An Inclusive and Scalable Crypto Economy for Sustainable Growth

NIKOLETTA MATSUR, Instituto Superior Técnico, University of Lisbon, Portugal
CATHERINE ELLEN ANNE MULLIGAN, Instituto Superior Técnico, University of Lisbon, Portugal

Small scale is characteristic to most complementary currencies (CCs) and the reason for their success and failure simultaneously. While it isolates communities from external economic conditions in periods of high inflation or recessions, it contributes to the short life of the currency and leads to marginal economic impact. In turn, it becomes unviable to prove their efficiency, which hampers the economic and interdisciplinary research. Therefore, scale is a fundamental problem of complementary currencies such as mutual credit and private money that emerges by design and is not being addressed. Instead of segregating the economy members, we propose to onboard the maximum amount of users when designing complementary currencies by employing the most relevant and versatile use cases that comprise monetary transactions. Inspired by the fidelity points of large companies, which are commonly not thought of as complementary currencies, and have a longer life, we design and develop a credit network based on blockchain where each individual or organization can issue their own money tailored to specific use cases such as salary payments, debt registering, fundraising, donations, gift cards and fidelity points, creating a market of interoperable currencies and leveraging trust connections in a community. By encompassing a significant variety of IOU use cases, more opportunities for users arise in the credit network, increasing the scale of the complementary currencies' network, potentially leading to significant economic impact.

Additional Key Words and Phrases: Complementary Currencies, Cryptocurrency, Blockchain, Credit Network, Debt Clearing, Mutual Credit

ACM Reference Format:
Nikoletta Matsur and Catherine Ellen Anne Mulligan. 2022. An Inclusive and Scalable Crypto Economy for Sustainable Growth. 1, 1 (December 2022), 11 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

Complementary Currencies (CCs) have been used to solve liquidity problems during economic downturns. Their main purpose was to serve as a means of exchange in periods of high inflation, in which the supply of fiat money in a community is insufficient, but the need for goods and services as well as their availability prevails. The failure of fiat currencies may be a result of assigning multiple incompatible functions to its role of medium of exchange, as is further discussed in this study. When the role of exchange medium was not being fulfilled, fictional money filled the gap. Thus, the economy did not have to stop as trades could proceed with an alternative currency that circulated in parallel to fiat currency, until a supply of had fiat money was re-established. In some cases (e.g. WIR), CCs are believed to be the reason for the nation's economic stability, whereas in other cases, they end up falling into disuse and disappear shortly after the recession.

Since most complementary currencies usually isolate groups to protect them from external shocks, their impact on the economy is marginal. It means that by design, complementary currencies are small-scale hence their impact on economic development cannot be confirmed, leading to less interest from economists, less experimentation, less innovation, which in turn, leaves the state of the art in complementary currencies as is, making the field stagnant. This issue is currently not being addressed in economic or computer science literatures.

We address the problem of complementary currency scalability in the following way: instead of protecting the most vulnerable users by creating a smaller economy within the economy, we try to onboard the maximum amount of users in the complementary currency network by enabling several use cases with fictional money, issued by any user. To increase the potential for economic impact, we chose use cases as main incentives for users to join the network. Users may be individuals, big, small and medium enterprises, charity organizations, communities, etc. We want to cause the fewest possible restrictions in regard to the use cases in the network of interoperable personal complementary currencies. However, some constrains must exist to guarantee user's economic and technological safety.

On the other hand, cryptocurrencies are being analysed for the suitability of complementary currency roles and emerging as open, shared, decentralized, digital currencies. However, due to the characteristic volatility, cybersecurity attacks, price manipulation, cryptocurrencies have been deemed unsuitable for a reliable complementary currency. However, mutual credit-like system started emerging with blockchain. This means that not all cryptocurrencies are subject to price manipulation, especially if the supply is elastic. We explore these unusual blockchains, compare and choose one to help us to develop our solution.

2 SYSTEMATIC LITERATURE REVIEW FINDINGS

2.1 Complementary Currencies Economic Impact and Challenges

Complementary currencies (CCs) build up communities' self-reliance [Seyfang 2004][Reppas and Muschert 2019], "[insulate] local economies from larger exogenous shocks" [Reppas and Muschert 2019], "[build] social capital and [strengthen] social cohesion" [Reppas and Muschert 2019], "reduce people's dependence on unsustainable labour and consumption practices [...] and facilitate the workings of commons-based sharing platforms and organisations" [Huttunen and Joutsenvirta 2019]. Mutual exchanges and other CCs based on the principle of credit clearing "improve the stability of production and consumption" [Lucarelli and Gobbi 2016] and have "the effect of stabilising

Authors' addresses: Nikoletta Matsur, nikoletta.matsur@tecnico.ulisboa.pt, Instituto Superior Técnico, University of Lisbon, Portugal; Catherine Ellen Anne Mulligan, Instituto Superior Técnico, University of Lisbon, Portugal, catherine.mulligan@tecnico.ulisboa.pt.

XXXX-XXXX/2022/12-ART $15.00
https://doi.org/10.1145/nnnnnnn.nnnnnnn

the profits of firms while attenuating the impact of the credit crunch at same time" [Lucarelli and Gobbi 2016]. "CCs can contribute to sustainability first of all because they can promote localization or foster local economic activity by preventing global outflows of wealth and increase the circulation of money in the community[...]. When the usage of the currency remains local, it is safe to assume that the money will circulate faster and in larger proportion, thereby stimulating the local economic multiplier and increasing local incomes" [Michel and Hudon 2015]. They "[allow] people to incorporate social and environmental factors into their valuations and purchasing decision" [Seyfang 2004], "valuing and rewarding the development of social capital and active citizenship" [Seyfang 2004]. "CCs promote social participation, allowing fringe groups, (for instance, the poor and the elderly) to participate in economic relations from which they might otherwise be excluded, and therefore create/maintain bonds of reciprocity between people within a community" [Reppas and Muschert 2019]. Make the exchanges happen: "a large proportion of the time exchanged would not have happened without the time bank"[Seyfang 2004]. Regarding time banks, the "valuing all labour (or time) equally seeks to explicitly recognise and value the unpaid time that people spend maintaining their neighbourhoods and caring for others. Thus voluntary work is rewarded in credits, and so incentivised, rather than squeezed out by the conventional economic system which accords it no value" [Seyfang 2004]. In "the mobile currency system have a larger set of people in their network to rely upon whenever there is an economic shock. Put another way, it is easier for participating households to receive a remittance quickly from friends or family, making them less vulnerable to shock" [Reppas and Muschert 2019].

Experimentation and Innovation. "[N]ew CC models are most often created by experiment-led forking in previous models" [Huttunen and Joutsenvirta 2019]. It does not work to copy and paste successful schemes of CCs to solve local problems: community banks from Brazil that "copied from models used in other countries, have performed incredibly poorly in comparison to these community banks, who have developed their own local methods of operation" [Tsivopoulos 2015]. For instance, "Sardex's trial and error development has been firmly attached to the island's existing social networks with the blessing of the local officials" [Huttunen and Joutsenvirta 2019]. However, "[c]urrency innovation has suffered from the inflexibilities of political ideologies that hinder radical sustainable innovation from taking place" [Huttunen and Joutsenvirta 2019]. While general purpose money "disregard[s] the need for trading partners to establish and solidify particular social ties and trust relationships"[Huttunen and Joutsenvirta 2019], "CCs represent new forms of valuation systems that allow re-connecting money to the social realm" [Huttunen and Joutsenvirta 2019], as "[t]he very idea of distinguishing between the social and the economic aims and features of money is, however, questionable" [Lucarelli and Gobbi 2016]. "[R]esearchers stressed the importance of 'the emergence of new information and communication technologies' to promote local projects that use 'open source money' or 'collaborative money' " [Lucarelli and Gobbi 2016]. "Some of these digital currencies are specifically created to promote sharing and cooperation among community members, yet their deployment is still in its infancy" [Huttunen and Joutsenvirta 2019]. "We are currently moving to a new era of currency innovation that utilises digital networks and new technologies (for instance distributed ledger technologies, also known as blockchains) to produce, numerate and distribute value [...] modern CCs include cryptocurrencies and digital tokens to support person-to-person collaboration" [Huttunen and Joutsenvirta 2019]

Economic Impact. The general conclusion to the economic impact of complementary currencies is that their impact is marginal: "although there is some evidence that CCs promote localization and support local businesses, the results of the analysis demonstrate that CCs' impact on the overall economic activity remains marginal" [Michel and Hudon 2015]; "the economic activity of CCs is too low and not significant in macro-economic terms" [Michel and Hudon 2015]; "the beneficial impacts of CCs are endogenous/marginal to the local mainstream economies" [Reppas and Muschert 2019]; "CCs have at best resulted in modest economic benefits for their local societies, and that these benefits fall short of the anticipated economic gains" [Reppas and Muschert 2019]. Other reviews claim that CCs have a positive impact: "it is effective in building economic sustainability, as some CCs improve employability and promote local economic activity; most CCs seem to have a positive impact in terms of social sustainability and in the achievement of social goal" [Reppas and Muschert 2019]; "CCs may ease negative aspects of traditional financial exchange by serving those on the fringes of and/or excluded from formal economies, and without necessarily competing with public or private traditional banking institutions" [Reppas and Muschert 2019]. Local currencies "were regarded as 'small and marginal' by the Seyfang research group, who stated that 'little is known about the processes and contexts necessary for mainstreaming them" [Lucarelli and Gobbi 2016]. [Huttunen and Joutsenvirta 2019] regards that "[l]ocal and community currencies have thrived especially during economic downturns and played a stabilising role when official money is hard to come by". "[T]he implementation of the Red de Trueque had an added value to Argentina's GDP of just 0.6% while this system is considered as one of the most successful" [Michel and Hudon 2015], and "their impact seems greater in period of instability as was the case in Argentina with the RT, Switzerland with the WIR or El Salvador with Punto Transacciones" [Michel and Hudon 2015]. "Local currency Bristol Pound (a local currency in the UK), Marshall and O'Neill (2018) find that the system has very little economic impact even within the local economy and that as a result, it has done little to foster either local production and or regional economic development" [Reppas and Muschert 2019]. "LETS in Australia, British LETS, and the French SOL revealed that the levels of trading were too low to have a meaningful impact on the local economy" [Michel and Hudon 2015]. "In the case of the Swiss WIR system, Stodder (2009) finds a positive (stabilizing) relationship between the WIR and the country's economy" [Reppas and Muschert 2019]. With " Sardex, bank deposits tend to decrease while consumption and firm profits show an increase. In this case, the decrease in deposits, being related to the increase in consumption and ultimately to the capacity of firms to pay their debts, tends to improve the solidity of bank balances by reducing the volume of bad debt. The result is an attenuation of the credit crunch for local firms belonging to the Sardex circuit" [Lucarelli and Gobbi 2016]. "[T]he most positive contribution of CCs is their social benefits, and that

the economic benefits are somewhat diminished by the small scale of these systems and the lack of awareness on their scope, making it difficult for them to have a significant impact on the local economy" [Michel and Hudon 2015]. "CCs thus appear to have a greater social dimension of sustainability than on the economic and environmental ones" [Michel and Hudon 2015]. Other benefits were present, such as "recognizing informal work and valuating skills usually not valued by the formal labour market" [Michel and Hudon 2015]; "promot[ion of] local economic activity" [Michel and Hudon 2015], "stimulat[ion of] local consumption and increas[e of] the economic multiplier" [Michel and Hudon 2015], "access to goods and services otherwise not affordable" [Michel and Hudon 2015], "act[ing] as cushions against external economic shocks during economic recessions" [Michel and Hudon 2015]. "Regarding Mutual Exchanges (MEs), a majority of [...] studies [...] indicate no significant impact" [Michel and Hudon 2015]. The limitations to these findings include "the limited number of studies evaluating CC's impact" [Michel and Hudon 2015], "a wide range of different frameworks, methodologies to collect and analyze data, and performance indicators to assess CCs' outcomes" complicate the comparison of the data [Michel and Hudon 2015].

Challenges. The main challenge with CCs is that "the positive social and economic impacts [...] tend to be small-scale" [Reppas and Muschert 2019]; "scale is an issue, particularly for LETS" [Reppas and Muschert 2019]. "While the scale of these examples is presently small, they have demonstrated that they do achieve their objectives and have the potential to achieve much more if scaled up and mainstreamed" [Seyfang 2004]; "CCs would be better able to achieve their social goals if they could attract more users, and if more goods and service providers were to accept them for payment purposes" [Reppas and Muschert 2019]. "One reason generally outlined in the literature and confirmed during the data extraction process regards the small scale of CC systems, and the low number of transactions per member. With such small scales, CCs are thus creating relatively small local economic circuits of exchange, and only a small proportion of wealth remains local" [Michel and Hudon 2015]; "one reason for the low participation rate is the lack of awareness on CCs. In fact, either people don't know that CCs exist or what they are, either they are not fully conscious of their potential. One study in particular revealed that improved mindfulness leads to increased participation, which in turn provides greater benefits" [Michel and Hudon 2015]. "[T]he impact of some CCs (for example, in boosting the local economy and benefiting users) is hindered by their small size, or by restrictions on the range of good and services exchanged" [Reppas and Muschert 2019], and "government regulations are a significant obstacle. Current social security rules deter benefit-recipients from participating in local exchange systems like LETS, by counting LETS earnings as equivalent to cash income" [Seyfang 2004]. In time banks, "the unemployed are officially encouraged to participate, for social and community reasons, but may only exchange their credits for services, not goods" [Seyfang 2004] and "those in receipt of incapacity benefits are deemed to be capable of working if they take part in time banks, and so risk losing their benefit payments. This is a short-sighted and misguided policy, as much time banking work is carefully targeted towards the abilities of participants, so for example a housebound person might earn credits for making telephone calls to others, but still be incapable of conventional employment" [Seyfang 2004]. Other obstacles for time banks include "Limited range of services available in exchange for credits; difficulty becoming established, as projects take a long time to develop yet they are reliant upon short term funding; and reciprocity is slow to materialise due to a cultural shift needed to alter the reluctance of participants to ask for help" [Seyfang 2004]. Many currencies are "short-lived" [Huttunen and Joutsenvirta 2019], which can affect trust and long-term goals; "projects dependent on funding often struggle for survival" [Seyfang 2009]; "many time banks have also ceased operating due to lack of funds" [Seyfang 2009]. [Reppas and Muschert 2019] indicates that "CCs would need institutional recognition from public authorities and banks, which could either come in the form of financial support, or as official validation by governmental authorities", since "[i]n the past, many CC initiatives have been challenged or depleted by regulatory action"[Huttunen and Joutsenvirta 2019], "[s]upport from the public authorities has been seen as vital for the impact, legitimacy and viability of the CC projects" [Huttunen and Joutsenvirta 2019]. Although "CCs are frequently designed as a means of exchange rather than a store of value, hoarding is still a problem which contributes to system stagnation" [Seyfang 2009] which happens due to the " reluctance to ask for help, inability to find goods and services to purchase, and a desire to save for a rainy day in some cases, this is 'irrational' behaviour" [Seyfang 2009]. Transaction costs of CCs tend to be higher than using conventional methods of payment [Seyfang 2009], and "it is reasonable to assume that these costs and unfamiliar mechanisms deter some participants" [Seyfang 2009]. "[P]revious experience with LETS and time banks demonstrate that it is not sufficient to simply introduce new systems of exchange and expect people's behaviour to adapt to the new infrastructure. Barriers include the high levels of social skills and personal confidence required to initiate a transaction" [Seyfang 2009], *i.e.,* the new systems should be familiar and people should be skilled in performing the actions the new system require them to perform. Since Mutual Exchanges "do not appear to achieve their economic objectives" (*i.e.,* "Provide additional liquidity; ease access to interest-free credit; encourage import-substitution"[Michel and Hudon 2015]) [Michel and Hudon 2015].

2.2 Bitcoin as a Complementary Currency

Benefits of Bitcoin. Bitcoin is powered by the blockchain technology which, in turn, provides safety, verifiability and quasi-anonymity. Bitcoin accounts for more benefits as "tie savings, business flexibility, cost minimisation, avoids third-party commissions, does not generate inflation; anonymity of traders, and escapes central intervention" [Kayal and Rohilla 2021], moreover, it "overcome the difficulty of transport and storage compared to standard currency" [Kayal and Rohilla 2021]. It is, thus, "an inexpensive fund transfer system" due to the low transaction costs which "helps improve access to financial services" [Kayal and Rohilla 2021].

Disadvantages. However, it also faces issues of "extreme volatility of price, uncontrolled transaction, large speculative attacks that can cause negative effects, limited confidence[...], and increased

vulnerability of cyber theft" [Kayal and Rohilla 2021]. Its transactions are considered secure as long as "no party controls more than 50% of the network's computing power" [Kayal and Rohilla 2021], which leads o significant electricity consumption "to carry out high computational problem" [Kayal and Rohilla 2021], "leav[ing] behind a carbon footprint" [Kayal and Rohilla 2021]. There are expectations that with time, technology evolves and the mining process decreases its difficulty, "making the entire process more efficient" [Kayal and Rohilla 2021]. Other means to improve efficiency include "implementing transaction fee and limited block size in mining" [Kayal and Rohilla 2021].

Alternative Currency. It is recommended "to create a mass demand for Bitcoin to have a parallel economy and later serve the instability and deflationary pressure issues" [Kayal and Rohilla 2021]. However, when "[t]esting against standard definitions of money", a reviewed study "**does not pass Bitcoin to be an alternative currency** and asserts that **it cannot function as a store value of money**" [Kayal and Rohilla 2021]. Similarly, other studies "declare Bitcoin as **unfit to be used as currency since the high volatility feature** adversely affects its store of the value property" [Kayal and Rohilla 2021] as they find it "to be thirty times more volatile than other currencies (US dollars, Euro and Yen)" [Kayal and Rohilla 2021]. Other comparable study "hails Bitcoin as a digital Ponzi scheme down the road if it fails to prove itself as cheap, efficient, ingenious, democratic, and a stable payment system" [Kayal and Rohilla 2021]. In contrast, other authors suggest that Bitcoin is "highly effective for transactions and can be used in conjunction with fiat currencies i.e., it is not a substitute but a compliment" [Kayal and Rohilla 2021].

Price Manipulation. Since Bitcoin is generally unregulated, "makes it highly vulnerable to manipulations" [Kayal and Rohilla 2021], which have "substantial distortive effects on Bitcoin" [Kayal and Rohilla 2021]. News impact it's price, specifically, "bad or negative news has a greater effect on the volatility of Bitcoin prices than good or positive news and is highly driven by presumptions of the market participants" [Kayal and Rohilla 2021]. Similarly, "word of mouth and expanding Bitcoin user base are significant influent on the existence of a pricing bubble" [Kayal and Rohilla 2021]. The cycle starts with "media reports a price increase which further triggers search activities among investors" [Kayal and Rohilla 2021], lifting investors' interest in buying Bitcoin, which, in turn, increases the demand, ultimately uprising its price and "attract[ing] new investors thus increasing the user base" [Kayal and Rohilla 2021]. Interestingly, "the number of searches declines as the bubble nears its end" [Kayal and Rohilla 2021].

2.3 Credit Networks and Decentralized Credit Networks

Credit Networks (CNs) and Decentralized Credit Networks (DCNs) model the social ties and trust [Long et al. 2020] [Panwar et al. 2019] "among users in a peer-to-peer system as a directed, weighted graph and the capacity of an edge (link) indicates the level of trust that a user is willing to extend to another" [Long et al. 2020]. They "are essentially peer-to-peer lending networks, where users extend credit, borrow money and commodities from each other directly, while minimizing the role of banks, clearing-houses, or bourses" [Panwar et al. 2019], but "with much lower transaction fees" [Panwar et al. 2019]. Moreover, CNs have the "capability of performing same and cross-currency settlement transactions between fiat currencies, cryptocurrencies and even user-defined currencies at a very low cost in few seconds" [Pedro et al. 2017]. Since CNs are systems based upon the trust of the users, their functionality is inherently different from Blockchain, a trustless system. A CN "provides the basic infrastructure for building distributed payment networks" [Panwar et al. 2019], just as Blockchain. However, while in a Blockchain any user (Alice) can transact directly with another (Bob), in a CN "Alice and Bob can trade credits directly with each other, if there exists a direct trust relationship between them, or via a path between them through network peers, built on peer-wise credit relationships" [Panwar et al. 2019]. This means that Alice and Bob can trade directly if they trust each other (thus having a link (edge) representing this trust in the graph of the CN) or they can trade if there is a path of trust in the graph that links the two (*i.e.,* if some of their neighbours or their neighbours' neighbours trust each other)

IOUs Lending markets have not been able to provide the needed liquidity for the SMEs due to asymmetric information, imperfect competition and systemic biases which decrease SMEs chances of obtaining loans [Goldstein et al. 2020]. CC, and commodity money "have proved to be useful instruments to facilitate economic regeneration" [Petri et al. 2012]. They are "useful for facilitating exchange among selfish peers" [Petri et al. 2012]. "They can be valued and exchanged in relationship to national currencies but also function [...] their own" [Petri et al. 2012]. Although towns and SMEs issue their own scrip (a kind of SME CC) and sell coupons with future-redeemable goods on a discount to increase their liquidity, they "face significant challenges including information hiding, liquidity, fraud, problems with valuation, and acceptance" [Goldstein et al. 2020]. SLAs are "efficacious tools for managing resources" [Petri et al. 2012]. It "provides a contract between a service provider and one or more users"[Petri et al. 2012] in which "contains guarantee terms that need to be satisfied by a provider, and a payment that needs to be made by a user when such guarantees have been met" [Petri et al. 2012]. "The relationship of such a currency to a "service" is particularly interesting" [Petri et al. 2012] and is explored in [Petri et al. 2012]. Issuing a new personalized kind of IOUs "currently resides only in the hands of technologists" [Balbo et al. 2020]. There are efforts, such as [Balbo et al. 2020] to put the power of issuing IOUs in communities by and for their own members in a "single app, rather than different ones for different associations and retailers" [Balbo et al. 2020]. "It provides commons and associations with instruments to help finance themselves with tokens representing prepaid cards, crowdfunding, complementary currencies, to share tools and infrastructures with tokens representing access rights" [Balbo et al. 2020]. The impact of the financial inclusion initiatives is still marginal, but blockchain can be a suitable infrastructure for CCs especially due to its ability to tokenize assets [Balbo et al. 2020]. [Goldstein et al. 2020] also uses a DLT to create a system where "businesses can raise money by selling claims to their future goods and services at a discount" [Goldstein et al. 2020], which can also work as a medium of exchange as the claims are tradeable [Goldstein et al. 2020].

3 AN INCLUSIVE CREDIT NETWORK

The most urgent problem that remains unattended regarding complementary currencies is the marginal impact of complementary currencies in the economy. The potential of these systems remains in most part unexplored, as its impact is negligible in the large scale, leaving a gap in the economic literature. Which, in turn, creates a loop, leading to less experimentation, less innovation, less progress in the technological field, thus maintaining the low level of impact. A conclusion that researchers have reached is that there is a need for experimentation, rather than imitation, as it most likely leads to undesirable results. Experimentation with complementary currency systems are healthier alternatives for the community and research in this field.

Thus, our goal is to make complementary currencies large in scale. A scalable system needs a scalable technology, however, **there is no use for scalable technologies without a large amount of users**. Technological scalability can be a requirement, but it should be justified by the number of users interested in it. Complementary currency systems sought to isolate an economic or social group to protect it from the outside economy. This strategy can be the reason for their success and failure at the same time. Our approach to create a scalable system is to not isolate individuals or groups, but to **include the most significant amount of use cases** possible and build a credit network that supports them. The economy is not restricted to a small group, it is for everyone — every element should contribute and receive the benefits from being part of the system, potentially resulting in a more significant economic impact. The next sections elaborate on the solution, its use cases and requirements.

3.1 Solution Overview

In economic recessions, the economy slows down. There can be inflation, people might become more cautious on spending money when making purchases, more likely to save money than spend, slowing down the circulation of money. Small businesses are among the first entities to suffer liquidity shortages, and eventually the economy is in a state where services and products are needed, meaning there is a demand, and offer, but no medium of to settle the exchange, as there is no liquidity. This issue of fiat money, which combines the clashing functions of medium of exchange and store of value, can lead to wasted products and unmet needs, a market failure.

To overcome difficult situations such as crises, but also to help with liquidity problems for any reason, it is possible to leverage peoples' and businesses' connections and more specifically their trust. The principle is similar when people informally lend money to their friends, as they trust their friends will be able to pay back. The maximum amount lent is proportional to the confidence of the lender in getting their money back from the borrower, or in other words, the lender's trust in the borrower. Hence, trust can be quantified by one of the functions of fiat money that has been working, unit of account. This is how trust can be exchanged for currency, typically fiat currency. But it may not work when both parties need liquidity, or more generally, when most parties in an economy need liquidity. *How can we use trust as a currency without having to exchange it for fiat currency?* Our solution builds on concepts of:

(1) **CC**, a medium of exchange that circulates along the fiat currency, not intended as a substitute to it but to close gaps and solve issues created by fiat currency. (2) **Mutual Credit** (MC), allowing anyone creating money according to their necessity, making the supply elastic. Typically, MC consists of ledger entries that map an entity to a balance which can be negative if they had received more products or services from others than given, or positive otherwise. Positive balances can be thought of as a claim or debt of any participant of the MC system to that party, and negative balances are the debt of that party to any other party of the system. All balances in the ledger sum to zero. The most common problem with mutual credit is acceptability, that it can be difficult to redeem the positive balance when no service or product offered is desirable, which happens when the amount or diversification of businesses is small. No other party will want to exchange their negative balance for fiat money, as they would prefer to offer their service instead. Unfortunately, this is a disincentive to participate in the MC system for entities that are most wanted for this system. (3) **IOUs** are claims to redeem goods or services in the future. IOUs can solve the acceptability problem from MC systems as there is accountability — owning an IOU is similar to a positive balance in MC but it is not general, it is with an entity that explicitly gave the claim, which mitigates the acceptability problem. IOUs can also be traded for profit and sold to recover invested money. (4) **CN and web of trust**, allowing anyone to register and leverage their connections, and their connections' connections, to increase their credit potential proportionally to their trust relationships. (5) **Credit clearing**, which consists of registering the debts of everyone, summing them up, some debts will clear others out and settling the remaining debts, saving liquidity. (6) **Blockchain**, an immutable distributed and decentralized ledger to keep track of transactions and balances of cryptocurrencies. (7) **Cryptocurrency**, which uses cryptography to secure the currency transactions on the blockchain.

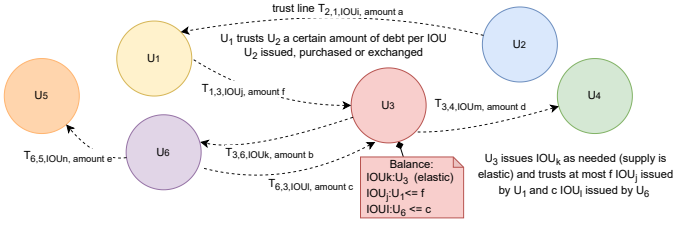

Fig. 1. Overview of the credit network and trust lines

Combining the mentioned concepts, we define a credit network, which can be represented as a **weighted and directed graph** $C_N(U, T)$, with nodes U representing the **users** of the network and edges T represent the **trust relationships** between users. Each edge $(u_1, u_2, \alpha, I_IOU)$ (see Figure 3.1) can represent the maximum amount of debt α issued by I_IOU that u_2 trusts (or is comfortable lending to) u_1. The system is dynamic, and these α in each edge can change over time. The flow in the network represents the amount of actual debt that exist in the system. It could be represented with positive and negative balances as in mutual credit, the edge maximum capacity would create a bound to the problem with acceptability.

However, it is more expressive to represent the balances as IOUs, as the balance is assigned to the source of the debt, leading to more accountability, **further mitigating the acceptability problem**. Moreover, IOUs make bigger markets, as it **encompasses more use cases**, capturing the interest of more users who can employ different market strategies, which is our goal. It enables people to make payments with currencies (IOUs/debt) they trust or exchange those they do not trust with other connections. This is how **trust becomes a (scalable) currency**.

3.2 Use Cases and Incentives

To invite the maximum amount of users to the network, there should be support for a vast number of use cases that comprise users' most frequent economic activities. "A key characteristic of resilience and adaptability is diversity" [Seyfang 2004]. The inclusion of different use cases could also help the complementary currency system to exist and be used when there is no economic crises. The incentive to join would be the size of the network, resulting from the broad use of the credit network. A list was compiled of supported use cases of credit networks and IOUs:

Purchases (supermarket, grocery stores, cinema or concert tickets, restaurant, bookshop, online shopping, *etc.*) — users can purchase products or services by exchanging IOUs.

Fidelity points scheme — stores can easily employ a fidelity point scheme.

Discount coupons — stores can easily employ a marketing scheme comprising selling discounted store points. Keep **track of debt** among friends, family, colleagues, businesses, organizations, *etc.*. Help (local or not) businesses — buy IOUs to redeem in the future (pre-buy).

Invest in (local or not) businesses — buy IOUs to sell at a higher price in the future. Invest in **future businesses** (ICOs) — buy IOUs to redeem in the future form a business that does not exist yet.

Sell IOUs that are not wanted/needed any more, recovering the spent money. Trade coupons (IOUs) from other businesses — even if they have the same value, some people may value certain coupons more than others.

Trade or exchange fidelity points — fidelity points can be viewed as IOUs and can be traded or exchanged.

Gig economy — independent contractors such as Uber and Uber eats drivers can issue their IOUs when paying for products or services as the services in this emerging type of economy can are widely used and can easily be traded, and redeemed with these contractors (*e.g.,* someone who needs a ride can redeem the IOUs).

Gift economy — *e.g.,* schools can gift its students with IOUs, for good behaviour or grades, good deeds, or simply gift and have agreements with bookshops or zoos so that students can redeem. The main principle of gift economies is *the more you give, the more you will have* (from the literature review Chapter - *e.g.,* Napster). In the example of the school, the behaviours that are rewarded are incentivized by giving IOUs. Wage payment IOUs — when a business does not have enough liquidity, it can pay (or partially pay) its workers in IOUs, which can then be used to make payments.

Wage advancement — "employees who need an advance on wages to cover unexpected expenditure can draw on this account and avoid using their own savings or applying to some credit company and paying high rates of interest. The benefit is twofold. On the one hand, the workers do not have to spend their savings and pay interest; on the other, employers who advance wages in SRD form will save money in the following periods as their wage bill is reduced by the amount advanced" [Lucarelli and Gobbi 2016].

Unemployment IOUs / state benefits — pay with personal IOU in the supermarket and buy it back later, or future employer or state can buy it from the holder Change shortage — when a customer pays for something and there is not enough change, instead of spending more than wanted, losing money or not getting the intended product, the store can issue an IOU to be redeemed later.

Forgive debt — buy debt issued by a certain entity and burn or send it back to the entity (such as the healthcare debt from literature review), certain entities holding others debt may exchange them on a discounted price to incentivize the issuer of the IOU or others buying that debt.

Charity or donations (for organizations, businesses, or individuals, not just charities) — can be done by buying or exchanging directly from the entity or from other source entity's IOUs and burning them or sending them back to the entity (forgiving debt); or simply sending fiat money or reputed and relevant for the entity IOUs to the entity's wallet, potentially making donations more transparent, or buying a zero note worthless/symbolic currency.

Time banking for community service / community currency — organization or community can issue IOUs that are accepted in local stores, helping value informal jobs (*e.g.,* reward for finding a lost animal, helping someone with their garden — 1h of human work equals to the medium salary in that region).

Except for community currencies, other activities from the list above involve businesses activities, and it is possible this system being subjected to tax, however it is out of scope of this project.

Use cases regarding coupons or fidelity points trading could sparkle hesitance for large companies who already have fidelity schemes implemented, such as Pingo Doce and Continente (supermarkets) in Portugal. Fidelity points and coupons are strategies that draw customers to purchase items in the stores when a specific discount is available. "Spending on the part of consumers within the circuit is rewarded with credits to be spent in the same sphere [...] which offers a concrete incentive to remain inside the circuit" [Lucarelli and Gobbi 2016]. If the coupon or fidelity points are not spent, they are wasted, and the customer feels a sense of lost opportunity, nudging them to purchase in the store. Giving customers the possibility to exchange their fidelity points and coupons with other people (for a small profit), removes the sense of loss of opportunity and may lead to more coupons and fidelity points being redeemed than usually. While it is true that the statistics of big producers would need to be adjusted as more offers (coupons, discount) would be taken, which may result in less profit than expected. On the other hand, these offers would do their job: bring more customers, increase sales. Although strategies in the coupons or fidelity points would need to be slightly adjusted, to issue less or different offers, these adjustments are more than common even with centralized fidelity points/coupon systems, and present opportunities to reach a wider market and a bigger potential to reach sales goals. From the technological perspective, the centralized fidelity points apps

can resort to the public ledger as an external database or use the microservice that exposes an API. This system enables **a trust-based marketplace of debt intended to make the economy move** when it usually slows down or stagnates. The network incentivizes to create new trust connections (and to do so, good participations are rewarded with more connections) to increase the credit potential and the acceptability of tokens, thus creating cohesion in the economy, along with resilience to external shocks.

3.3 Benefits

Bounding Loss. By giving the possibility of limiting trust, *i.e.,* the debt amount, in each connection, and by assigning the debt to IOUs, the loss in case of default (when a participant refuses to pay their debt or goes bankrupt) becomes **localized and bound**, whereas in mutual credit (MC), the entire network suffers, including users who have never interacted with the defaulting party.

Scalability and Impact. MC systems are not scalable by design, as trust in these systems is a relationship from each party to every other party, which does not correspond to the reality. At best, such relationships exist in small groups. But smaller economic groups, especially those who are most likely to participate in MC systems, do not have the potential to impact the economy as large groups do. By using CNs, large groups can emerge in a form of less connected graph than the graph of MC systems, but it more closely resembles real trust relationships. Trust in mutual credit is not scalable ([Ramabaja 2022]), while trust in CNs is.

Currency Interoperability. Zooming out on a CN, the network will look sparse, but connected. The trust relationships will enable users to trade their own produced currency, *i.e.,* IOUs, but also to trade valuable IOUs from other trusted owners of the claims, enabling currency interoperability. This benefit is vital for a decentralized monetary system, as there is no authority enforcing the acceptability of the claims. Thus, each node can issue their tokens, but it is a decision of other nodes to trust the tokens and exchange them for other tokens, making the owner of the debt the authority in a decentralized network.

Accountability and Acceptability. CNs specify the trust relationships, and IOUs work as the flow in those connectors, a special kind of flow that is assigned to the owner of the debt. This allows the holders of the claims that represent the debt to keep track of where their *positive* balance come from, which creates accountability and increases the acceptability of the claim. The root cause of acceptability is that there is an unmet expectancy between having a positive balance and being able to redeem it. CNs with IOUs remove that false expectancy, as they are more specific regarding the amount of debt that can be accepted, by whom and for whom, leading to more realistic expectations regarding acceptability. Comparing to nowadays cryptocurrencies, each node works as a bridge to other types of currencies when they exchange a certain currency for other, both of which they trust.

Free Network. No one should be obliged to accept offers they otherwise wouldn't just to be part of the network to collect benefits. A participant A might want to not allow another participant B to redeem their high positive balance, as A might never need that amount of positive balance in the network. In a sense, this is a more general scenario of double coincidence of wants (someone wants to redeem a big value the other party is, coincidentally, willing to take as they also trade that amounts), which is the reason bartering does not work. In the proposed solution, everyone is free to accept or not the IOUs, or debt, and their corresponding amount of others as they please, following their trust relationships. Every participant has more control (thus, freedom) over their relationships and trust amount.

Transparency / Reduced Information Asymmetry. SMEs rarely get credit from formal banking due to lack of transparency. Moreover, when lending in a setting with high information asymmetry, one can unknowingly/naively trust and lend funds to a party that is already very indebted, further increasing the risk of default of that party. In this credit network, because the debts are visible to all the participants, when accepting IOUs (which is a form of lending), participants are taking more informed decisions as there is less information asymmetry, decreasing the risk of default.

Increased Welfare and Social Justice. There is an incentive to provide better services and products and not behave maliciously in the network, as then no trust connections will be extended to the misbehaving party. Fewer connections mean less potential credit, therefore less liquidity. Social justice emerges, increasing the welfare in the network.

Disincentive to Hoarding. The problem with hoarding is that "any number of hoarders in a population will eventually lead to a crunch. This is because hoarders store-up increasing amounts of credit and eventually deprive all other peers of credit" [Rahman et al. 2010]. Hoarding positive balances is less common in MC systems than with fiat currency, however, human psychology can trick rational agents into *saving for the rainy day*, or saving to redeem something bigger and more important if the balance is higher, even if the system has no intrinsic value.

Demurrage was invented to devalue positive balances to incentivize expenditure. In the IOU setting, there is no incentive to hoard other's IOUs unless it is an investment, which does not qualify as hoarding (irrational practice), but as a rational strategy. Each participant can diversify their IOUs to manage risk. Due to the expressive nature of the IOUs, each claim can have a specific purpose (*e.g.*, IOU 3 kg of apples) which makes hoarding less appealing as it does not give the owner of the IOUs endless possibilities (or at least the vague notion of it). The service or product the claim represent is more valuable than the claim itself, and when not, it is because there is an expectancy of increase of value (investment). Essentially, the problems of MC come from positive balances, IOUs subtly remove vague positive balances with others' (specified and quantified) negative balances.

Circular Economy. By exchanging IOUs for other IOUs, *i.e.,*, making them circulate, the claims that belong to the owner return have a higher probability to their hands, creating a circular economy, and employing the principle of credit clearing as the owner will not need to redeem (or pay) that debt. In other words, cycles in credit networks make the IOUs return to the claim issuer, the equivalent of cancelling debt in cycles.

Inclusivity. IOUs are versatile to represent any product or service, quantify its value and exchange it. This enables an exchange

of any trusted object for others. The use cases are endless and are enumerated in section 3.2.

4 IMPLEMENTATION

4.1 Proof of Concept CLi

To limit the scope of the project, the proof of concept consists of a CLi that receives commands and arguments to execute operations that are familiar to users, such as issuing IOUs, sending fidelity points, redeeming gift card, making payments, register debt, *etc.*. These high-level operations are composed in the CLi service of different transactions, techniques, and processes tied to the functioning of the ledger and are seamless to the end user, but complex underneath. The architecture is presented in Figure 2. All the features were designed to offer the maximum benefit with the lowest possible risk, economic and security-related.

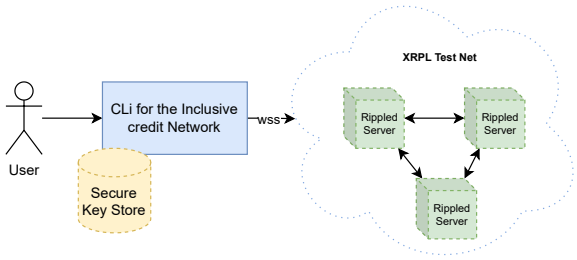

Fig. 2. CLi system architecture

A CLi is not destined to be the final application a user would use, nor it is production ready. Instead, a suitable architecture of the system that would use the service CLi and the development of such system including the scalability (*e.g.,* load balancing of the microservice), secret storage security (represented by a local key store in the CLi) and the configuration of the sidechain rippled network is future work. Since our goals are focused in XRPL and support for our use cases and features to serve the user model, external services such as a key store are assumed to be implemented. With the CLi we are capable of testing the functionalities of the XRPL service without the need to solve networking and interface design which are two research streams by themselves in distributed computing and web3 systems. A CLi provides us with a reliable prototype of our inclusive credit network service concept in real life and draws the limits of what is possible to achieve with XRPL and its limitations.

4.2 Features and Commands

The fundamental commands of the CLi are: IssueIOUCommand, CreateAccountCommand, GenerateAccountCommand, ShowAccountDetailsCommand, SetTrustCommand, PaymentCommand, ExchangeOfferCommand, ShowAccountOffersCommand, ShowOrderBookOffersCommand, CancelOfferCommand, SendCheckCommand, RedeemCheckCommand. Fundamental commands' options (flags and command line arguments) allow for generic and versatile transactions. However, to enable specific use-cases, there are special `IOUTypes`, which are different currencies codes such as "FID" for fidelity points, "DON" for charity and donations, "GFT" for gift cards, "SLY" for salary, "DBT" for debt, and "OOO" for the zero note. The commands that enable the use-cases which use the mentioned currencies are **decorators** for some fundamental commands. For example, BuyGiftCardCommand is a decorator of the general and fundamental command of ExchangeOfferCommand that automatically fills certain fields tailored to the use case, including the currency code "GFT".

Create Account Process. The XRPL does not provide an explicit endpoint to create accounts. Instead, creating accounts on the ledger involves a process. An account, in our system, is composed by two wallets. One is used for IOU issuing and the other for transactions, to disallow rippling in the transactions and ripe the benefits of rippling in the issuing account. Moreover, since the issuing account will be used less than the transacting account, the risk of exposing the secret is reduced. To open an account in XRPL, a valid address needs to receive funding from an existing wallet that covers at leat the account reserve. In the Inclusive Credit Network, the user (named username) requesting an account inserts in the CLi "`create-account` -u username". The application will generate two wallets using, save them in the key store and display the addresses of the wallets that need funding. The user should then request to a member of the XRPL network to send to their wallet a sufficient amount of XRP to cover the reserve (currently 10XRP). A suggestion is to have a responsible entity in the early stages of the network to board users who are not expected to be tech-savvy. After the wallets are funded, the user should type "`configure-account` -u username" so that the default rippling is enabled in the issuing wallet and an authorization to hold issued tokens is enforced on the transacting. Rippling allows other users to pay with your IOUs, but your transacting account (which holds other people's tokens) will be protected, mitigating the faulty gateway attack. Enabling authorization on transacting account is a safety measure against issuing and sending money from the wrong wallet, which could lead to security risk and render the wallet separation pointless. For development purposes, a wallet generation command ("`generate-account` -u username") was created that uses faucet wallets, and configures them immediately since the wallets come funded from the test net.

4.3 Set Trust Command and Special Use Cases.

Every user with a valid account can issue tokens, but there is no point in doing so if no one is willing to accept the tokens (*i.e.,* extending a trust line to their issuing wallet). The purpose of this command is to make the network reflect the amount of trust there is in real life between two people. Figure 3 illustrates the trust lines that limit the amount of tokens that each wallet can send. IOUX:Y means tokens with code IOUX issued by wallet Y are accepted. The segregation and configuration of each wallet allows other users in the network, for example, users that trust Alice, to make payments to Bob through Alice even if they do not know Bob. To set trust, users need to input into the CLi the command "`set-trust` -u username-account -a amount [-i issuer-address] [-in issuer-name] -c currency_code". In every command, users can choose to indicate either the issuer-address or the issuer-name. This shows that trust is per issuer and currency code. Trust line limits can only be exceeded

by acquiring more of the token from the DEX, by decreasing the limit of the trust line below the amount of tokens already in possession, or by cashing a check.

Special Use Cases. The above command can be simplified to only indicate the issuer and the amount, since the *FID*, *SLY*, *DBT*, *OOO*, *DON*, *GFT* can be trusted from commands such as "trust-fidelity-points", "trust-salary", "trust-debt", "trust-donations". For example, "trust-salary [-i CURRENCY_ISSUER] [-in CURRENCY_ISSUER_NAME] -a TRUST_AMOUNT" which translates to "trust-salary -in AliceStartUpWaller -a 100", which is equivalent to running the generic command: "set-trust -a amount AliceStartUpWaller -c SLY". The name of the user ("-u username") has always to be indicated to let the CLi know who is interacting.

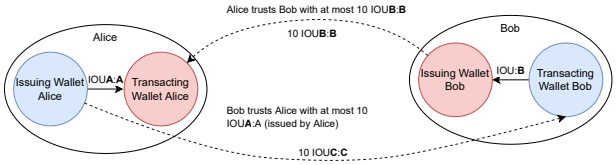

Fig. 3. A representation of trust lines between Alice and Bob

4.4 Issuing Custom Tokens or *FID*, *SLY*, *DBT*, *OOO*, *DON*, *GFT*

Issuing tokens is the central feature of the credit network as it enables transactions, credit clearing, and multiple use cases. Assuming a user has created an account successfully, it was funded, and the user ran the configuration command on the wallet, they can now issue any amount of token desired. Tokens are defined by their currency code (3 capital letters – standard) and the issuer wallet address. Tokens always exist in trust lines, *i.e.*, bidirectional relationships between wallets, where each side has a maximum amount of trust and a balance (positive or negative) of that token. Issuing of tokens on the CLi, "`issue-iou` -u user-name-account -a amount-ious -c code-ious", (code-ious cannot be XRP), creates a trust line between the transacting account to the issuing account with the amount-ious value as the capacity of the network edge and the currency code as well, or if such trustline already exists, updates the trust to let amount-ious be transacted. Then, the issuing wallet transacts the amount of IOUs with the wanted currency code. Special for the Inclusive Credit Network tokens have currency codes of *FID*, *SLY*, *DBT*, *OOO*, *DON*, *GFT*. These tokens can also be freely issued by anyone using the generic command or special commands (decorators). However, it does not mean everyone will be able to use them. Users need to trust each other for the transaction to take place, *i.e.*, have a trust line.

Special Use Cases. To simplify the execution of the special use cases by users, this step is hidden. That is, the user is not made aware that it is issuing tokens (unless an error occurs which allows the user to resume from the failed step), instead, the tokens are issued on demand and for a purpose, which is executed promptly. The issuing is intrinsic to the commands such as "send-fidelity-points", "pay-salary", "register-debt", "donate-as-institution", and also "start-marketing-campaign", "ask-for-donations", "sell-gift-card". The first step of these commands is to issue tokens such as FID, SLY, DBT, DON, OOO, GFT and then other commands are composed, which makes the issuing be performed seamlessly.

4.5 Payments with Tokens, XRP and Special Use Cases

Making Payments is the second most central feature from the Inclusive Credit Network. After issuing custom or tokens and making the trust connections from the real life known to the network, the trust becomes the main driver for transactions. In XRPL, only XRP payments do not use trust lines, therefore, for to make IOU payment, a path with available (not exhausted) trust must exist between the sender and the destination. The XRPL engine searches at most 6 hops and uses the decentralized exchange to find the lowest cost path for the payment. The amount that can be filled partially is reported by the engine and in turn, from the CLi to the user in a user-friendly manner. Thus, to make an XRP payment using the CLi, run "`make-payment-xrp` -u user-name-account -a amount-xrp [-d destination-address] [-dn destination-name]". For example, "make-payment-xrp -u alice -a 10 -dn bob" (or the address of Bob using -d instead of -dn). To make custom token payment, "`make-payment` -u user-name-account -a amount-ious [-d destination-address] [-dn destination-name] [-i issuer-address-of-the-ious] [-i issuer-address-of-the-ious] [-c code-ious]". For example, "make-payment -u bob -a 6 -dn alice -in alice -c IMA".

Special Use Cases. This command enables a set of decorators, such as "pay-with-salary", "pay-with-donation", "pay-with-fidelity-points" and "confirm-debt-repaid" (which sends the debt back to the issuer of the debt, freeing them from the obligation). Partially, this command also enables "send-fidelity-points", "pay-salary", "register-debt", "donate-as-institution" in combination with other commands automatically executed (issuing IOUs and sending Checks).

4.6 Trade IOUs in the Decentralized Exchange and Special Use Cases

The DEX allows users to express willingness of holding a certain amount of an asset while exchanging for an amount of other asset. Assets can be XRP and non-XRP tokens. When the offer is created, the default behaviour is to partially fill the offer with offers that match it in the opposed direction (coincidence of wants), and which exchange rate (the ratio between amount) at least as good as expressed in the created offer. To buy and sell tokens, there does not need to be a trust line as the issuer and currency code is specified, it is implicitly created by the XRPL. The generic command in the CLi for exchanging is "`exchange-asset`", and the currency codes and amounts of selling and buying currency as well as their issuer names or addresses are necessary for the offer to be defined. For example, "exchange-asset -u alice -a1 10 -c1 ALE -i1n alice -a2 1 -c2 BOB -i2n bob". To buy or sell XRP (not possible to exchange XRP for XRP), only the amount should be filled. Additionally, there are multiple strategies for placing offers, such as making the off indivisible (`all-or-nothing`), `immediate-only` offers (not placed into the ledger, consumed with matching offers), offers which objective is to `sell` rather than buy the other token, or make the offer `permanent`. These options are added as flags (-s/–sell, -e/–entire, -n/–now, -p/–permanent) to the main generic `exchange-asset` command. The

offers from the account can be seen with "`show-my-offers` -u alice" and removed with "`remove-offer`". Additionally, the offers from the order book can be seen with "`show-market-offers`".

Special Use Cases. This command is called when decorator commands are executed due to user input such as "buy-fidelity-points", "buy-gift-card", "buy-donation". Partially, this command pairs with issuing IOUs for the inputs of "start-marketing-campaign" (divisible, sell offer), "ask-for-donations" (divisible buy offer), "sell-gift-card" (indivisible sell offer), which issue the corresponding token of FID, OOO and GFT and then place it to the exchange with the correct offer type. The cancelling or removal of the offer is used by "`finish-marketing-campaign`".

4.7 Send and Redeem Checks, and Special Use Cases

Checks are an XRPL inbuilt method of payment which does not need trust lines to be executed. The payment is divided in two phases: the sender sends the check of currency they own or not (the tokens are not locked), and the receiver can redeem/accept the check or not. If the check fails due to lack of funds, it can be tried to be redeemed again later. To send a check, `send-check` input is used. and details about the destination and currency should be provided (if XRP check, the issuer and code name are not specified, while in tokens are). Additionally, an expiration date can be set up. For example, "`send-check` -u alice -dn bob -a 3 -c ALE -in alice -e 10-10-2023". The checks are visualized in the account with "`show-account`", the number is presented to then redeem the check (*e.g.,* "`redeem-check` -u bob -c 32366704").

Special Use Cases. Checks enable a considerable amount of use-cases with the two-phase payment logic (and still satisfying non-functional requirements such as safety and trust). Decorators for the "SendCheckCommand" are "pay-with-salary-promise", "send-gift-card", "pay-with-promise", "promise-salary-payment", "donate-as-individual". Checks provide the mechanism of promising, which is when a currency is expected to be in the wallet any time soon, a check can be sent and the receiver can redeem the check when the currency arrives to the account. "RedeemCheckCommand" decorators are: "redeem-fidelity-points", "redeem-gift-points", "accept-debt". Adding the "SendCheckCommand" to IOU issuing and payment commands, more use-cases are enabled, such as "send-fidelity-points", "pay-salary", "register-debt", "donate-as-institution". These commands issue the corresponding IOU (FID; DBT; DON; SLY), attempt to make a payment, and if there is not enough trust, a redeemable check is sent (the user can control what happens after the payment failure).

5 SYSTEM LIMITATIONS

The limitations of the system comprise (1) vulnerability to scams, *i.e.,,* an IOU is defined by the currency code and issuer. Multiple issuers can issue the same currency code, and users need to understand who the debt belongs to. While it is not difficult to explain or grasp, malicious users will try to take advantage of ingenuous users by selling them worthless tokens. Over time, this risk is minimized. And the accounts on XRPL undergo geolocation traceability and reporting of such cases to international authorities. (2) Since the system is decentralized and most users are accustomed to centralized systems, the response times and errors may increase, leading to users dissatisfaction. To mitigate this, our system checks the last validation index following the best practices for transaction acceptance. (3) In the same line of decentralization, users may not be familiar to have to pay a small fee for each operation, and some operations cost more than others. However, this is a paradigm shift that users will be (or already are) part of. To mitigate this, a production architecture could use a side-chain, where the fees can be abandoned and a mechanism to pay for transaction elaborated (such as conventional advertisement placements). (4) Whitewashing, or creating account then abandoning it to re-emerge with another account, or having multiple accounts for transactions which users that trust each other are unaware of may increase the information asymmetry problem. To overcome this, a responsible entity (which is a regular account in the network) can hold a list (using Hooks of XRPL, for example) of the verified users and their identities so that other accounts can check the list and transact to only that account.

6 CONCLUDING REMARKS

The implemented system is a minimum viable inclusive credit network. The system comprises the core features of a credit network: IOU issuing, transactions with IOUs, updating trust, debt clearing (rippling), account creation, tracking their debt (one can see how much is their debt and to whom by seeing their circulating issuing balance), burning IOUs (by returning them to the issuer). The innovation contributions of this system and the underlying mechanisms are the following.

Secure Account Creation and IOU Issuing. Because the system is a proof of concept for its deployment in the real world, where users are innocent and oblivious to security risk, account creation and IOU issuing are designed with best practices that enhance the security of the user, without requiring security knowledge. Achieved by, with a single user command, creating two wallets, one that only issues tokens, the other which only receives the issued tokens to minimize the risk of compromising the issuing wallet.

Use cases. Enabling different use cases for end users (such as **debt registering**, **payments** with own and others' **debt**, fidelity points **exchanging**, **gift** cards, donations, fundraising, and salary payments) which paves the way for an inclusive economy, unlike most complementary currencies that restrict users, hampering the economic impact of the system. This is achieved by leveraging functionalities of the XRPL such as payments, checks, and different types of mechanism from the decentralized exchange.

Fidelity Point Campaign. Enabling SMEs, who usually do not have a fidelity points campaign, set it up easily. Any enterprise can benefit from this fidelity point scheme. Achieved by designing DEX offers and IOU exchange process.

The evaluation of the credit network in this stage of development consists in testing its functionality correctness and in a simulation of the economy where each agent has the possibility to issue custom tokens, which is the most fundamental and broad, concept of the Inclusive Credit Network. The simulation with users should be done at a later stage, after more granular simulations for each functionality are designed, developed and run with synthetic and real world data.

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