application (Dapp), decentralized autonomous organization (DAO), decentralized autonomous corporation (DAC), and decentralized autonomous societies (DAS).

The decentralized autonomous organization (DAO) is much similar to the notion of the D^3 (Destination of Decentralized Digital ecosystem) in our D^3 Accelerator, it is more labyrinthine than the decentralized application. It provides an agent running on blockchains for the rules that are pre-specified based on the context of smart contract and can be arranged dynamically along with the changing conditions. Fortunately, there are not only groups of smart contracts that can be operated on the blockchain and realize the ideal model of autonomous corporation, but also the functions and operation of real physical-world businesses that could be conceived on the blockchain (Swan, 2015). That is, our research attempt to give assistance to service designers to fulfill a design pattern that is decentralized operating without limitations based on the blockchain technology.

2.2 Critical Mass

The concept of critical mass is central to many understandings of collective actions, and the focal business in the digital ecosystem uses the term when talking about getting together enough resources to accomplish some goals (i.e., the focal business expresses comprehension that takes the minimum number of participants or the minimum accumulation of seed money to draw in the participation and contributions of others) (Marwell & Oliver, 1993). Network effects have a significant impact on the evolution of the market, especially in the Internet-based services. In particular, critical mass is a fundamental element due to the relevance of the growth process of these services (Arroyo-Barrigüete, Ernst, López-Sánchez, & Orero-Giménez, 2010). Nowadays, there are still many goods and services launch every month and every year, however, it is not effortless for enterprises to develop a prosperous, well-received merchandise or service. In fact, countless service providers can not create a popular service or even failure to

launch happened everyday, for instance, Sidecar, Prismatic, Pixable, Dine In, Quirky, and so on (Tam, 2016).

Owing to every good or service provision has its lifetime, and network effect confirmed that it has absolutely impact on the service development, the differentiation as shown in Figure 2.2 and Figure 2.3 (Easley & Kleinberg, 2010). In this research, we roughly divide the digital ecosystem development lifetime into apart – the vacuum stage and the exploded stage. We define the critical point between this two stages we named it as the Critical Mass, which means the crucial number of participants has relationship to make the digital ecosystem been through vacuum stage and get into exploded stage.

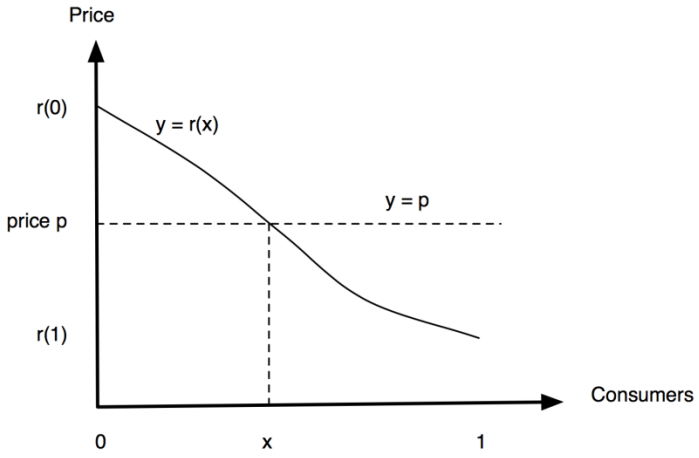

Figure 2.2 The economy without network effect (Source: Easley & Kleinberg, 2010).

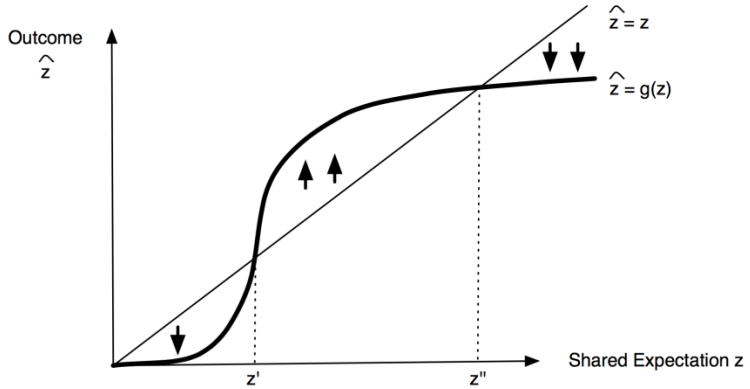

Figure 2.3 The economy with network effect (Source: Easley & Kleinberg, 2010).

As proposed, critical mass is a concept of meeting an equilibrium point within the ecosystem (Liebowitz & Margolis, 1995; Evans & Schmalensee, 2010). Voigt & Hinz (2015) published their research based on the same concept of equilibrium, and they measured the network effects by utilizing positive network effects and mitigating the negative ones to fulfill a stable equilibrium. Our research references their measurement, especially how to reach the equilibrium, and we find out there are two research paths to study for the digital market: one focused on pricing considerations examines what price structure to apply and whom to charge for accepting the service delivered (Jullien 2005; Armstrong 2006; Eisenmann, Parker & Van Alstyne, 2006; Rysman, 2009; Chao & Derdenger 2013). Another explores the effectiveness of the intermediary's investment decisions (Yoo, Choudhary & Mukhopadhyay, 2002; Bakos & Katsamakas, 2008; Kraemer, Hinz & Skiera, 2012), familiar to analyzing the design strategy such as the quality of service delivery, the supporting infrastructures, and the arrangement of smart contract in our research foundation. We choose the first concept which focus on pricing considerations for our measurement by virtue of the sustainability of the designed ecosystem because the price structure will influence the coordination between stakeholders and the subsequent social welfare's enhancement (Chao & Derdenger 2013). Thus, our measurement positions on a reality consideration for service designers to comprehend the fulfillment of digital ecosystem design.

2.3 Network Effect Level

Network externalities (Network effects) are a natural feature of networks (Rohlfs, 1974), which composed of humans and display like certain connections of groups. Joining a network is valuable for new participants due to other stakeholders are beneficial to the ecosystem (Rohlfs, 1974), and that is because the value from one

participant to other is positively affect while other joining and enlarging the network (Katz & Shapiro, 1994). In other hands, network effect has been defined as the variation in benefit, or surplus, that one participant acquires from a service when the number of other participants consuming the same kind of service changes. This has become increasingly influential in economic thought (Liebowitz & Margolis, 1995).

Based on previous research, it can be divided into two types of positive network effect, direct effect and indirect effect (Katz & Shapiro, 1985). It indicated that the direct network effects are produced by a physical effect of a number of participants on the quality of the service; for instance, the huge number of residence attached to the telephone network that give rise to a positive network effect directly.

The indirect network effects are generated deviously by the complementary services or goods growth and decrease the price, as the number of users of services increase; for examples, the application store opened the application programming interface for developers to provide better applications as the number of mobile phones of a particular type increase (Katz & Shapiro, 1985).

In this research, we ponder the level of both direct and indirect network effect and give an effective measurement. The level of network effect is conceivably related to the operation of whole network. For instance, if the externality is strong, the network effect overshadows the standard competitive effect of entry, and the high network externalities provide the encouragement for an exclusive owner of a technology to free the license (Economides, 1996). Beside, the achievements of the organizational network spawn new conjectures about the competitive advantage of social forms of organizations relative to market-based value exchanged network (Powell 1990; Inzerilli 1990; Perrow 1993). Specifically, in the digitalized world, the participants of digital ecosystem can be thought fruitfully as composing a virtual network, giving rise to the effects that is similar to those in physical networks (Katz & Shapiro, 1985; Arthur, 1989, 1990). Thus,

we believe the greater the positive network effect has created, the more powerful advantage the digital ecosystem has.

Referring to the measurement of network effects, previous research has proposed that network effects in two-sided markets can be measured in several ways (Kraemer, Hinz & Skiera, 2012). For instance, there are diffusion models (Gandal, Kende & Rob, 2000; Gupta, Mela & Vidal-Sanz, 2009; Chu & Manchanda 2015), vector autoregressions (Chen, Narasimhan & Zhang, 2001), choice models (Stock & Yogo, 2005; Rysman, 2009) and linear regressions (Hendel, Nevo & Ortalo-Magne, 2009; Seamans & Zhu 2013).

In order to account for the specifications of our proposed module – Destination of Decentralized Digital-ecosystem Accelerator, we estimate the Destination Value Configuration of Digital Ecosystem Entities shows in Figure 4.1 (comprise Completeness Operant Configuration, Degree of Operant Empowerment, and Operation Flow of Linkware Design). The Destination Value Configuration of Digital Ecosystem Entities ponders upon the relevance of each stakeholder, the level and influence of empowerment, also the interaction between service delivery and ecosystem participants. The conceiving logic is as similar to the concept used by Liebowitz and Margolis (1995), providing a method that is discussing the relationship between network participants and their willingness to pay for participation.

Chapter 3 D^3 ACCELERATOR SYSTEM

D^3 Accelerator PROJECT

As time goes by, goods or services that provided by companies are different from those we have known before. With the rising emphasis on user experience and user interface design nowadays, customer satisfaction is no longer determined only by functionalities, but also the user experiences during service. Therefore, a fluent, convenient, and memorable experience become principle effect of company's achievements. For service designers, D^3 Accelerator provides a model for design reference, which is based on the Customer-Dominant logic, offer an assistance for the designed service, that can press close to customer's demands and have chance to achieve the critical mass. This chapter aims to describe the framework and the procedure of our integrated research project—D^3 Accelerator.

3.1 The Conceptual Framework of D^3 Accelerator

D^3 Accelerator is an assistant design instrument for all designers who are going to create a new service or to optimize an existing service. This instrument is built to support the designed service to become the destination of digital ecosystem in its domain and constructed with the Customer-Dominant logic in service design. First of all, different from previous researches, which are more related to the Service-Dominant logic. D^3 Accelerator is sufficiently focusing on customer's requirements and feelings rather than a company-based view. With this foundation, D^3 Accelerator provides designers a useful, thoughtful, and helpful implement to devise a well-considered service.

- **Destination:**

In general, destination is taken for granted that is a geographical region. It is the first place that traveler want to visit. Destination is also defined as the focus of facilities and services designed to meet the needs of the tourists by Cooper, Fletcher, Gilbert, Shepherd and Wanhill (1998). In this paper, we use this concept of destination to describe a digital ecosystem that integrates operants and provides a series of services to meet customers' need. We believe if a digital ecosystem is well constructed with Customer-Dominate logic, it will become the best choice of customers in that industry.

- **Customer-Dominant Logic:**

Customer-Dominant Logic, emphasizing the primacy of customer, is a mindset that can be used in business, marketing and service design. Adopting this view means shifting the focus from how (systems of) providers involve customers in their processes to how customers in their ecosystems engage different types of providers. In other words, emphasizing how customers embed service in their processes rather than how firms provide service to customers (Heinonen, 2015).

Different from Customer-Dominant Logic, Service-Dominant Logic emphasizes the importance of value co-creation and customer involvement, in other words, this perspective focus on how customer can participate in the business process through the lens of service provider. Even though the SD logic has widened the scope of understanding the function of marketing, the view on SD logic is still very production and interaction-focused, i.e. service Provider-Dominant (Provider-Dominant logic), not Customer-Dominant (CD) (Heinonen et al., 2010). On the contrary, CDL does not emphasize the interaction between the customer and the provider/market. The focus is on the key stakeholder in businesses – the customer – and how customers embed service in their processes. This is in contrast to how (multiple) providers (and other institutional

stakeholders) in service (eco)systems provide service to the customer, which is the basis of SDL (qtd. in Akaka et al., 2015). The following table is the difference between the mindset of Provider-Dominant logic and Customer-Dominant logic:

Table 3.1 Comparisons between PDL and CDL

Provider-Dominant logic	**Customer-Dominant logic**
Value creation is orchestrated by the service provider	The customer orchestrates and dominates value formation
Value creation is defined by the service provider	Value formation is determined by the customer relative to alternatives on multiple levels
Value is based on customer perceptions of company-created value propositions	Value is based on experiences of customer fulfillment

D^3 Accelerator aims to build a sustainable digital ecosystem, so as to provide a one-stop service and eventually becoming the destination to every customer. CDL focuses on customer logic and the customer's constellation of activities, actors and experiences and the role of providers in this context (Heinonen et al., 2010). After applying CDL to D^3 Accelerator model, it will be a lot easier to inspect customer's behavior, to find out the potential operants, and to have a comprehensive view on customer.

3.2 The System Architecture of D^3 Accelerator

D^3 Accelerator is composed of four parts that are the elements of becoming the destination of digital ecosystem. D^3 Accelerator comes up with a three-dimensioned model including Stakeholder Value Configuration System, Value Network Empowering System, Linkware Flow Experience Maximization System, and a dimension of measuring the achievements – Fulfillment of Critical Mass System.

- **Stakeholder Value Configuration System:**

The first dimension puts forward candidate value activities that are best related to the service value proposition, also helps designers to configure their value network. This system will give a service desirability score, service disruption score, and consensus level of the ecosystem to be a prediction of the ecosystem performance.

- **Value Network Empowering System:**

It receives the output of first dimension and examines the empowerment degree of each service operant and provides a guideline to facilitate each stakeholder's collective commitment toward shared goal within the ecosystem. Then makes some adjustments and suggestions to improve the degree of empowerment.

- **Linkware Flow Experience Maximization System:**

It obtains the given value network from second dimension, draws on the linkware of service operation, examines the degree of flow experience, and assists designer to design the linkware to integrate the whole service based on blockchain toward maximum flow experience.

- **Fulfillment Testing System:**

This system is to check on the fulfillment of the destination of decentralized digital ecosystem based on the fulfillment of critical mass and the network effect level, which accomplish the graduation of D^3 Accelerator or not. After these processes, D^3 Accelerator proposes a prototype of designed service, designers then can realize and inform the services base on the results.

3.3 The System Flow of D^3 Accelerator

Kelly is nominated to design a digital ecosystem about destination of living assistance for the people who have a sum of money and pursue a sustainable quality of life. However, Kelly is at a loss as to what to do. Thus, she can utilize our model to facilitate accomplishing this tough mission.

In the first stage, ***Stakeholder Value Configuration System*** provides the Puzzle model to help Kelly construct the initial value network. When Kelly places the value proposition into the model, it shows the related context like ‘sustainable’ and ‘Affordable’. With these key words, it is going to break down into the second-layer context; for example, ‘Transportation’, ‘Health’, ‘Shopping’, ‘Communication’, ‘Residence’, and ‘Finance’.

Based on these contexts, our model searches for the related value activities individually and finds key stakeholders of those activities. After that, through examining the desirability score, disruption score, and consensus level provides an initial value network with the score level which lets Kelly know whether it is making sense or there is a suggestion for improvement.

In the second stage, ***Value Network Empowering*** provides the smart contract analysis module to examine the importance of resources, correlations between resources, accessibility of smart properties, and each stakeholder's influence degree of value activities. And this information can be acquired by inviting the stakeholders to participate a collaborative design meeting. Based on this information, the smart contract empowerment module will provide three data to each stakeholder inside the ecosystem. The first one is the recommended available resource, which can be used to enhance the stakeholder's capability and achieve their purpose eventually. Second, the recommended investing resources, which enable stakeholders to input certain resources so that they can receive an expected and ideal outcome. Last but not least, this system provide each stakeholder's influence degree of the value activities occurred in the ecosystem so that they can know if their investments worth or not. In the final stage of this system, we will calculate the collective commitment level of each stakeholder in order to know their willingness to co-create, hoping to carry out the synergy among all stakeholders of the system.

In the third stage, ***Linkware Flow Experience Maximization*** draws on the linkware of service operation, examines the flow experience, and assists designer to design the linkware to integrate the whole service. First, Kelly needs to identify the sub-service of the given value network and to decompose this sub-service into five customer-introduced variability. Then, she could follow the recommendation we provide to decides the strategy for each sub-service of each variability. Second, our module would suggest the suitable elements used in existing database. Kelly could keep track of the degree of completion for each flow elements. Third, we provide the Linkware Design Deployment as a representation of linkware to guide Kelly. Now, she could observe which one is relatively low and she wants to deal with it first. Therefore, she could design a linkware, for instance, a linkware that transfers the price more

instantly between Agency and the other buyer or seller. Moreover, she could evaluate the costs when adding or integrating the linkware. Besides, by our module that provides the current degree of linkware flow experience, Kelly could adjust the variable through other modules if the degree is low or is not be satisfied.

In the last stage, ***Fulfillment Testing System*** assists Kelly in checking on the effects of each above stages and in monitoring the condition of service design, which accomplishes the graduation of D^3 Accelerator or not. This sub-model attempt to find a balance point between above three stages and examine by measuring the network effect level and the fulfillment of critical mass. Accordingly, Kelly is ware of the variables which are the negative effects and needs to adjust the corresponding stage above to reach critical mass.

In summery, our model facilitates designing a destination of digital ecosystem through four stages based on the given value proposition.

Chapter 4 METHODOLOGY

4.1 Conceptual Framework

At the beginning of this section, we will illustrate the conceptual framework of our system which shows in Figure 4.1. There are five significant concepts in our conceptual framework, which are Completeness Operant Configuration, Degree of Operant Empowerment, Operation Flow of Linkware Design, Network Effect of Ecosystem, and Critical Mass of Ecosystem Participants. Besides, the first three concepts are the Destination Value Configuration of Digital Ecosystem Entities, which is proposed to help designers construct a digital ecosystem with a mindset of destination.

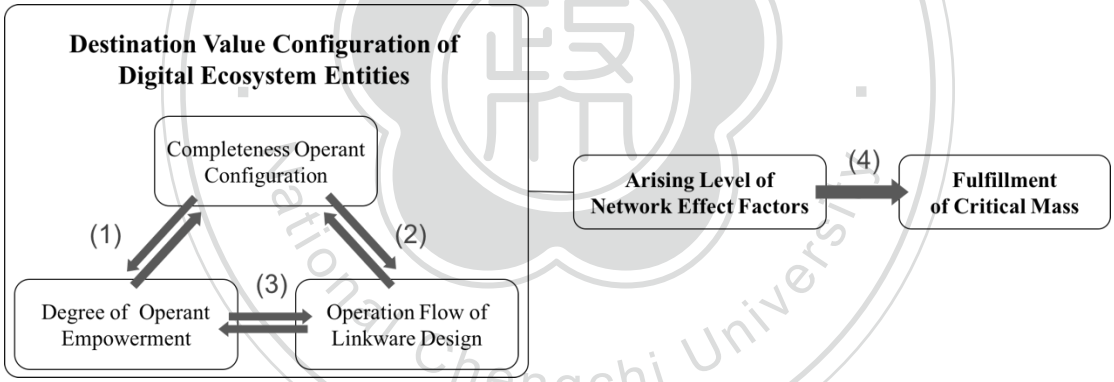

Figure 4.1 Conceptual Framework of D^3 Accelerator

- Destination Value Configuration of Digital Ecosystem Entities:

In order to construct a digital ecosystem with the lower cost and efficient blockchain technology, that is also qualified to become a destination, we propose a meta concept: Destination Value Configuration of Digital Ecosystem Entities. This meta concept is composed of Completeness Operant Configuration, Degree of Operant Empowerment, and Operation Flow of Linkware Design.

In Service-Dominant Logic, the core value is to increase human well-being, based on the specialized knowledge and skill of individuals (i.e., the operant resources). This is the way to realize the notion moving to the exchanges of operant resources from those of the operand resources. From operand to operant resources has implications in comprehending the interactions within digital ecosystem and the construction of digital ecosystem, that are markedly distinct from focusing on only the exchange of operand resources and has ramifications for realizing the value exchange process potentially (Vargo & Lusch, 2008).

First of all, to design a quality digital ecosystem with positive interactions, we need every stakeholder to be an operant rather than an operand. Constantin and Lusch (1994) defined operand resources as resources on which an operation or act is performed to produce an effect, and they compared operand resources with operant resources, which are employed to act on operand resources and other operant recourses (Vargo & Lusch, 2004). Operant is more valuable and can cause value added effect in the digital ecosystem. That is the reason why we provide a Completeness of Operant Configuration, which is an operant analysis instrument for designers to get to know about the resources their partners and stakeholders in the ecosystem can supply for value-adding. And we believe that completeness of operant resources is the basic requirement for designing a digital ecosystem and for reaching the critical mass further, also why we need to define a combination of stakeholders that can co-create value, can operate harmoniously, and can sustain permanently to fulfill a de-centralized, interactive digital ecosystem.

Next is about the Degree of Operant Empowerment, an empowerment strategy designs guidance that can help designers come up with a well-planned manipulation to enhance the motivation of stakeholders' value co-creating, make sure the strategy is developed with feasibility, and confirm all the stakeholders are beneficial and necessary.

According to previous research, top management leadership and employee empowerment are considered to be two of the most important principles of total quality management (TQM) due to their assumed relationship with customer satisfaction. And the research result reveals that positive correlation between top management leadership, employee empowerment, job satisfaction, and customer satisfaction. (Ugboro & Obeng, 2000). Matching to the concept of stakeholder empowerment in the digital ecosystem, we believe a superior empowerment strategy can improve levels of stakeholder satisfaction and also customer satisfaction. Furthermore, the satisfaction exerts an influence on the willingness and the probability of joining the ecosystem, that is certainly without any doubt. In this way, we subsume the concept of empowerment into the Destination Value Configuration of Digital Ecosystem Entities.

Last but not least comes to Operation Flow of Linkware Design, an implement that can measure the fulfillment of the flow experience. Service provision is a set of procedures from the very beginning to the end of service operations. The interaction and communication within these procedures has become an important component in the development of better service (Dong & Siu, 2013) and we believe that is the pivot of success or failure to launch a destination of digital ecosystem. Since Internet has arisen, online service can be seen as an information-intensive industry. We can argue that a business' performance, for instance, customer satisfaction, loyalty, share of voice, etc., will be dependent on its customers' experiences related to the flow of events within the service delivery process (Chase & Dasu, 2001). As a matter of fact, the concept of flow experience is wildly used in service optimization, especially for hasten customer's decision making and service delivering (Gentile, Spiller, & Noci, 2007; Verhoef et al. 2009). Thus, we believe reaching the flow experience can consolidate the existing customer and can be the incentive for new customer to accede to the digital ecosystem.

In conclusion, possessing enough participants (include stakeholders and customers) that is able to cause the network effect is the first step to grow into a destination. Destination Value Configuration of Digital Ecosystem Entities is composed by the factors of service design that is related to the network effect, and have a positive impact on reaching critical mass. That is to say, it is an implement for service designers to make sure their designs are conforming with ecosystem participants' demand and are getting on the track of the fulfillment.

- Arising Level of Network Effect Factors:

As reaching the critical mass, network effect is the cause and effect of the following to be considered, which is the concept about how the participation of one participant will affect others when making service choices, and so does the other hand (Liebowitz & Margolis, 1994). The value of the ecosystem service can be increased by the number of participants while the network effect was triggered. Arising Level of Network Effect Factors are influential elements of network effect proposed in our research project – D^3 Accelerator, elaboration of each element please reference to Chiang, 2017; Kuo, 2017; and Chen, 2017. To ensure the sustainability of the designed digital ecosystem and to be ambitious of growing into a destination, we assume that to reinforce the network effect will be beneficial for approaching the critical mass, in addition, to make sure there is no negative effect interact within the Destination Value Configuration of Digital Ecosystem Entities is also a prerequisite of reaching our value proposition. Besides, in the research of Boudreau & Jeppesen (2015), they discovered that there is a positive causal response between platform development rates and the growth of platform usage. Mapping to our research means that improving the efficiency of building the digital ecosystem will cause a positive effect on the growth to reach the critical mass. We argue that designing a digital ecosystem with the blockchain

technology, which can lower the development cost and can increase the efficiency, has somehow interdependent with decreasing the negative effect and help the digital ecosystem reaching the critical mass.

- Fulfillment of Critical Mass:

Critical mass in this research represent a concept of the number of participants in the digital ecosystem meeting a critical point that is able to trigger network effect (or we can say as network externality). As the Internet provides an universal access media for people all over the world, the connection between each node of the access and the power of its effect is unable to be underestimated. The universal access alike the concept of a public service that every participant can not be prevented from enjoying even if they do not contribute to the ecosystem. In addition, the participant of the ecosystem should entail the mutual interdependence of the previous participants and afterwards (Markus, 1987). Consequently, for providing a value-added service, for increasing the participants of the ecosystem, and for lasting out the duration of the digital ecosystem, we deem that reaching the critical mass will be the first priority to do and also the prerequisite of the design pattern. As a result, our research proposition is to measure fulfillment of critical mass in order to help service designers acquaint with their position of service design and to give some hints of direction that can improve the design.

4.2 System Architecture

Our system intends to provide a guideline and a measure instrument for service designers to come up with a framework that is capable of being a destination of de-centralized digital ecosystem. In this section, we will illustrate the complete system

architecture of our research, that is to provide a method based on the conceptual framework.

The system architecture is show in Figure 4.2 consists of two modules, which is the Fulfillment of Critical Mass Module and the Network Effect Testing Module, and a supporting module, D^3 Accelerator Assistant Module

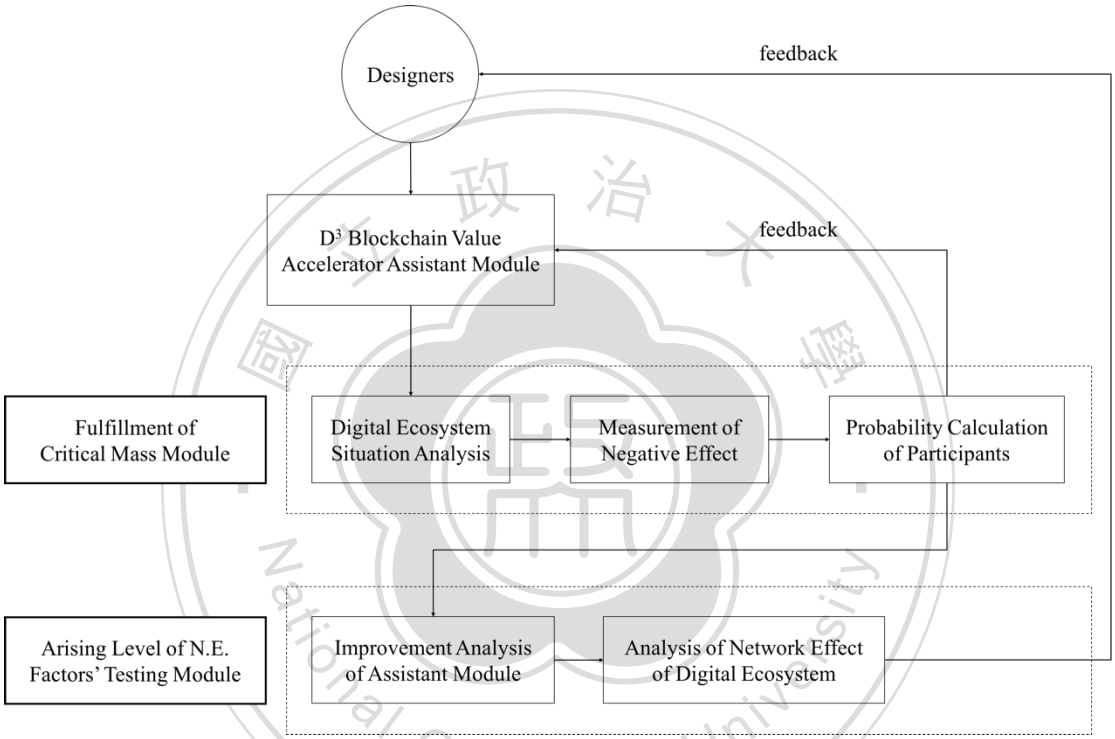

Figure 4.2 System Architecture

1. Arising Level of Network Effect Factors' Testing Module

In this research we assume that triggering the network effect should accumulate enough participants in the ecosystem network, which means every service design has to scale up in order to reach the critical mass. We believe when the number of participants reach to a critical point, there is crucial point to trigger the bigger network effect and lead the service into the explosion stage, that is also our definition of the Critical Mass in this research as well. Based on the assumption, we attempt to manifest

network effect within the digital ecosystem and try to reinforce it in this section.

According to the network effect propose by a book named Platform Revolution: An Innovation of Business Model Sweeping Global Social, Commercial, Game, and Media Industry (Chen & Yu, 2013), it says that to initiate the network effect should have positive same-side effect and cross-side effect. That also means the interactions between the designed digital ecosystem should be corroborated as none negative.

To achieve the objective of our research, which is to strengthen the network effect level by the improvement of the D^3 Accelerator Assistant Module, we examine those dimensions in high level perspective and look out for their solution for our research propose. We try to ascertain that every improvement of each dimension can lead the designed ecosystem a better state in the digital ecosystem lifetime. At that time, we can give a feedback to those dimensions, support them to their completeness of operant configuration, degrees of operant empowerment, and the operation flow of linkware design. Last but not least is to scrutinize the network effect on the alteration of those dimension, make certain the improvement is conducting the whole digital ecosystem operation towards the maximum network effect level.

2. Fulfillment of Critical Mass Module

In order to substantiate the digital ecosystem design having the ability to reach the critical mass, we provide a verification module for facilitating designers to orientate the service design. Furthermore, with the designed position, designers may know the expansibility of the ecosystem design and then ponder the ability to improve the service ecosystem design.

Networks are characterized by positive size externalities, which is commonly called network externalities. The benefits of the addition of an extra participant exceed the private benefits accruing to the particular participant (Economides & Himmelberg,

1995). So as to measure the participants that is empower to expand the network effect, we put forward the Digital Ecosystem Situation Analysis for designers to comprehend the ability and expansibility of the design at the very beginning.

According to previous research, customers' willingness to accede to the service system and patronize the same service again is determined by the comparison analysis of the costs and benefits which is associate with the customer and the service provider (Lee & Cunningham, 2001). All things considered, the Digital Ecosystem Situation Analysis measures the cost and benefit of all stakeholders in the digital ecosystem, and simulates the participants in the lifetime of the digital ecosystem. Focusing on the vacuum stage of the lifetime (show in Figure 4.2.1), endeavor to meliorate the design to reach the critical mass.

With the condition's analysis, next we are going to gauge and control the negative effect of the operation of digital ecosystem, so that we can make certain the designed ecosystem will expand positively then evolve into mature. After the negative effect measurement, for designers we try to estimate the probability of the digital ecosystem participants to realize their service acceptability and the increment in future. Aiming to help designers to position, to arrange, and to adjust their design to fulfill a better service ecosystem that is in line with demand expectations.

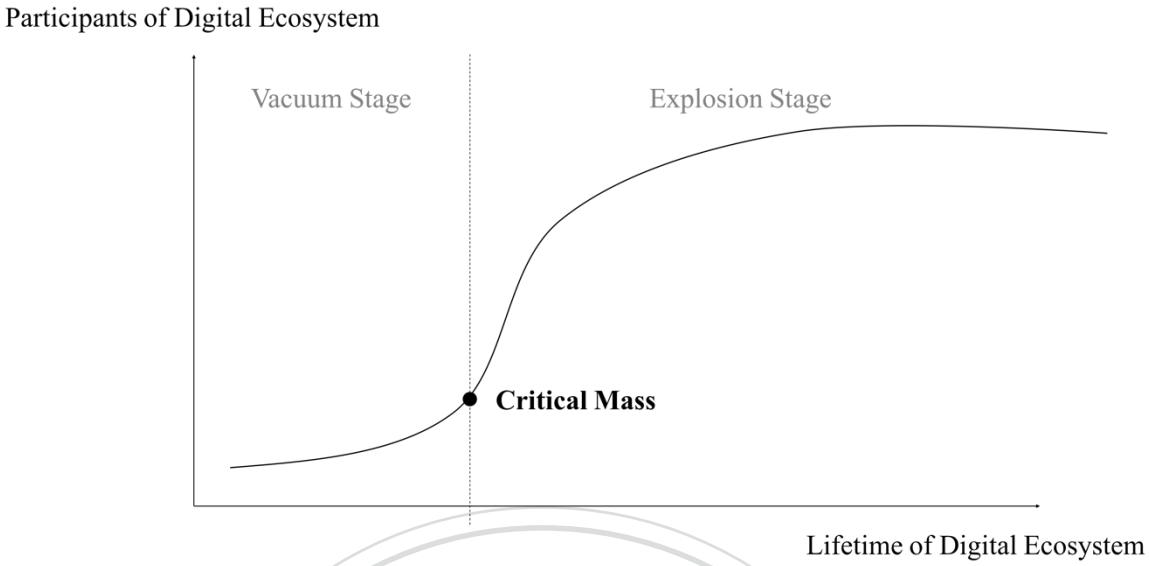

Figure 4.2.1 Digital Ecosystem Development with Network Effect

The following section will go into details and explicate the operation of these modules and sub-modules.

4.3 Arising Level of Network Effect Factors' Testing Module

The core value of Arising Level of Network Effect Factors' Testing Module is to ensure the digital ecosystem evolution is operating on the proper track toward the correct direction. To examine the influence from the D^3 Accelerator Assistant Module to the designed ecosystem, to improve the D^3 Accelerator Assistant Module, and to look over the network effect circulating within designed ecosystem at last, are the main functions of this module. These functions will only be started up if the designed ecosystem is capable of reaching the critical mass, that is to say it is qualified to estimate arising level of network effect factors.

Network effect level is a measurement that designers can comprehend the network effect of the digital ecosystem goes along to what extent. When we ponder over the level of the network effect of the designed ecosystem, we are trying to do the improvement of the designed pattern based on three dimensions of D^3 Accelerator Assistant Module. Moreover, we believe the improvement of those dimensions is related to the network effect level. Figure 4.3 shows illustrate the interaction between D^3 Accelerator Assistant Module and the network effect, and the following three sections are going to explain the cause and effect of assistant module's improvement and the level of network effect.

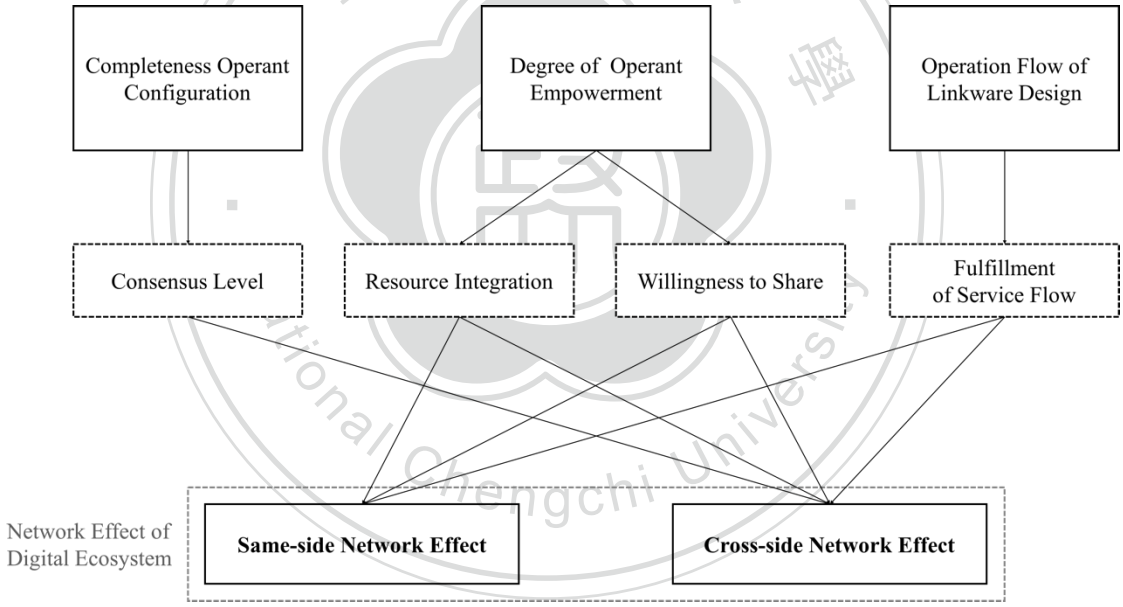

Figure 4.3 Relationship between Assistant Module and Network Effect

4.3.1 Completeness of Operant Configuration

In this sub-module of Destination Value Configuration of digital Ecosystem Entities, the output value represents the consensus level of digital ecosystem. In other hand, the consensus level of digital ecosystem is to examine the interactions between

stakeholders and also, the designed ecosystem will have higher successful rate with the higher level of consensus. Consensus level is not only related to the successful rate of digital ecosystem, but also highly correlated to the operating level of network effect.

Due to the consensus of ecosystem cognition of stakeholders, the identification of the digital ecosystem will be consistent in every stakeholder's mindset. They share the same vision and recognize the equivalent prospect, that is to be conductive to the interactions within the stakeholders of digital ecosystem from different perspective or different side. Consequently, we believe that to improve the consensus level of the Completeness of Operant Configuration could help increasing the cross-side network effect of the digital ecosystem.

In addition, we calculate the extent of network effect from the input of three dimensions, divided into two parts of variables that can affect same-side network effect and cross-side network effect (the function is shown in Formula 4.4.1). The sum of the variables represents the fulfillment of the network effect of digital ecosystem, that can be a feedback for designers to better understand whether their design corresponds to the service demand and that is to perform an immense network effect.

$$\text{Arising Level of Network Effect Factors} = \frac{\overbrace{\text{Consensus Level}}^{\text{Completeness Operant Configuration}} + \overbrace{\text{Resource Availability}}^{\text{Degree of Operant Empowerment}} + \text{Willingness of Contribution} + \overbrace{\text{Fulfillment of Service Flow}}^{\text{Operation Flow of Linkware Design}}}{\textbf{Max}(\text{Value of Destination Configuration Entities})} \times 100\%$$

Formula 4.4.1 Arising Level of Network Effect Factors

4.3.2 Degree of Operant Empowerment

The output value of the empowerment degree on behalf of the smart properties and resources integration and empowerment can be regarded as the willingness to license the smart properties and resources for other stakeholders. When we are going to enhance the network effect, first we have to make sure there is a powerful motivation attracting people to join the digital ecosystem. That means every participant can draw benefits which is not limited to the access of money from the ecosystem. We believe that the improvement of smart properties and resources integrating can make the motivation of participant more powerful and that will also result in the positive impact on both same-side and cross-side effect.

After creating enough motivations, we devote to transform the passive reception into active sharing, rely on the authorization of stakeholders' own smart properties and resources to facilitate the digital ecosystem operation based on the network effect. The value of the degree of operant empowerment contains the willingness to devote one's owns to others, that is to say, the improvement of the degree of operant empowerment can support the same-side effect and the cross-side effect for increasing the smart properties and resources that can be utilized and also stakeholders' willingness to share.

The function shown in Formula 4.4.1 as the above, also provides a useful feedback for designers to connect the empowerment degrees to the network effect of digital ecosystem, in light of the Fulfillment of Critical Mass that has be mentioned in the first section of chapter 4.2, especially the negative effect and the probability of participants together with the resources integration and willingness to share. They can give designers some inspiration of how to regulate the variables that can increase the fulfillment of critical mass and can enhance the network effect. That is a serviceable information which can be used in further advanced digital ecosystem design by

monitoring the variation of variables from the Degree of Operant Empowerment and the network effect of whole digital ecosystem.

4.3.3 Operation Flow of Linkware Design

The output of the Operation Flow of Linkware Design is a concept of the fulfillment of the service flow level. Operation Flow of Linkware Design considers about the elements of fulfilling flow experience, participants perceived service quality, cost of designing the linkware, and the interaction complexity, and so on. All the above is to lower the barriers for stakeholders to entry the digital ecosystem, so that we can attract more participants to join the digital ecosystem. In this way, that is somehow to bring the positive impact on the same-side and the cross-side network effect for the digital ecosystem.

The same as the function shows in Formula 4.4.1, the arising level of network effect factors measures the entirety of service flow completeness, in light of melioration of the advanced ecosystem design, completeness of service flow and the consideration of barriers to entry, illustrated in Figure 4.3, allude the tendency of service design's probability. We believe the outcome of the Network Effect Testing Module can help designers to do the amendment while proposing the improvement program in advance. Furthermore, the feedback also can assist designers to master the dynamic equilibrium relationship between linkware design and the critical mass.

4.4 Fulfillment of Critical Mass Module

As we mentioned before, our system D^3 Accelerator serves as an assistant instrument for service designers to create a digital service ecosystem that can go through the vacuum stage and smoothly reach the critical mass, in order to trigger the network effect and get into the explosion stage. Therefore, the destination of Fulfillment of Critical Mass Module is about to analyze the status of the designed model, whether it is qualified to pass through the vacuum stage successfully or not, and to give assistance to designers for evolving into a better blueprint of digital ecosystem design.

4.4.1 Digital Ecosystem Situation Analysis

To achieve the destination of the Fulfillment of Critical Mass Module, we have to let our designers comprehend with the available resources that can support their design pattern. Consequently, this submodule come up with the result based on the input data of anticipative funds and revenue which are the foundation of operating a digital ecosystem. The anticipative funds and revenue are the determinants of operation of digital ecosystem, neither of a digital ecosystem can be sustainable without sufficient funds and revenue. Acordingly, we calculate the variables that have be mentioned above and inputted by the designers, give a total amount and named as the present benefit, that is the positive situation of the digital ecosystem shown in Figure 4.3.

4.4.2 Measurement of Negative Effect

After the positive ecosystem situation analysis, we have to know the obstacles to launch a digital ecosystem, that is the reason why we attempt to measure the negative

effect could bring to the participants. The negative effect can be considered as the cost while participants would like to join the designed ecosystem. We roughly divide the cost into moneyed and non-moneyed, the moneyed cost refers to various kinds of currencies including the virtual currency, and the non-moneyed cost mentions to the participants' ability, time, barriers to entry, and even acquisition cost. Briefly speaking, the moneyed cost which means the digital ecosystem wishes to gain in substance from the participants, and the non-moneyed cost signify all obstructions that would keep the participants out of the digital ecosystem. These data all come from the subsidiary, which is D^3 Accelerator Assistant Module, mentioned before in Chapter 3, and give a total amount then named as the present cost, that is the negative situation of the digital ecosystem shown in Figure 4.3.

4.4.3 Fulfillment Calculation of Critical Mass

After measuring the positive situation analysis and the negative effect of the designed ecosystem, we have a conceptual idea of the position and the competitiveness of the designed ecosystem. Next we will move on to measure the maximum value of the difference between present benefit and present cost, which can connect our previous analysis to the fulfillment of the critical mass. Our concept of critical mass fulfillment formula shows at the below of Figure 4.3, we believe that the maximization of the present benefit, especially for the anticipative revenue will cause the positive effect on reaching the critical mass. Due to the research launched before, the revenue and the willingness to invest has positive correlation (Mai & Shi, 2001), and on the contrary the minimization of present cost of the designed ecosystem will lead to a high proportion of reaching the critical mass. Based on reasons above, we do the subtraction of present benefit and present cost, then divide by the maximum of the difference

between them, and finally conceive the formula of fulfillment of critical mass as below.

$$\text{Fulfillment of Critical Mass} = \frac{\textit{Present Benefit}\ (\text{Invested Funds} + \text{Anticipative Revenue}) - \textit{Present Cost}\ (\text{Participant's Ability} + \text{Monetary Cost of Participants} + \text{Acquisition Cost} + \text{Barriers to Entry}) + \text{Coefficient of Correction}}{\boldsymbol{MAX}\ (\textit{Present Benefit} - \textit{Present Cost})} \times 100\%$$

Formula 4.4.2 The Function of the Fulfillment of Critical Mass

4.4.4 Adjustment of Methodology and Conclusion

Although we have measured about the fulfillment of critical mass, the definitions and the characteristics of the considered variables is quite different, the consideration of critical mass is composed by multi-dimensional concept and that is truly difficult to measure them based on a same standard. In this way, we are going to develop our own evaluation mechanism in order to deal with the complicated situation of the multi-dimensional concept.

Designers may need to ponder over the whole digital ecosystem designed with the multi-perspective value exchange that is able to contain the smart properties and also the cash flow. In this way, we formalize the considered variables into the same basis in order to estimate every variable by an equitable criterion. Besides, the outcome can be served as a norm that designers can accordingly receive an initial value of the fulfillment of critical mass after the calculation. Afterwards, if the fulfillment is not able to motive the network effect, we will suggest designers to go back to the D^3 Accelerator Assistant Module to amend and improve their service design until the designed pattern is capable of reaching the critical mass.

Chapter 5 APPLICATION AND SCENARIO

As we have mentioned in Chapter 3, D^3 Accelerator is composed of a three-dimensioned model including Stakeholder Value Configuration System, Value Network Empowering System, Linkware Flow Experience Maximization System, and a dimension of measuring the achievements – Fulfillment of Critical Mass System, to help designers come up with a prototype which is capable to meet critical mass.

After elaborating our proposed approach, we then are going to show the details of our system scenario. However, our proposed is designed for service designers, in order to testify the validity and reliability of our theory, we design an application based on D^3 Accelerator – BlockFarm. In this chapter, we will not only illustrate the background and motivation of BlockFarm, but also how the implementation complete. Besides, how our design completed following the proposed theory, and gradually become a critical mass propinquity application will be demonstrated in the evaluation of Chapter 6.

- Background and Motivation of BlockFarm:

  We are fortunately to be born in an era be rich in various resources, and the resources are constantly growing larger. Notwithstanding we have so much, we do not know to cherish and be satisfied. Contrary to the past relatively deficient in resources, the more we have, the more we waste. And it gives rise to a condition of resources wasted getting worse, and allocating is more unevenly than before.

  In order to improve the situation mentioned above, we design a system to realized an equality, prosperity and harmony world with resource evenly distributed and not wasted. We expect our system to fulfill an ideal world has a great resemblance to the Utopia.

- Introduction of BlockFarm:

  BlockFarm is a blockchain-based online game proposed for academic research (shown in Figure 5.1). As a farming game, planting crops is the fundamental function of our system. To connect with our research proposed and to increase the gamification interest of BlockFarm, we come up with an alignment mechanism for user to choose whether they would like to stole others crops or to help others to guard their farm, this also is a bonus mechanism for user to gain extra experience points.

  Different from other farming game, the core value of BlockFarm will be the Blockchain-based transaction mechanism. We proposed a match-making system, users setting the importance of each crop at first and also determine the average significance of each crop to the ecosystem of BlockFarm. Based on the average significance and user's preference, system will automatically execute crop's ownership transference while successfully find out a best solution for property trading within all users. After each transaction completed, user will obtain additional experience points. New crops and properties will be unlocked as our user levels up.

Figure 5.1 Blockchain-based Farming Game

The following shows whole application scenario of a teenage player named Claire, she is an extrovert who likes to interact with people and be open-minded to have connection with others. Nevertheless, familiar to other internet and smartphone addicts, Claire is also a heavy user of internet who on the other hand, has greater acceptance to new technologies and innovative applications. Due to the familiarity with technology, Claire gets the hang of BlockFarm fairly quickly.

- User Application Scenario:

I. First Encounter Point: Registration

To be a part of our partner in this farm ecosystem and for especially operation of crops transactions, Claire has to register and log-in first. In order to make our system easy to use and convenient to connect to blockchain, user registration is simplified while we were designed. Claire just have to enter her email and set up password, our system will automatically register a blockchain address for her and binds it with her account (shown in Figure

5.2). The motivation of not fetching user's address on blockchain automatically to be the identification of BlockFarm by virtue of helping users to save trouble of the complicated procedures of becoming an authorized node on blockchain.

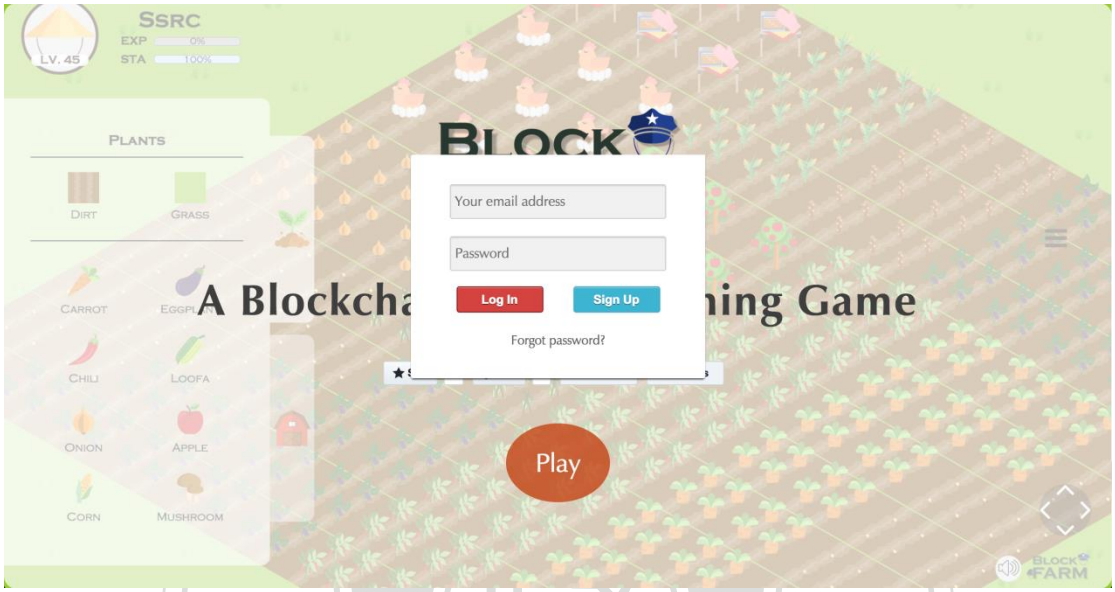

Figure 5.2 Login and Registration of BlockFarm

II. Second Encounter Point: Alignment Selection

Along with the registration, user have to select an alignment of their characters (shown in Figure 5.3). Two alignments of characters are the Thief and the Police respectively. The thief can steal other player's properties by sneaking into their farms, and get the crops and extra experience points when mission succeed. Get nothing and drop the value of energy yet mission failed. Besides, the chance of thieving successfully determines on the ranking of "the Thief". The higher the ranking, the greater the chance of success.

On the other hand, the Police is to guard farms against thieving. Players can hire a police to guard their farm conditional on some crop rewards, the police also can decide whether giving assistance to the player or not by

rewards. The employment of guarding and the rewards provided from employers (other farmers) should also be connected through match-making mechanism. The chance of guarding successfully determines on the ranking of "the Police", and the Police will gain extra experience points while achieve defending.

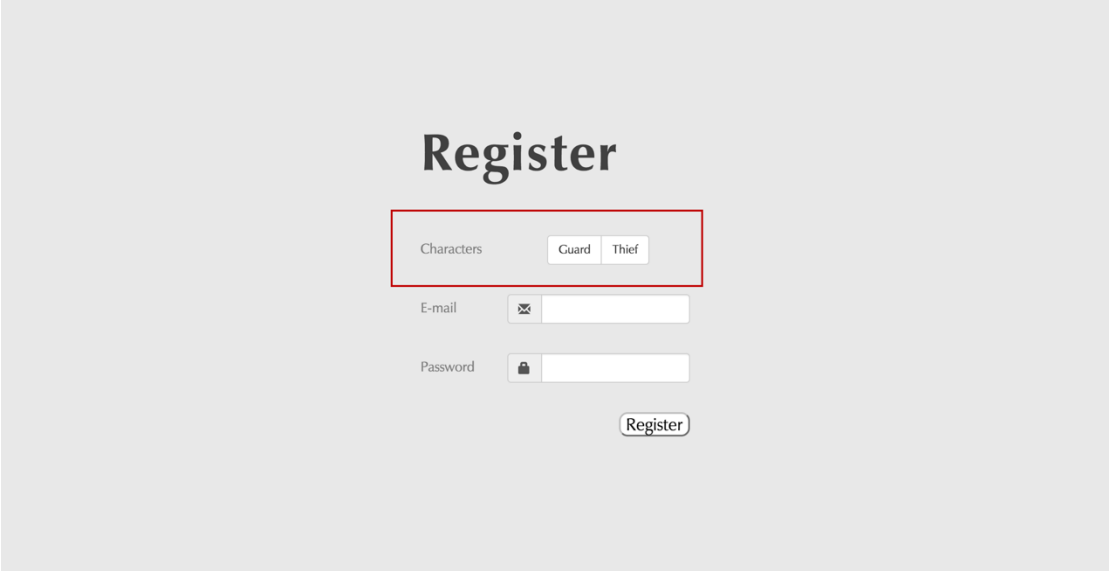

Figure 5.3 Alignment Select at Registration

III. Third Encounter Point: Planting Crops

For easy operating, we design a user friendly interface for players to get the hang of it. Before planting, Claire is taught to have soil filled by the pop-out reminding window (Figure 5.4 Reminder of Farming). She can instinctively manipulate whole planting process against menu of plant that is settle in the resident column on the left-hand side (Figure 5.5 Resident Column of Planting), a click on it will be ready to plant/put on. After finish planting, just wait for her crops to grow and to mature, waiting time will be demonstrated when Claire's mouse hover to her crops (Figure 5.6 Remaining Time of Maturation). Clicking the button draw with a cross to close the foreseeing of planting then Claire is free to operate the other functions or can

visit other player's farm. Incidentally, the tradable number of the crop will also be demonstrated and can be modified in the resident column (Figure 5.7 Resident Column of Tradable Crop).

Figure 5.4 Reminder of Farming

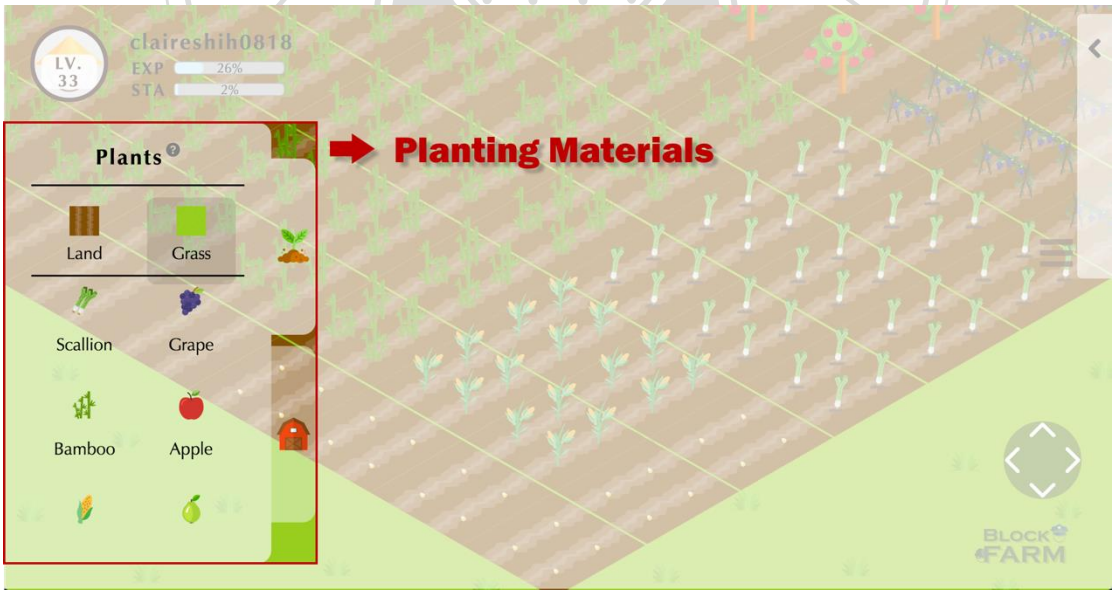

Figure 5.5 Resident Column of Planting

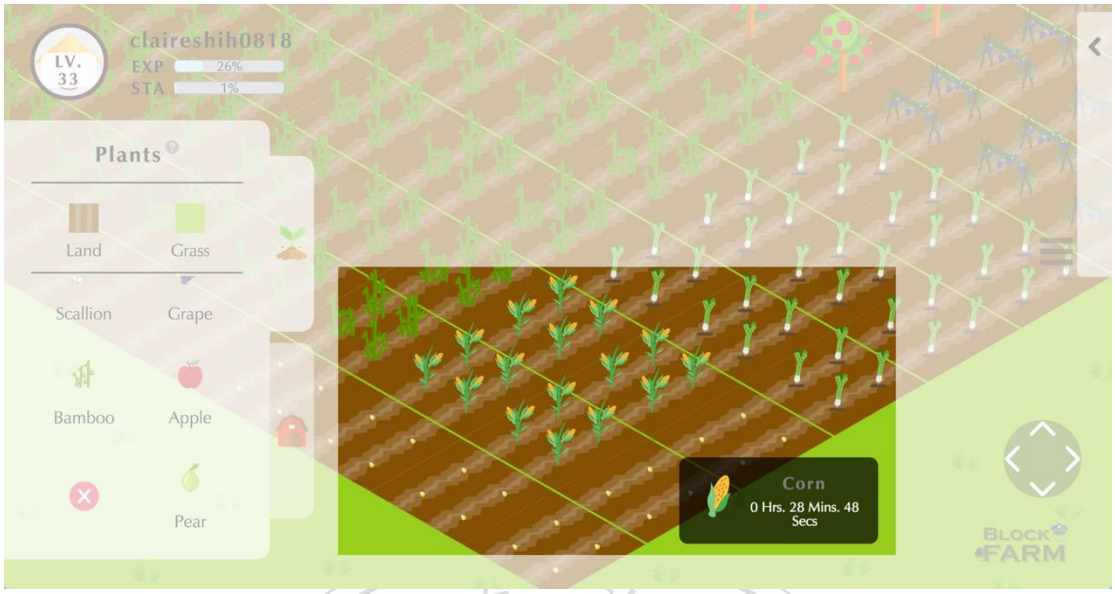

Figure 5.6 Remaining Time of Maturation

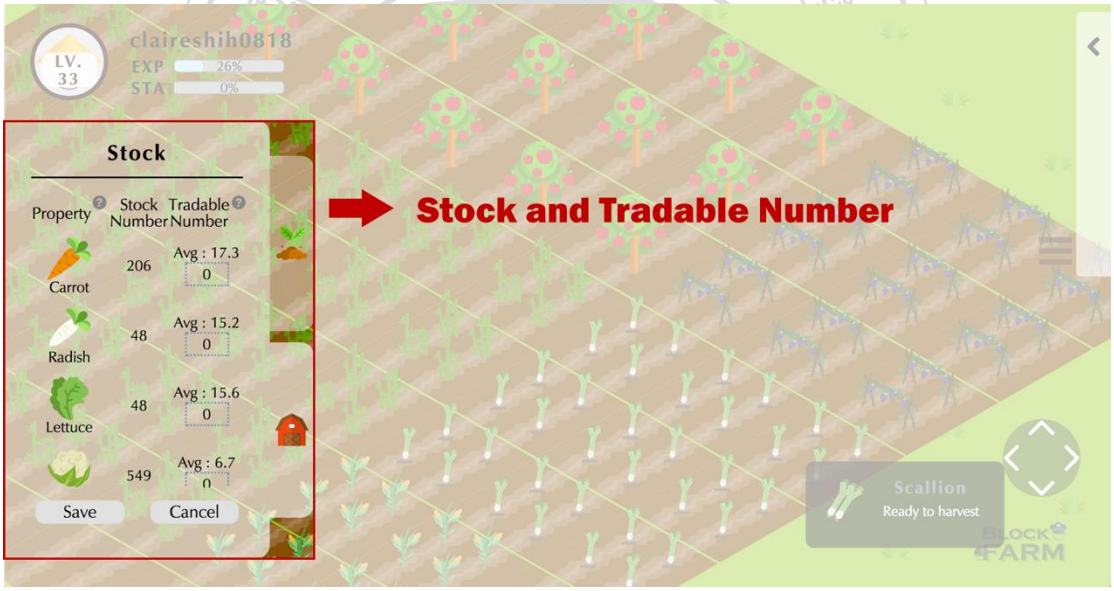

Figure 5.7 Resident Column of Tradable Crop

IV. Forth Encounter Point: Crop Trades

As we have mentioned before, crop trading is based on the average importance of each crop setting by all players (including owners). First, Claire should note down the importance of all crops in this farming ecosystem,

she can refer to the average importance of the crop made by other players. Then our system will calculate an updated average importance based on Claire's modifications (Figure 5.8 Set up Rating for Transaction). It is the most significant process that means a lot to the match-making mechanism and will directly cause an impact on the transaction result. Next, Claire should proclaim the amount of expected to be transferred of each crop (the same as tradable number show in Figure 5.7), meanwhile, Claire's crop will be taken into the process of transaction calculating operation.

First of all, the algorithm of match-making will choose a starting point which is the maximum of the difference between average importance and every player's importance setting of each crop. Next, according to the greedy algorithm, our system will come up with an initial result of match-making. It is worth to be mentioned that our algorithm considers about user's degree of tolerance toward the transaction. We set up minimum acceptable rating (shown in Figure 5.8 as well), that will dislodge the crops which are below the rating from receiving list of properties. After match-making, we establish a checking point for players to determine whether they accept the result or decline the transaction within ten minutes (match-making executes every five minutes). The transaction will be compulsorily executed if there are over a half of participants agree this transaction. Finally, the bartering transaction accomplished and Claire got the crops that she desires for.

Figure 5.8 Set up Rating for Transaction

V. Fifth Encounter Point: Questionnaires

In our research, questionnaire is not only for knowing our users but most for testifying our proposed. For better answering experience, we had considered about separating our questionnaires of this research and other three from the Destination Value Configuration of Digital Ecosystem Entities into several and display in different circumstances. However, pondering deeply over whole gaming process and the data collecting discrepancy of each question, we decide to require our users to fill in a 39 questions questionnaire at Level 5 of their farmer characters (Figure 5.9 Questionnaire of BlockFarm). The reason of setting a threshold of Level 5 is owing to that we believe our user is familiar to the gaming mechanism after having a succession of interactions and reaching Level 5.

Each dimension in this research and the Destination Value Configuration of Digital Ecosystem Entities has its own question for users to answer. For instance, first perspective, Completeness Operant Configuration, has to

verify the concepts of service desirability and disruption. Second perspective, Degree of Operant Empowerment, has to certify the concepts of influence, efficacy and empowerment. Third perspective, Operation Flow of Linkware Design, has to testify the concepts of complexity, completeness and linkware design. In our research, we have to verify the concept of critical mass, and our design logic will clarify in Chapter 6.2 at below.

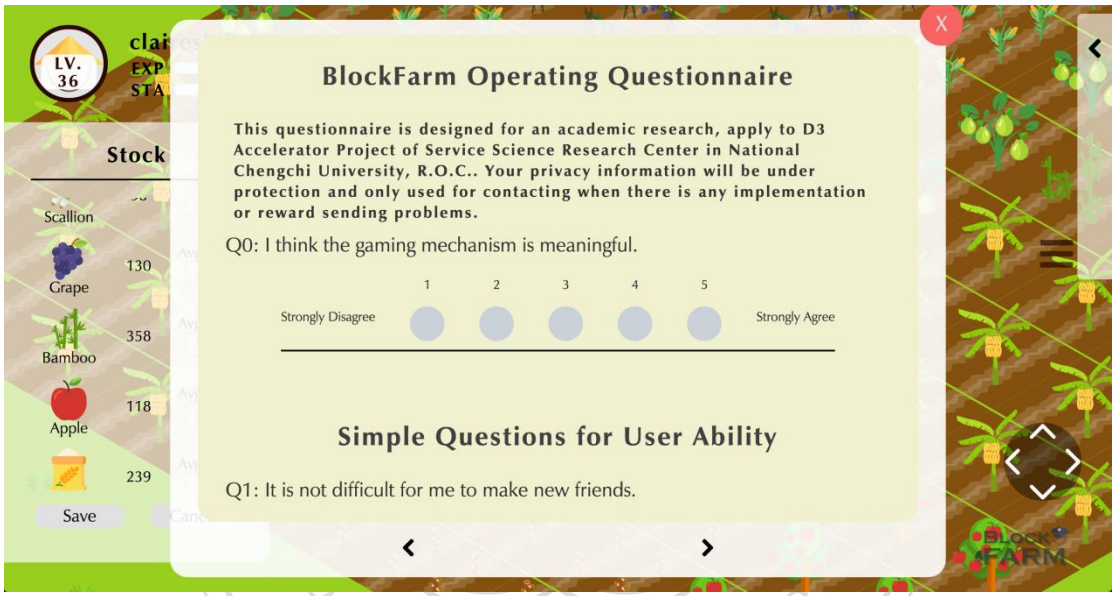

Figure 5.9 Questionnaire of BlockFarm

After introductions of motivation, background, concept and scenario, we are going to talk about the structure of implementation. We all know that we should evaluate the situation, arrange project schedule, consider funds and limits, think over data storage and information security, and so on. before developing a system. In BlockFarm project, due to the limitations especially transaction complexity and waiting time of blockchain, our farming game which depends on a large quantity of interactions and instantaneity is not suitable to implement on blockchain in its entirety. Moreover, our core value of property transfer is involved in the issue of personal assets and privacy, therefore, our

system puts into practice by both blockchain and platform.

On blockchain side, we allow data bound up with ownership transfer of properties in storage. For instance, the ranking of crop importance, the computing path of match-making, the period and result of match-making, and the ownership transference. On the other side of platform, we deal with all processes during farming behaviors and store up data related to personal privacy. Theoretically speaking, the best solution to user is to retain their private information at the individual user side of blockchain. For simplicity of the implementation of this project, we build a platform and to manage the safekeeping.

Chapter 6 EVALUATION

The evaluation is designed for examining our framework and mechanism proposed for service designers to achieve a digital ecosystem capable of reaching critical mass. According to the design science research evaluation method (Von Alan, March, Park & Ram, 2004), we design our evaluation model by simulations and observational field study. Developing an operating system based on proposed guideline and to collect user's data from both system operation and questionnaire feedback. The system simulation has illustrated in Chapter 5, after elaborating our propositions in Chapter 6.1 shows the questionnaire reference and designed logic in Chapter 6.2.

6.1 Propositions

In order to justify the proposed contention mentioned in the conceptual framework in Chapter 4 and to certify the correlation between this research and the Destination Value Configuration of Digital Ecosystem Entities, we propose three propositions as follows. The propositions composed according to the assumption and the interactions between network effect and critical mass. In other research, we also try to attest to the connection between our research architecture and the designed system mechanism.

- *Proposition 1. There are no counter effects between three dimensions of D^3 Accelerator.*
- *Proposition 2. Improvement of each dimension of D^3 Accelerator can lead to the expansion of ecosystem participants.*
- *Proposition 3. Three dimensions of D^3 Accelerator have positive correlation towards reaching critical mass.*

6.2 Experiment Simulations

As aforementioned, our decentralized application designed for this research experiment simulations are based on proposed theory. At the very beginning of our design, we start from the share of voice in the world using a tool – google trend. As we deeply believe that the only reason of designing a service or even developing a system is to solve some problems, we use the word "problem" to be the starting point of our design. When talking about the unsolved problems all over the world, we might think about crime, violence, war, disease, climate, or economic situations. However, due to the result of "world problem" in google trend, the only noun connected with world problem is "Poverty" (Figure 6.2.1), so as the first problem published in "The 10 Biggest Problems In The World According To The EU" in Business Insider.

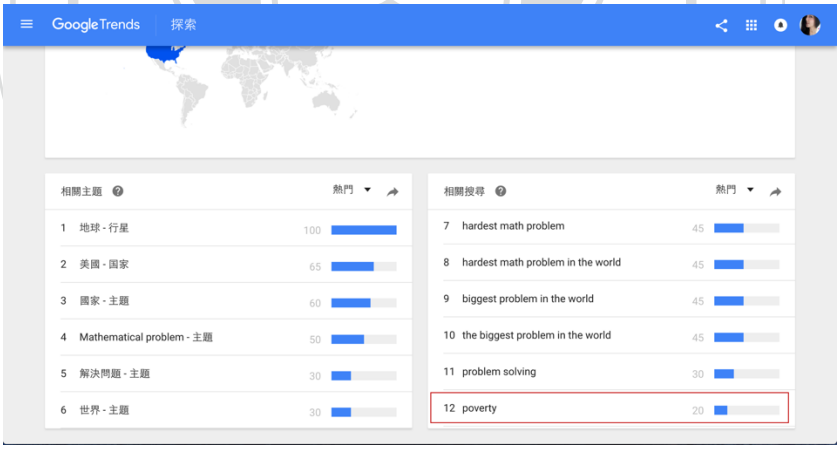

Figure 6.2.1 Result on Google Trend of "Problem in the world"

Our value proposition is to make the world filled with happiness and try to narrow the gap between rich and poor. Gross National Happiness (GNH) is an index of development philosophy indigenous to the country of Bhutan, and be used to measure the collective happiness in a nation. It attaches importance to sustainable and equitable socio-economic development, environmental conservation, preservation and promotion

of culture, and good governance (Source: Wikipedia). We extend its concept to our development and contemplate upon the probabilities of the causes of poverty. We finally determine to choose the cause of “resources allocated unevenly” which is possible to be solved, then come up with a bartering system to fulfill reducing poverty and increasing average level of GNH.

When talking about implementation, due to the fundamental instrument of development – blockchain, our bartering system is characterized by decentralized, consensual, trustworthy, and so on. We think that are the superiority value-added to the bartering mechanism, users can possess all advantages of making transactions on the blockchain instead of platform. Moreover, it is worthy to mention that we had a great discovery while searching for the inspiration on google trend. We enter the word “better world” as our value proposition and we got a relation share of voice of “gaming can make a better world” (shown in Figure 6.2.2 as below). This seems a stroke of genius to our implementation, we had never thought of solving problems with a gamification prospective. Owing to the inspiration, we decide to develop a farming game which involves a bit of healing and entertainment, also allows users to simulate abnormal property bartering contrary to traditional transactions. So as to realize the gamification solution of resource allocated problems and to achieve the vision of improving poverty. The whole process of our experiment system design thinking shows in Figure 6.2.3 at below.

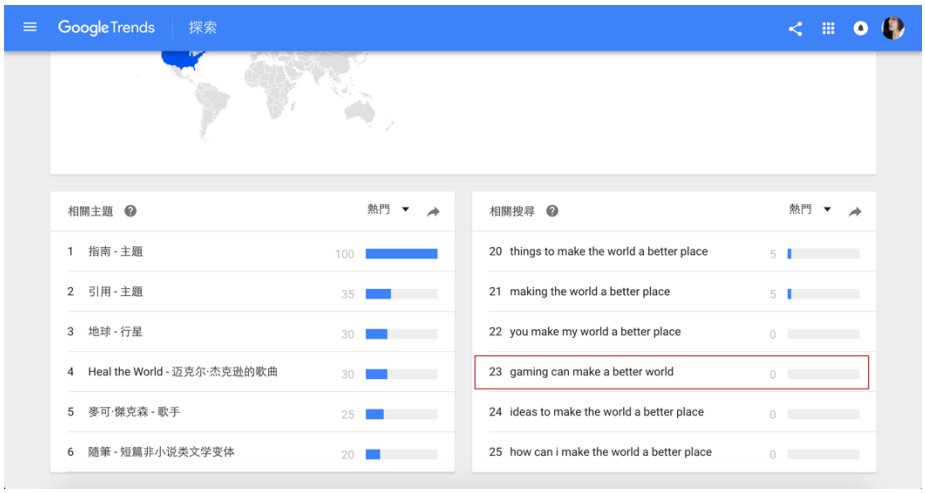

Figure 6.2.2 Result on Google Trend of "Better world"

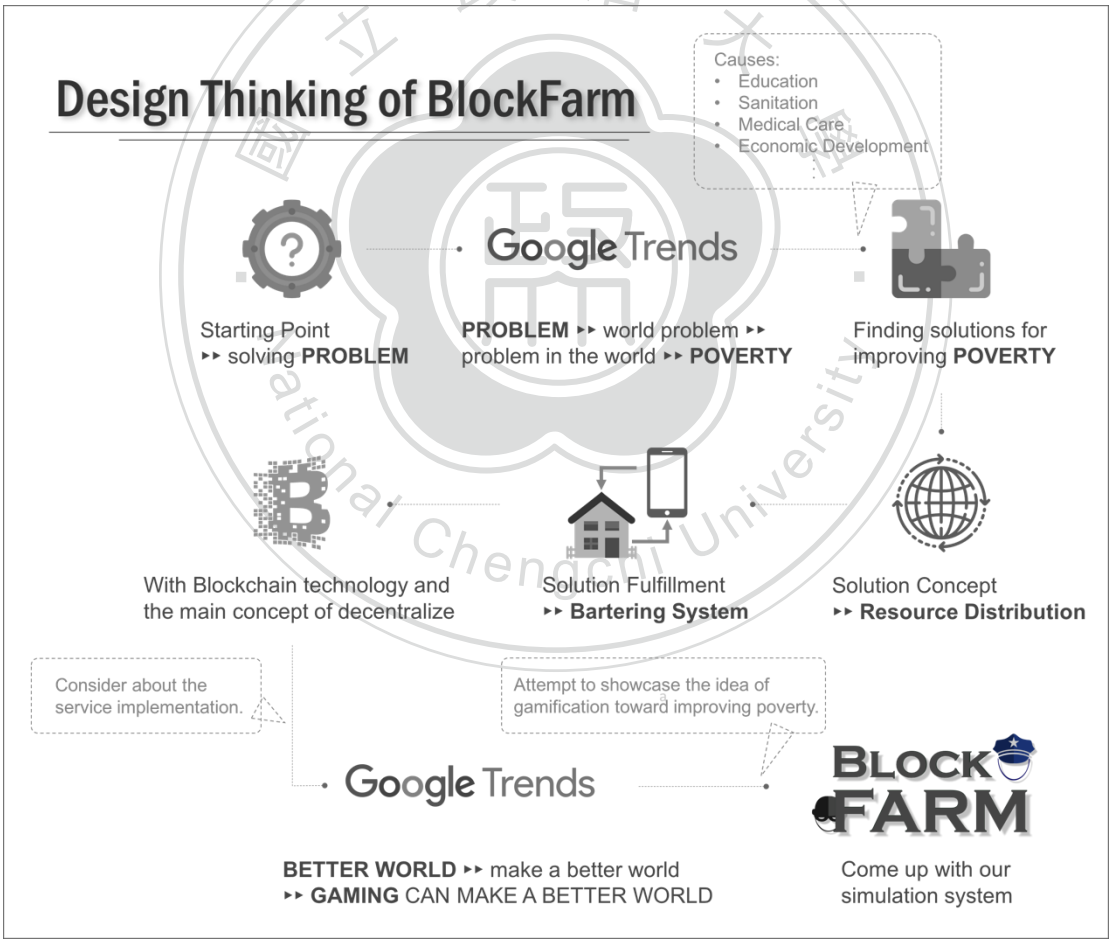

Figure 6.2.3 Design Thinking Process of BlockFarm

6.3 Questionnaire Design

Perceived critical mass is a measured degree of which current or potential users of a service perceives, that enough individuals have adopted so that the service's further rate of adoption becomes self-sustaining as a critical mass point, has been reached (Sledgianowski & Kulviwat, 2009; Shen, Cheung, & Lee, 2013) and it is believed to influence social norms through the direct and indirect interactions especially among technology users (Shen, Cheung, & Lee, 2013). When talking about critical mass in our digital ecosystem design, we include this concept and propose a measurement from both system-collected and user's feedback. Designing to collect data from our user experience, we consider both the frequency of the usage (Lou, Luo & Strong, 2000; Shen, Cheung, & Lee, 2013), and the concept of community influence (Sledgianowski & Kulviwat, 2009).

In Lou's research, perceived critical mass refers to believing most of their peers are using the service, and the validation of "using" is not only a use-or-not problem but the loyalty of participation. We consider that to reach critical mass, participant's influence exerting on other potential participants should be mighty and persuasive, thus, we deem that heavy users is more influential than light users. Beside, network effect is viewed as a significant element of reaching critical mass. Influence from the community user can directly connected (both communities in reality and virtual communities on Internet) is a powerful factor related to causing network effect and further reaching critical mass (Sledgianowski & Kulviwat, 2009). At the beginning of this research has declared our position is to arising the level of network effect for the sake of reaching critical mass. Consequently, we would like to evaluate the community influence of user behavior to be the second perspective of the measurement. Last, the questions designed based on the referred references are shown as follow:

I. Frequency of usage:

♦ Q1. I play BlockFarm frequently.

♦ Q2. I will continue playing BlockFarm frequently in future.

II. Influence of community:

♦ Q1. Many people I communicate with play this game.

♦ Q2. Many people I communicate with regularly play this game.

♦ Q3. People I communicate with will continue to play this game.

In addition, reaching critical mass requires a very essential condition is to make people desire for your applications or services, thus, we refer to previous researches and find out their measurements had some connections with the concept of critical mass. First of all, we had mentioned that increasing participants in order to reach critical mass is not only a use-or-not problem but the loyalty of participation. Hence, pleasant experiences and positive interactions among ecosystem members will lead your service to leave a good impression on your customers and to pay a return visit further (Afthinos, Theodorakis, & Nassis, 2005). Besides, an emphasis on service quality, desirability, user satisfaction is now a top priority in the digital ecosystem design, they also reflect on the experiential value which is regarded as one of the most important determinants of consumers' behavior (Abedi, & Rostami, 2012; Jia, He Michael, et al., 2012). On the basis of these researches, we design some questions combine the intuitive concepts of critical mass, such as service desirability, user expectation, word-of-mouth marketing and the loyalty of participant in order to certify critical mass in diversification of testing perspectives.

6.4 Assumptions

- Assumption 1: Subjects are familiar with our gaming mechanism and the vision of this research is well-delivered.
- Assumption 2: Subjects can comprehend with our match-making mechanism through the guiding tutorial.

6.5 Experiments of Observational Field Study

For realizing the idea of gamification toward improving poverty, our experiment is designed based on a game implementation, collecting data from user behavior through playing the game and filling-in a questionnaire after stride over a threshold. To maintain the healing and relaxing capability of recreation, our experiment develops the game function basically similar to other products of farming game on the market. There are some mechanisms worthy to be mentioned which are related to our research, the following shows these mechanisms and gives some simple narrative of them.

- Character Alignment

  The operating mechanism of alignment has elaborated in the second encounter point of Chapter 5, and this design is basically for imitating different stakeholder's position. In our farming game there is only one stakeholder called "user", however, with the alignment mechanism, users will have distinct claims and different opinions (even conflicting behaviors) in order to stand their ground. In a real-world bartering or even making transactions, there inevitably will have some deceptive or robbery behaviors, or the fraud-on-market as well. The alignment mechanism makes our simulation more approaching to the ecosystem

in the real world which may contain multiple groups of stakeholders and show the realistic side of conflicting situations. Moreover, we believe the conflict in the digital ecosystem will finally reach an equilibrium which is correlative to the consensus level in the Completeness Operant Configuration of the Destination Value Configuration of Digital Ecosystem Entities (Figure 4.1).

- Mission Request

  At different level of the farmer, we set up distinct missions for players to conquer and the experience points they can get is far greater than just being a farmer. The very fundamental concept of this design is to increase player's willingness of exchanging properties with others. Willingness to share is the mainstay of bartering ecosystem, and the spirit of our core value to carry out the mission to improve poverty as well. Besides, in the project of D^3 Accelerator, operant empowerment starts off property sharing, affects the efficacy of stakeholders and their behaviors (See in Figure 6.5.1). Also the share goal of whole digital ecosystem will be influenced, thus, the mission mechanism can be regarded as a thruster in BlockFarm in order to facilitate the bartering system.

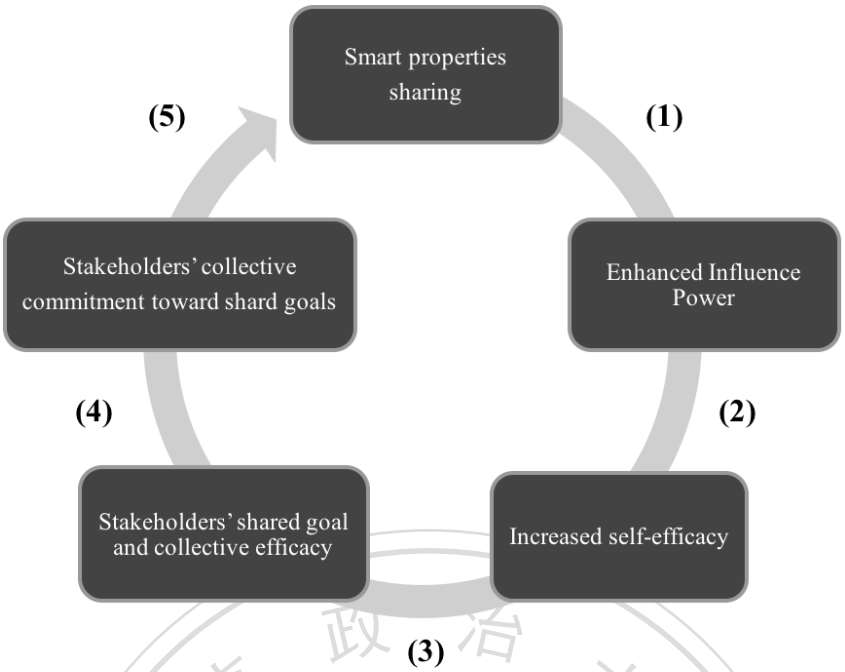

Figure 6.5.1 Conceptual Framework of Empowerment

- Property Rating

The computing logic of property transference in BlockFarm is fundamentally based on the average importance of each property set by all players. Before match-making mechanism operates, we require players to fill in the importance of each crop in accordance with their preference. Next, we will begin match-making from the highest difference between average importance and player's preferences of calculation result as the starting point. We give free rein of property transference to the players by empowering them to access the control of transactions so as to reach consensus and collective efficacy in this ecosystem and toward the global optimum in every round of bartering.

6.6 Measurements and Data Collection

In this chapter we will expound data gathering on BlockFarm and correlative variables mapping to our measurement proposed in Chapter 4. We estimate to monitor user's behaviors on the system for improving our system lasting about two weeks, the result will be transformed into our measurement during the session of data collection. For providing better user experience to our players and becoming more persuasive of our theory, system updating of BlockFarm will keep making based on the feedback data arrangement.

6.6.1 Measurement of Critical Mass

Critical mass is the kernel of this research, which contains two sides of concept: benefits and costs (show in Formula 4.4.2, The Function of the Fulfillment of Critical Mass). Data of benefit is the anticipation and the sense of marketing from service designers, besides, data of cost includes four different perspectives of obstruction which are participants' ability, monetary cost of participants, acquisition cost, and barriers to entry, and both of them are measured by our assistant module.

Phase 1: Data Fetched by Designer and D^3 Accelerator Assistant Module.

In this application of BlockFarm, the invested funds and the anticipative revenue is evaluated and determined by our project members that we will explain in Chapter 6.7. On the other hand, cost measured by our assistant module correspond to the variables as follows:

1. Participants' Ability:

It is mapping to the variables of willingness to provide and collective efficacy in Degree of Operant Empowerment. By reason of willingness to provide refers to all smart properties the participant owned and are ready to contribute to the digital ecosystem, including their real assets and capabilities. When reaching collective efficacy means participants are willing to do more efforts than they must to for improving the environment of digital ecosystem and the sustainable conditions. These two measurements are correlate with the concept of participants' ability proposed in our research.

2. Monetary Cost of Participants

Monetary cost is also and anticipation made by service designers in order to equilibrate the present benefit. Notwithstanding services are often free to users in the digital world, they are not always acquiring without charging anything especially for some services that are developed to make profits. Consequently, we think our service designers should consider about redressing the balance of the shortcomings of charging and the realism of ecosystem sustainability. Accordingly, we ponder over the implementation cost, the unfamiliarity of blockchain application and the destination of BlockFarm during design thinking, we determined not to charge monetary cost from our players yet. However, we will still possibly charge to our participants while BlockFarm is no longer a gamification application of blockchain.

3. Acquisition Cost

In our proposition, acquisition cost is resembling to the opportunity cost of not taking part in the designed ecosystem. In this circumstance, the variable of searching volume proposed in the degree of desirability of Completeness Operant Configuration can best represent the opinion of it. The degree of desirability is an evaluation which refers to the share of voice according to google trend. By virtue of google is the first searching engine in the world, we use the tendency that people all over the world pay attention to and desire for on purpose of standing for the opportunity cost of people who refuse to join the ecosystem.

4. Barriers to Entry

Barriers to entry is the opposite to acquisition cost, it means people are willing to participate in the digital ecosystem but is blocked from the enter barriers. They often take place when the manipulation is too complicated or the service design is not friendly enough to the public. Correspondingly, the variable of complexity of interaction in the Operation Flow of Linkware Design can best symbolize the measurement of the obstacles made by the unfriendly design.

Phase 2: Calculate Network Effect Level and Critical Mass by formula.

After two-weeks data gathering from designer and the D^3 Accelerator Assistant Module which collecting data from system fetched and players' feedback, we had collect 75 sample size of raw data using for calculation. The function of measuring arising level of network effect factors and critical mass are proposed in Chapter 4, Formula 4.4.1 and Formula 4.4.2, and our system will measure the arising level of

network effect factors to see the correlation between it and the fulfillment of critical mass based on the computing result.

$$\text{Arising Level of Network Effect Factors} = \frac{\overbrace{\text{Consensus Level}}^{\text{Completeness Operant Configuration}} + \overbrace{\text{Resource Availability}}^{\text{Degree of Operant Empowerment}} + \text{Willingness of Contribution} + \overbrace{\text{Fulfillment of Service Flow}}^{\text{Operation Flow of Linkware Design}}}{\textbf{Max}(\text{Value of Destination Configuration Entities})} \times 100\%$$

Formula 4.4.1

$$\text{Fulfillment of Critical Mass} = \frac{\textit{Present Benefit}\ (\text{Invested Funds} + \text{Anticipative Revenue}) - \textit{Present Cost}\ (\text{Participant's Ability} + \text{Monetary Cost of Participants} + \text{Acquisition Cost} + \text{Barriers to Entry}) + \text{Coefficient of Correction}}{\textit{MAX}\ (\textit{Present Benefit} - \textit{Present Cost})} \times 100\%$$

Formula 4.4.2

6.6.2 Supervisory of Interaction between D^3 Accelerator Assistant Module

In accordance with the conceptual framework shown in figure 4.1, we had declared that there are interrelationships between our D^3 Accelerator Assistant Module (Figure 6.6.2.1). After data fetching and the measurement of critical mass, we have to monitor the interactions between each dimension of the assistant module for the purpose of giving designers feedback about how to improve their digital ecosystem, and whether to ameliorate the mechanism design of digital ecosystem, the function development, the system delivery, the user interface, or the user experience, etc. as first priority under limited budgets. Moreover, we will also pay more attention to justify if there are surely no negative effects between those dimensions, and all of them are definitely related to reaching critical mass.

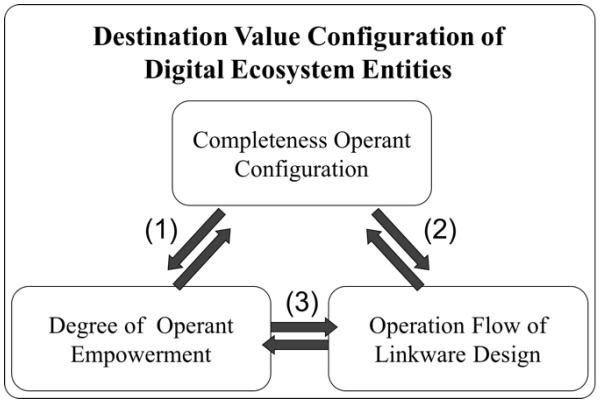

Figure 6.6.2.1 Correlation between D^3 Accelerator Assistant Module

6.7 Result of Field Test

In this chapter we will illustrate our questionnaire result collected from BlockFarm, the calculation of network effect level and fulfillment of critical mass based on designer's insight and the assistant module. We will also monitor the interactions and correlations between each dimensions of the outcome of assistant module.

6.7.1 Effect of Field Test and System Improvement

Within our questionnaire collection, we had demarcated the data into two sections. The interval between the two sections is based on a demarcation line of system improving. Owing to the instability of system when BlockFarm had just launched, and our matching-making mechanism was designed to be executed every hour as default setting. After running for about five days, we received many feedbacks from the users and we roughly divide them into four dimensions (Figure 6.7.1) to examine the problems of reaching critical mass and set up the direction of our system improvement.

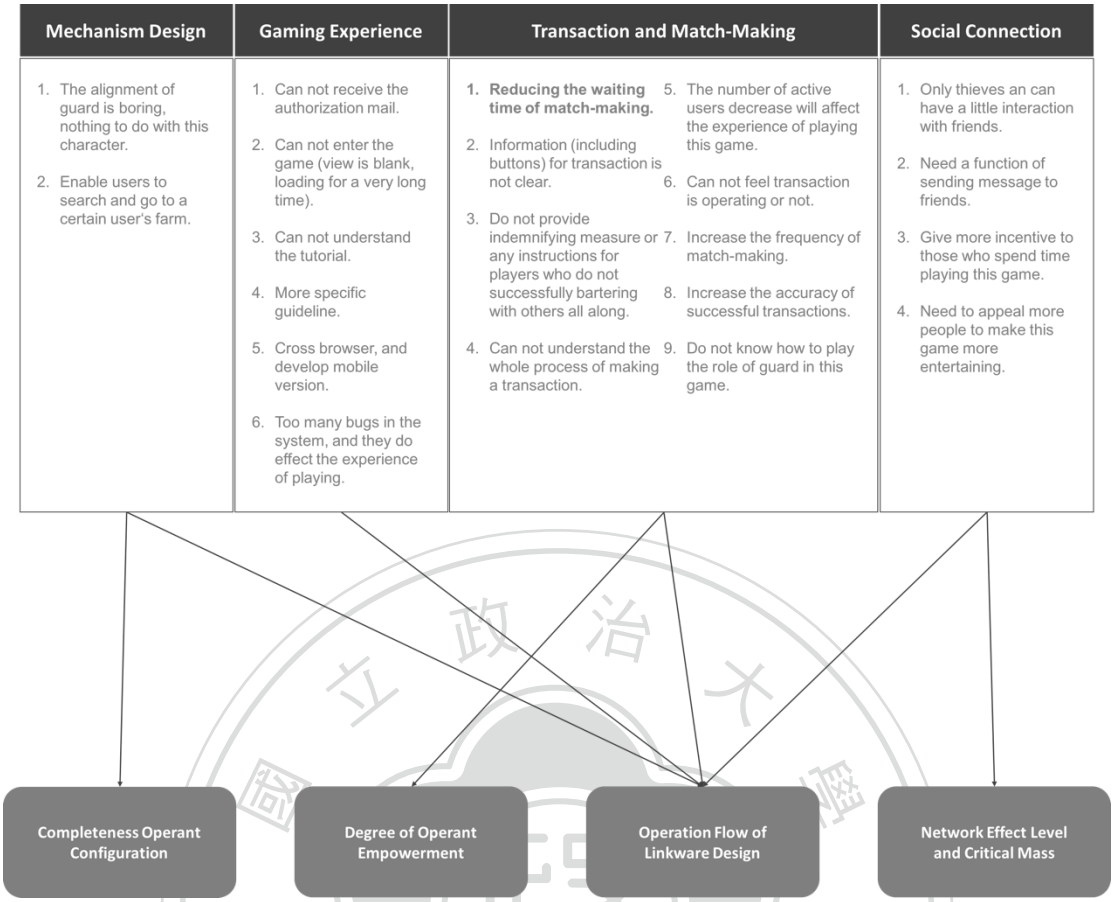

Figure 6.7.1 Feedback received from BlockFarm users

As BlockFarm was designed to simulate a bartering system in the real world, the most important and also our core value is the match-making mechanism which anticipated to provide a smoothly, effortlessly, satisfactorily bartering experience for our players. However, the result does not meet our expectations in the light of users' feedback at the beginning. At that time, we decided to improve the transaction experience as our first priority of next stage of system improvement. First of all, the most problems are related to the match-making mechanism. We realized that a gamification simulation which user experience is emphasized on the real-time operation and instant messages transference should be regarded as the fundamental of implementation as well. Consequently, in order to make our users perceive that

bartering is ordinary and common in their farming ecosystem, we improve not only the operation of gaming, the stability and the flow experience of match-making mechanism, but also the executive period of it (from execute once every hour to five minutes once).

6.7.2 Assistant Module's Result of System Improvement

D^3 Accelerator Assistant Module includes completeness operant configuration, degree of operant empowerment, and operation flow of linkware design. In Figure 6.7.2 to Figure 6.7.4 as below show the data before and after system improvement of each dimension in the assistant module. X-axle represent the questions that use for measuring the concepts, and Y-axle symbolize the result of questionnaire based on Likert scale. First of all, we can tell that every degree of each dimension has remarkable growth after system improvement, there are no negative effects exist after our improvement. Besides, each dimension of the assistant module has its own score to stand for the fulfillment of their dimension. For instance, consensus level of stakeholders means the fulfillment of completeness operant configuration; empowerment degree refers to the collective commitment of every stakeholder in ecosystem; and the degree of flow experience act for the fulfillment of service flow.

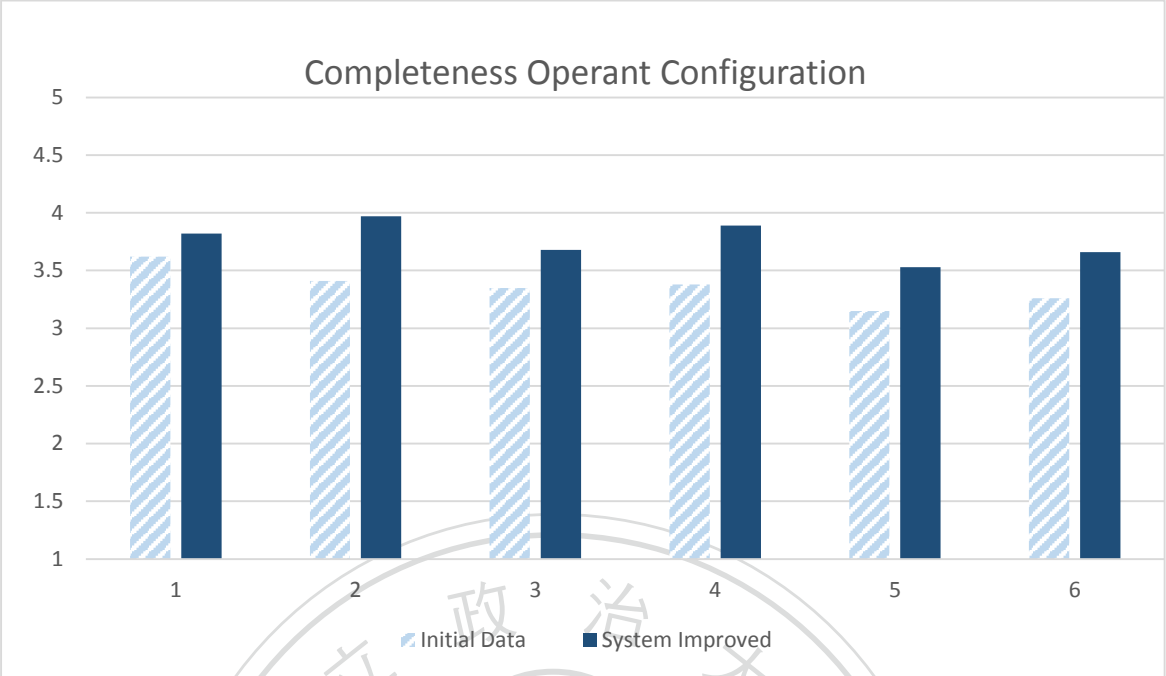

Figure 6.7.2 Questionnaire Result of Operant Configuration

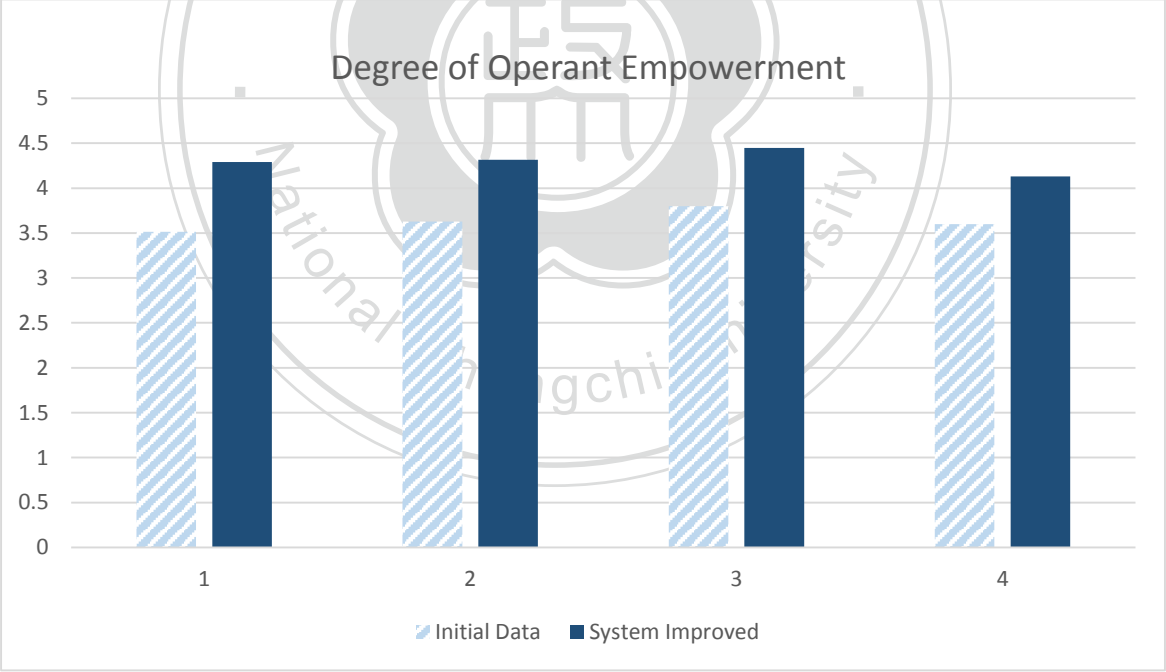

Figure 6.7.3 Questionnaire Result of Operant Empowerment

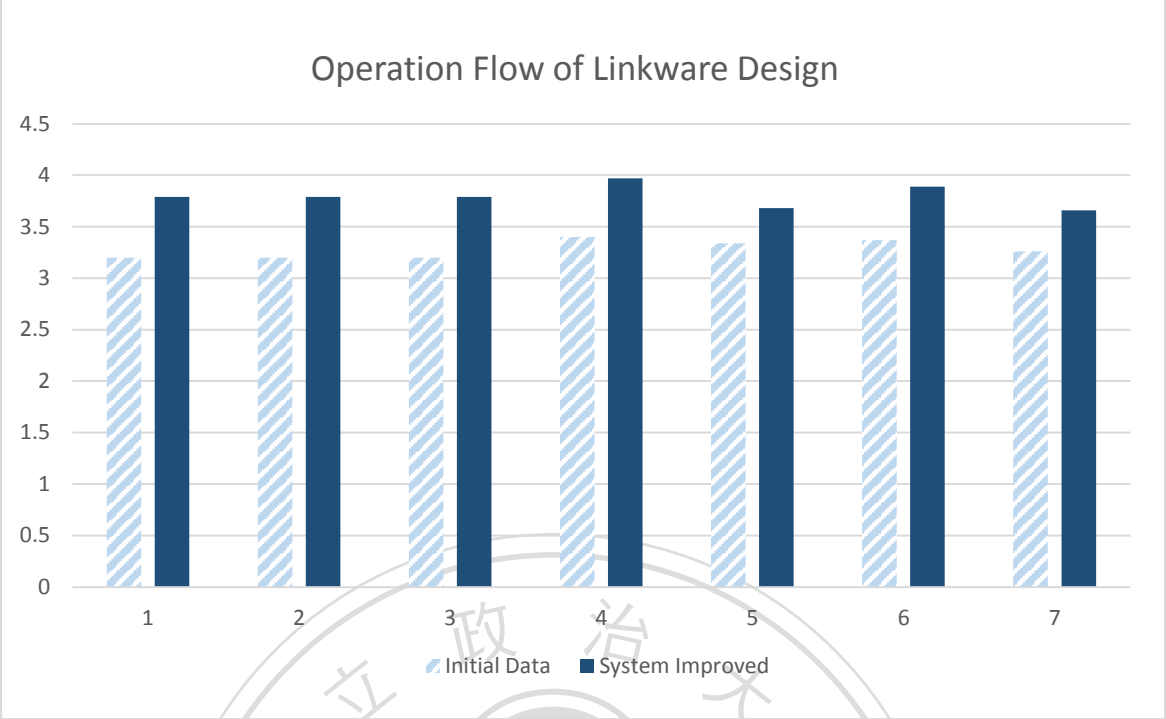

Figure 6.7.4 Questionnaire Result of Operant Flow

Conforming to the outcome of each dimension shows below (Figure 6.7.5 Computing Outcome of D^3 Accelerator Assistant Module), the score of initial data and after system improved are all based on the measurement of the research of our assistant module (Chiang, 2017; Kuo, 2017; and Chen, 2017). In the computing result, scores of each dimension are all improved so as to the result of questionnaire (Figure 6.7.2 – Figure 6.7.4, and Figure 6.7.6). It is worthy to be mentioned that the range of computing result located in 0 to 100, and the questionnaire result is based on Likert scale which scope of 1 to 5. We can say that the computing data has some correlation with the questionnaire feedback collected from users due to Figure 6.7.5 and Figure 6.7.6, it also confirms the credibility of the destination value configuration of digital ecosystem entities. In order to attest to our propositions, we will analyze the relationship within the assistant module and elaborate it in the next paragraph of chapter 6.7.3.

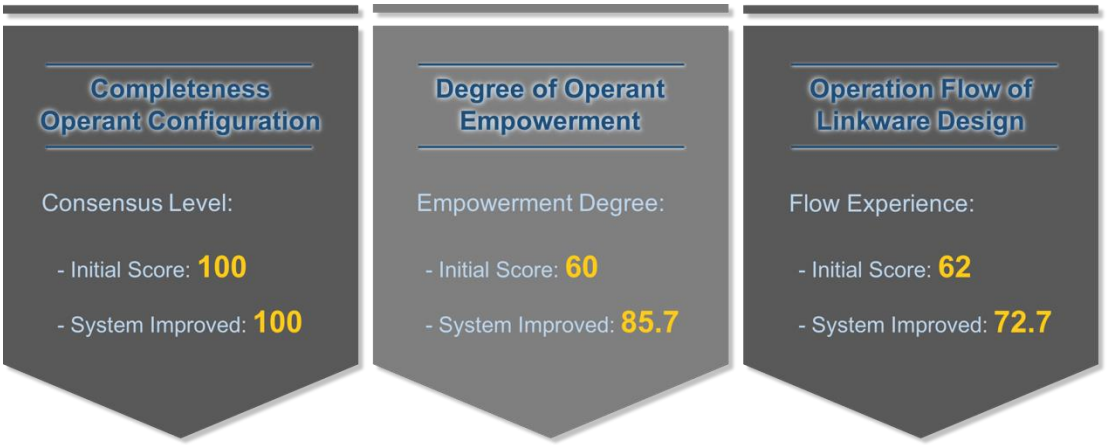

Figure 6.7.5 Computing Outcome of D^3 Accelerator Assistant Module

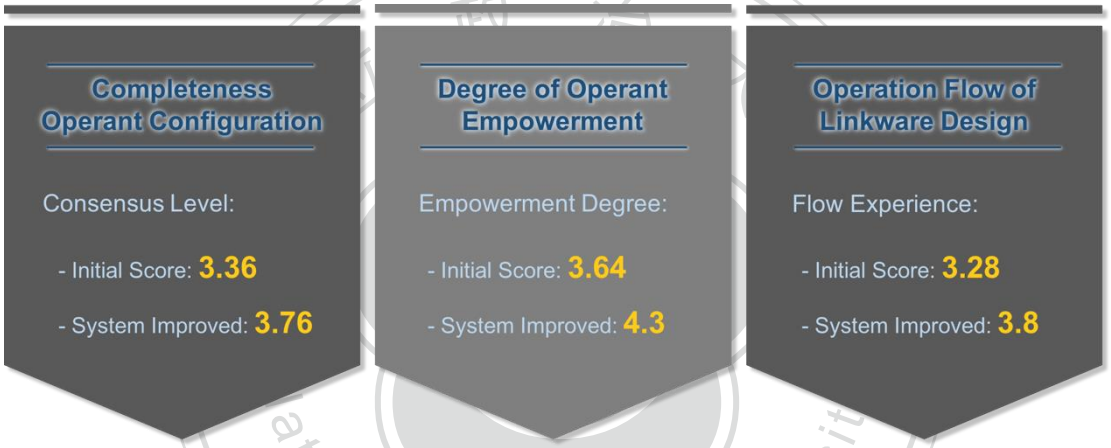

Figure 6.7.6 Average of Questionnaire of D^3 Accelerator Assistant Module

6.7.3 Correlation Verification within Assistant Module

According to the computing outcome shows in Figure 6.7.5, we make a radar chart that illustrate more clearly about the correlation between the assistant module (Figure 6.7.7). First of all, the outcome of Degree of Operant Empowerment and Operation Flow of Linkware Deign are all improved after we made some adjustments in the light of first-mover's feedback. On the other hand, the outcome of Completeness Operant Configuration does not change owing to two reasons: one is because of its score is already the optimum number of the measurement; second is by virtue of our system

improvement did not require any modification about insert or delete stakeholders, thus, system improvement does not cause an impact on the calculation result of operant configuration.

Subsequently, there are some discrepancy between the consequence of theory computing and the result of questionnaire in reality circumstance. Accordingly, we normalize the proportional scale of two measurements to the range of 0 to 100, then observe what features of them are in common and distinct from. In light of Figure 6.7.9, we can tell that the questionnaire feedback of Degree of Operant Empowerment and Operation Flow of Linkware Deign are all similar to the computing result, even better than them. Besides, they still have conspicuously progress after system improvement. In contrast to other two dimensions, the outcome of Completeness Operant Configuration does not meet the expectation of computing result. Following is going to discuss whether the Completeness Operant Configuration can not reach the prospect.

On the one hand, the result of Completeness Operant Configuration represents the proportion of stakeholders reaching consensus. Theoretically speaking, feeling consensus to the digital ecosystem is not only affected by the operant configuration but the controlling power to the ecosystem (which is mapping to Degree of Operant Empowerment) and the user experience while interacting in the ecosystem (that is mapping to Operation Flow of Linkware Deign). That are the reason why our conceptual framework supposed that there are connections between proposed Destination Value Configuration. Neither the computing result of Degree of Operant Empowerment nor the Operation Flow of Linkware Deigns' is the optimum number. There is room for their improvement, thus, they will involve consensus level in defectiveness.

On the other hand, when talking about service science, we know that service discover, define, develop, and deliver are all necessary for success. In our simulation of BlockFarm, our service develop and deliver are not good enough to support the proposed theory. For instance, the advantage and essentiality of Blockchain did not well-deliver to our users, many of them even do not know what is Blockchain needless to say to perceive Blockchain's value in our game. In addition, our system quality and match-making mechanism relies on server provider, Heroku to a certain degree, server stability will also cause an effect of user experience and consensus level further. In this way, we can draw a conclusion of there is exactly correlation between the assistant module, and the relationship between them does not have any conflict. This also verify proposition 1 we had proposed in chapter 6.1 as follow:

- *Proposition 1. There are no counter effects between three dimensions of D^3 Accelerator.*

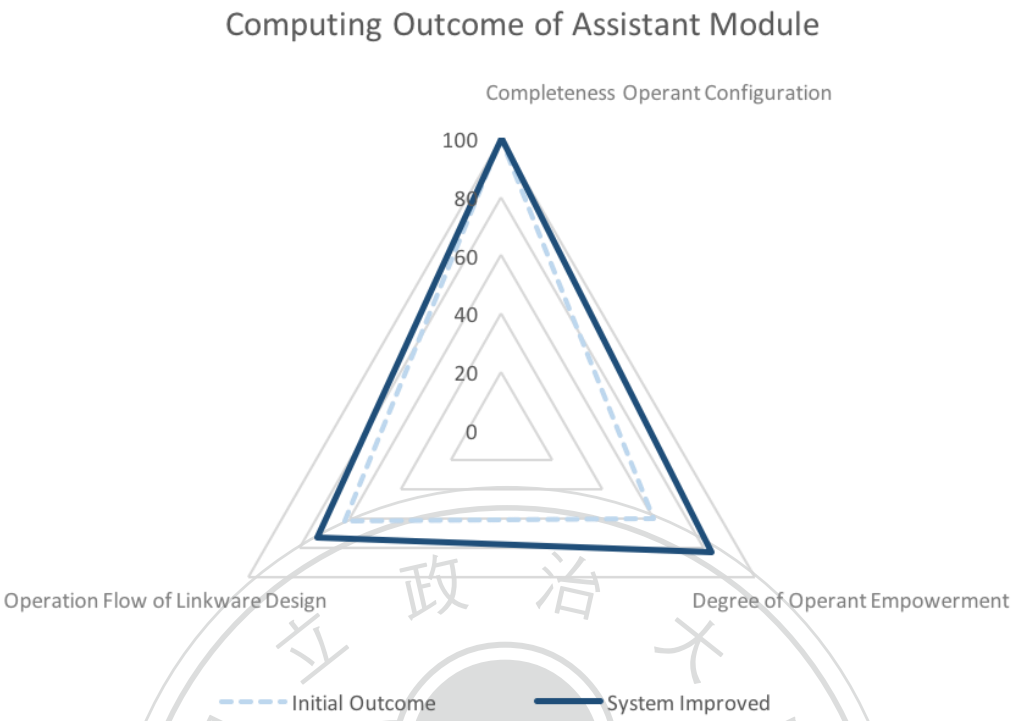

Figure 6.7.7 Comparison of Computing Outcome of Assistant Module

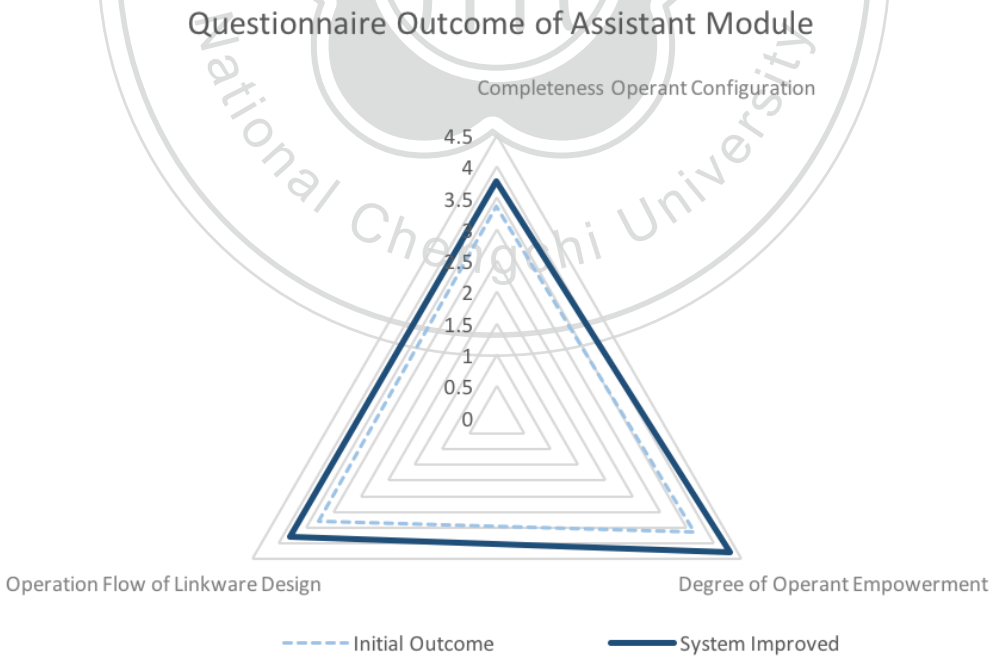

Figure 6.7.8 Comparison of Questionnaire Outcome of Assistant Module

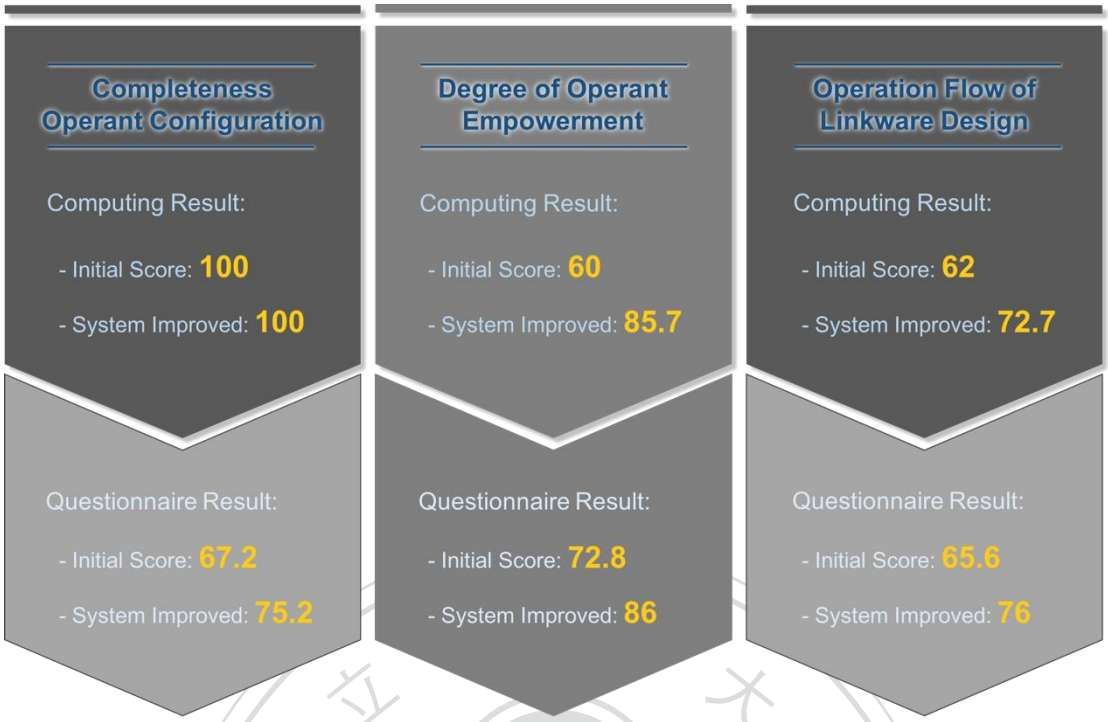

Figure 6.7.9 Comparison of Computing and Questionnaire Outcome

6.7.4 Result of Arising Level of Network Effect Factors

$$\text{Arising Level of Network Effect Factors} = \frac{\overbrace{\text{Consensus Level}}^{\text{Completeness Operant Configuration}} + \overbrace{\text{Resource Availability}}^{\text{Degree of Operant Empowerment}} + \text{Willingness of Contribution} + \overbrace{\text{Fulfillment of Service Flow}}^{\text{Operation Flow of Linkware Design}}}{\textbf{Max}(\text{Value of Destination Configuration Entities})} \times 100\%$$

Formula 4.4.1

Calculation formula of arising level of network effect factors shows in Formula 4.4.1 as above, we receive data from the assistant module and measure the arising level of network effect factors before and after system improvement. For example, in Figure 6.7.10 we obtain value 100 in Completeness Operant Configuration, which composed the concept of service desirability and service disruption; acquire value 60 in Degree of

Operant Empowerment, that represent the controlling power and the inclination to contribute to digital ecosystem; and gain value 62.08 in Operation Flow of Linkware Design based on the notion of perceived flow experience of participants. Furthermore, in Figure 6.7.11 we obtain the value 100 in Completeness Operant Configuration; value 85.7 in Degree of Operant Empowerment; and value 72.73 in Operation Flow of Linkware Design. To be worth mentioning that resource availability and willingness to contribution is the two concepts included in the value of empowerment degree. The conceptual framework of empowerment shows in Figure 6.5.1, it is measuring the average empowerment of each stakeholder by examining the importance of possessive resource and willingness to share with the ecosystem. Thus, there is only one value of empowerment degree, but we elaborate it as "resource availibility and willingness of contribution" in Formula 4.4.1. After the calculation, subsequently, we will measure the fulfillment of critical mass and to testify the relationship between them. The result of arising level of network effect factors shows in Figure 6.7.10 and Figure 6.7.11 as below:

$$\text{Arising Level of Network Effect Factors} = \frac{100 + \overbrace{60 + 62.08}^{\text{Including resource availability and willingness of contribution}}}{300} \times 100\%$$

$$= 74.03\ \%$$

Figure 6.7.10 Initial Arising Level of Network Effect Factors

$$\text{Arising Level of Network Effect Factors} = \frac{100 + \overbrace{85.7 + 72.73}^{\text{Including resource availability and willingness of contribution}}}{300} \times 100\%$$

$$= 86.14\ \%$$

Figure 6.7.11 Arising Level of Network Effect Factors after System Improved

6.7.5 Result of Fulfillment of Critical Mass

$$\text{Fulfillment of Critical Mass} = \frac{\textit{Present Benefit}\ (\text{Invested Funds} + \text{Anticipative Revenue}) - \textit{Present Cost}\ (\text{Participant's Ability} + \text{Monetary Cost of Participants} + \text{Acquisition Cost} + \text{Barriers to Entry}) + \text{Coefficient of Correction}}{\boldsymbol{MAX}\,(\textit{Present Benefit} - \textit{Present Cost})} \times 100\%$$

Formula 4.4.2

Calculation formula of fulfillment of critical mass shows in Formula 4.4.2 as above, we also use the data received from the assistant module and measure the fulfillment of critical mass before and after system improvement. For instance, in Figure 6.7.12 we acquire the value 80 in Completeness Operant Configuration, which is the degree of share of voice from the world and the participants and it stands for the opportunity cost of not join the ecosystem; obtain value 41.9 in Degree of Operant Empowerment, mapping the concept of willingness to share to the participant's ability owing to their efforts contributed to the ecosystem; and gain value 38.4 in Operation Flow of Linkware Design that means the complexity of designed interactions which forms a barrier for participants to enter the ecosystem. Moreover, in Figure 6.7.13 we obtain the value 95 in Completeness Operant Configuration; value 54.5 in Degree of Operant Empowerment; and value 28.7 in Operation Flow of Linkware Design. It is worthy to be mentioned that in our research project of simulation, we do not apply for any sponsor and funds, even expected to get revenue either. Therefore, our measurement needs an additional coefficient of correction so that we can focusing on the present cost and the differences between system improved or not. Following shows the result of fulfillment of critical mass in Figure 6.7.12 and Figure 6.7.13:

$$\text{Fulfillment of Critical Mass} = \frac{(1) - (1/41.9 * 1000 + 0 + 1/80 * 1000 + 38.4) / \mathbf{400}}{1} \times 100\%$$

$$= \frac{1 - \mathbf{74.77 / 400}}{1} \times 100\%$$

$$= 81.31\%$$

Figure 6.7.12 Initial Fulfillment of Critical Mass

$$\text{Fulfillment of Critical Mass} = \frac{(1) - (1/54.5 * 1000 + 0 + 1/95 * 1000 + 28.7) / \mathbf{400}}{1} \times 100\%$$

$$= \frac{1 - \mathbf{57.58 / 400}}{1} \times 100\%$$

$$= 85.6\%$$

Figure 6.7.13 Fulfillment of Critical Mass after System Improved

In the measurement displayed above, the first thing we are going to explain is the denominator and the class of present benefit. By virtue of the explanation we have mentioned above, we omit the present benefit in D^3 Accelerator project and concentrated on correlation between the improvement of present cost. In order to achieve this goal, we, then, adjust the present cost from a normalized value into a proportion value. Owing to the maximum of every variable of present cost is normalized into 0 to 100, the coefficient of correction then deigned to be divide into 400. The sources and correspondence of variable of present cost has elaborated in chapter 6.6.1, phase 1.

6.7.6 Certification of Fulfillment of Critical Mass

Figure 6.7.14 shows the result of initial players' feedback and last movers' feedback. We can see that the average number of after system improving are all better than before, what it can tell is that the information refer to our module can really give designers an effective and helpful feedback to ameliorate their design. Besides, our improvement is based on each dimension of D^3 Accelerator Assistant Module (show in Figure 6.7.1), and the result indicate that our system amelioration can efficiently increase the result of critical mass measurement and furthermore lead to the expansion of digital ecosystem participants. This occurrence also verify proposition 2 we had proposed in chapter 6.1 as follow:

- *Proposition 2. Improvement of each dimension of D^3 Accelerator can lead to the expansion of ecosystem participants.*

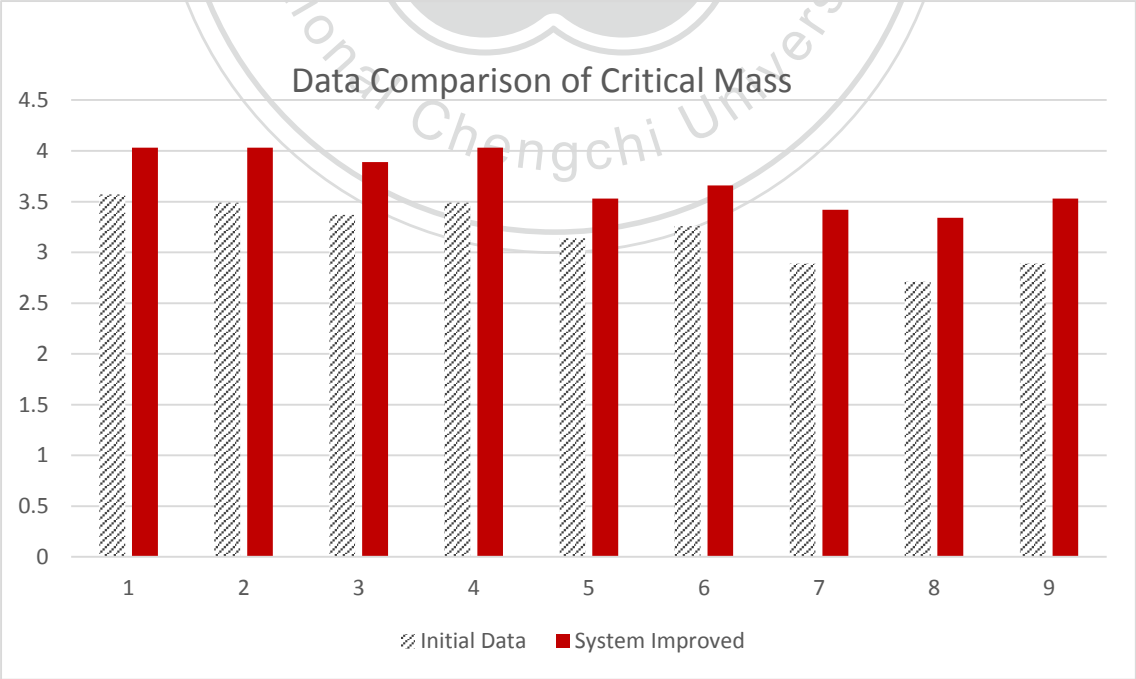

Figure 6.7.14 Questionnaire Result of Critical Mass

6.7.7 Correlation of Fulfillment of Critical Mass and the Assistant Module

In order to reinforce the persuasiveness of the comparative results of system improvement, we had selected few people who had filled-in the questionnaire before system improvement and invited them to experience BlockFarm and give us a questionnaire feedback again after system improvement. We chose fifteen subject to keep track of their behaviors and eventually obtained the result of their direct feedback to BlockFarm (show in Figure 6.7.15). The X-axle stands for the whole questions of our questionnaire (including questions for this research and for the assistant module), and the Y-axle is the average of the fifteen subjects' answers. We can see that about 90% of questions' average are improved, the average increase value of the assistant module is 0.32 and the increase value of critical mass is 0.19.

Whether referring to the result of measurement or the consequence of user's questionnaire, our finding of this project is that there will cause positive effects on the score and feedback of both Fulfillment of Critical Mass and D^3 Accelerator Assistant Module after designers make an improvement of the service. The growth of the assistant module can be seen in Figure 6.7.9, and the rise of fulfillment of critical mass shows in Figure 6.7.12 and Figure 6.7.13. Based on the proving process mentioned in previous chapters, moreover, according to the verification of *proposition 1* and p*roposition 2*, the certification of *proposition 3* as follow is also validated:

- *Proposition 3. Three dimensions of D^3 Accelerator have positive correlation towards reaching critical mass.*

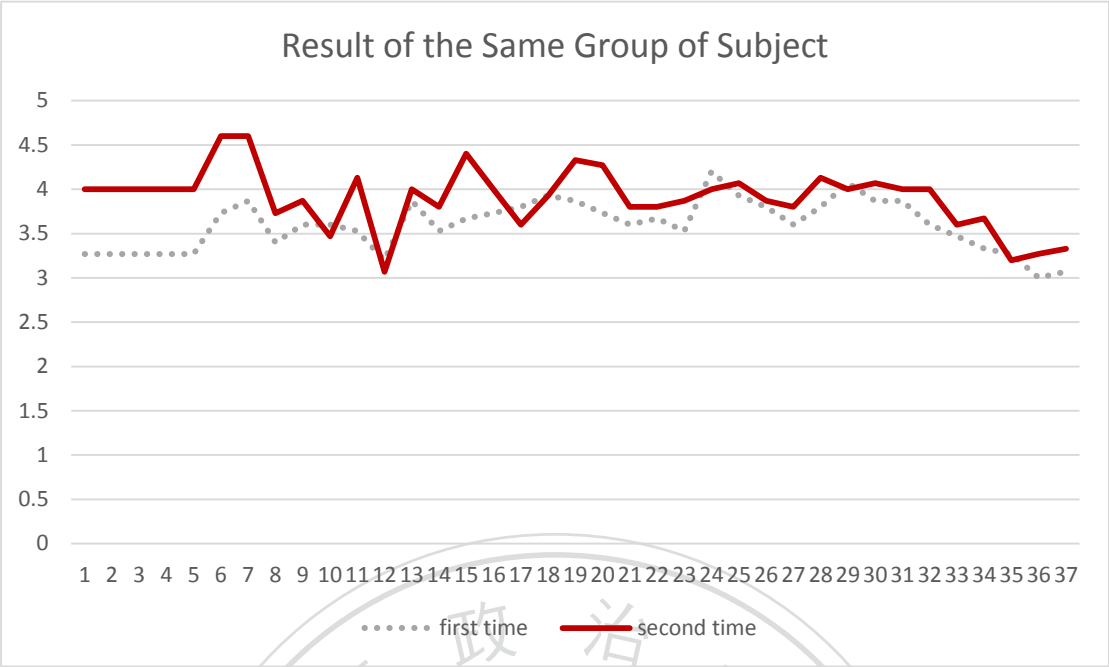

Figure 6.7.15 System Improvement Result of the Same Group of Subject

Chapter 7 CONCLUSION

By the mechanisms and modules proposed, we hope this research could help service designers to comprehend with the advantages and disadvantages of their design. In order to shorten the gaps between service design and marketing demands. We also desire to support designers to facilitate the design process and to devise a better service that is useful and contributed to our society then to improve the world.

Combining with other researches in D^3 Accelerator project, we provide an implement that is well-considering based on the Customer-Dominant Logic and the Digital Ecosystem-thinking. Besides, we developed a simulation system, BlockFarm, for the sake of validate our mechanism. We endeavor to analyze the design through different dimensions, which are all benefit to the designed service. In this research, we focus on service capability of reaching critical mass and next we will conclude all experiments results and findings.

7.1 Academic Contribution

In D^3 Accelerator project, we proposed a design pattern that is composed of blockchain and service science. The design pattern comprises service operant configuration and value exchange design, interactions and stakeholders' empowerment design, user experience of service delivery and Linkwre design, and ecosystem capability of sustainability design. Particularly in this research, our framework is to verify the proposed theory, in order to narrow the gap between design and deliver. Also to prevent our proposition from becoming an idealism only for academic research and not appropriate to implement in the real world. We utilize other dimensions of D^3 Accelerator Assistant Module to monitor whether the degree of network effect really

can cause impact on reaching critical mass or not. Besides, we proposed a measurement based on the concept of cost and benefit which seems to be very simple and common, yet it contains a lot of sturdy theories in order to form its measured foundation.

7.1.1 Propositions

In order to testified the conceptual framework of our research, we design three propositions as follow:

- *Proposition 1. There are no counter effects between three dimensions of D^3 Accelerator.*
- *Proposition 2. Improvement of each dimension of D^3 Accelerator can lead to the expansion of ecosystem participants.*
- *Proposition 3. Three dimensions of D^3 Accelerator have positive correlation towards reaching critical mass.*

These propositions respectively verified the correlation between our framework, especially for the connection between network effect factors can critical mass. For instance, *Proposition 1* certified the assumption of our research and also endorse our framework of D^3 Accelerator project. Besides, *Proposition 2* connect the arising level of network effect factors with the fulfillment of critical mass. Last but not least, *Proposition 3* can be seen as the conclusion of *Proposition 1* and *Proposition 2*, in terms of testifying there are no counter effects within the arising level of network effect factors and between them and the fulfillment of critical mass.

7.2 Findings and Discussion

According to the consequence of simulation illustrated in chapter 6, there are not only the certification of our proposition but also some additional findings during this project. The following are going to sketch out the result and conclusion of our measurement, then will elaborate on new findings in this research:

I. Result and Conclusion:

Refer to the result of chapter 6.7, first of all, we measure the arising level of network effect level which is corresponding to three dimensions of D^3 Accelerator Assistant Module. We discover that when one dimension improved, there will not cause any counter effect to the other dimensions. Furthermore, the improvement of one dimension will also exert a positive influence on the other dimensions. The most important is that the variation of the assistant module will remarkably make an influence of reaching critical mass. If the assistant module has improved, the fulfillment of critical mass will increase too.

II. Findings:

Although there are no counter effects between the assistant module, there are still a result that is out of our expectations. Moreover, we find out some negative effects happened when we are monitoring the correlation of the assistant module. Due to these situations we observed user's behavior and analyzed the probabilities of their influential factors, finally come up with two findings about them:

- Gap between designs and implementations are really exist and will be seriously affected by service delivery.

- Fulfillment of the network effect factors will decrease while other dimensions of the assistant module have not reaching optimal numbers.

- Flow experience has significantly impact on the other dimensions of network effect factors.

III. Discussions:

1. **Do three factors of the network effect have the sense of hierarchy?**

   According to the findings mentioned above, if the gap between designs and implementations are really exist and will be seriously affected by service delivery, we are wondering if we can say that service delivery is the most important part of the whole process of design thinking. Because of whether the value create in every stage of design can surely perceived by user has to be determined by the last stage, service delivery. Besides, the three factors of the network effect have different correlations with service delivery, thus, the first discussion we have an inquisitive is whether do three factors of the network effect have the sense of hierarchy or not.

2. **Is flow experience the most important and influential factors of causing network effect?**

   Continue from the preceding paragraph, we think of that flow experience has the most significant relationship with service delivery. In this way, if the answer of former discussion is yes then does that means we

will get evidence of flow experience is the most important and influential factors of causing network effect?

3. **If the implementation result is beyond the satisfaction, can we proposed an improvement guideline for designers to reference?**

   The analysis of computing result and questionnaire indicate that the arising level of network effect factors will be influenced by other network effect factors. It is the reason why the implementation of design may beyond the designers' satisfactions. We are wondering if we have more application data of D^3 Accelerator project, can we propose a rule of the most reasons of the implementations that are out of expectation.

7.3 Managerial Implications

There is no such a research discussed the issue about service science combine with Blockchain yet, needless to say to propose a blockchain-based digital ecosystem design guideline for service designers to follow up. Previous researches may proposed a lot of design patterns for designers, however, they often deliver questionnaires to public as the verification, few of them really implement a service by their propositions and certified the correlation between proposed module. Though our D^3 Accelerator project, we can make design more simple and effortless; decrease the cost of development; even to lower the threshold of becoming a service designer. Furthermore, we had testified the relationship between network effect and reaching critical mass. We expect D^3 Accelerator could improve the condition of service failure effectively and also ameliorate the perceived value of our customers.

7.3.1 Case Study of BlockFarm

In the project of D^3 Accelerator, we had implemented BlockFarm as to verify our proposed theory. In this case, the interactions within D^3 Accelerator Assistant Module and between critical mass are the most significant parts of this research. Furthermore, one of the core value of this research is to monitor the fulfillment of the assistant module in order to improve the fulfillment of critical mass. Consequently, how to trigger the agent to do the improvement and what is the trigger point is another essential component in this project. The trigger point will be differentiate owing to different application domain, the belonging of industry structure, and also on balance of cost and benefit. Next paragraph we will simply elaborate the trigger point we design in this case.

Before we had launched the implementation to public, we assume if the first stage of implementation can reach 80% of the critical mass that will be good enough. However, after implementation, the arising level of network effect factors was 74.03% and the fulfillment of critical mass was 81.31%. Although the fulfillment of critical mass is over 80%, yet the arising level of network effect factors is not good enough. Besides, by virtue of the feedback from our target user and the questionnaire result, we thought that the core value of BlockFarm and the motivation of designing this digital ecosystem were not well-delivered to our users, we decided to do the improvement of BlockFarm.

To summarize the design process of our project, we think the trigger point of design improvement is the gap between design thinking and the perceived value of customers. Based on user's feedback and the insight of designers, also consider about the executive capability of the project and estimate the reality circumstance, designers can decide whether to trigger improvement of the assistant module or not. The improvement can be triggered at anytime designers think it is necessary and appropriate.

7.4 Limitations and Future work

First of all, owing to our sample size is too small to do the statistic analysis, the reliability and validity of our research can not be enough yet. Due to the same problem, the variation of proposed module after system improvement is significant. However, to include more users to the digital ecosystem, we may discover more findings that is out of our expectations or the result may be no longer significant. Consequently, we need to expand the participants in order to reduce the variability and normalize our samples.

Second, our framework is proposed for service designers, therefore, we assume that our readers have enough specialty and professional knowledge of their service design domain. That is really a limitation for general public and even junior designers who is interesting or eager to do the design of blockchain-based digital ecosystem. To generalized the research framework we had proposed, the instructions and guideline should be more easier to follow and more clearly for general public to comprehend. In this way, the concept of service design and improvement will be widespread to everyone's mindset and further to advance service quality and perceived value of all services in the world.

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APPENDIX

Questions of the Questionnaire:

♦ Q1. I play BlockFarm frequently.

♦ Q2. I will continue playing BlockFarm frequently in future.

♦ Q3. Many people I communicate with play this game.

♦ Q4. Many people I communicate with regularly play this game.

♦ Q5. People I communicate with will continue to play this game.

♦ Q6. Playing Blockfarm makes you feel pleasant that you are expected to play this game.

♦ Q7. You feel enjoyable to have interactions in Blockfarm and would like to recommend this game to your friends. (interactions refers to thieving and guarding, crops transaction, etc.)

♦ Q8. You are satisfied with our system's quality and will keep playing this game.

♦ Q9. This game is entertaining to you and you are willing to share this experience to others.

Result of Questionnaire:

Phase 1 (Initial Data):

Player	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
01	4	4	3	3	4	5	5	5	5
02	3	4	3	3	3	4	4	3	3
03	3	4	2	2	4	4	5	4	5
04	2	1	4	2	2	2	2	2	1
05	4	4	4	4	3	4	4	5	4
06	4	2	2	3	2	4	3	2	4
07	2	2	2	2	2	3	3	2	2
08	3	2	2	2	2	4	4	4	3
09	4	4	4	4	4	4	4	4	4
10	3	2	3	2	2	3	3	3	3
11	3	3	3	3	3	4	3	2	3
12	5	5	5	5	5	5	5	5	5
13	4	3	5	5	4	4	4	3	5
14	2	3	2	2	3	3	3	2	2
15	4	4	4	4	4	5	4	5	5
16	4	5	4	5	4	5	4	5	4
17	4	5	5	5	4	4	5	5	5
18	3	3	3	3	3	3	3	3	3
19	4	4	5	3	4	4	4	4	5
20	2	1	1	1	1	2	3	1	2
21	3	4	3	3	2	3	3	3	3
22	4	4	4	3	3	4	4	5	4
23	4	4	3	4	4	4	4	4	5
24	2	2	1	1	1	2	3	1	2
25	3	3	3	3	3	4	4	4	4
26	3	4	3	2	3	4	3	4	4
27	2	4	1	1	3	3	3	3	3
28	3	3	3	3	3	3	3	3	3
29	1	3	1	1	3	2	1	1	1
30	5	4	4	4	4	4	4	4	4
31	3	3	1	1	1	4	2	4	3
32	1	2	1	1	2	3	3	2	2
33	2	2	1	1	1	2	3	3	4

34	3	2	1	2	2	2	2	3	2
35	4	5	5	2	3	5	5	5	5

Phase 2 (System Improved):

Player	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**
01	4	4	1	1	1	4	3	4	4
02	2	2	2	3	3	4	4	3	4
03	4	4	4	5	4	4	4	5	5
04	5	5	4	4	4	5	5	5	5
05	5	5	4	3	4	4	4	3	3
06	5	5	5	5	5	5	5	5	5
07	4	4	3	2	4	5	4	3	4
08	1	1	1	1	1	1	1	3	1
09	4	4	4	4	5	4	4	4	4
10	2	2	2	1	1	4	3	3	3
11	4	5	4	5	4	5	4	4	5
12	1	1	1	1	2	4	5	4	4
13	2	3	2	2	3	3	4	3	3
14	5	5	5	5	5	5	5	5	5
15	4	3	2	2	3	4	4	3	5
16	4	5	4	4	4	4	4	5	4
17	5	5	5	5	5	5	4	5	4
18	5	5	5	5	5	5	5	5	5
19	3	4	4	4	3	4	4	4	5
20	3	4	4	4	5	4	4	3	4
21	4	4	5	4	4	4	5	4	4
22	5	5	5	5	5	5	5	5	5
23	5	5	5	5	5	4	4	4	4
24	2	2	4	3	3	2	2	3	3
25	5	3	2	4	3	5	5	5	5
26	2	3	2	2	2	4	4	3	4
27	3	3	3	2	3	4	4	3	4
28	5	4	5	4	4	4	4	5	4
29	4	4	4	4	4	4	4	5	4
30	4	4	5	5	4	5	5	4	5
31	3	4	3	3	3	5	5	5	5
32	2	3	2	2	2	3	4	3	3

33	2	2	2	2	2	2	3	3	3
34	3	3	3	3	4	3	3	3	3
35	4	4	2	2	3	5	4	4	5
36	3	4	4	4	4	4	5	4	4
37	4	5	5	5	5	4	5	5	4
38	2	1	3	2	5	3	2	1	2