Cornell University
The Johnson School

Johnson School Research Paper Series #27-2010

Virtual Money in Electronic Markets and Communities

Levent V. Orman—Cornell University

June 2010

VIRTUAL MONEY IN ELECTRONIC MARKETS AND COMMUNITIES

Levent V. Orman
Cornell University
orman@cornell.edu
www.johnson.cornell.edu/faculty/profiles/orman

ICAST Journal 2010

Abstract

Money is an information system to value, record, and track economic transactions. It is an information system with minimal semantics and centralized control. Consequently, the monetary system fails to support many transactions directly, but requires intermediaries such as banks, brokers, insurance companies, credit card companies, and investment firms, increasing transaction costs greatly. Semantics of money can be increased, and the management of money can be decentralized by creating virtual money. Management can be decentralized by issuing private currencies and creating an automated peer-to-peer network of currency exchange systems to support complex transactions. Semantics can be increased by incorporating transaction information in the money, and building semantic hierarchies of money types by aggregating underlying privately issued currencies. Resulting virtual money can disintermediate many financial institutions, possibly leading to drastic reductions in transaction costs.

Keywords: Virtual Money, Electronic Money, Networked Money, Peer-to-Peer Networks, Semantic Money, Private Money, Decentralized Money, Electronic Markets, Disintermediation

1. Virtual Money

Money is an information system. It is used to value, record, and track economic transactions. It is implemented in a variety of ways, such as currency, checks and demand deposits, certificates and time deposits, bonds and shares of stock, credit and debit cards, and electronic funds [29]. Although the implementation mechanisms are complex and varied, conceptually money is a simple information system with minimal semantics and centralized control. Its semantics only captures the value exchanged, and the net value accumulated by each party. It ignores the products and services exchanged, the parties involved in each transaction, and the performance requirements and guarantees placed on those products, services, and the parties. It ignores how the net value of an individual or business was acquired, and it fails to provide an audit trail for integrity and security. Consequently, the monetary system fails to support many complex transactions directly, but requires many intermediaries such as banks, brokers, insurance companies, credit card companies, and investment firms; and those intermediaries add considerably to the cost of economic transactions [10].

Consider a wage employee who performs services, in exchange for food and shelter for his family. Each half of the transaction is valued in a national monetary unit by the parties; they are recorded in terms of that unit, either as cash transactions by the parties, or as electronic records by banks and credit card companies; and the remaining funds are either held as cash, or distributed among various savings instruments by bankers, brokers and investment firms for future use. The national monetary system requires a number of intermediaries even in such a simple transaction. It requires even more intermediaries in complex transactions such as long-term contracts involving education, retirement, employment, and home ownership; high variability transactions of health care, disaster recovery, and accident remedies; and high risk transactions of investments and entrepreneurial ventures. Minimal semantics of money does not support such transactions directly, but requires extensive intermediation. Intermediation increases transaction costs considerably [17].

Money is a centrally controlled information system. Central management of money typically involves the central bank of a nation-state which controls the amount of money in the system; and it involves the commercial banking system which implements the creation and tracking of money through commercial and individual lending. Central control of money leads to information overload and complex decision making at the central bank; it creates a single-point of failure, leading to system-wide crises when the decisions are not correct; and it encourages extensive political struggle to control or even corrupt the central management to serve powerful interests [11].

Consider the financial crisis of 2008. It was instigated by large increases in the money supply, inadequate regulation of the resulting expansion of lending by commercial banks, and the consequent insolvency of critical financial institutions that are big enough to create system-wide failures. All of these failures confirm the difficulty of centralized decision making under information overload, the difficulty of centrally managing a commercial banking system with powerful interests, and the system-wide implications of incorrect decisions with no ability to isolate and localize crises. Most of these problems can be alleviated, or even eliminated, by utilizing new information technologies to semantically enrich money, and to distribute and decentralize its management [14].

Money can be semantically enriched by incorporating information about the transactions, goods and services involved in those transactions, parties to those transactions, timing of transactions, guarantees and commitments for future transactions, and the underlying assets guaranteeing the transactions. Such increased semantics can lead to a more stable value for money and more confidence in its future purchasing power. Moreover, the management of money can be distributed and decentralized over many marketplaces and communities, possibly leading to dramatic increases in the efficiency of economic transactions. Distribution can reduce information overload, simplify macroeconomic policy making, reduce systemic risk by localizing and isolating failures, reduce political struggle to manipulate the money supply, and lower transaction costs by eliminating many intermediaries [2, 5].

Consider the purchase of a private home. The transaction requires a credit investigation of the buyer, initiation of a loan, a commercial bank determining the interest rate and the transaction fees under the regulatory guidance of a central bank, tracking and recording the payments towards the loan, payments to the seller, selling the loan to investors or bank depositors, returning the profits to investors, and, managing the default risk of individuals and banks. In fact, the transaction is a rather simple transfer of funds from residents to builders over time as the services are provided and consumed. The time difference between the provision and consumption of the services is the only complication. That time difference encourages intermediation and investment to facilitate the transaction, but at a considerable cost. With increased semantics and distributed management of money, the builders and residents of homes can build long-term relationships and transfer payments directly, thereby disintermediating banks, real estate brokers, developers, speculators, and investment firms, leading to large savings. Similar savings in transaction costs can be achieved in entrepreneurship, insurance, and investments from increased semantics and distributed management. However, the task is not trivial. It requires a complex technology infrastructure to connect and network large numbers of people over long periods of time, through complex and novel electronic marketplaces; and it requires a complex social and legal infrastructure to establish trust and confidence involving large numbers of people simultaneously over long periods of time [14, 23].

2. Distributed Money

National money is debt created by national governments or by regulated commercial banks. It is managed centrally, with all the consequent problems of central management, such as information overload at the center, single point of failure, and incentives for political struggle to influence and corrupt the decision makers. A distributed and decentralized management of money would alleviate these problems. There is some historical precedence for decentralized management of money in the United States. In early 19th century, many commercial banks issued their own private currency, and the federal government largely stayed out of the money business. By mid 19th century, there were approximately

30,000 different private currencies in the United States. There were many problems with such decentralized management of money through private currencies, such as the non-universal acceptance of money, the risk of bank default, and the difficulty of consistent currency exchange among all the different currencies [8, 25]. Modern information technologies can be used to solve these problems while maintaining all the advantages of decentralized management. Communication networks can be used to connect all currency issuers for universal acceptance of all currencies; social networks and recommendation systems can be used to collectively judge the default risk of currency issuers; and electronic exchanges can be used to automatically exchange currencies to support multi-currency transactions [14, 26].

There are a number of principles that can guide the design and implementation of a distributed and decentralized monetary system, involving both technical and economic issues:

a. All businesses, and even some individuals, can issue private money as credit to their suppliers and employees. Such private money is merely an electronic IOU signed by a business in exchange for goods and services. It is fundamentally different from debt-based money, since it is issued only in exchange for goods and services, and hence its quantity is expected to be self-regulating [2, 10]. It is implemented merely as an electronic record in a database shared by all parties involved. The shared database can be housed and maintained by a third party electronic marketplace, or merely duplicated as a shared electronic record in the databases of all parties. It can be accessed using public computer networks, and possibly cell phones and smart cards that can access the networks. Such shared databases have complex integrity constraints, since they cannot be modified without the consent of all parties, and the parties involved maybe different for each shared record. Such shared inter-organizational databases have been studied in great detail, and they are used extensively in building electronic exchanges and auctions. They also have complex transparency requirements that reveal transactions and provide audit trails to all relevant parties, while hiding information from all others [3, 7].

b. All businesses can act as currency exchangers by automatically accepting the currencies of their trusted business partners. A transaction between non-business partners is intermediated by others. Such intermediation can be completely automated, and go through many intermediaries before the two parties can be connected by a chain of intermediaries where each is trusted by the next. Each intermediary accepts the currency of a trusted partner, and replaces it with its own, before pushing the payment to another trusted partner, on its way to its ultimate destination. Such automated intermediation is similar how internet operates as a distributed network, where a message goes through multiple intermediaries, called routers, before it reaches its destination. Such dynamic network management is well understood, where each node has extensive local information, but very limited global information. Each node acts as a traffic controller, and routes the message to its next node on its way to its destination. Each node does only local optimization, selecting the best next node from the alternatives, with only limited information about the global space, guaranteeing only a positive movement towards the ultimate destination. Such dynamic route selection with local information does not guarantee the global optimum route, but finds sufficiently good solutions within the strict time and cost constraints of the network. Similarly in a distributed monetary network, the intermediaries would only know and trust each other locally; and they would make local decisions by selecting the next step in pushing payments towards their destination. Such local decision making can find feasible and sufficiently good routes within the time and cost constraints of the network [7, 12].

c. Each intermediary can impose fees or commissions on each transaction it routes, for facilitating the movement of the payment through the network, and for guaranteeing the performance of their trusted partners by holding their currency. Each transaction, as it finds its way through the network, accumulates fees. The total would be charged to the originator of the transaction as a transaction fee. The computation of the best route to take through the network would involve an effort to minimize the total transaction fee. The problem is similar to the task of minimizing delay for each message in a computer network by considering the load and capacity at each node. Such routing algorithms are widely available, and they can be readily adapted to route selection with minimum transaction fee on a payment network, by replacing the node delay with the node transaction fee, and the node capacity with the currency holding capacity of a node which is determined by its risk tolerance [12].

d. Each business acts as a bank by accepting and exchanging the private currencies of its trusted partners, and thereby facilitating their transactions for a fee. In the process, each business may accumulate the currencies of its partners, if there is a deficit in trade balance. Excessive accumulation of a currency may prompt a business to stop accepting it, or to start charging a higher transaction fee for that currency. Basically, each business dynamically adjusts its transaction fees to earn more transaction income, while minimizing its exposure to default risk due to holding the currencies of its trusted partners. In other words, each business guarantees the credit worthiness of its trusted partners by holding their currency (in effect, extending a line of credit), and in return it benefits from the transaction fees paid by its trusted partners whenever they utilize its services as a currency exchange intermediary. Each business tries to find the optimum trade-off between the two by utilizing their knowledge of its business partners. The problem is similar to network design where each node benefits from the traffic flow it receives (i.e. transactions), and tries to maximize it within the limits of its capacity (i.e. risk tolerance). Each node of such a decentralized network has to decide which other nodes to connect to, and how much traffic to accept from each. Network design literature provides many algorithms to attack this general problem [4].

e. The need for formal bank loans is minimized, since the distributed management of money enables extending credit automatically to one’s business partners, and indirectly to others, by merely accepting their private currency. Each business utilizes its knowledge of its business partners to judge their credit-worthiness, and decides on the credit line to extend to them. In effect, formal bank loans are replaced by the network of business relationships, and the collective and distributed judgment of credit-worthiness within the network. This results in decentralization of control and management of the money supply. Default risk of a business is also distributed among all its partners that hold its currency. Consider an entrepreneur A who needs to buy $50K worth of equipment from a business B to start a new business.

All he needs to find is one or more routes of connections between A and B in the money management network. Each route is a chain of businesses that accept each other's currency, starting with the currency issued by A, and ending with a currency acceptable to B. Multiple routes may be needed to collectively add up to $50K. For example, A could raise $50K from 50 business partners at $1K each. The funding would be automatic as the business partners merely accept the issued currency as payment, and the aggregation of funds would take place over the network infrastructure. Such partitioning of messages (funds), and sending them over different routes, to be aggregated at the end to recover the message (total payment) is a fundamental principle of packet switching networks such as internet. The algorithms to split and aggregate messages (funds) according to the capacity and load (risk tolerance and accumulated currency) of the nodes on each path are widely available as part of the IP protocol. In this environment, each node only sets limits on how much of what currency to accept, and what transaction fees to charge and the transactions find their routes automatically using network protocols and routing algorithms [12].

f. Businesses use their knowledge of each other in performing these intermediary roles, and judging each other's credit worthiness. Such knowledge is acquired during the normal course of business, but needs to be supported by a legal framework that requires transparency. Businesses need to reveal the identities of their partners, and the amount of currency (credit) they have issued to each partner. Businesses need to be able to observe the underlying assets and the total currency issues (debt) of their partners to judge their credit-worthiness, to facilitate the distributed peer-to-peer payments without any central control. Such transparency can be implemented by independent electronic exchanges that keep public records of all transactions among partner businesses, and their outstanding currency balances. Industry-wide electronic exchanges are common, and the technologies to implement them are widely available in terms of industry standards, or inter-organizational data exchange protocols [7, 9]. Actually, all public corporations already have such reporting requirements, but the reporting can be automated by electronic exchanges that facilitate and record all relevant transactions. We will see in Section 4 that distributed money framework can be extended to accommodate private individuals by utilizing social networks and recommendation systems, but that would require a much more expansive regime of transparency [23].

g. Distributed money management relies on the knowledge of business partners about each others' business practices and financial solvency. Such knowledge is typically acquired informally during normal business activity. But privately issued money can be semantically enriched to capture such information formally and automatically. Such detailed semantics can include the underlying assets of the issuer, the amount of money issued to each of its partners, and the amount of money its partners are willing to accept. If such information is captured automatically during the normal course of business, and made widely available, it would help other parties decide how much of a private currency to accept and hold, since it conveys the risk of holding a particular currency as viewed by the issuer's business partners. Transparency of such information by including it in the money itself would accomplish that goal, because it reveals it publicly and conveniently. The information can be useful at multiple levels of aggregation. At the most detailed level, how much a business is willing to hold the currency of another is a measure of trust it places on the other's credit. How much a business already holds the currency of another is a measure of relative financial strength (ctredit). At the most aggregate level, how much of its own currency, all of its partners are willing to hold in total, is an indication of its credit-worthiness. How much of its own currency, all of its partners already hold, is a measure of overall financial weakness (debt). The difference between the partners' total willingness to hold and the amount they actually hold is a good measure of aggregate confidence in a business, leading to a realistic measure of future performance, since it is actually the difference between their aggregate credit and their aggregate debt. Conversely, a business that is holding a great deal of others' currency is a high performing business that does not have to issue large amounts of its own currency, and it is in a position of great power in deciding whose currency it will hold (i.e. extend a credit to). Such businesses may be more reliable than others in judging the credit-worthiness of their partners, and aggregation algorithms may be modified to weight individual businesses differently, leading to considerable complexity. However, even with simple aggregation semantics, such a distributed banking function is likely to be reliable and stable with minimal transaction costs, because it relies on business partners' knowledge of each others' business practices, and makes such knowledge public through the semantics of money [26].

Such rich semantics of money can be implemented as a multi-dimensional multi-level ontological hierarchy and placed in public databases. Money as a semantic concept can be classified into many dimensions such as its issuer, its acceptance by partners, and its past transactions. At each dimension, there are many attributes, at multiple levels of aggregation. One can search such an ontology for the attributes of a given currency at a specific level of aggregation, such as the total held by all partners; or one can search for currencies that satisfy certain attribute values, such as finding a currency B that can convert A to B and B to C for an amount X at a transaction fee less than Y. Such publicly searchable ontologies are critical to the optimum routing of transactions, and they are updated dynamically as new money is issued, and new transactions are executed by member businesses. Such ontologies can be placed in public databases of electronic markets and exchanges, by using universal protocols designed for web data and web services [13, 15, 21].

3. Aggregate Money

Individuals can also benefit from distributed money management by issuing their own currency, and by accepting other individual's currencies, and hence facilitating transactions within their social network. But such private currency issued by individuals has high default risk. To reduce risk exposure, individuals need to limit their holdings from each issuer, or they need to use aggregate or virtual money created by merging many underlying private currencies into one. Aggregate money can be issued by electronic markets or communities on behalf of all of their members, and a default by any member is covered by all other members collectively and automatically, simply by accepting the aggregate money. Such aggregate money transfers the default risk from holders to issuers, and it is an effective confidence-building tool for a community by accepting more of the risk on behalf of its members, to reduce the risk of holding the community's currency. Consider a community of n individuals, each issuing x dollars in a joint currency where the default rate is r for each individual. Assuming independence, the default risk for the joint currency would be r^n, and the expected loss would nxr^n. If each individual issues x dollars separately, the default rate for each would be r, and the expected loss would be nxr, which is considerably higher. The risk dos not disappear of course, but it is transferred to community members. With individual currencies, an issuer has no risk of loss. Yet, with a joint community currency, one member's default requires the others to honor its currency, which leads to an expected loss of (n-1)xr for each member. Since community members are expected to know about each others' financial stability, communities can be an important vehicle to evaluate the risk-worthiness of individuals correctly, and communicate that to the market efficiently by incorporating the default risk within the community [27].

Aggregation is useful in reducing the default risk of holding a currency, but it also reduces the information content of money by eliminating information about the specific transactions and the parties involved, and replacing it with the information about aggregate transactions and the groups involved. There are two distinct types of risk in commercial transactions. One is the risk of default by the money issuer resulting in non-acceptance of the currency. The other is the default by the parties to a transaction resulting in non-performance or non-payment. With privately issued money, the two risks are merged since the parties to the transaction are also the issuers of money. With aggregate money, the two risks are increasingly separated. The risk of default by the issuer goes down since the group currency is acceptable by all in the group, but the risk of non-performance or non-payment goes up because the money issuer is increasingly decoupled from the parties to the transaction, and the parties know little about each other on the basis of the money issued and exchanged. At the extreme levels of aggregation, one can eliminate almost all default risk, but have no information about the transaction and the parties involved. National currencies are examples of extreme aggregation. They are issued on behalf of all citizens of a nation, and the default risk is negligibly small, but the performance risk is very high since national currencies contain no information about the parties to a transaction. Consequently, many intermediaries are needed to facilitate the transaction, and to investigate and confirm the reliability and credit-worthiness of the parties to the transaction. With private money on the other hand, those who accept a private currency vouch for the reliability and trust-worthiness of the issuer, but the default risk remains. Clearly, there is an optimum level of aggregation that strikes a balance between the default risk and non-performance risk by carrying enough information about the parties, yet with enough aggregation to reduce the default risk. Neither extreme is likely to be optimum [22].

Aggregate money can be further enhanced by using a variety of techniques. Non-performance risk can be further reduced if communities are designed carefully to include multiple similar businesses that can insure and honor each others' contracts. In effect, consumers can contract with a community for services, and any member of the community may provide the service, but the community remains responsible for providing the service. Similarly, non-payment risk can be further reduced by building consumer communities with similar consumers with similar needs. Then, the community may acquire some goods and services for all of its community members, and the community collectively pays for the goods and services using community currency, and remains responsible for the payment for all of its members. Such communities behave as if they are a single business or a single consumer issuing their own currency and guaranteeing services and payments as a community. More limited communities may issue currency collectively, but they may remain as separate businesses or consumers with individual transactions [16].

Consider a hospital that provides medical services. By including multiple providers that can provide the same services, the hospital can act as a business community that reduces non-performance risk. Not only the hospital acts as a quality control system for individual providers, but also reduces non-performance risk, since the failure of any particular provider to perform is covered by others that honor the contracts of the hospital. Similarly, a community of patients can contract for medical services with the hospital collectively, and the payments are made by the community on behalf of all the patients, reducing non-payment risk. Such community transactions can eliminate insurance companies, and replace them with direct transactions between a community of providers and a community of consumers. The currencies issued by these communities facilitate community transactions, and their enriched semantics conveys the trust placed on these communities by their business partners, peers, customers, and investors.

Further aggregation of communities, both on the provider and the consumer side, can lead to further reduction in transaction costs. Business communities providing complete sets of services for events such as weddings or conferences can contract for large sets of services with a single transaction, and guarantee performance through its private money, both with the underlying assets backing the currency, and the community's reputation established by the currency. Similarly, large consumer communities built around abstract lifestyles such as environmentally friendly living or intellectual and artistic communities can acquire large collections of services for all of their members collectively, and eliminate the need for individual transactions specific goods and services. They can also act as purchasing agents or recommendation systems for large sets of services for large numbers of people. Such professional procurement for end consumers has the potential to reduce transaction costs and change consumer marketing profoundly [22].

Consider a community of newspapers and news web sites. They can collectively sell subscriptions to all of their services, meeting all the news needs of their subscribers. Such a community is much more viable than each trying to sell separate subscriptions, because an average citizen gets news from a variety of sources, and subscription to all individually may be infeasible, especially when each individual news source may be used only sporadically, and does not justify subscription. A further consolidation of news with entertainment and social networking may lead to packages that meet the information needs of complete lifestyles. Such large packages may well justify subscription, especially if they can be customized, described, easily subscribed, and their performance guaranteed. The currencies issued by these communities facilitate such large-scale and long standing community transactions, and solve the monetization problem of many online information sources such as newspapers and social networks [22]. Such large business communities have great advantages such as economies of scale and uniform quality control, but they are also viewed with great suspicion because of monopoly power they exercise. Their advantages can be kept, without the disadvantages, if their power can be checked by large consumer communities that can act as a single consumer due to their common currency.

4. Conditional Money

National currencies have simple semantics, but that simplicity comes at a price of minimal information content. They convey some purchasing power information, but only when combined with prices of goods and services. Since prices are not fixed, money provides very little information about the future purchasing power, except indirectly by comparison t the total amount of money in the economy and the total production. Total amount of money in the economy is also variable, controlled by political forces, leading to great uncertainty about the future purchasing power of money. This uncertainty leads to the need to hoard money and accumulate wealth for financial security, since the amount of money necessary to maintain a lifestyle cannot be accurately predicted. Increased semantics of money can be used to capture information about the future purchasing power of money for various goods and services. The semantics can be aggregated over large collections of goods and services, over long periods of time, and over large communities of businesses and consumers to distribute risk and further reduce uncertainty about future purchasing power, and to guarantee complete lifestyles [2].

The semantics of private money can be further enriched by attaching arbitrary conditions to its redemption, creating conditional or virtual money. The conditions can be implemented as constraints on the attributes and classes of private money ontologies, and stored in a semantic ontology protocol such as OWL [15]. The conditions can be simple restrictions on the time of redemption; they can be restrictions on the goods and services that can be acquired or the vendors that can provide them; or they can be restrictions conditioned on the occurrence of random events such as accidents, machine break downs, illnesses, or natural disasters. Such conditional money can supplant a variety of financial instruments from loans and credit to subscriptions and insurance. A combination of such conditions can be used to support more complex financial instruments such as bonds, stocks and futures contracts. Money conditioned on time is simply a time deposit or a loan. The loaner exchanges his unconditional money for the borrower's time conditioned money which is the equivalent of a payback at a later time, possibly in installments; but the whole transaction takes place at one point in time, reducing transaction costs, and the conditions attached to money implement installment payments automatically. A transaction fee can be charged for the exchange which is similar to interest payments. The transaction fee can be fixed, amount dependent, time dependent, or a combination. Money conditioned on both time and specific goods and services are subscriptions or futures contracts. The subscriber exchanges his unconditional money for the provider's conditional money that is redeemable for specific goods and services at specific times. The redemptions are scheduled at automatically executed at predetermined times, which is equivalent to subscriptions or futures contracts. Such conditioning of money by specific goods and services are guarantees of future purchasing power, and can be viewed as protection against inflation. Money conditioned on the performance of a business is investments. Specifically, money conditioned on time and the financial solvency of a business is bonds; and money conditioned on a proportion of the assets of a business is shares of stock. Money conditioned on specific random events such as illnesses, accidents, machine breakdowns, or natural disasters is insurance or maintenance agreements. All of these conditional moneys can be issued without intermediaries, by the service providers themselves, by utilizing the extended semantics of money, greatly reducing transaction costs [26].

Money conditioned on the performance of a business is especially useful, as it serves as a generalized investment vehicle. The conditions may involve the solvency of the business as in bonds; may entitle the holder to a percentage of the assets as in stocks; or combine the two in various ways as in preferred shareholder arrangements. By combining multiple conditions, money issued by a business can be viewed simultaneously as a loan, a futures contract, a subscription to future goods and services, a bond issue possibly with inflation protection, insurance, or as shares of stock, by using the rich semantics of money to entitle the holder to money, goods and services, or a share of the business assets, under various conditions. With increased semantics of money the distinctions among loans, commercial bonds, and shares of stock begins to disappear, and more complex financial instruments can be created merely by adjusting the conditions attached to virtual money. This creates an opportunity for entrepreneurs and existing businesses to raise capital from a large number of retail investors, customers, and business partners directly, simply by issuing virtual money. Those who are willing to hold the virtual money are the investors in the business as subscribers, bond holders, shareholders, or as a combination of those, and the semantics of virtual money supports all. The conditions attached to virtual money specify which interpretation is allowed when and under what conditions.

For some new ventures, the risk may still be too high to raise capital from retail investors in a distributed fashion, although virtual money allows a large number of investors to contribute small amounts directly and with minimal transaction costs. To reduce investor risk further, businesses can form communities, and issue money jointly as discussed in Section3. Such group currency backed by group assets facilitates investing in a group of businesses collectively, as in mutual funds, without any intermediation. Such a tool is also useful in funding a group of similar new ventures collectively to reduce risk. Such joint currencies can even be used by individuals, by forming communities and raising capital to invest in long-term personal development or life style improvements as in education, child rearing or home ownership.

Consider a community of professional students issuing currency as a group to pay for educational expenses, thereby allowing retail investors to directly invest in them by simply accepting and holding their currency. Most education can be funded in this fashion with very low transaction costs. The community currency can be accepted with fixed or term dependent transaction fees (loans or bonds); they can be accepted in exchange for future goods and services (subscriptions or inflation protected bonds); or they can be accepted in exchange for a percentage of the future assets (shares of ownership).

Implementation of such complex conditions relies on constraint-based systems [6, 18]. Money can be classified into multi-dimensional ontologies with respect to the issuers, holders, and the transactions, each with their own attributes, and arbitrary conditions can be attached to the classes and attributes to define legitimate transactions [13]. The user interface is also a challenge since users cannot be expected track multiple currencies and their arbitrary constraints on electronic wallets. In fact, the users need to see only their primary currency, and all of their currencies to be expressed in terms of that currency. The management of multiple currencies such as the enforcement of holding limits for each currency, netting and balancing of mutual holdings with partner businesses, and the selection of appropriate currencies for each transaction are all done automatically, by routing and network management algorithms. Conditional money is also a challenge to represent, as it is with many existing insurance and investment products. They can be described as part of an ontology using semantic ontology representation tools such as OWL [15]. But more importantly, many types of conditional money can be aggregated into complete services or even lifestyles, and described in aggregate form. For example, a variety of entitlements to hospital, doctor, nursing, and pharmacy services can be combined into health care services and presented to the user as health care currency. As the consumer spends it as an aggregate health care currency, the system dispenses the correct components as micro payments. This is probably one area where micropayments can be useful; not as a user payment system, but as an automated payment system to partition an aggregate payment correctly to individual services. Further aggregation can lead to lifestyle currencies. For example a healthy maintenance currency may include many components for athletics and hobbies in addition to health care. The consumer spends the aggregate money for the activities, and the money system converts the aggregate currency automatically to the relevant currencies for payment, and reports only when there are exceptions such as inability to convert the aggregate currency to an acceptable currency by a provider, or low balance in one currency to cover any particular expenditure. Even such imbalances may be temporary, and can be merely tracked by the system over time, and can be settled by the system by merely adjusting the distribution of currencies supporting the aggregate. More of one particular currency can be acquired by selling another to deal with temporary imbalances without consulting with the user [4].

5. Conclusions

Money is an information system. Virtual money is money built from underlying components by increasing its semantic content, by aggregating different types into higher level types, or by attaching arbitrary conditions to it. Information content of money can be increased by including information about transactions, parties to the transactions, and the financial viability of the parties. To manage such vast information content, to reduce risk, and to support complex transactions, money can be aggregated into virtual money that is based on many underlying currencies. Further increases in semantics is possible by attaching arbitrary conditions to the redemption of money, and the resulting virtual money can replace many investment vehicles and financial intermediaries, and hence drastically reducing transaction costs.

The first step in the implementation of virtual money is issuing private money in small closed worlds of social networks, virtual worlds, or electronic markets. Many electronic communities and virtual worlds already have private currencies but they are all limited to use within the community [20, 24]. The second step in the implementation of a virtual currency would be a multi-currency system where multiple communities with their own currencies can interact through a currency exchange system. This step is straightforward to implement in small scale with the existing technologies of electronic exchanges; and it may be a profitable route to monetizing the large memberships in social networks. The implementation becomes more challenging in large scale with thousands of currencies, since that would require finding optimum exchange routes and maintaining consistency. Here, many existing networking and routing algorithms would be helpful, but an incremental development is desirable since any change to a monetary system is risky. The third step would be to start expanding the semantic content of money by aggregating them into hierarchies, and by attaching arbitrary constraints to its use. This step is likely to be most challenging especially in tracking the money, and in presenting a convenient user interface.

References

1. Anderson P., Anderson E. The New E-commerce Intermediaries. *Sloan Management Review* 43, 4, 2002.

2. Boyle D. *Funny Money: In Search of Alternative Cash*. Harper Collins 1999.

3. Chi L., Holsapple C., Srinivasan C. Competitive Dynamics in Electronic Networks: Model and the Case of Interorganizational Systems. *International Journal of Electronic Commerce* 11, 3, 7-49, 2007

4. Chow A., Guo J. VONEX: A Novel Approach to Establishing Open Virtual Money Exchange Regime. *Proceedings of 11th International Conference on Electronic Commerce* 352-357, 2009.

5. Cordella A. Transaction Costs and Information Systems: Does IT Add Up? *Journal of Information Technology*, 21, 195–202, 2006.

6. Dechter D. *Constraint Processing.* Morgan Kaufmann Publishing 2003.

7. Eom S. B. *Inter-Organizational Information Systems in the Internet Age.* Idea Group Publishing 2004.

8. Federal Reserve Bank of San Francisco. *Early Banking in the United States.* http://frbsf.org/currency/expansion/history

9. Gorham M., Singh N. *Electronic Exchanges: The Global Transformation from Pits to Bits*. Elsevier Publishing 2009.

10. Greco T.H. *The End of Money and the Future of Civilization.* Chelsea Green Pub 2009.

11. Greco T. H. Money: *Understanding and Creating Alternatives to Legal Tender.* Chelsea Green Pub 2001.

12. Halsall F. Computer Networking and the Internet. Addison Wesley 2005.

13. Hearst M.A. "Clustering versus faceted categories for information exploration," *Communications of the A*CM 49, 4, 59-61, 2006.

14. Huber J., Robertson J. *Creating New Money: A Monetary Reform for the Information Age*. New Economics Foundation, 2001.

15. Kashyap V**.,** Bussler C., Moran M. *The Semantic Web: Semantics for Data and Services on the Web*. Springer 2008.

16. Kock, N. E-collaboration and E-commerce in Virtual Worlds: The potential of Second Life and World of Warcraft. *International Journal of e-Collaboration* 4, 3, 1-13, 2008.

17. Lietaer B. A. *The Future of Money: Beyond Greed and Scarcity*. Century Publishing 2000.

18. Luger G. F. *Artificial Intelligence: Structures and Strategies for Complex Problem Solving.* Addison Wesley Pub. 2005.

19. McAfee A. Will Web Services Really Transform Collaboration?" *Sloan Management Review*, 2005.

20. McCarthy C. Facebook Launching Virtual Currency. cnet.com, mar 25 2009.

21. Orman L.V. Virtual Organizations as Electronic Services. *Communications of AIS* 24, 1, 701-718, 2009.

22. Orman L.V. Consumer Support Systems. *Communications of ACM* 50, 4, 49-54, 2007.

23. Radin M.J. et al. Internet Commerce: The Emerging Legal Framework. Foundation Press 2006.

24. Reuters. Cellufun Launches First Global Virtual Currency for Mobile Phone. reuters.com, Oct 27 2009.

25. Rothbard M.N. *A History of Money and Banking in the United States.* Ludwig von Mises Institute 2002.

26. Solomon E.H. *Virtual Money.* Oxford Press 1997.

27. The Economist. Virtual Economies. Jan 2005.

28. Uddin M.N. Janecek P. Faceted Classification in Web Information Architecture: A Framework for Using Semantic Web Tools. The Electronic Library 25, 2, 219-233, 2007.

29. Weatherford J. *The History of Money*. Three River Press 1998.