

#CoFi working paper 1: Constructing systems of exchange

by Matthew Slater

With rigorous feedback from Teodoro Criscione, Dave Darby, Jeff Emmett, Dil Green, Alex Kampa, Stephen de Meulenaere, Will Ruddick, Mohammed Sohail & Thomas Woodroof,

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15 years of intensive investment blockchain has yielded many tools, but Satoshi's original intention to create an alternative payments system has not been realised: Bitcoin is said to be too unstable, stable coins backed by dollars are not a meaningful alternative, and algorithmic stable coins are expensive/risky since they must be over-collateralised. The focus of the blockchain sector has moved firmly away from payments and into financial instruments with less relevance to the 'real' economy and its real problems.

The word 'payment' actually refers to the peace made when an existing debt is settled. But in modern society every marketplace transaction is settled with a payment a money. This means that 'payments' is almost synonymous with the 'medium of exchange' function.

In this paper we consider how payment media can be constructed from the bottom up ie. from trust alone. The challenge, if not the paradox, is to create an unbacked financial asset which is stable in value and low in risk. If it was about manipulating tokens, or telling stories, some Silicon Valley startup would have cracked it already. Some other component is needed, either:

- (legitimate use of) force as the state has,
- assets in the vault as the bank has,
- or that more elusive treasure, trust.

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1. The medium of exchange function

When you cooperate outside of your kinship groups, apart from specific acts of altruism, you probably think it is important that an exchange feels 'equal' and hence 'just'. Anthropologically speaking there are many ways to achieve this, but to most modern humans a system of exchange supports multilateral exchanges of arbitrary complexity, spread out over time.

It solves the problem of how to value apples against oranges against everything by declaring a unit of account in which everything is priced. (This paper uses 'the dollar' as shorthand for whatever unit that might be. It is not about the politics of the dollar!)

It solves the problem of how everyone can agree how much someone should give and how much they should receive using accounting tools like ledgers and coins.

Systems of exchange however only really serve when the parties to exchange do actually exchange. They need to have strong protections against parties who take without giving and also sometimes against parties who give, but never demand anything back, leaving others permanently obliged to them. That is not an exchange. When exchanges cannot be completed using products from within the network, the debt can still be settled using assets from outside of the system, such as money or gold.

In our globalised economy there are very few distinct systems of exchange. The world is more like a single system in which every transaction is settled on the spot and exchange is the secondary function that helps channel the medium of exchange towards the already rich with whom it stops circulating. The resulting scarcity of circulating money greatly hampers the activity and aspirations of the majority. Ironic. This confused state of affairs is perfectly expressed in a Harvard textbook when it describes the medium of exchange function thus:

"A medium of exchange is an item that buyers give to sellers when they purchase goods and services. When you go to a store to buy a shirt, the store gives you the shirt and you give the store your money. This transfer of money from the buyer to seller allows the transaction to take place."¹

The supposed medium in this story is clearly an *object* of exchange. It supports the notion that that the object of commerce is money. But this is a fetish of capitalism. Commerce is actually not about exchanging products for money, but products for products. Marx and others have pointed out that 'money' cannot serve two masters. It cannot work properly as a medium of exchange and long term store of value at the same time². Those who use money mostly as a store of value (i.e. the rich and creditors) want it to have different and opposing properties than those who use money mostly to facilitate exchange (i.e. producers and debtors). That suggests that monetary policy has always been battleground between these interests, but if the functions were performed by different financial instruments, that front in the class war could be closed.

One path, then, towards autonomy, justice, and climate adaptation, is to take exchange more seriously, creating spaces and systems dedicated to facilitating and encouraging it.

1 Mankiw, G. "Principles of Economics" 6th Edition p621

2 Discussed in Marx, Capital, Vol I, "The General Formula for Capital" and many other places.

1a. Commodity media

Way back in 1870 Jevons lucidly explained the medium of exchange function, as performed by notes and coins.

"...one of the articles exchanged is intended to be held only for a short time, until it is parted with in a second act of exchange. The object which thus temporarily intervenes in sale and purchase is money."³

An exchange of one thing for another thing is comprised of two swaps with different parties. The medium connects those two (or more) swaps to make a single 'exchange'. One imagines the medium like a catalyst, enabling the exchange, participating in the exchange, but emerging unchanged from it. It circulates for ever (or until it falls down the back of the sofa) closing one exchange and opening another every time it changes hands. Whoever holds the medium could be said to be half way through an exchange, having delivered their goods to market but received nothing in return, nothing of course, except for a metal token. One could say that the quantity of the medium of exchange in circulation IS the quantity of yet-to-be-closed exchange

In order to fulfil its function though, that token cannot be entirely worthless because it is swapped for valuable objects, and is valued the same as them, at least for the purpose of exchange. The two paradigms of monetary theory frame the value of the medium in very different ways. [this is another aspect in the class war, and is recurring theme in Graeber]

- In the commodity-money discourse, The medium is valuable because it itself is a commodity. More than that, it is a market commodity whose value is determined by supply and demand.
- In the credit money discourse, the medium is valuable because someone is promising something for it. Money is not the 'thing' but points to or represents another thing.

Jevons explanation makes perfect sense in the first case. Each half of the exchange is paid, settled and balanced on the spot at every step. But when the medium is at one remove from a market commodity, that's no longer true. Something else is going on. Imagine the medium has no value - it is purely imaginary. The two transactions that comprise the exchange now appear as the exchanger giving to one party and (later) receiving from another party. There is a scary period between the two operations when the exchanger has lost everything and gained nothing. There is always a chance that the second transaction will not happen, but the exchanger must be confident that it will, that the system and the other traders somehow know this trader must receive product up to a certain value.

This 'knowledge' or information is built into the system of exchange. It can be decentralised, as when the traders themselves manage the information, by keeping records or holding on to tokens. In that case the 'value' of the tokens is ambiguous, leading to strange notions like 'exchange value' vs 'use value'⁴. Alternatively the information can be centralised as when an institution like a bank or a blockchain keeps a ledger. In this case the ledger records how much each trader has given and received, and consequently what should receive or give in order to complete the exchange. Those quantities are called credit and debt.

The practical differences between the two systems are significant. Using a commodity medium is expensive but prevents risk of loss when an exchange doesn't complete. It is expensive because the

³ Jevons, WS (1875) Money and the mechanism of exchange, Chapter 4

⁴ Adam Smith, Wealth of Nations, Book I

commodity must first be acquired - the gold must be mined, it must be transported to market and handed over at a specific time and place, it must be kept secure because once it is stolen, one piece of standard commodity looks very like another. I speak about physical commodities but this is analogous even for modern cash today, if for example you've heard banks complaining about the cost of handling it. The expense of commodity money is tolerated when the alternatives are not available, when there is no trust, no government, or no enforcement of debt.

Credit, if the circumstances allow it, is essentially free to create, can be re-allocated as easily as writing a line in a ledger, and hard to steal, especially if the credit is made out to a specific person. Even bearer instruments can be cancelled after they are stolen, leaving the thief with a swag bag full of broken promises.

Commodities and credit also carry different risks. Commodities suffer from market risk which is the risk of the commodity price changing. The purchasing power of the medium of exchange varies with the market price. Commercial actors do not like speculating on commodity prices, they prefer to make predictable profits from buying and selling. They want money to have a stable value, and to be able to depend on it.

Credit suffers from the risk that the issuer might go bankrupt. But unless or until that moment, one can expect the credit to be redeemed at face value. Whichever instrument is used, large spaces of exchange, e.g. governments have various strategies to mitigate or manage these risks, in order to make the medium stable against the products of the particular market.

Sometimes credit is itself and traded on markets like a commodity, but it is a strange commodity with no intrinsic value, whose supply and demand is purely political. That means the price of such credit is then determined by supply and demand, and speculation more than default risk. This behaviour has been described as a big mistake and the distinguishing feature of capitalism⁵. I mention it though, to stress that though I'm drawing careful distinctions here, reality is less careful.

To summarise, a medium of exchange can be a commodity or a promise of a commodity. The challenge of constructing it is to keep its purchasing power stable by managing the market risk or the default risk.

2. Some foundational concepts.

2a. *For which, and by which*

When John Law said "Money is not the value *for* which goods are exchanged, but the value *by* which they are exchanged."⁶ he was addressing the commodity/credit money issue from another angle. When money is a commodity, it is swapped *for* other goods (what I call products). But the other way to think about money is as the dollar sign on all the prices in the market. When we exchange goods for goods, we use the dollar to calculate the exchange rate. A ton of my goods is worth X dollars, a ton of yours is Y dollars, therefore my ton of goods is worth X/Y tons of your goods. Law's use of the word 'by', indicates this division calculation.

⁵ Amato and Fantacci (2009) "The End of Finance"

⁶ John Law, "Money and Trade Considered: With a Proposal for Supplying the Nation with Money" Chapter 1

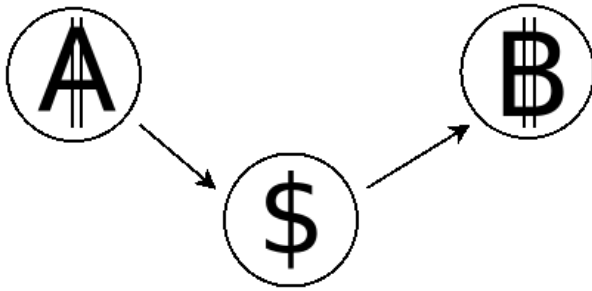


Figure 1: In the exchange of asset A for asset B dollar assets serve as a medium.

In both cases you can visualise a sort of movement from good X to \$ to good Y. If the \$ is a commodity then the exchanger acquires B by first acquiring \$. If the \$ is a pure measure, then A acquires a quantity of B by merely comparing it to the \$. No dollars are actually deployed in that transaction, and the transaction might actually be easier without them.

2b. Balance of trade

Accounting for exchange does not itself ensure that exchange will happen or be equal. Much real world trade is not balanced, even with the best of intentions of all parties. And when trade imbalances are not managed but allowed to compound year on year, they become a great source of tension at all levels of society, from the minimum wage worker struggling to balance income with expenses, to nations unable to develop because all their cash crop exports barely cover the interest on the national debt.

Most trading relationships require some kind of intervention to help manage persistent surpluses and deficits. There are only three possible approaches, even though they take many different institutional forms:

- move production towards the deficit parties
- move consumption towards the surplus parties
- forgive debt

We see things happening in a 'fiscal union' such as the United States where states rich in natural resources who have a trade surplus give money or invest in states without large industries to create jobs. This is not charity, this is ensuring that trade can continue because it remains in balance. Meanwhile in Europe's 'Monetary' Union all the talk of Greek Secession and PIIGS⁷ a decade ago was a direct result of unresolved internal trade imbalances

This illustrates the larger principle that without interventions some parties will almost certainly become subjugated to others through structural debt. Trade justice requires that all parties maintain a balance of trade in the long run.

2c. The price of risk

With a commodity medium of exchange, there is no debt and no incomplete exchange. If producer 2 dies before delivering the product, it doesn't matter because producer 1 has a commodity that they can swap with any other producer. But with a credit/debt medium, if the issuer cannot redeem it, the

⁷ Peripheral European countries at risk of default in the wake of 2008. Portugal, Italy, Ireland, Greece, Spain.

credit-note is rendered worthless. That is why holding someone's credit is doing them a favour. The bearer of the note is also bearing the default risk. For this reason when credit/debt circulates in the market it typically does so at a discount. The difference between the face value and the market value is called the risk premium. It varies for every issuer because each is judged individually by the market for their likelihood of defaulting.

3. The 'ideal' system of exchange

There is one system of exchange that manages to support a unit of account stable against the products being exchanged, without using a commodity medium of exchange. This is achieved when all the members of the system agree to be 'joint and severally liable' for credit defaults. It means that if everyone in the group defaults except for one person, that person is responsible for all the debts. This arrangement is often used in an adjacent field, micro-credit. The contract also states that every party may only close their account when their balance is zero, which is a way of saying that they have completed their exchange with respect to the other parties. This system of exchange called mutual credit. The contract renders the credit of each member essentially the same as the credit of every other member: it is redeemable by the same products, guaranteed by the same people under the same rules and crucially bears the same risk. Another way to say this is that each member's credit becomes fungible with each other members' credit, which is a great convenience. (Section 4 explains how credit rendered fungible without such an agreement)

Mutual credit allows members to trade amongst themselves in a closed group with a common unit. Creditors and debtors can switch roles as fate determines, so have a much more equal relationship - if interest is charged for example, it is not for the rental of a scarce commodity⁸. It has another pleasing attribute: that since the credits and debts is always in balance in the system, and every debtor is looking to earn back up to zero and every creditor is looking to spend back down to zero, supply and demand of products are driven towards balance as well, guarding against the evils of over-production and under-supply.

A mutual credit ledger can be represented as a bar chart in which the sum of assets always equals the sum of liabilities.

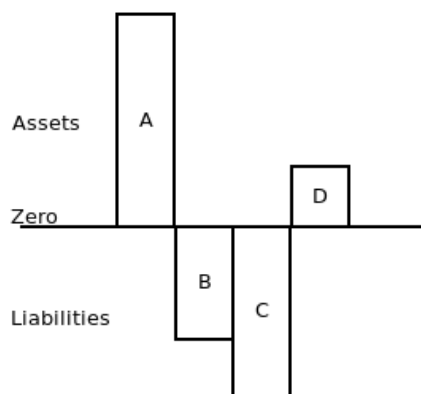


Figure 2: Assets and liabilities of four accounts comprising a mutual credit.
Note that total assets = total liabilities.

⁸ Interest is sometimes said to have several components. Rent is the largest, but also administration fees, compensation for default risk, and compensation for inflation. Some commentators offer more.

Mutual credits is the methodology behind business to business barter exchange, as well as, less formally, behind LETS (Local Exchange Trading Systems) and time banks.

In practice, the extent to which people are willing to become joint and severally liable is very limited. There is a dimension of flexibility though, when members, while remaining equally liable can be liable for different amounts, but still equally liable. Shareholders, for example, before the advent of limited liability, were equally liable for their company's failure, up to the proportion of shares that they hold. That is why each member of a mutual credit typically has a balance limit, which limits the amount of credit they can access at the same time as limiting the amount they are liable for.

Now when a member defaults, the liability is not with the unfortunate 'bearers', the value of the unit of account remains stable and trade is not affected. Instead the liability passes into the governance space where there are agreements between members about how to make up the loss between them. The unit of account remains stable. This structure is often recursive, so if the business fails, the bank pays, if the bank fails, the government pays because the stability of the means of exchange is in the interest of everyone. When the highest authority pays by issuing new money, it is spreading the cost as thinly as possible, so the medium of exchange is perceived as stable, like an abstract ideal untethered to the risky business of trade.

Mutual credit is often criticised as not being 'scalable' and it is true that as more members join a system, the average level of trust, and hence credit, is sure to fall. But mutual credit systems can nest very nicely using the Credit Commons Protocol, retaining all their pleasing qualities when they trade with each other as part of a larger mutual credit exchange.⁹ Far-reaching exchange becomes possible using a stable unit, in which each member is liable only for the amount they are allowed to issue.

I've noticed a slow growth in interest in these systems over the years. Mutual credit has an aura of perfection about it because it simply does accounting for exchange within the membership, without the distortions introduced by an exogenous commodity. This only works though because it is a closed group of parties whose whole intention was exchange. This is better suited to geographically bound economies, and unfortunately finds few niches in today's globalised system of exchange.

It is possible to view the whole global economy as a mutual credit, albeit a dysfunctional one.

4. 'Open' systems of exchange

A system of exchange that works outside a mutual group works very differently. Without the premise of shared liability, the risk of the credit issuers defaulting falls to the bearer of the credit. Bearers compensate by pricing in that risk so that each voucher is discounted by a different amount when they are used for payments on the open market. Having to evaluate or negotiate the value of the notes (as well as the merchandise) increases transaction costs. So the challenge for 'open' systems of exchange is to solve that fungibility problem.

By open I mean that they enable exchange with people who might be anonymous. Credit is issued as a 'bearer instrument' like vouchers or bonds and can be redeemed to anybody. No relationship is posited between creditor and debtor. In principle, issuance of credit is also open - anyone can issue credit to anyone who will accept it.

⁹ See the Credit Commons white paper, <https://creditcommons.net/assets/credit-commons.pdf>

In fact, much of the financial system worked like this in 19th Century especially during the 'free banking' era 1830-1860 and in UK when industrial supply chains were lubricated by credit in the form of credit notes and bonds. It is from this period that I will borrow the term 'credit note', to mean a promise to pay which can circulate on the open market. When there isn't enough media of exchange to meet the needs of commerce, commerce is more than happy to augment the supply by issuing credit themselves.

Historically, if not also morally speaking, credit/debt relationships are between named parties; a debt cannot simply be sold on the open market unless the agreement allows it. It is a closed relationship or contract between named parties.

There's a case to be made that anonymising the creditor is detrimental to the creditor / debtor relationship. A creditor who can simply pass the debt on to someone else has no solidarity with the debtor, no interest in the debtor's ability to pay. If they lose confidence in the debtor, they won't help, they will just offload the note, and the debtor, rather than having a partner in finance, finds themselves answering directly to the court. Worse, speculators can toy with other people's financial instruments, driving them out of business through no fault of their own. Nevertheless, being able to trade widely has other advantages.

4a. Non-fungible credit

Credit notes have a face value, which is what the issuer will redeem it for, e.g. 1 dollar, or 1 dollar's worth of the issuer's product. But because there is a risk of default, the circulating value of credit notes is always less than face value. And because each issuer has a different perceived risk of default, the discount is different. This makes credit notes very hard to pay with because:

- Who can price the risk of a given company defaulting. In a large system, creditors and debtors are estranged and creditors unable to judge the risk of the credit notes tendered to them.
- Even once the risk is priced on the market a seller might simply not want to take on a particular issuer's risk.
- Payments typically would use credit notes from multiple sources - they are all sloshing around together, which makes evaluating them harder still.
- As the credit notes venture further from their issuer and ultimate redeemer, they lose value because less is known about the issuer and they need more hops to return.

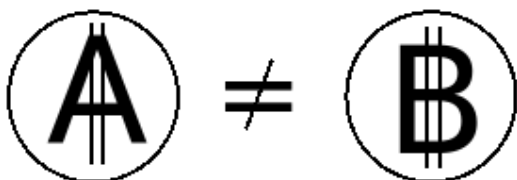


Figure 3: Credit notes are not fungible.

4b. Brokerage

Brokers are independent actors who hold a 'pool' or a portfolio of assets, and offer a price to buy and/or sell with the public. In a credit market those assets are credit notes from different issuers.

They make it their business to know and price the creditworthiness of different issuers. This helps merchants in two ways. Firstly they can suggest a price at which credit notes should change hands, and secondly brokers will actually give cash for those notes if cash is needed. Conversely if a merchant wants to buy from an issuer, if they can buy that issuer's credit notes at 99c per \$1 to gain a 1% discount from the issuer.

Note that while merchants ultimately exchange products for products, these brokers exchange credit for credit as part of the merchants' exchange. Exchange of the media of exchange could be characterised as 'meta' exchange.

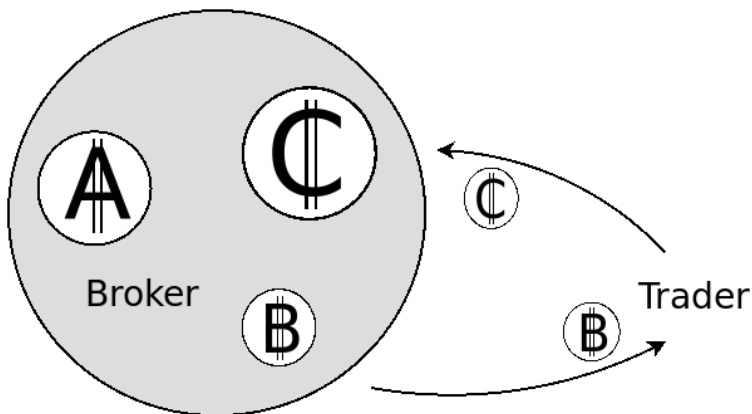


Figure 4: A broker has a portfolio of A, B and C and a trader swaps some C for B, leaving the broker with very few B.

When brokers advertise prices for each note and offer to exchange them for predictable amounts of money, then help to makes the credit notes more fungible. This fungibility has a cost though, which is the spread and transaction fees that accrue to the broker as a cost of the service.

4c. Bridges

If a broker doesn't have the needed asset he probably has an assets than can be exchanged with another who does have the needed asset. Those assets could be though of as linking the brokers into a network which allows any asset class to be exchange for any other.

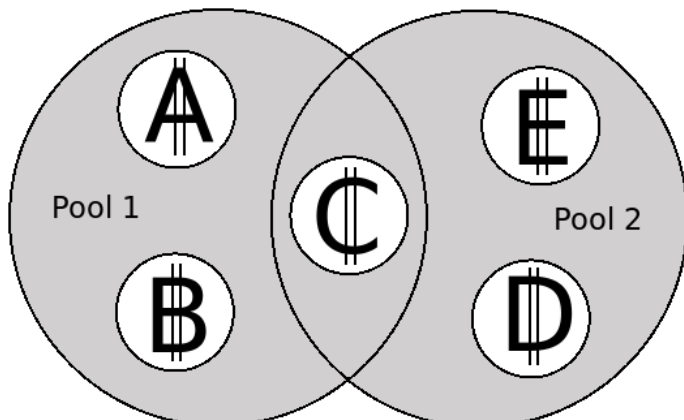


Figure 5: To exchange asset A for asset E, first exchange A for C in pool 1 then exchange C for E in pool 2.

Those assets can be imagined as bridges but that is not a perfect metaphor. The new fungibility is constrained by the size of brokers' asset pools and the mixture of assets they are holding at any moment. Just like a seesaw can only rotate so far in one direction before it can only go the other way, a pool can only exchange as much of an asset as it is holding before it must trade in the opposite direction. So the fungibility is still limited in principle, and costs more if multiple hops are needed, and, as with any system of exchange, if it doesn't flow equally in both directions, it will stop working. Pools which have a target asset balance, will try to balance the flow using price mechanisms, but this doesn't always have the desired effect.¹⁰

As we start to regard this as a network it's function is more likely to be payments than mere exchange. Outputting direct to the vendor, after all, requires one less transaction than exchanging credit and then paying.

4d. Mesh

Many pools and many bridges can be represented as a network diagram in the form of a mesh where anything might link to anything.

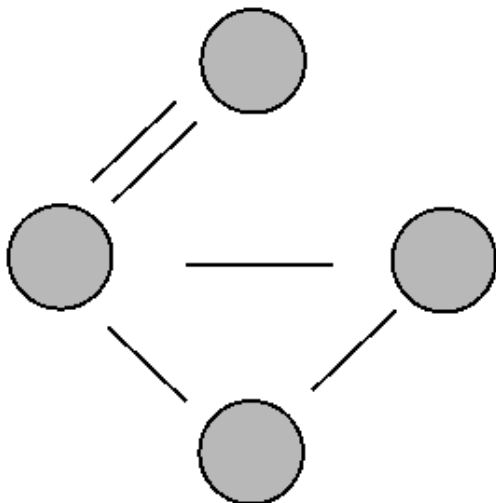


Figure 6: Bridges between pools in a mesh; some pools may share multiple assets asset

In this network, each connection is a possible payment channel, and more connections means greater fungibility. Multiple channels allow more options when some routes are blocked, and can even compete against each other to provide the best exchange rates.

Choosing routes in a large network is a science in itself. Each pool offers its own exchange rates and each path results in a different amount received at the other end. Arbitrage becomes a possibility. Just using the cheapest routes is very effective, especially if pools signal their availability using price. But there are other possible parameters an algorithm might factor in. Exchange rates could be constantly changing; priority may be given to some links over others.

¹⁰ The idea that prices adjust automatically resulting in balanced trade was described by Hume as the Price-Specie Flow Mechanism, but is criticised for describing an ideal and ignoring many real-world factors.

Returning to mutual credit for a moment, those systems allow only one possible payment path (as shown in Fig 7) and one possible price, and no arbitrage. Even when mutual credit systems network together using the Credit Commons Protocol the resulting tree structure allows only one possible path between any two accounts.

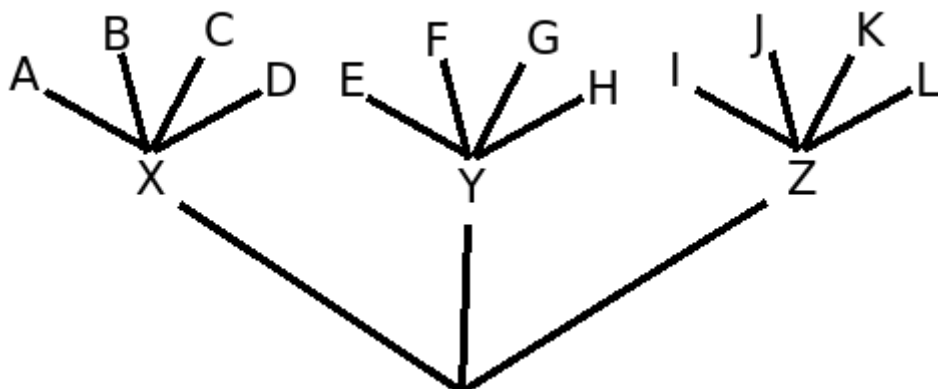


Figure 7: Payment routes in a mutual credit tree

5 Ripple

Above I pieced together the system from first principles:

1. a system for anyone to issue tokens
2. brokerage
3. enough connections to make a mesh
4. (sometimes) a system for routing payments across a mesh

Several DLTs (distributed ledger protocols) already exist to do exactly these functions in a single specialised system. [Original creator Ryan Fugger has published a few versions] The general idea is called 'Ripple', because of the way payments ripple through the network, moving balances up and down as they go. We looked at some of these systems in the first #CoFi gathering.¹¹

Ripple does all four of the above, but with the language of trust and credit rather than assets and swapping.

First there are accounts. You don't have to pay anything into your account before making payments. Accounts do not issue tokens, but rather extend 'trustlines', which allow the target accounts an amount of your own credit.

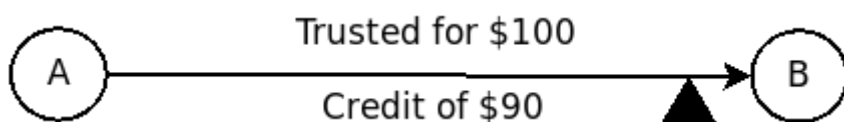


Figure 8: A trustline for \$100 with \$90 owed

The amount that A owes B changes every time a payment ripples along this trustline, as would the amount that is owed and owing to those parties. This trustline shown would be maxed out after another \$10 and another route would need to be found until more trust was extended or a payment

¹¹ See conference materials <https://miro.com/app/board/uXjVMRG45iA=/> and the authors own blog <https://matslats.net/cofi-is-now-a-thing>

rippled in the opposite direction. Extending a trustline is equivalent to issuing assets with a face value and giving someone permission to borrow a certain amount of them.

Each account can be the target of many trustlines which is the same as having a 'pool' of assets. A single protocol provides for mapping the whole mesh and a routing payments through it.

The most commercial implementation, ripple.com¹² at one point sought to enhance liquidity by increasing the number of pathways through the network. They upgraded every trustline to a market so anyone could make bids and offers on anyone else's trustlines, becoming a broker and earning a cut, whenever that trustline was used.

6. Conclusion

When all potential bearers of the payment asset agree that default risk should be subject to a governance process, the payment asset can change hands at face value, and be stable. In an 'open' system, diverse assets can be made fungible with the help of various additional mechanisms but in the end the anonymous bearer of the asset also bears the default risk of that asset.

The anonymous bearers can spread their risk by holding a wide range of credit notes with minimal due diligence on each. This can also be accomplished using pools, where all the assets are put in a pool, and creditors hold and exchange a derivative of that pool. In this way the creditors of the pool would become effectively joint and severally liable for defaults which would enable them to use the assets at face value. This would be the mirror image of a mutual credit system, perhaps a mutual debt system? We have come full circle.

Solidarity happens between people who know each other. Discreet groups provide a scope for governance, which doesn't occur naturally in a mesh of relationships, as I discuss in my blog.¹³

This paper has shown how, in payments if not in every area of society, open systems by definition, must commit resources to managing the risks of remote events and untrusted and hostile actors. In some contexts, the benefits of openness outweigh the costs.

The fiat currencies evolved in the capitalist crucible change hands at face value because the guarantor, which is the state, is a sort of mutualist association of the citizens. But this type of mutualism is vulnerable to non-public and extra-national actors. To counter these actors' ability to extract wealth using the money system, citizens could form networks of closer groups with more internal trust. Such groups would not be able to issue credit as hard as their government's credit, but what they lose in purchasing power they might make up in other efficiencies that come from reduced need for security, owning their own payments infrastructure, and the ability to issue credit without a banking intermediary. Their essential competitive edge is precisely that they could leverage that trust which is absent in the open market.

¹² <https://ripple.com>

¹³ <https://matslats.net/ripple-reciprocation-credit-commons>