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Free Banking for Peers

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ABSTRACT

Since every peer represents an autonomous individual, individuals tend to behave in a selfish manner, and the constituent attribute of a peer-to-peer network is not to impose a certain code of conduct on its members, these networks often suffer from malicious, collusive, or at least non-cooperative behavior. Consequently, there exist plenty of different approaches that try to create appropriate incentives for the peers within the network in order to prevent a "Tragedy of the Commons". All these approaches face an accounting problem: How can the peer's behavior be recorded and evaluated while avoiding the introduction of a powerful central authority? The market-based mechanisms among these approaches often rely on "tokens" that are defined and traded within the network mirroring the exchange of resources. The accounting concept necessary for a market-like environment is a currency system, but it is questionable in how much these "tokens" do – or can – provide the functionality of a currency. In consequence, this work proposes the usage of individual deposit money on the basis of these tokens. The resulting currency system works without a central bank, and the creation of money in such a system is called "Free Banking". The deposit money owns full currency functionality and its usage bears minimal transaction costs. The main problem is to prevent that the system descends into runaway inflation. This paper presents evidence that this problem is solvable, although the solution must include technological as well as institutional aspects.

Keywords

Peer-to-Peer Networks, Currency, Free Banking

INTRODUCTION

A peer-to-peer network is a computer network whose members are equal in power and functionality. The peers interact directly with each other so that no central mediator is needed. In contrast to the widespread client/server architecture, a peer-to-peer network relies on the resources of the community rather than on a central server. Furthermore, since the typical peers are only temporarily connected an outstanding attribute of these networks is their transience. Comprehensive definitions are given by (Barkai, 2002; Schoder and Fischbach, 2002; Shirky, 2001).

A problematic feature of the most peer-to-peer networks is that the community's resources on the one side, from the perspective of a consuming peer, appear as a public good while on the other side, from the perspective of the peer which provides the resource in question, represent a costly effort. The appropriate accounting mechanisms are missing because their implementation is hardly compatible with a decentralized, flat structure of autonomous entities. Consequently, the empirical verified (Adar and Huberman, 2000; Ripeanu and Foster, 2002; Saroiu, Gummadi and Gribble, 2002; Sen and Wong, 2002) prevalence of "Free Riding" within peer-to-peer networks results directly from the nature of these networks.

The existing approaches for preventing a "Tragedy of the Commons" (Hardin, 1968) rely either on reputation systems (for example: Kamvar, Schlosser, and Garcia-Molina, 2003; Xiong and Liu, 2003; Ye, Makedon, and Ford, 2004) or on marked-based mechanisms (for example: Antoniadis, Courcoubetis, and Weber 2004; Cooper and Garcia-Molina, 2005; Fontoura, Ionescu, and Minsky, 2005) and both have to solve an accounting problem. The task is first to record and to evaluate the peer's behavior and secondly to present the aggregated information to the community. The easiest way to perform such a service reliably is to delegate its execution to a central authority. This is obviously not an appropriate option for a peer-to-peer network. Another possibility would be to let the peers report their data individually. But now the peers have a strong incentive to lie. Although this conclusion is contested by (Obreiter and König-Ries, 2005), it seems necessary to incorporate some sort of a third party. The quest for an accounting pattern for marked-based mechanisms leads straight to the question of currency which is in turn inevitably connected to the reputation problem.

Note that a market-like peer-to-peer structure could not only prevent the described, endemic "tragedy", but could also compete with the established, centralized, and fee-taking institutions that can be found in the Internet today.

THE ESSENCE OF MONEY

The first question to answer is: What is money? It is clear that money is an instrument for accounting represented by divisible, numerical units that promise to be tradable for amounts of any commodity whose value corresponds to the number of money units in question. It is more difficult to guarantee that this promise is kept, a problem that leads to the issues of the creation and administration of money. Almost every famous economist did research in that field, but since these works are concerned with the "real" world they are in the most cases hardly applicable to peer-to-peer networks (for example: Keynes, 1930).

A common approach is given by a paper of (Kiyotaki and Wright, 1989): Different goods circulate through an economy and are more or less suited to fulfill the role as media of exchange. Consequently, the most suitable good emerges as the commodity money of that economy. But this process requires that a certain number of definable goods are traded by the whole network, and that the economic interactions are enduring and form a closed graph – prerequisites that are not guaranteed for peer-to-peer networks.

The author considers the money book of (Schumpeter, 1970) as a rich source for this papers' topic: In chapter four (Unfortunately, only the first two chapters of this work are accessible in English, see Schumpeter, 1991.) Schumpeter starts his considerations with a hypothetical socialist community that produces just one good needing just one factor of production. He concludes that for a single-product (or single-factor) production the accounting can be restricted to the task of computing the value of all factors (or products) in terms of the single product (factor). But for a multi-product and multi-factor production the central planner is forced to determine relative values of each factor and each product. Schumpeter now regards the introduction of a universal scale as a separate, almost unnatural step: The scale allows to formulate the relative dependencies in absolute terms but subjects the whole system to the arbitrarily determined total number of units of accounting, the so-called "critical number of the system". This is what the essence of money is and where the entelechy of money starts (Schumpeter, 1970, pp. 206-253).

PEER-TO-PEER CURRENCY SCHEMES (RELATED WORK)

The main distinction which has to be drawn is whether the currency can be considered to be autarkic. The "inside" money could be coupled directly to the "outside" monetary system. This case is treated by standard textbooks (for example, Guttmann, 2003; Kou, 1998). The same idea could be applied to person-oriented reputation systems by simply making the usage of digital signatures compulsory. This paper, in contrast, is concerned with the question how the autarkic case could work. There exist different proposals for creating an internal currency system:

First to mention is a paper by (Moreton and Twigg, 2003) which compares reputation-based and "token"-based systems and concludes that both approaches should be combined to create a stamp trading protocol. The token-based system, called payment protocol in the paper, requires a centralized trusted third party that creates and controls the amount of tokens in the peer-to-peer network. "Mojo Nation" is given as an (historical) example for a token-based protocol. Now (Moreton and Twigg, 2003) suggest that every peer could issue its personalized stamps and accepts only its own stamps in return for the provision of any service. Consequently, the peers have to trade their stamps in order to accomplish a transaction with a particular partner. The exchange rate of the stamps reflects the stamp creation/resource contribution ratio of the single peers. Therefore the peers have an incentive not to devalue their stamps by inflationary creation. Since the peers issuing behavior is evaluated in the described manner, (Moreton and Twigg, 2003) claim that their stamp trading protocol also captures the attributes of a reputation system. This is true, but the mechanism in question is called currency.

A second source of contributions evolved around the MMAPPS project (Market Management for Peer to Peer Services, European Fifth Framework, Project IST-2001-34201, see Loosemore, 2004): The goal of the project was to provide a wide range of possible peer-to-peer applications with a middleware capable of implementing different incentive schemes. The paper of (Hausheer and Stiller, 2005) describes a decentralized accounting system that operates using a structured overlay network (see Rowstron and Druschel, 2001) in order to avoid any server-like entities. For any transaction between two peers there exists firstly a group of session mediation peers coordinating the exchange and secondly two further groups of accounting peers which are in charge of the accounts of the two peers involved in this transaction. The arbitrary assignment of transacting to controlling peers is performed on the basis of the structured overlay network. A detailed accounting pattern within (or similar to) this framework (Hausheer, Liebau, Mauthe, Steinmetz, and Stiller, 2003) is presented by (Liebau, Darlagiannis, Mauthe, and Steinmetz, 2004): Each peer is assumed to be permanently identifiable and starts with an initial amount of individual tokens which is the only type of token he is able to spend. Again, every peer is mapped to a group of others peers holding its account. Foreign tokens that the peer might receive as a seller/provider have to be exchanged for new native tokens in order to substantiate the purchasing power gained through the sale/provision. This so-called token aggregation process is performed by a set of trusted peers which is again determined by the structured overlay network, interacts

with the respective accounting peers and is therefore able to detect double spending. A problematic feature of these two related approaches is that the session mediation as well as the accounting or the token aggregation could itself be viewed as services that should be paid for. Further, a mechanism of such complexity might be vulnerable to malicious or collusive behavior. Since the data and the functionality are distributed, a peer-to-peer network is hardly able to guarantee that none of the participating peer applications denies to fulfill the tasks that were arbitrarily imposed on it.

The approach of (Yang and Garcia-Molina, 2003) avoids much of these concerns because it only minimizes the role of the trusted central bank instead of distributing it over the network. The paper emphasizes not on the institutional power of a central bank but on the heavy network load that a central node must bear. In order to avoid a bottleneck (Yang and Garcia-Molina, 2003) propose "floating" tokens that can be traded directly between the peers. The initial owner of a token purchases it from the central bank and tracks all transactions in which the token is used until a future owner decides to redeem this token at the central bank. This mechanism allows for a high degree of independence, and every peer is only responsible for the tokens which it initially purchased. Importantly, (Yang and Garcia-Molina, 2003) note that this protocol is only useful when the peers act on both sides of the market. One can easily conclude that, in the end, this must be true for every closed marked system.

Obviously, the described mechanisms are sophisticated and intricate to implement. Further, due to their complexity it seems likely that they are prone to organized collusion involving groups of cooperating peers. And finally, since these tokens are not divisible, they must be of low value and great number which is unfavorable in respect of the effort necessary in handling them. On the other hand, a token-based system seems to be the necessary mechanism to prevent the runaway inflation that would occur without a predefined medium of exchange.

Peer banking is a rational reaction to the fact that electronic money is either not secure (especially not inflation-proof) or expensive to use. Economic behavior demands a unit of account. The emergence of similar monetary innovations in the face of scarcity of money is historically proven (Sylla, 1982).

FREE BANKING

Even though the existence of a central bank is accepted standard for currency systems today, there is considerable interest in and rich historical evidence of systems that provide money without a central bank. The following summary of the different fields of research is based on the seminal paper of (Selgin and White, 1994):

1) An unregulated banking system with a single base money: There exist various historical episodes in which a system of otherwise unconstrained money issuing banks that guaranteed the redeemability of their (paper) money into base money (specie) was more or less realized.

2) A competitive supply of money with different non-commodity brands of base money to ensure that the "critical number" (Schumpeter, 1970, pp. 206-253) is chosen appropriately.

3) A competitive payment system without any base money. The idea is to divorce the unit of account from the media of exchange (White, 1984), which might have evolved according to (Kiyotaki and Wright, 1989) or by government decree.

Since autarkic peer-to-peer systems own no commodity base money (specie) and there is no reason to restrict the system to a monopolistic token provider, this paper incorporates aspects of all three fields of research. In the proposed scenario every peer starts with an account of tradable tokens. The prevalence of "Free Riding" implies that a minor number of peers will soon own the majority of the tokens. The central idea of this paper is now to allow these peers to issue individual deposit money under the constraint that every unit of that money is redeemable for a token which, in consequence, takes the role of the base money. Issuing money means that the peer opens a bank account for the transaction partner, fills it with the appropriate amount of the individual deposit money and notifies the partner. There are three incentives:

- The usage of the deposit money is safeguarded by the guaranteed redeemability. Therefore, besides the payment messages itself, no further mechanisms are needed which, compared to the token-based transactions (see above), greatly reduces the transaction costs.
- Since the probability that every unit of the deposit money is instantly redeemed into tokens is low, the peer can issue more units of deposit money than it owns tokens while maintaining the guaranteed 1:1 redeemability of its money.
- If the peer manages to establish its individual deposit money, other peers might exchange their tokens for this money in order to save transaction costs.

The only prerequisite is that these new banks subject themselves to public accounting in order to gain the reputation of a reliable money supplier. Real-world free banking systems usually were exploited by remotely located, so-called wildcat banks which evaded the redemption of their money (Rockoff, 1974). But there exist examples in which all banknotes were still traded at par relying on bilateral agreements (Scottish Banking System: Cowen and Kroszner, 1989) or centralized control (Suffolk Banking System: Lake, 1947; Smith and Weber, 1999). A "Suffolk Peer" would be similar to a super peer as used in the later versions of the Gnutella protocol.

In the Internet, this problem is of no concern as long as the public accounting works reliable. The implementation as software makes the banking operations accessible to automation, which allows bank client peers to effortlessly control numerous token/deposit money ratios in real-time. Under such circumstances neither Suffolk peers nor bilateral agreements would be necessary. It would be impossible for a bank to inflate its money (openly) since the retaliation (a bank run) would follow automatically and therefore immediately. If this were not the case, however, the described, historically proven solutions could still be applied.

DESIGN

After the institutional pattern has been explained in desperate brevity it remains to demonstrate the technological prerequisites. Peer-to-peer applications operate in the application layer of the TCP/IP protocol suite. It is useful for the purpose of this paper to further disaggregate the different functions of a peer-to-peer network. On the top is the decentralized, flat structure of the payload layer (Figure 1) that determines the outstanding properties of these networks: Autonomous decisions and direct interactions. Since it is hardly possible that every peer exchanges resources with every other peer, the graph is not connected.

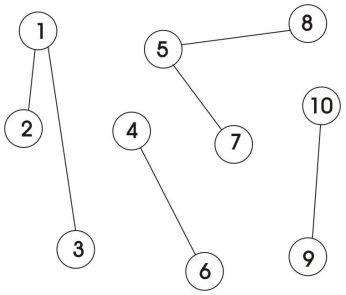

Figure 1. Payload Layer

This layer is always accompanied by a search infrastructure layer whose presence is the attribute that distinguishes peer-to-peer networks from other forms of direct interaction (Figure 2). This automated infrastructure layer provides the peers with the necessary information to perform direct interaction within the huge peer communities. The question to be answered is in the most cases: Who has what?

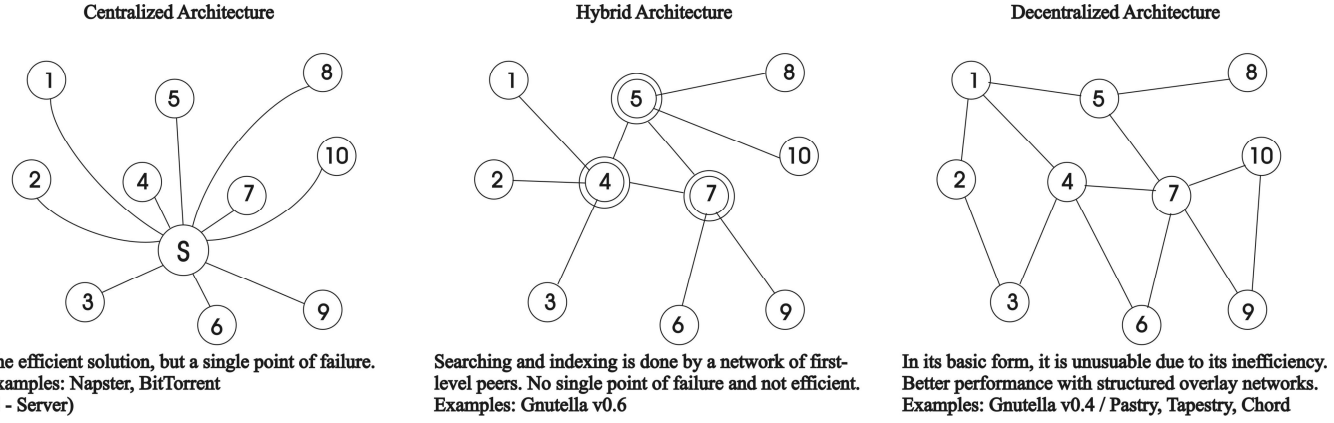

Figure 2. Possible Realizations of the Search Infrastructure Layer

Optionally, further organizational layers are possible. For example, a JXTA-like group structure could be located between the payload and the search infrastructure layer (Figure 3). Note, that there is no third party determining that certain nodes are in charge of certain groups. These structures evolve in a social process while JXTA only provides the technological potential to do so.

The conclusion is, that as long as the peers face an environment as described by Figure 1 on top of the stack the constituent attributes of the network are maintained.

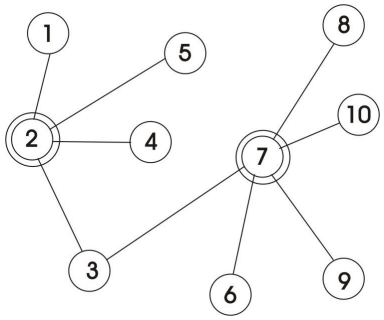

Figure 3. Example of a Group Formation Layer

Necessary for this papers' approach are a service responsible for the provision and the control of the tokens and a layer that allows the peers to obtain information of the amounts of money created by the different banking peers (both Figure 4).

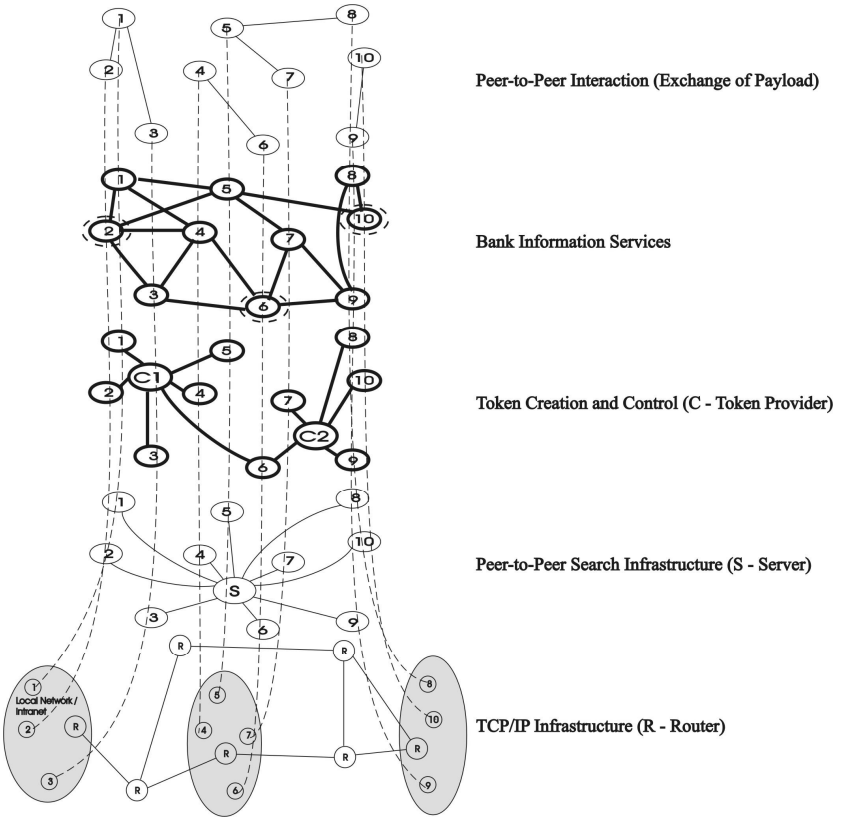

Figure 4. Currency System Infrastructure Layers, embedded

In consequence, the peer client applications have to operate on at least three infrastructure layers in order to allow the peers to become banks and to use individual deposit money.

The Token Creation and Control Layer

The basis of this paper's currency system is the token. Ideally, the token should own the characteristics of a real-world coin: It should be anonymous, directly tradable between two peers, and the owner should be unable to spend it more than once. None of the described peer-to-peer currency schemes complies with these requirements. Fortunately, this impressive problem was already solved by (Chaum, 1982, 1991) who also founded DigiCash to exploit this achievement commercially (Guttmann, 2003, pp. 115-117). Although no security problems were reported (Guttmann, 2003, pp. 115-117), the company was not successful, probably because the procedure is highly sophisticated and not intuitively understandable.

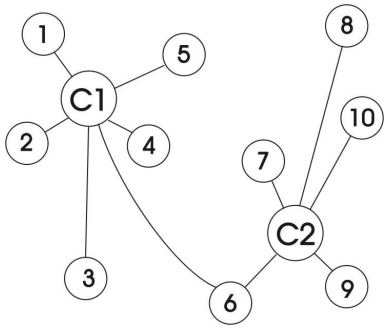

Figure 5. Token Creation and Control Layer

These constraints are of minor importance for this work since, after the pre-banking phase of the network is over, these electronic coins (tokens) take the role of the base money and are not intended for the bulk of transactions. Therefore, for the further explanation it is assumed that the network owns an external provider of digital coins, minted as pioneered by Chaum.

The primary need of every peer bank must be that the base money exhibits constant purchasing power. According to (Hayek, 1978, pp. 43-46), the solution is to allow for competing token providers. (Figure 5 shows a scenario in which two token providers compete for a peer-to-peer network consisting of ten peer nodes with a single peer holding tokens of both brands.) In response, (Selgin and White, 1994, p. 1734) argue that a profit maximizing token issuer would choose to immediately hyperinflate its tokens unless the profit from doing so is less than the profit of staying in business. But note that in the Internet such an unanticipated attack would not create any noticeable profit because the reaction time of automated peer banking applications is almost zero.

It could be a business model for a creator of a commercial peer-to-peer network to be such an external token provider.

The Bank Information Service Layer

Imagine a peer-to-peer network that owns one or more stable electronic base monies. The usage of the described coins is burdensome for every peer involved in a transaction so that only high-value transactions are worthwhile to conduct. It would be much easier to exchange only notification messages, with the effect that lower-value transactions would also become desirable resulting in an increase of the overall value-added of the network. Out of this reason, it can be expected that, given the technical possibility, certain peers (as for example the peers 2, 6, and 10 in Figure 6) would start issuing their individual deposit money by paying with that money, in other words, by opening a bank account which holds the particular amount of money followed by an appropriate notification message for the recipient. The peer on the other side of the transaction should accept this payment because the peer bank, which just came into existence, guarantees the full redeemability (1:1) of that money into tokens and the transaction costs of this simple message are lower than the costs that have to be borne for a token transfer. Furthermore, the new deposit money is almost indefinitely divisible whereas the tokens are not.

Assuming a trustworthy bank, it even makes to sense for other non-bank peers to open bank accounts at this peer bank in order to lower their transaction costs. The trustworthiness is again secured by the fact that suspicious behavior would automatically lead to instantaneous retaliation in form of a bank run: It should be an easy task for a peer client application to monitor different token/deposit money ratios autonomously, and it should be in the interest of every peer bank to provide this information. The peer community could verify this data by using a collective shared-storage system as described by (Lauw,

Hui, and Lai, 2004, imperfectly illustrated by Figure 6). The token providers could play the role of a control instance by invalidating and replacing the tokens occupied by a tough-minded wildcat bank.

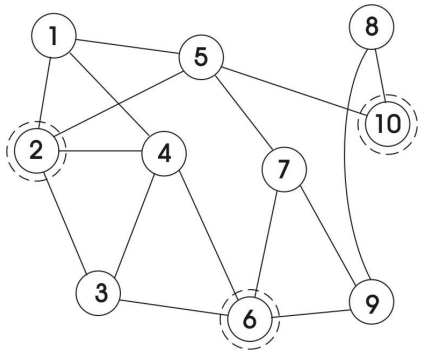

Figure 6. Bank Information Service Layer

Note that it is left to the individual peers whether, or at which value (measured in tokens or other deposit monies), they accept a certain deposit money as payment, as well as the concrete banking strategy is left to the particular peer bank. It may be arguable whether the notification messages actually can be considered to be a "payment" since no coins – real-world specie or the electronic one as described by Chaum – were exchanged, but according to (Schumpeter, 1970, pp. 206-253) the historically predominant usage of coins only marks a special case of the phenomenon that diverted the attention in the wrong direction: Money is more the "unit of account" than the "media of exchange" and always owns a contractual character.

A downside of the system is that the issuing bank has to take part of every transaction in which its money is involved. The problem how deposit money can be used for transactions when the corresponding bank is not online was addressed by (Yang and Garcia-Molina, 2003, see above).

CONCLUSION

The central problem of this paper is the lack of hard data. The technological feasibility as well as the possibility of a successful simulation is unquestionable. But decisive parts of the system are more of social than of technological nature. For example, the questions whether a certain peer bank provides "good" money or under which circumstances a peer should start issuing money or acting like a "Suffolk Peer" are all dependent on the individual valuations of the peers. This peer-to-peer network is therefore a social phenomenon under the conditions of a certain technological environment.

In physical sciences the conclusions are based on elements and their properties as the number, the weight, or the probability of occurrence. In social systems these elements are additionally interconnected by autonomously formed relationships. In consequence, (Weaver, 1958) distinguishes between "phenomena of unorganized complexity" and "phenomena of organized complexity". For the latter case (Hayek, 1989) concludes in his Nobel lecture that without full information about each element "we shall be confined to what on another occasion I have called mere pattern predictions".

In contrast to many real-world social phenomena there exists almost no usable statistical data about peer communities which is a result of the fact that, besides the relative lack of importance, the defining attributes of those networks are autonomy, autarky, decentralization and transience. The remaining path to validation was forged by the MMAPPS project (Loosemore, 2004) in which the proposed mechanisms were implemented as parts of real-world peer client applications. But apart from the possibility of succeeding in the creation of heavily used peer-to-peer networks the scientist examining a "phenomenon of organized complexity" seems to be constrained to "predictions of some of the general attributes of the structures that will form themselves" (Hayek, 1989). Other members of the so-called Austrian School (see for example, Mises, 1949; Rothbard, 1973) adopt an even more pronounced position against the usage of methods used in natural science.

Nevertheless, the advent of large-scale simulations increased the potential of quantitative research of social systems *up to a certain degree*. The simulation of a peer-to-peer network that exhibits behavior as complex as banking would have to rely on too far-reaching assumptions to produce valid results. Therefore, the task of future work is to provide real-world peer-to-peer applications with the technical requirements that make the development of autonomous banking institutions possible.

Finally, it is important to note that peer-to-peer (currency) systems may not only gain knowledge from economists but could also prove as a rich source of insights for economists. In 2002, Vernon L. Smith received the Nobel Prize in Economics

(Prize Lecture: Smith, 2003) "for having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms" (Kungl. Vetenskapsakademien, 2002). The question how to organize a society's currency system is an important one, and a number of economists (most notably: Friedman, 1969; Hayek, 1978, 1979) consider "Free Banking" as a possible, if not superior solution. From this perspective, even a malfunctioning peer-to-peer banking system is a valuable "Free Banking" experiment. Furthermore, within peer-to-peer networks, laboratory experiments and real-world systems could gradually merge.

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