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GEO: DECENTRALIZED CREDIT NETWORK

1. Introduction

1.1. Credit Networks

Decentralized solutions have been drawing attention of researchers seeking to find an alternative for systems built around a centralized entity acting as an intermediary for all transactions for a long time. In terms of monetary relations, Bitcoin network has become the first alternate solution to enable counter-parties to interact directly, thus eliminating so-called 'third party risk'. The network's important feature is its trustless principles: nodes do not have to trust each other in order to conduct bitcoin transactions.

Meanwhile, credit relations implying mutual trust of counter-parties, are not something arbitrary or unwanted. Those relations are necessary for normal functioning of capitalist economy, therefore Bitcoin-like cryptocurrency networks cannot replace credit networks. Those networks are complimentary: credit relations exist there as a supplementary for monetary relations, thus expanding interaction opportunities for economic actors.

In this case, a credit network is a network composed of economic agents acting as nodes that exchange goods not with money, but with debt obligations. Issuer of such obligations, as opposed to an issuer of, say, a debt security, does not undertake to exchange it for a pre-set amount of money. The issuer undertakes to supply goods to the tune of the obligation, thus performing a cross-charge for a store credit. This credit network makes goods a subject of the credit and the means for its repayment in money's stead.

In the simplest model of a credit network, interaction occurs only between the nodes immediately trusting each other, i.e. being ready to supply goods on trust for a certain amount of money. In more complex models, nodes may interact with those nodes lacking previously established trust. This is possible due to transitivity of trust: if node A trusts node B to the tune of n, whereas node B trusts node C to the tune of n, then node A may have goods from node C on credit to the tune of n. Or rather, in this case node C owes node B the amount of n, node B owes node A the amount of n, but node C owes node A nothing, even though node C receives goods from node A.

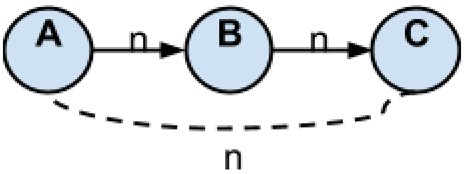

Figure 1. Transitivity of trust in a credit network

A credit network, much like a monetary system, may be either centralized or decentralized. In a centralized credit network, only one node is entitled to create its own obligations that it accepts in exchange for its own goods without restrictions. Those obligations have to be accepted by all nodes of the network in exchange for their goods without restrictions. All transactions in a system of that kind are centralized, i.e. they use an intermediary entity of some sort.

A decentralized credit network enables each node to create its own obligations acceptable in exchange for its own goods without restrictions. Those obligations are accepted by network nodes with some restrictions depending on the degree of trust of a node to the issuer of the obligations. Transactions in this kind of network are to be effected immediately between the counter-parties.

	Centralized system	**Decentralized system**
Issuance of obligations	Only one node is an issuer	Эмитентами являются все узлы системы.
Number of nodes trusting the obligations	All nodes	Только те узлы, которые имеют прямые или косвенные доверительные отношения с эмитентом.
Trust limit for the obligations	Unlimited	Ограничен.
Obligations payoff limit	Unlimited	Limited
Method of transacting (method of obligation movement)	Centralized (via an intermediary entity)	Decentralized (immediately between network nodes)

Table 1. Comparison of obligations in centralized and decentralized credit networks.

Economic agents are interested in flawless transactions in, and reliability of a network. Liquidity of a p2p credit network, i.e. probability of a successful transactions, considering normal tolerance, is mostly comparable to that of a centralized network (though a little lower), yet it is compensated with benefits originating from its decentralized nature [3]. Additionally, it has been proven that liquidity of a p2p credit network depends on the number of links for each node and size of trust lines, i.e. amounts within which the nodes accept each other's obligations, not the network's actual size [ibid.]

1.2. Projects of Decentralized Credit Networks

Ripple. The first project to partially implement the principles of decentralized credit network is Ripple [12]. Ripple's protocol enables the nodes to provide loans to each other within the trust limits both directly and using transitivity of trust. Apart from node obligations, Ripple also features an internal currency of XRP, which is, similar to bitcoin, is not a debt obligation.

Ripple network is eligible for money remittances. For that purpose, Ripple features so-called gateways, i.e. nodes converting money into their obligations within the Ripple network and paying off those debts with money. Similarly, gateways may conduct input and output of any other values in and out of Ripple network. For instance, a gateway may issue obligations denominated in gold in exchange for gold, and then may pay off those obligations with gold on demand.

Ripple implements cross-currency transaction mechanism. For example, nodes A, B, C, and D do not trust one another, but they trust some gateways issuing obligations denominated in various currencies. For instance, node A has gateway obligations denominated in USD (O$), and it has to transfer JPY to node. For that purpose, node A exchanges USD obligations with node B that trusts their issuer for some gateway's obligations in Euro (O). Then node A exchanges the Euro obligations with node C that trusts their issuer for obligations of some gateway in Yens(O¥). Then node A transfers those obligations to node D that may pay them off in Yens with th issuing gateway. Obviously, node D accepts obligations only from a trusted gateway. The search for node A's most profitable chain of exchanges, as well as the exchange itself, occur automatically and in a decentralized manner via Ripple protocol.

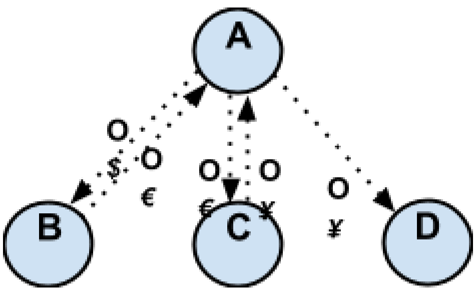

Figure 2. Movement of obligations under cross-currency transaction without transitivity of trust

If there is a chain of trust between nodes A and D, cross-currency transaction will take a different path.

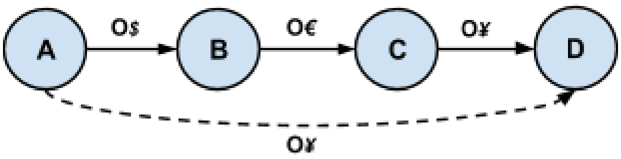

Figure 2.1. Cross-currency transaction using transitivity of trust

Ripple's disadvantages include the following.

1. Insufficient privacy. Availability of list of public ledger for all transactions allows for deanonymizing network nodes notwithstanding the fact they operate pseudonymously [8]. In addition to that, maintaining a constantly expanding ledger requires continuously increasing disk space.

2. Ripple network features so-called semi-centralized authority [2]. A part of servers validating transactions, just like a part of XRP currency, is owned by Ripple Labs [11], which controls the fate of the entire system [1].

Theoretically speaking, any node in Ripple network is able to issue its own obligations and thus be a gateway, however, actually only a small number of nodes are gateways [10]. Similar to Bitcoin, Ripple is de-facto not peer-to-peer network. The requirements for a mining node in Bitcoin and gateway node in Ripple are impossible for regular users to comply with [9]. Ripple originated in local currency LETS, however, its ideology is different from that of complimentary currencies, as it focuses on servicing financial entities like banks, which can potentially be gateway nodes.

3. Internal currency. One cannot use Ripple without XRP: there has to be some amount in the internal currency to register in the network and to pay transaction fees. Thus, even if a node uses only gateway obligations denominated in national currencies, it is obliged to purchase XRP.

4. Difficulty in obtaining information on available creding. Ripple protocol lacks a mechanism for calculation of available credit between any two nodes in real time. Network nodes have no information as to the amount of possible credit from a certain node (under the principle of transitivity of trust).

Stellar. Following the emergence of Ripple, Stellar protocol was devised [13]. Even though Stellar features p2p consensus, the system is mostly alike to Ripple. It incorporates such elements as internal currency, gateways (anchors), multicurrency transactions and, therefore, a system for decentralized exchange of gateway obligations denominated in different currencies or goods, as well as a public distributed ledger of all network transactions.

Apart from the aforementioned implementations of decentralized credit networks, there are several projects currently being in development. One of them is Whispers [6], which is positioned as the first project to overcome Ripple's insufficient privacy. This is obtained via a solution enabling one to do without public ledger of transactions stored by all nodes. ther Ripple's disadvantages were not subject to any research by the project's authors. In particular, Whispers implies for presence of second-level nodes (landmarks), so the network ceases to be peer-to-peer.

Independently from Whispers, protocol GEO was developed to cover issues like creation of a p2p credit network without internal currency and public ledger of all transactions stored with all nodes. The most complex objective first accomplished by the project is in calculating the available credit for any two nodes of the network in real time. This paper analyzes GEO as a p2p credit network.

2. GEO

2.1. The Network

GEO is an open source protocol for decentralized credit network. Nodes of the network create connections via establishing trust limits for exchange of goods for obligations. This connection may be both two-way or one-way, when just one node of two opens a trust line for the other one.

GEO network is pseudonymous: nodes know only each other's ID, while the identity of the one controlling the node is revealed beyond the network. In order to facilitate the interaction, there is an option of personal identification, for instance, with social media profiles. Such services may provide intermediary functionality based on GEO protocol. The first service of that kind is GEOpay [16]. Using its interface, it allows nodes to create profiles identified via social networks (thus facilitating connectivity), quantify trust, and make further interaction within GEO easier.

2.2. Transactions

Kinds of Transactions. In GEO, transactions are about creating, changing, and using trust lines, as well as using obligations arising as the trust lines are being in use.

Trust lines can be opened and changed (including closure on sole discretion of just one counter-party). A node may open a trust line for a counter-party in any equivalent. The number of trust lines that a node may open to a counterpart is unlimited, provided each of those lines is denominated in its own equivalent. One cannot open two trust lines under the same equivalent for the same counter-party.

One may use trust lines two ways: via immediate reception of credited goods from a counter-party, or via assignment of the right to use the trust line. Using obligations, i.e. rights to demand for repayment of a credit for goods, may also be used right away or assigned to a third party[1].

GEO protocol counts only mutual demands and obligations of parties, while the movement of goods associated with the obligations is performed beyond the system. However, in order to understand how GEO services the exchange of goods, it is not just movement, emergence and annihilation of obligations that matters, but also the associated movement of goods purchased on credit or acting as the means of credit repayment.

Transaction Ways

Immediate Interaction. If two nodes have established trusted relations expressed in some trust limits, they may directly receive goods from each other.

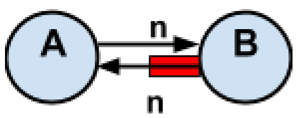

Figure 3. An example of immediate interaction between nodes

If node A and node B have established n as the trust limit, and node A has used a half of its trust line, node B may obtain goods to the tune of 1.5n from node A. The implementation of the right to use the trust line entitles it to receive goods to the tune of n from node A, and 0.5n more to enforce its right to demand repayment of previously granted store credit.

Indirect Interaction. E If nodes do not trust each other directly, they may transact using transitivity of trust. As was noted above, a node may obtain goods on credit from an unknown node if

[1] It means that a user, while signing up in the network, agrees that their trust line and obligations will be assigned to third parties. The node also agrees to act as an intermediary and de-facto bail grantor under assignment of rights to use the trust line and the right to demand for repayment of obligations.

one can lay a path between them, i.e. build a trust chain with five links at most. The amount of available credit in this case would equal the least of trust limits on the chain.

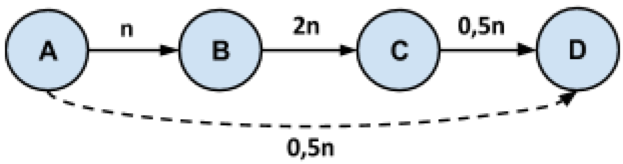

Figure 4. An example of indirect interaction between nodes

Every intermediary node on the chain assigns the previous one the right to use the trust limit and/or the right to pay off the store credit of the subsequent node. In that case, every intermediary node on the chain becomes de-facto direct bail grantor of the previous node in relation to the subsequent one, and indirect bail grantor of the node that had initiated the credit obtainment.

In GEO, immediate and indirect interaction of nodes combine in a way that the amount of the store credit a node may get from a counter-node equals the amount of its direct and indirect trust limit for this counter-party. Thus, a node's risk while interacting with the counter-party is measured by the amount of the trust line provided to the counter-party in question, while the profit is defined by the amount of the available credit exceeding the amount of the trust line immediately opened by this counter-party [4].

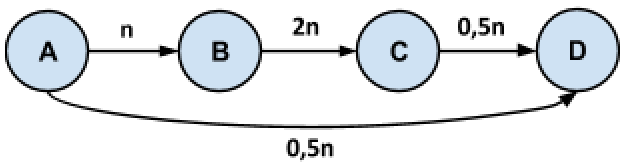

Figure 5. Excess of the direct trust limit value by the available credit value

Credit Risks. One of the advantages found in a decentralized credit network is that credit risks therein are localized as a node accepts obligations only from those counter-parties it has an open trust line with [3].

For a node that had opened trust lines with several counter-parties and/or used trust lines with several counter-parties, there is a risk of simultaneous request for a credit / for credit repayment from all counter-parties respectively. This situation is somewhat similar to simultaneous request to pay out all deposits to all depositors of a bank. Similar to the one with the bank, the situation is quite unlikely, yet in case it still occurs it's very likely that the node will have to refuse to provide goods on credit / repay the credit to some of its counter-parties on temporary basis.

An honest node willing to avoid the situation described above will use two principles. First, it will establish the trust line volume to a counter-party not solely on the basis of its assessment of trust to this specific node, but also considering the values of previously established trust lines and its financial state. Second, it will use trust lines not just on the ground of its ability to repay the credit to this particular counter-party, but also considering the existing debt to other nodes.

As GEO provides for both immediate and indirect interaction between nodes, in case of temporary refusal situation they may have goods from the nodes with a trust chain going through the node in question. If the node's credit cannot be repaid with cross-charging within the entire credit network, there's still an option of repaying it with money.

Consensus. GEO's consensus mechanism is different from that of the systems using blockchain. GEO lacks a distributed ledger of transactions stored and updated by all nodes of a network. In its stead, GEO employs local consensus algorithm based on a trust-chain-like technology.

Absence of a common blockchain reduces the cost of the network's functioning. Nodes need less memory to store the history of transactions, they don't have to spend significant computational capacity as it happens in case of Proof-of-Work, and they have no need to accumulate the system's currency, as it happens in case of Proof-of-Stake. Successful operation of a node requires just a smartphone or a laptop.

Transaction Fees and Interest Rates for Trust Lines. A credit obtained by GEO nodes from each other is interest-free and perpetual. Still, obligations in GEO network are different from debt security, and resemble classic bank notes repaid with money. However, they are most close to bonds, i.e. obligations to provide goods for a certain amount of money.

	Debt security	**Classic banknotes**	**Обязательства в GEO**	**Bonds**
Term of repayment	Limited	Unlimited	Unlimited	Unlimited
Payment for credit	Yes	No	No	No
Means of repayment	Money	Money	Goods	Goods

Table 2. Comparison of debt securities, banknotes, obligations in GEO, and bonds

There is no fee reward for nodes acting as intermediaries. Thus, transactions in GEO are free of charge.

2.3. Privacy

GEO, similar to cryptocurrency networks, is pseudonymous. However, as opposed to cryptocurrencies, GEO lacks a blockchain containing the common history of all transactions in the network stored and updated by all nodes. The following data are public in GEO: node ID, amount of incoming trust lines, amount of outgoing trust lines, amount of the node's obligations to counter-parties, amount of counter-parties' obligations to the node, and overall balance of obligations.

Information on transactions between nodes A and B is stored only on devices associated with those two nodes. In case of indirect interaction, intermediate nodes store information on their transactions with the previous and the subsequent nodes, without receiving any data concerning the origination and destination points.

Usage of intermediary services like GEOPay results in deterioration of privacy, as the intermediary's server retains some identifying information. Similar to cryptocurrency wallets, users have to choose between the convenience of intermediary services and reliability of peer-to-peer interaction via the protocol.

2.4. Emission

GEO lacks any internal currency that may become subject to speculations, manipulations or scamming. Theoretically, the right to use a GEO node's trust line, just like the right of store credit repayment demand, may be subject to buying and selling. Issuance of obligations in GEO has the following features.

Decenrtalization. Obligations circulating in Ripple are issued only by gateway nodes, whule XRP have been premined by the system's administrators. Thus, issuance of obligations is partially centralized, whereas XRP issuance is centralized completely. In GEO, any node may create its own obligations. For that reason, movement schemes for obligations in the said systems are dramatically different.

*Figure 6. Movement of obligations under indirect interaction of nodes in Ripple network**

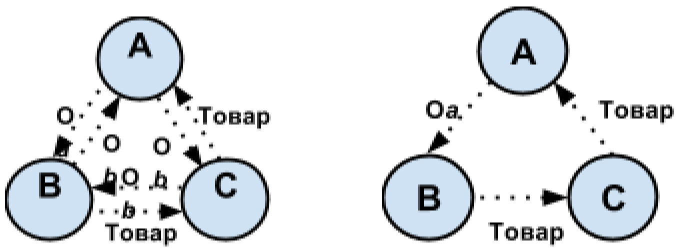

Figure 6.1. Movement of obligations under indirect interaction of nodes in GEO system

In the first instance, node A may obtain goods from untrusted node C only in exchange for obligations of node B (O*b*) trusted by node C. Node A purchases those obligations from node B in exchange for money. As a result, node A purchased goods from node C using node B as an intermediary, yet it has no obligations to node B. Thus, node A just paid node C through node B instead of doing it directly.

In the second instance, node A is also able to obtain goods from untrusted node C only in exchange for obligations of node B (O*b*) trusted by node C. However, in this case node A receives them in exchange for its own obligations (O*a*) instead of money. Node A purchased goods from node C via node B, thus creating obligations to node B that it has to repay with goods. Therefore, node A has indeed purchased goods on credit.

Backing. GEO nodes may denominate their obligations both in currencies and goods. While in case of e-money systems, obligation unit is the asset that the issuer undertakes to use for repayment, in GEO, there are no limits for obligation unit. A node doesn't have to have an asset denominating is assets, as the obligations are paid off with goods/services it sells, not the asset in question. In order to service circulation of goods in GEO, one doesn't have to run exchange for national or private currencies as GEO is a decentralized system for credit barter where obligations are repaid with the issuer's goods to the tune denominated in pre-selected equivalent. They just exchange them for one another for the purposes of credit barter.

Malleability. Issuance of obligations in GEO is not exogenically preset by algorithms, as in Bitcoin, or by a central bank's will, as in modern-day national currencies. Obligations in GEO are endogenic; it may freely change depending on needs of the nodes. In GEO, the number of obligations is determined by the discretion of botn the issuers (who decide, to what extent they should use the trust lines they've been provided with), but also counter-parties)who establish, limit and amend the lines). The trust limit for node B in interactions with node A is the issuance limit for B's obligations it may use to buy goods from node A.

3. Use Cases of GEO

3.1. GEO as a Platform for E-Money

GEO's opportunities are not limited to just credit barter. It may be useful in money remittances as well. For that purpose, it shall have nodes acting as gateways converting money into their GEO obligations and vice versa. Contents of such obligations is different from regular GEO obligations: it is money, not goods, that is the credit object and the means of credit repayment in that case.

If such obligations are used for settlements with third parties, they are subject to the definition of e-money as provided in the European Parliament and Council's Directive 2000/46/EC. According to the definition, electronic money is issued after reception of money to the tune at least equal to the amount of undertaken obligations, and have to be accepted as means of payment by the issuer and third parties [5].

Technically speaking, obligations in GEO network, as well as book money in general and e-money in particular, are not convertible. However, in economic sense, assignment of such obligations to third parties in exchange for goods is conversion. Technically, a GEO node may issue monetary obligations even if there is no money to repay for them, but non-backed issuance of e-money is legally prohibited. On the other hand, such monetary obligations may be interpreted as digital debt securities with unspecified repayment terms, and place of issue and redemption.

Monetary obligations are used not just as a tool for money remittances, but also as means of accelerating and cutting costs of transactions. For instance, a reliable transaction in Bitcoin requires six confirmations, i.e. takes an hour, while the transaction fee is high enough to rule micropayments out. Additionally, Bitcoin's bandwidth never exceeds 10 transactions per second. Lightning Network project [7], which is an add-in for Bitcoin network, is set to overcome those disadvantages via creating channels for transferring bitcoin rights beyond blockchain. Lightning Network is intended for Bitcoin in the first place, but a similar add-in may be implemented in any other cryptocurrency network with the aforementioned transaction limits. Thus, Lightning Network's limitation, as opposed to those of GEO, are in the fact that its channels are eligible only for the purpose of transfer of rights for the internal currency whose movements are recorded onto the original blockchain.

Lightning Network is trustless-based: bitcoins are not stored by a trusted node that undertakes to provide them on demand. Any member of Lightning Network's payment channel may close it any time and automatically have their bitcoins. Transfer of rights for money in trustless mode is less risky that using traditional e-money. However, notwithstanding this substantial advantage, one has to pay the same price in Lightning Network, i.e. the necessity to suspend the money in order to issue the rights, and the limitation of that issuance. Similar to classic banknotes repaid with gold, issuance of such rights may be possible only to the tune that has to remain untouched as long as the rights are in circulation.

GEO's advantage over those systems is similar to modern-day money's advantage over banknotes backed with gold. It is the option of issuing money accordingly with the economy's needs, not in relation with the available gold supplies. Moreover, as proved by WIR practice [16], a credit network complimentary to a national currency may have counter-cycling nature [14]. In recession periods, when monies are deficient, GEO-like networks allow entrepreneurs interact on the basis of interest-free credit barter. This kind of interaction doesn't require a network node to freeze or deposit an amount of money equal to the amount of obligations at an interest.

Whereas Lightning Network requires input and output of money, GEO requires the same only if the network is used as a payments or remittance system, not as a p2p network for credit barter. Furthermore, monetary obligations and bonds may circulate in GEO simultaneously, i.e. using GEO as an e-money platform does not exclude using it as a credit barter network. Theoretically speaking, Ripple and Stellar are also eligible for decentralized credit barter; however, currently it is impossible due to their gateways concept.

3.2. Other Applications

Whereas Lightning Network requires input and output of money, GEO requires the same only if the network is used as a payments or remittance system, not as a p2p network for credit barter. Furthermore, monetary obligations and bonds may circulate in GEO simultaneously, i.e. using GEO as an e-money platform does not exclude using it as a credit barter network. Theoretically speaking, Ripple and Stellar are also applicable for decentralized credit barter, however, currently it is impossible due to their gateways concept.

4. Conclusion

GEO is a decentralized network for credit barter whose nodes provide each other with interest-free perprtual store credits. Each node of the network may create its own obligations and use them for exchange with other nodes to the extent established by the nodes in question depending on the degree of trust to the issuing node. The network provides for interaction of non-trusting nodes if they can be linked via a chain of intermediaries following the principle of transitivity of trust.

The network's advantages include its peer-to-peer nature, high level of privacy, absence of internal currency, high speed of transactions and absence of fees, malleability of obligation issuance, a system for clearing and calculation of available credit in real time, localization of credit risks, counter-cyclic nature, and the option of parallel circulation of bones and monetary obligations. Apart from credit barter, GEO protocol may be used for e-money and p2p crediting platforms, loyalty / reputation systems, and protection of messaging systems' users from undesired communications.

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