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Virtual Wealth Realization in Virtual and Real Worlds

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Abstract

This paper has investigated the issue of virtual wealth and its realization in both real and virtual worlds, and argued that the realization of virtual wealth is necessary and possible. On the formation of virtual wealth, it has studied the labor theory of value, exchangeable value, and utility theory. From these theories, it has successfully explained the nature of virtual wealth that has difficulties in realization within a closed virtual world. It thus promotes an open virtual world for virtual wealth realization. In finding the approach to open virtual world, key elements about open virtual world are discussed. Based on the assumed open virtual world, the classification, measurement and factors of change on virtual wealth are described, and the methods of realizing virtual wealth in both virtual and real worlds are proposed. To validate the method, an accountability matrix is proposed and used to analyzing the case of Second Life virtual world.

1. Introduction

A *virtual community* (VC) is a technology-supported cyberspace, centered upon communication and interaction of participants, resulting in a relationship being built up for certain purpose [11]. The typical examples are blogs (e.g. Windows Live), social networks (e.g. facebook.com), games (e.g. secondlife.com), digital library (e.g. ssreader.com), file sharing (e.g. xunlei.com) and instant messager (e.g. qq.com). Many interrelated VCs constitute a *virtual world*, which evolves dramatically in recent years and tends to more and more connect to the real world life. In this evolution, *virtual wealth*, which we refer to the "power" ([23]:28) of acquiring virtual goods and resources in its creation, exchange and use, is increasingly created in the virtual world. A *virtual good or resource* is any virtual-world object/service that increases utility measuring satisfaction, desirability or usefulness, for example, website goodwill, e-books, music files, game equipments, rights to access web, or e-payment services a site provides. Virtual wealth can be measured by *virtual money* (v-money) (defined in [7]), which is a special type of virtual goods that can be used to store the value of other virtual goods as traditional money.

In this evolution, how to realize the created virtual wealth is becoming an important research issue such that whether the "power" can be actually used in both virtual and real worlds. The importance comes from not only the virtual money exchange problems [7][25][17] we are facing but also the fact that the virtual wealth is amazingly increased to a level of non-negligible. Although we are unable to accurately figure out how large amount the virtual wealth is in the virtual world, we could, however, see the potential amount from the example of Tencent QQ (*see* Table 1), where part of the virtual money of QQ is one-way created by consuming Chinese RMB (the row of Internet VAS in Table 1) for games, etc.

Table 1: Tencent QQ Income & Users (1000 in RMB)

	2004	*2005*	*2006*	*2007*
Internet VAS	439,041	786,680	1825,343	2513,728
Telecom VAS	641,190	517,265	700,114	807,645
Ads	54,801	112,826	266,684	493,018
Others	8,501	9624	8,300	6532
Reg Users (mil)	369.7	492.6	580.5	741.7
Active Users(mil)	134.8	201.9	232.6	300.2

Source: Financial Reports of Telcent Holdings Limited

If we admit that the virtual wealth is also a kind of imprescriptible property of human like that in real world, its value realization in virtual and real worlds is, thus, utmost important. It thereby requires us explaining the formation of virtual wealth and studying the virtual world construction that affects the realization of virtual wealth in both real and virtual worlds.

This paper aims to provide an understanding of virtual wealth, its related virtual world, and its relations to real world. It argues that the realization of virtual wealth in both virtual and real worlds is necessary and possible.

To describe the argument, the rest of the paper is arranged as follows: Section 2 studies and explains the formation of virtual wealth. Section 3 discusses the elements of open virtual world. In Section 4, the realization methods of virtual wealth are provided along with the descriptions of virtual wealth classification, measurement and changes. Section 5 proposes an accountability matrix for virtual wealth and validates it using Second Life vir-

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tual world. In Section 6, a brief discussion is made and the conclusion, contribution, research limit and future work are finally provided.

2. Virtual Wealth Formation and its Theoretical Explanations

As a collection of VCs, the virtual world appeared from various types of websites with a unique feature of group activities (*see* the changes of registered and active users of Table 1). The group dynamics makes virtual wealth created during the short history of virtual world just from the 1990's and the large part of it has a clear track for its growth.

2.1. Formation of Virtual Wealth

The Internet wave of 1990s brought many ideas to Website contents – discussion forums, sharing spaces for books, music, software, etc., online games, blogs, and social networks. In this wave, many digital items are named and created, for example, smilies, virtual game equipments, online land and home, and e-books. Anything and any behaviors we can imagine and to be digitalized become virtual items.

Nevertheless, in the early stage, many virtual items are free, for example, forums, blogs, shared files and software, smilies, and online decorating items. To live, the Website operators of these items often adopt the business model of online advertising. Also because of this business model, the Website operators wish users to click more ads to earn more profit. One new business model gradually appeared where clicks on ads, views on contents, download on items or play on games are paid in real/electronic money (e.g. bux.to, linkbucks.com) or virtual money (e.g. LB of xunlei.com, KinzCash of webkinz.com, Linden Dollar of secondlife.com, and QB of qq.com). The activities under this model have shaped virtual goods, where they are turned from virtual items and sunk as virtual wealth that is measured by both real and virtual money scales.

It is necessary to mention that the awarding schemes have pushed the formation of virtual wealth. Many VCs set up bonus points (e.g. scorecardrewards.com) with various plans to promote the participation of VC activities and have stimulated the creation of virtual money. Like traditional money that has properties of store of value, measure of value and medium of exchange, virtual money inherits these properties by being created in the virtual world environment as a special virtual good [7]. It stores the value measured by virtual goods. As long as a virtual money issuer (say the VC owner) declares that kind of issued virtual money (i.e. *virtual currency*) contains certain amount of value corresponding to certain quantities of virtual goods, virtual money is then used as the medium of exchange for virtual goods in the declared VC. It thus benefits the VC to reduce the complex process of bartering between virtual goods. This declaration further strengthens the endowment of the virtual money as the symbol of virtual wealth in the sense of the stored and measurable common value for that VC.

2.1. Theoretical Explanations of Virtual Wealth

It is interesting for us to explain the formation of virtual wealth and its related measuring tool of virtual money. From a prompt look, many people may easily link virtual wealth to real money. However, a deep investigation on virtual wealth may find many virtual goods do not necessarily to have a direct link to real money but only virtual money if there is no such need for a VC. For example, www.weiqi.cn is just simply a Chinese chess community. Its virtual money G currency is earned through the activities such as promotion of the website using MSN, QQ or forums of other websites, or writing the posts on Chinese chess. It is used to buy and sell virtual goods such as props, pets, attachments, and the rights of reading and posting. Likewise, we can see many similar examples.

To explain how virtual wealth is formed and how virtual money is used to store and measure the value of virtual wealth in its creation, exchange and use, more are needed to explore.

2.1.1. Labor Theory of Value

Virtual wealth has a common element that virtual goods cost labor in its digitalization. For example, to make a smilie or to produce an avatar image, they all have materialized the labor time in production.

From the above example, the *labor theory of value* [23][16] is revived and can explain why virtual items are wealth with value. According to Max [16], the produced items materialized with labor time have their intrinsic and *absolute values*. If a design of smilie costs 4 labor hours and a carton picture costs 8 labor hours, the absolute values of the smilie and carton picture can be scaled as 4 or 8 as virtual wealth in terms of their materialized labor.

The labor theory of value provides us a way to measure the different absolute values for varieties of virtual items. For example, "paid by ad click" (e.g. bux.to) can be regarded as a method of value return that compensates the labor time used for ad clicks. The theory also provides a rigid method for bartering virtual goods. For example, we can trade two smilies for a carton picture based on their absolute values.

However, like the arid soil has lower produce than rich soil, labors have different production capabilities [19]. Labor time for each individual item needs to be averaged to qualify as an absolute criterion for the value measurement. The *average labor time* (ALT) for a virtual good can be computed in the formula of $(\sum_1^n LT_i)/\mathrm{N}$, where LT is the labor time for *i*th person and N is the number of people to produce the same type of virtual goods.

Applying the ALT, different virtual goods are enabled to establish a comparison relationship between them. Bartering between virtual goods is thus possible and price can be introduced to label virtual goods when virtual money is declared as the symbol of ALT.

2.1.2. Exchangeable Value

While absolute value of average labor time exists in virtual goods and "labour, therefore, is the real measure of the exchangeable value of all commodities" ([23]:28), its computation is, however, difficult in reality due to several factors as follows:

- People tend to overate the value of their virtual goods in exchange because of the nature of human.
- No mechanism can be invented to mensurate the average labor time materialized in virtual goods and to find the way to split the absolute value into shares for each virtual good exchange.

The exchange of virtual goods thus cannot be really equal and convenient through measuring their absolute and intrinsic values. Put the equality aside, money was created to overcome the problem of inconvenience. Smith observed that money replaced barter and was used to estimate the exchangeable value of commodities ([23]:29-30). This is because money such as gold and silver are also materialized labor. The trade between commodities and money formulates the price of commodity, which fluctuates as the above situations occur. From here, value is not absolute any more but will vary as it is realized in exchange. Consequently, the wealth will also change.

Virtual world can well apply the above rules when the virtual goods are exchanged using virtual money as prices. Virtual wealth will change when it is estimated using price. So far, everything seems quite right. However, two issues are still left open: (1) what affects the fluctuation of exchangeable values of virtual goods hence to affect the amount of virtual wealth? (2) Whether the exchangeable value of virtual goods has been realized.

2.1.3. Utility Theory

By admitting materialized labor as part of wealth, Mill defines wealth as "all useful or agreeable things which possess exchangeable value; or, in other words, all useful or agreeable things except those which can be obtained, in the quantity desired, without labour or sacrifice" ([19]:77). He thought that wealth is an instrument of value realization as a means of the attainment of desired things or utility, that is, "pleasure" ([19]:76) or "happiness" ([18]:263). Related to utility is the "difficulty of attainment" ([20]:12) of goods. These two factors constitute the conditions of realizing value or "value in exchange" ([20]:8). Based on these two factors, Mill was thus able to explain the fluctuation of exchangeable value of goods around the absolute values. Wealth is hence turned into "purchasing power" ([20]:9), but its value realization fluctuates when factors of utility and difficulty of attainment change. This is because when people's utility on certain goods diminishes, the demand on that goods decreases and so the purchasing power on that goods increases. Likewise, when the difficulty of attainment of certain goods increases, the supply of goods reduces hence its purchasing power decreases.

Applying the utility theory, the total virtual wealth in the form of virtual money varies as the price fluctuation of virtual goods. In virtual world, this fluctuation is determined by the desirability of certain virtual goods and the difficulty of finding and obtaining them.

Utility theory answers what really affects the fluctuation of exchangeable values of various virtual goods hence affects the total virtual wealth of a virtual world.

2.1.4. Closed and Open Virtual Community

Existing virtual goods have realized neither their absolute values materialized with average labor time nor their exchangeable values based on demand and supply. This can be seen in many of the existing VCs, where virtual prices between virtual goods and real money are set lower or higher than their market prices. Some examples can adequately reflect this fact (*see* Table 2).

Examples of QQ and Xunlei in Table 2 illustrate the severity of casual setting of virtual money prices, where their official prices as per virtual wealth is much higher than the actually-happened in the black markets. On the other hand, WOW gold in Table 2 reflects another situation of corporate indifferency - WOW gold is officially regulated as disallowing to trade outside World of Warcraft[1] but the grey market of WOW gold trading booms.

Table 2: Virtual Money Comparison

	Virtual Money	***Official Price***	***Price in black / grey markets***
QQ (qq.com)	1	RMB1	RMB0.4 - 0.85
Lei (xunlei.com)	1	RMB1	RMB0.9 - 0.95
WOW Gold (2007)	1 (in US)		RMB1.7 - 1.82
WOW Gold (2007)	1 (in EU)		RMB0.21 - 0.23
WOW Gold (2008)	1 (in US)		RMB0.10 - 0.11
WOW Gold (2008)	1 (in EU)		RMB0.11 - 0.12
Linden $ (1/2009)	1000	US$4.14	

Source: QQ.com, xunlei.com, secondlife.com, and authors' investigation

The essence of the problem here is that: (1) in virtual world the prices of virtual goods are severely away from the absolute values that average labor time are materialized, and (2) demand and supply (i.e. the exchangeable value with regard to the utility and difficulty of attainment) in relation to the absolute value are also neglected.

Investigating the existing VCs, we can find three most important factors causing the above problem:

- *Legal obstacle*. Many governments are afraid of the impact of virtual money on real economy and thus disallow the free exchange between real and virtual money[2]. This flourishes the black markets of virtual money exchange and indirectly encourages the crimes of hacking to the existing virtual world.
- *Monopolistic thought*. Many VC operators favor a closed virtual world. By doing so, they maximize their profits by selling VC cards (e.g. game or gift cards) with prices higher than the real exchangeable values. They create rules of virtual world as if they

[1] http://www.worldofwarcraft.com/legal/termsofuse.html.
[2] http://www.law-lib.com/law/law_view.asp?id=191034.

are Gods and creators. This is the manipulation of the trade between the participants of the virtual world, which twists the normal exchange relations where monopolistic profits are forbidden.

- *Technology limitation*. No doubt, many VC operators wish to have an open environment that allows the participants to freely exchange what they have. However, existing interaction technology between virtual and real worlds is still limited. This hinders the realization of virtual wealth in both real and virtual world.

These factors lead to the *closed virtual community* and leads to the problem of none or insufficient realization of virtual wealth in both virtual and real world.

To enable virtual goods to be realized based on their actual exchangeable values, we must overcome the above three problems and encourage the building of *open virtual community* where participants can freely realize their virtual wealth so to realize their work of labor time based on demand and supply. An open VC is necessary and implies the "fair" [21] realization of virtual wealth within and between VCs. Enabling the free exchange of virtual currencies is an effective means of virtual wealth realization. SecondLife (see Table 2)'s example on the free conversion of Linden Dollar provides a way of virtual wealth realization that stops black market deals.

Some people compare a closed VC having virtual currency to a country with non-convertible currency and thus argue there is no need for an open VC. This comparison is not adequate. In real world, a non-convertible currency only means its non-convertibility to other currencies, yet it can still be used to purchase anything like gold, house or products enabling human to be alive. These represent the real wealth realization explainable by theories like purchasing power parity [10]. Differently, a closed VC, which lacks a tool to realize virtual wealth to real wealth, cannot provide a means for human (who is behind his/her representing avatar and has paid labor cost) to make a living. The missing of this tool destines a closed VC only to be a consuming place but not a working place.

3. Elements of Open Virtual World

How can, in general, an open virtual world be built? In current social environment, we not only face the technical difficulty but also have the legal and business problems. Nevertheless, a technical solution can always be preceded, ahead of solving other problems. Bearing this in mind, this section will study the elements of open virtual world, which might be used in future, in a technical orientation.

3.1. Construction and Inhabitation

Virtual world presenting to us is many things such as avatars, symbols, indications and actions. It is an abstraction, transformation and image of the real world on a computer-supported cyberspace. Like language and speech in Saussure's semiotics [22], the virtual world is dichotomic, clearly divided into a systematized set of patterns necessary to human interaction and indifferent to materials composing it.

Adopting the above view, the *construction* of virtual world is a social and technical institution, but drastically distinct from political, juridical and other institutions. It is a system of representations expressing the ideas of avatars, and hence comparable to the systems of bits, bytes, characters, words, axioms, rules, templates, formula and functions. As opposed to construction, *inhabitation* of virtual world covers purely individual part of construction, appearing as *avatars* and their behaviors to express personal ideas. It is a dynamic system that combines the part of the virtual world representations.

Construction and inhabitation is dialectic. The construction of virtual world needs bricks and mortars common for all avatars to build their virtual homes and requires unified language for every avatar to communicate and interact. This commonality does not reject the individual or group life but encourages individual avatars to bring about more colorful life to all to improve the process of further *reconstruction* of virtual world.

Thus, *construction* and *inhabitation* is twin about studying the role of representations as part of social and technical life of virtual world. It is related to semiotics and e-commerce, and would form the part of cyberspace study. We shall call it the *science of virtual world*.

3.2. Structure, Concept and Reification

The construction of an open virtual world requires a modular and layered design approach. "Modular" enables the represented objects of virtual world to be easily used and reused by avatars for expressing their ideas and behaviors. It can reduce the inconsistency between the avatars' interaction. "Layered" allows the separation of represented objects into different levels, individual to the respective avatars. This can effectively establish the system of division of labor and hence classify avatars into the system creators, knowledge engineers and virtual inhabitants of virtual world. The *system creators* sit in the low layer. They blueprint the virtual world and produce the schemes of how virtual world should be constructed. *Knowledge engineers* are situated in the middle layer, which can be called as virtual product designers. They create various behavioral patterns and templates that can assemble different virtual products. *Virtual inhabitants*, located in the highest layer, are producers, consumers, buyers and sellers of virtual goods. They produce virtual goods based on the patterns and templates designed by knowledge engineers, and buy, consume and sell virtual goods conforming to the already designed behavioral patterns.

The modular and layered thought of virtual world construction can be implemented by adopting Product Map theory [8], where a representation is a couple of structure and concept in construction such that:

Representation (Rep) = (structure, concept) = (S, C)

Here any idea (e.g. terms of vocabularies, or document templates), behavior (e.g. action logic) or their compound (e.g. process patterns of action series) is a representation divided into a meaningless structure that can convey any concept. *Structure* is forms of virtual objects indifferent to its users. It is a conveyor to convey meanings of all objects appeared in virtual world. *Concept* is the meanings of all objects, thought and meant by virtual world avatars that are transformed from human in real world.

For example, an XML schema can be regarded as a structure that can convey any concept like scoreboard of game or bill of purchase. More simply, if S=1, we can refer 1 as color or as water. Reversely, color can use 2 or 3 to convey itself. This feature enables us to separate the work of schema making from knowledge production.

The structure and concept reflects the division of labor between system creators and knowledge engineers. Their combined result is various types of patterns, templates, functions, components, etc. These artifacts are common to all avatars for their easiness to use/reuse and are in the category of virtual world construction.

In the virtual world construction, virtual inhabitants are drives of virtual wealth. They actively create a colorful virtual world with their work on producing, selling, buying and consuming virtual products and services. During this process, virtual wealth is drastically increased. Technically, this process is simply a reification process of the given representations initially made by knowledge engineers such that:

$$Reification = (structure, concept) \rightarrow reifier\ (R)$$

In this function, *reification* should not be narrowly regarded as a simple instantiation. It is a process of assembling and reifying representations that can create things like a value of a term (e.g. red for color), a particular document of a document template (e.g. content-filled bill of draft for draft template), a computing result of a formula (e.g. $8 = 2^3$ from m^n), a carton house of many pictorial shapes, an execution of an action logic, or a component of many combined representations.

Structure, concept and reification constitute the *representation and execution* of all kinds of virtual objects transformed and imaged from real world. Their mutual interaction constructs, inhabits and reconstruct the virtual world in a dynamic and evolutionary way.

3.3. Context and Conflict

A single virtual world without external contacts is only a closed VC. As defined previously, a true virtual world is a collection of VCs interrelated to each other. Nevertheless, interrelation causes an openness problem when open virtual world is required. Existing VCs, mostly, are not open for their value exchange in terms of virtual wealth realization, as we have discussed in Section 2. In case analysis of some well-known VCs such as qq.com, facebook.com, xunlei.com, www.weiqi.cn, worldwarcraft.com and secondlife.com, we can only find that secondlife.com is open to the outside by supplying APIs and Web services. This is a restriction of non-openness on the existing VCs, and must be removed if open virtual world is desired.

We have noted that this restriction is formed due to three factors of legal obstacle, monopolistic thought and technology limitation (discussed in Section 2). Put the legal and business constraints aside, it is obvious that the technology limitation comes from the heterogeneous designs and uses of VCs. The heterogeneity makes each VC differently in structure, concept and reification. In another word, each VC has its own *context* of structurization, conceptualization and reification of all objects in system design, knowledge representation and virtual goods production. Heterogeneous VCs caused by different contexts can be simplified as follows:

$$(structure@context, concept@context) \rightarrow reification@context$$

This function reflects a status of *conflict* between existing VCs, where they are incompatible in technical design and inconsistent in semantic expressions of virtual world knowledge. A ready solution to resolving this conflict is the collaborative conceptualization approach [8]. Applying this approach, a third-party common community can be designed by following a semantic consistency model, which ensures three properties for PM representations [8]:

Structure Mappability ("$\approx$"): Given two PM_1 and PM_2, then $PM_1 \approx PM_2$ if and only if: (1) $IID_1 \in PM_1$ and $IID_2 \in PM_2$, and (2) there exists a structure map Ξ such that $\Xi(IID_1, IID_2)$, where IID_1 and IID_2 have a mapping relation ($\leftrightarrow$). This ensures VCs to have a mappable messaging structure for interoperation in communication.

Concept Equivalence ("$\cong$"): Given two PM_1 and PM_2, then $PM_1 \cong PM_2$ if and only if: (1) AN_1, $IID_1 \in PM_1$ and AN_2, $IID_2 \in PM_2$, (2) $IID_1 \backslash AN_1$ and $IID_2 \backslash AN_2$, (3) $AN_1 \Rightarrow IID_1$ and $AN_2 \Rightarrow IID_2$, and (4) $AN_1 \Leftrightarrow AN_2$, where "$\Leftrightarrow$" is a semantic equivalence relation such that AN_1 and AN_2 refer to the same meaning. This guarantees VCs with different knowledge engineers to be semantically consistent in their cross-VC conversation.

Context Commonality ("$\propto$"): Given three PM_1, PM_2 and PM, then "PM_1, $PM_2 \propto PM$ if and only if $PM_1 \upharpoonright PM$ and $PM_2 \upharpoonright PM$. PM is called the common context of PM_1 and PM_2, where "$\upharpoonright$" is a reference relation. This ensures VCs of different system creators, knowledge engineers and virtual inhabitants share a collaboration mechanism that maintains semantic consistency in participated VCs.

The solution can be sketched in Figure 1, where common community collaboratively create common artifacts of vocabularies, document templates, and process patterns of actions, rules and logics. It also provides collaborative client engines and mapping rules to existing virtual communities for them to collaboratively map their local artifacts to common artifacts. In this way, conflicts can be

resolved, heterogeneous virtual communities can mutually interact, and an open virtual world can then be created.

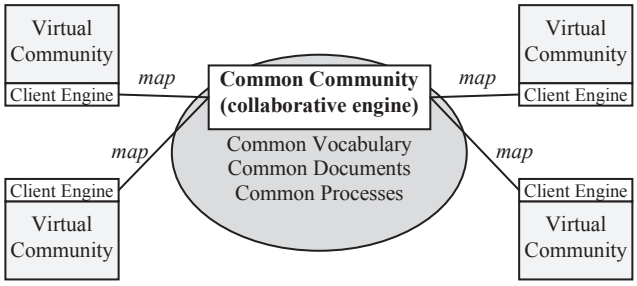

Figure 1: The Sketched Solution to Heterogeneity

3.4. Morality and Law

A technically open virtual world cannot be realized if no moral support from the VC operators and no lawful guarantee from the governments that juridically control the VCs. *Morality* is a code of conduct and is relative in time and space to the modes of societies, traditions, practices and social progress [24]. In building open virtual world, the code of conduct must be the permission of freely realizing avatars' virtual wealth where avatars' labor is materialized. This is because the right of work result cannot be exploited, which is universal and irrelevant to any morality discussion.

Many of the existing VCs do not open or refuse to supply programming application interface (API) that can connect to their VCs to permit virtual wealth realization in virtual/real world (e.g. QQ, Xunlei and World of Warcraft, shown in Table 2). This behavior is morally flawed. As we all know, an avatar is an embodiment of a particular person in real world. The avatar's labor is actually the labor of the corresponding real-world person. The denial of avatars' labor is the denial of human's labor in real life.

Governments of the VC precinct, therefore, must take the responsibility of protecting the right of virtual wealth, hence protecting the rights of labor. Laws and regulations should be published and modified to envisage the reality of open virtual world requirements. This could not only protect the work effort of human but also combat with negligence and crime happened to the existing VCs.

4. Realization of Virtual Wealth

Assuming we already have an open virtual world, our task thus becomes how to realize virtual wealth between VCs and between VCs and real world. Before that, we need a classification of it.

4.1. Classification of Virtual Wealth

Virtual wealth can be classified into individual virtual wealth, community virtual wealth and world virtual wealth. *Individual virtual wealth* is created from individual virtual inhabitants on their work in virtual world (e.g. playing games, writing posts, making virtual products, and virtual trading). *Community virtual wealth* as a whole in a VC is created from three sources: the aggregation of all individual virtual wealth (we name it as W3), the aggregated virtual wealth created from all knowledge engineers, for example, virtually designed patterns, templates or graphics for sale (we type it as W2), and the aggregated virtual wealth created from all system creators, for example, from the plans, schemes, building and serving for a VC (we call it as W1). *World virtual wealth* is the sum of the virtual wealth of all interrelated VCs.

4.2. Measure of Virtual Wealth

While virtual wealth represents the labor cost materialized in virtual goods, it is often measured by virtual money in the amount of virtual currency of a VC.

As we know, a VC is created by human of real world. It thus costs certain *amount of real money* (say R amount) for paying certain *quantity of labor* (say L days). Using the virtual wealth classification, we know building, setup and maintenance costs of VC system creation is W1, and may be paid by the amount of real money (say R1) for certain labor days (say L1). To enrich the VC with content varieties, the operators may hire or invite some knowledge engineers to create virtual world knowledge. This may cost certain quantity of labor days (say L2) in the certain amount of real money (say R2). To play the roles of VC, virtual inhabitants will transfer some of their real world wealth in real money (say R3) to virtual world wealth (W3) that has materialized labor days of L3.

When a VC is open to use, system creators and knowledge engineers become system administrators, non-player characters (NPCs) or knowledge engineering avatars, and virtual inhabitants become role player avatars. Virtual money (V) is then supplied to measure the total virtual wealth (W) of a VC, where R1, R2 and R3 are changed to V1, V2 and V3 by establishing an exchange rate between V and R. To summarize, we simplify the relations between L, R and V in Table 3.

Table 3: Measure of Virtual Wealth

	Labor (day)	Real Money	Virtual Money
W1	L1	R1	V1
W2	L2	R2	V2
W3	L3	R3	V3
W	***L***	***R***	***V***

Table 3 provides a measure of how much virtual money should be issued in terms of virtual wealth at an exchange rate (E_{vr}=V/R) between virtual money and real money. For example, the E_{vr} of QQ is always fixed at RMB1 = QB1, and its R1+R2+R3 sunk in qq.com becomes QB = V = V3 + V2 + V1. It is suggested that government audit the exchange rate by establishing a law when VC operators introduce a new virtual currency.

4.3. Change of Virtual Wealth

After VC has been operated, the increase or decrease of total virtual wealth could be measured by its *gross virtual community product* (GVCP) in a yearly base, equivalent

to the increased or decreased virtual wealth (W of the year) calculated by total *quantity* (Q) multiplies *product price level* (P). Its needed virtual money is called *virtual money supply* V, such that:

$$GVCP = W \text{ increased of the year} = Q*P.$$

Due to the extent of openness status different in VCs, the above equation is different in cases.

4.3.1. Within a Virtual Community

In a closed VC that virtual inhabitants only pay subscription fees to systems creators, the virtual wealth increase is measured by W1, W2 and W3, such that:

$$GVCP = W = W1+W2+W3 = Q1*P1+Q2*P2+Q3*P3$$

where W1=Q1*P1 is the spending of systems creator (S) adding the charges on knowledge engineers (K2) and on virtual inhabitants (K3) and subtracting charges paid to VC's government (K1), W2=Q2*P2 is the added value by knowledge engineers deducting Q1*P1 and K2, W3= Q3*P3 is the added value by virtual inhabitants deducting Q1*P1, Q2*P2 and K3. To smoothly operate, the required *virtual money supply* (V) at certain E_{vr} is as follows:

$$V = V1 + V2 + V3.$$

This equation reflects the needed total virtual money supply for the increased GVCP of a year. However, the imbalanced changes of the real and virtual money supply may change the actual value of virtual wealth.

First, when *real money supply* (R) decreases or deflation happens in real world, if GVCP and E_{vr} remains unchanged, the *total real value of virtual wealth* (GRW) of the VC increases, and vice versa, if inflation happens in real world. Second, when *virtual money supply* (V) increases less than the increase of GVCP and E_{vr} remains unchanged, deflation of virtual money appears and the *unit real value of virtual wealth* (URW) increases.

4.3.2. Between Virtual Communities

In an open VC that has interactions with other VCs, the virtual wealth increase is measured by W1, W2, W3, W4, where W4 = X – M – K4 (X is export, M is import, and K4 is a charge adding to W1) such that:

$$GVCP = W1 + W2 + W3 + W4,$$

in which its needed virtual money supply V is:

$$V = V1 + V2 + V3 + V4.$$

where V4 is determined by two situations of *convertible virtual currency* (CVC) and *non-convertible virtual currency* (NVC):

(1) When a VC with CVC trades and settles with its domestic CVC, V4 = W4 if and only if W4 is surplus. If W4 is deficit or its settlement is in foreign CVC, W4 = FVR (foreign CVC reserves).
(2) When a VC with NVC trades and settles with the CVC of another VC, V4 = 0, but W4 = FVR.

In these cases, only the trade with CVC possibly increases the virtual wealth of a VC and enlarges its virtual wealth realization scope.

4.3.3. Between Virtual Community and Real World

In an open VC that interrelates to real world, real money can be converted to virtual money and possibly vice versa. There are two cases: (1) virtual money can buy real goods but not real money, and (2) virtual money can buy both real goods and real money. For the both cases, GVCP turns into GVRP (*gross virtual real product*), which combines GVCP and part of real-world GDP, such that:

$$GVRP = GVCP + GRPC,$$

where GRPC (*gross real product and capital*) is a part of real-world GDP. GVRP is computed as follows:

$$GVRP = W1 + W2 + W3 + W4 + W5 + W6,$$

in which GRPC = W5 + W6. The W5 is the quantity of real product deducting K5 paid to W1, representing the purchase of real-world goods and services. The W6 is the quantity of real capital deducting K6 paid to W1, representing the purchase of real money or real-world financial derivatives. Consequently, the matched virtual money supply (V) turns to:

$$V = V1 + V2 + V3 + V4 + V5 + V6,$$

where V5 and V6 covers W5 and W6.

It is quite obvious that the increase of V5 and V6 will realize more virtual wealth in real world and increase the competition of the VC. However, it should be noted that a healthy open VC must keep a stable price level of virtual goods, that is, GVRP must be suitably matched with the virtual money supply (V). To enable it, a *virtual price index* (VPI) must be designed such that:

$$VPI = \frac{V}{VQ + RQ} = \frac{VP_1 + \cdots + VP_m + RP_1 + \cdots + RP_n}{m + n}$$

where VQ is the total quantity of virtual goods and RQ is the total quantity of real product and capital. VP is the average price of categories of virtual goods and RP is the average price of categories of real product and capital.

VC operators must keep watching on the VPI change to adjust virtual money supply quantity to prevent VC inflation or deflation that may harm open virtual world.

4.4. Methods of Realizing Virtual Wealth

A VC targets at increasing its GVRP and meanwhile maximizes the realization of virtual wealth in both virtual and real worlds. The general methods are:

First, in a closed VC, the VC operators should encourage more avatars to become knowledge engineers, so virtual product design elements can be enriched. This will reduce the VC operators' investments yet increase W2 and attract more virtual inhabitants, and finally increase both W3 and K3. These will lay a solid foundation for moving towards an open VC.

Second, when a VC already has a channel to interact with other VCs, the VC operator should maximize its export through providing inter-VC product design technology. Meanwhile, it should promote more use of its own currency. This will increase W4 and K4, and enlarge the scope of virtual wealth realization.

Third, in a VC permitted to buy in real world, the VC operator should best promote its virtual currency and provide high quality virtual marketplace towards real world. This will increase W5 and K5, and realize more virtual wealth in real world. More importantly, it will strengthen its virtual currency in both virtual and real world.

5. Accountability of Virtual Wealth

In most commercial and legal governance, the ability to hold individuals or organizations accountable for actions is important [9]. Accountable is often defined as responsible for giving an account as of one's acts (i.e. answerable) or, alternative, capable of being accounted for (i.e. explainable) [6]. To maintain a sustainable VC where virtual wealth can be formed and realized, this paper views the accountability of virtual wealth as an explicit match of an accountability matrix by VC operators towards an open virtual world.

5.1. Accountability Matrix

Our goal is to provide a set of answerable and explainable indicators that can assess whether a VC is sustainable for its virtual wealth to be realizable. To achieve this goal, we build an accountability matrix in Table 4.

Table 4: Accountability Matrix for Virtual Wealth

Indicator	Account	Measure
Sustainable finance	Profit rate (PR)	$PR = \frac{K - S}{S} \times 100\%$
Sustainable growth	Growth rate (GR)	$\mathrm{GR} = \frac{\mathrm{GVRP}_2 - \mathrm{GVRP}_1}{\mathrm{GVRP}_1} \times 100\%$ or, $\mathrm{GR} = \frac{\sum \Delta W}{\mathrm{GVRP}} \times 100\%$
Sustainable Participation	User rate (UR)	$\mathrm{UR} = \frac{\mathrm{U}_2 - \mathrm{U}_1}{\mathrm{U}_1} \times 100\%$
Wealth security [15]	Happiness rate (HR)	$\mathrm{HR} = \frac{\mathrm{WG/WL}}{\mathrm{W}} \times 100\%$

In Table 4, the *profit rate* is a key account for a VC, measuring whether the VC is financially well-performed as a sustainable VC. The *growth rate* accounts for a VC, measuring whether the VC has sustainable growth. Specifically, detailed check is required on its balanced growth between each sector such as systems building, knowledge engineering, inhabitation, foreign trade and real-world penetration. The *user rate* accounts for a VC in the aspect of the sustainable user (U) participation. The *happiness rate* is an account for a VC to check whether the VC provides wealth security to its users against the *wealth gain* (WG) or *wealth loss* (WL) of the existing wealth caused by VC system failure, avatar fraud, virtual money inflation/deflation, virtual money exchange rate changes, etc.

5.2. Second Life Example

Second Life (secondlife.com) is an open 3D world inhabited by its Residents (i.e. virtual inhabitants) that's bursting with entertainment, experiences, and opportunity. Its VC system was created and maintained by Linden Lab (lindenlab.com) (i.e. system creator), and technically managed by Second Life Gird (secondlifegrid.net), which is a platform where the Second Life world resides and offers the tools by both Linden Lab and various solution providers (i.e. knowledge engineers) for business, educators, nonprofits, and entrepreneurs to develop a virtual presence. Based on Second Life, Xstreets SL (xstreetsl.com owned by Linden Lab) and other third-party websites are *virtual marketplaces* (v-marketplaces or VMP), specialized for trading virtual goods using Linden Dollar (L$) as the settlement means. Linden Lab, Second Life Grid and Xstreet SL are all owned and managed under the name of Linden Research, Inc. Second Life world, in general, matches the open virtual world discussed in Section 4 and can be modeled in Figure 2.

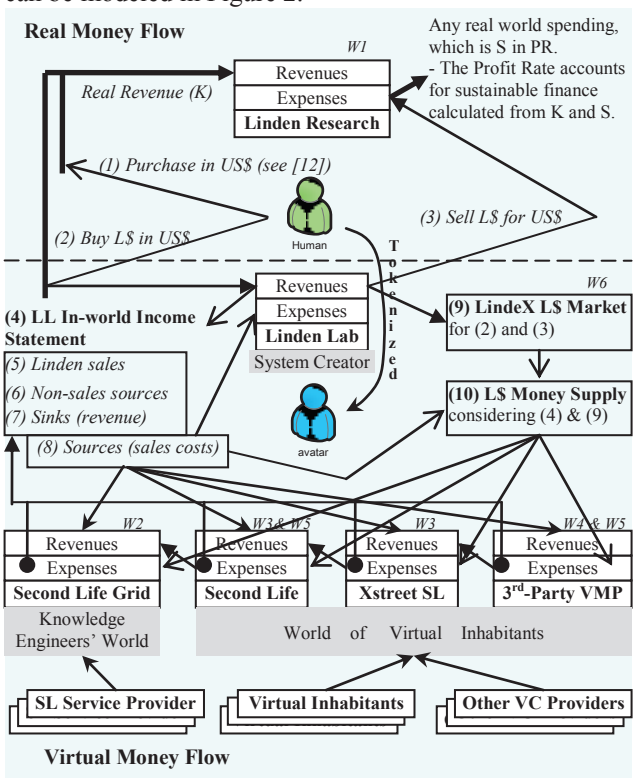

Figure 2: Second Life Virtual World

Check the Second Life against the accountability measures listed in Table 4, we find Second Life as an open VC is generally healthy for the virtual wealth realization, based on our data analysis. Its GVRP can be calculated from (4) adding the real-world expenses through the formula of:

GVRP = Linden Sales (5) + Non-sales sources (6) + Sinks (revenue) (7) – Sources (sales costs) (8) + real-world investments – real-world expenses paid to real world

where (5), (6), (7) and (8) is available by analyzing its L$ supply data from the Linden Lab publicly published in real-time [13]. These data are fine, showing in Figure 3.

However, it is difficult to find the accurate real-world investment and expense data from Linden Lab. Thus, it is still doubtful whether Second Life world is in sustainable growth.

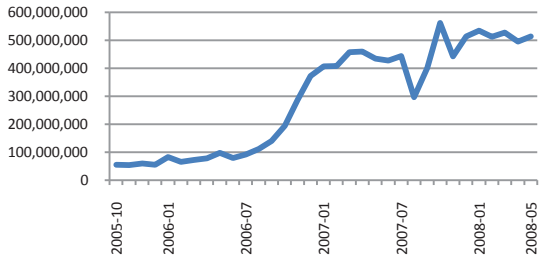

Figure 3: Linden Lab Virtual Revenue (L$) (monthly)

The user rate of Second Life is much positive in terms of the data of Total Hours Used by all Residents compiled from Linden Lab [13], which represents the sustainable user participation.

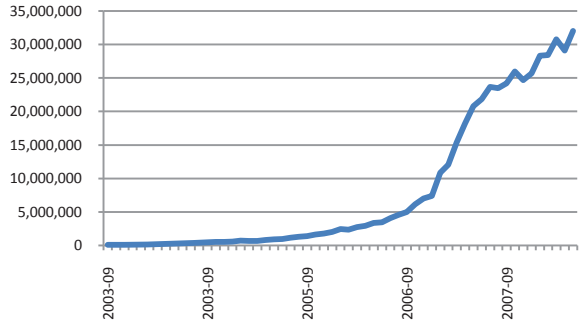

Figure 4: Total Hours Used by all Residents

We calculate the happiness rate using the formula of HR = % of wealth change due to loss or gain from exchange rate (WLGE) + % of total user hours lost due to downtime (WLT) according to Linden Lab data.

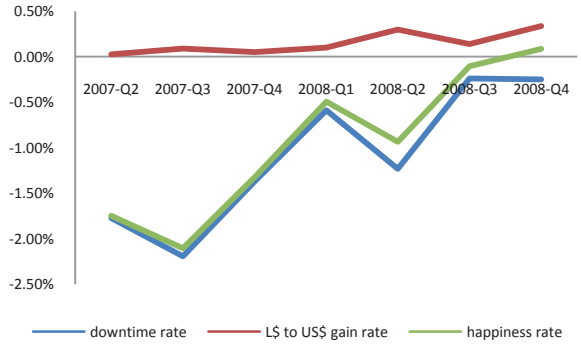

Figure 5: Happiness Rate

By this measure, we can check the wealth security in Second Life world.

For the profit rate of Linden Lab, the revenue can be roughly computed from Linden Sales and Non-sales sources, shown in Figure 6.

While non-sales sources can be a guess of real-world sales for US$, the difficulty is obtain the expenditure data from Linden Lab. This seriously affects the evaluation of ability of Second Life for its virtual wealth realization ability. The question left is "Will Second Life be stable enough for investment and doing business not just only for fun?"

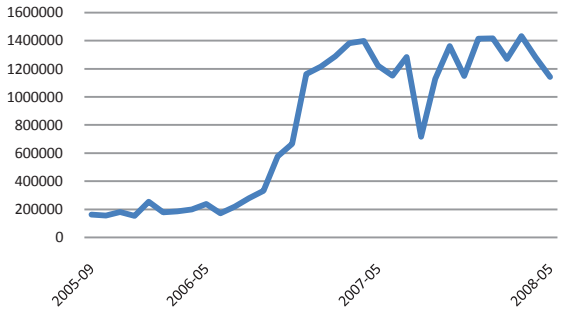

Figure 6: Linden Lab Real Revenue in US$ (monthly)

Second Life, in general, is healthy, but to strengthen the users' confidence, its financial data must be available to public for users' assessment.

6. Discussion and Conclusion

Virtual wealth realization relates to the understanding of virtual wealth and construction methods of virtual world. Existing researches on VCs mostly focus on social aspects (e.g. sense of VCs [5], trust relation [3], or membership continuance [2]), modeling aspects (e.g. model for virtual learning community [4]), and legal issues (e.g. [14]). None of them discuss virtual wealth, its measurement, and its realization, though it is important.

This paper has investigated the issue of virtual wealth and its realization in both real and virtual worlds. It provides a better understanding of virtual wealth and its underlying VCs. It argues that the realization of virtual wealth in both virtual and real worlds is necessary and possible. On the formation of virtual wealth, the paper has studied the classic theories of labor theory of value, exchangeable value, and utility theory. By these theories, it has successfully explained the nature of virtual wealth that has difficulties in realization within a closed virtual world. It thus promotes an open virtual world for virtual wealth realization. To have an open virtual world, the key elements of it have been investigated. Given an open virtual world, the methods of classification and measurement, the factors of changes on virtual wealth, and the approach to realizing virtual wealth in both virtual and real worlds have been described. To make the open virtual world more accountable, an accountability matrix is proposed to

measure whether a VC is properly designed and used, beneficial to its users to realize their virtual wealth. To validate the open virtual world theory, the Second Life example is adopted and analyzed. This has proved the suitability of the proposed theory.

In summary, this paper has contributed a new understanding of virtual world. It opens a door in which readers can see how virtual world look like and how it is now in operation and will be operated in future. It exposes the importance of virtual wealth realization and proposes the methods of its implementation.

This paper has several implications: First, legal policies on VCs, especially the permission of conversion between virtual and real money and VC's financial data availability, must be discussed and published. Second, code of conduct and views on operating VC must be changed from "close mind" to "open mind". Third, technology study on VC should more focus on its construction methods and the inter-community integration technology.

Realization of virtual wealth is a new topic. Many research researches are still needed in the level of discovery. In future research, more in-depth study is needed.

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