Anvil: A collateral utilization protocol

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Abstract

Despite its myriad forms and context, money is discernably not a commodity but merely an accounting tool. Money is simply an abstract unit of account—which measures *debt*. As the inextricable basis for the efficient issuance of credit, collateral has thus become the primary factor affecting global liquidity. The strategic utilization of collateral and its derivative secured credit transactions comprise the prevailing catalyst for economic growth and stability.

Anvil is a system of Ethereum-based smart contracts that facilitate generalized collateral utilization. The protocol originates fully secured credit to provide a composable, economic guarantee for any transaction. The contracts are designed for maximum efficiency and extensibility to incorporate transparent collateral management throughout decentralized and traditional finance.

Contents

1 Introduction

Non-possessory secured transactions are principal components of market economies worldwide. The primary advantages of secured transactions are reduced revolving cost and maturity duration resulting from mitigation of risk; lenders acquire a security interest in borrower assets, with entitlement to foreclose and seize collateral in the event of default. The use of collateral is the most predominant and widespread counterparty credit risk abatement technique throughout both wholesale and retail markets. Collateral facilitates the spectrum of global lending channels, augmenting capital flows for productive investment and economic growth. In this sense, credit (*i.e.*, debt) assumes *de facto* medium of exchange and a universal measure of monetary value—quality collateral is requisite to the greater financial system. Inherently linked to the inception of money itself, the credit market is regarded as the second largest financial market worldwide[1]. By underpinning global liquidity, collateralization becomes systemically important to financial infrastructure, and resultant demand has evolved resource management processes to become increasingly complex and interdependent. Consequently, collateral interests often lack transparency which severely limits collateral versatility and utilization.

Permissionless distributed ledger technologies have the potential to revolutionize the entire collateral lifecycle by introducing advancements in security and transparency. Through canonical validation, decentralized applications directly enable greater flow velocity (*i.e.*, collateral usage rates) which defines market liquidity and hence financial stability. To realize this potential, an open-source, extensible collateral protocol is proposed to facilitate the origination of fully secured credit. Through the issuance of transparent and generalizable credit, sustainable liquidity (*i.e.*, money) can be provided to an economic system. A modular collateral primitive can ameliorate both acute and systematic risk, safely expanding the use of collateral while instantiating a more efficient process for the creation of money.

2 Money and economic exchange

In the traditional economic paradigm, money fulfills several pivotal functions: it serves as a unit of account, a medium of exchange, and a temporal store of value. Throughout its extensive history, money has assumed numerous forms ranging from tangible assets (*e.g.*, grain, shells, and iron) to abstract constructs [17]. This diversity extends to its various modes of operation, spanning cuneiform tablets and tally sticks to contemporary paper and electronic ledgers. A prevailing hypothesis proposes that money is an emergent property of a formalized market system, predicated

[1]Considering the entirety of extant derivatives and bond market instruments, the total secured public and private debt outstanding is estimated to exceed $0.25 quadrillion [38].

on the assumption that barter was the incipient form of economic trade. In this narrative, money emerges as a commodity product of pre-existing economic activity, a solution to the complexity of mutual exchange [31]. The eminent commodities needed to be valuable, durable, divisible, and portable; precious metals such as gold and silver were found to be most applicable [20]. From this perspective, the perceived value of contemporary money is inherently secured to gold or a similar asset bearing intrinsic value. However, this view rooted in the historical scarcity of precious metals has inadvertently led to the misconception that the foundation of money must be a limited resource [3].

Predating coinage by millennia, money has materialized as an *abstract* measure of value in various forms across diverse societal structures [35]. Ancient civilizations evidenced substantial banking systems[2] predicated on grain storage, with early proto-monetary systems facilitating socioeconomic functions such as tribute obligations and religious offerings [48][66]. The barter-origin theory suggests that money emerged organically from the market; however, a notional scale of values must have previously existed to mediate the exchange of goods. Consequently, money is both logically anterior and historically prior to market exchange. From all available ethnography, no quintessential example of a barter economy has ever existed; money clearly did not emerge from such a system [34].

2.1 Fiduciary origins

The inception of money in the form of coinage[3] primarily utilized electrum, a naturally occurring alloy of gold and silver [72]. Subsequently, minted coins were leveraged to finance military expeditions and catalyze imperial expansion[4], inevitably reaching wide circulation throughout Asia, the Middle East, and Europe[5] [5][73]. Despite the historical association of coinage with precious metals, the constituent weight or composition of coins has varied considerably; rarely has the nominal value of coinage been congruent with the intrinsic value of its base metal [59]. Given this perpetual variance in precious metal content, the only reliable assurance of value resided in the pervasive stamp of the coin issuer, reflecting a seal of the minting authority [69][71]. Coinage has almost exclusively been issued as fiat (*i.e.*, fiduciary) money. Instances where coinage was closely

[2]Barley and silver were common denominators of value and units of account within the non-market economies of Egypt (*c.* 2700-2200 BCE) and Babylon (*c.* 2500 BCE) [4][54]. In particular, Egyptians developed a banking system in which cheques could be drawn against grain deposits in government depots. These cheques were redeemable at any government granary, enabling negotiability and the settlement of third-party debts. Through this rudimentary Giro system, grain was transformed into a verifiable payment medium [4][33].

[3]Coins were introduced as a more efficient means to collect fines and taxes, attributed to the Lydians of western Anatolia (*c.* 550 BCE) [59].

[4]Alexander the Great (*c.* 333 BCE) initially used coins to remunerate soldiers, pay for supplies, and provide incentive for Macedonian officials [73].

[5]The Roman Empire (*c.* 31 BCE – CE 476) established a highly organized system of currency which became the model for many later states [62].

tethered to scarce precious metals often resulted in constricted economic activity and growth [70]. Conversely, many economies experienced prosperity when coins were abundant, evidenced by the direct correlation between long-term periods of depression and expansion with the relative scarcity of gold and silver[6] [32]. Even the debasement of coinage through the reduction of precious metal content did not inherently promote economic decline [40]. Veritably, during the Middle Ages, nations that experienced the most substantial economic growth were those which experienced the greatest debasement of their coinage [9].

Commodity-based currency conflates the role of money as a measure of value, with its inherent physical value. While gold and silver possess value as commodities, it is reasonable to project this value as intrinsic to the coins themselves. However, their definite worth is subject to variation, requiring numeraire expression in another form of commodity or money (*e.g.*, silver or dollars)[7] [36]. This suggests that money cannot be a commodity, as its value necessitates another standard of value—an impossibly recursive measurement [37]. Irrespective of its composition, money cannot be assumed to have inelastic value. In practice, money does not innately possess a value; rather, it serves to *measure* relative values. This principle is central to the chartalist[8] perspective which asserts that the value of coinage is derived exclusively from the distinctive mark of its issuer—that money serves as a *token* of value [2][43].

Supplementing coinage, the inception of paper money[9] and its acceptance initially proliferated across large Eastern empires[10] [52]. In contrast to assets with intrinsic value, paper material has no tenable value as a substance. Accordingly, commerce was facilitated through the issuance of promissory notes which were explicitly based on the trustworthiness of the issuer [49]. Offering a more secure and efficient alternative to transporting coins, the adoption of paper-based trade was pivotal in the burgeoning commercial markets. [17]. The integration of paper money catalyzed inter-regional exchange, unhindered by the limitations presented by the supply of precious metals. As trade records and promissory notes became widespread, the receipts of these transactions necessarily acquired generic transferability, transitioning from the mere validation of a contract to a negotiable instrument itself [64]. This commercial paper became money when it was universally accepted from its bearer, directly leading to the emergence of modern banking in Europe. Nascent banks originated loans by issuing their unique form of promissory notes which circulated alongside

[6]The continuous debasement of coinage was offset by a relatively inelastic supply of precious metals that did not expand proportionally to the increase in monetary demand [6][18][60].

[7]Early abstract accounting systems corresponded to utilitarian instances of weight. The basic unit of silver in Ancient Greece was the drachma (*handful*) of grain; the precise quantity to represent this varied considerably [44].

[8]This principal was derived from the Latin *chartal*, meaning *token.* Circulating coins varied in size, weight, and purity. These discrepancies proved irrelevant, provided there was a stable system for measuring credits and debts [35].

[9]Promissory notes were first used in China during the Tang Dynasty (CE 618-907) [52].

[10]Paper money was widely used for government tax payments during the Yuan Dynasty (CE 1260-1294) [52].

state-issued coins[11]. While the reserves of precious metals held by bankers were notionally perceived as underpinning the paper receipts, the real basis was the collective trust that future obligations would be met [17]. This critical aspect underlines the significance of confidence in the functioning of monetary systems, central to the development of contemporary money.

2.2 Debt and money creation

Money originated as a medium to denominate and fulfill obligations towards governments and socio-cultural institutions [29]. One of its earliest forms appears to be a system of price equivalencies predicated on the specific weight of barley, instituting a sense of proportional valuation[12] [53][54] The additional numeraire value dimension was facilitated by formal accounting, which enabled temples and palaces to coordinate internal resource flows and economic planning. Silver served as the standard of measure (*i.e.*, the unit of account) rather than a means of settlement[13] [19]. Within this framework, money emerged from non-commercial considerations as a medium to denominate *debts* valued by portions of metal. Debt created money as a means of settlement, but the debts themselves were the primary construct; money originated purely as a vehicle to settle debts rather than as a quasi-barter exchange medium for goods [15][16].

Money comprises a standard measure of abstract value, denominated in a unit of account, and accepted broadly as a means of payment. It confers value on a substance or form by the unit of account, serving as a provisional promise[14] to pay, irrespective of the material of its composition[15]. Money itself is a socio-economic construct—a *credit* constituted by social relationships that exist independently of commodity production and exchange [36]. The universal acceptance of money requires social credibility as it represents a claim or credit against the issuer (*e.g.*, a monarch, state, or bank) [31]. However, it is not necessary for debtors to acquire credits from the respective party to which they are a debtor; accepting a monetary payment volunteers the beneficiary as the reciprocal debtor *pro tem* [37]. In modern economies, this fluidity is facilitated by banks, the clearing houses of commerce which reconcile a network of claims and obligations.

Contemporary pecuniary systems are characterized by the conveyance of claims between parties as a method of debt payment. Commercial bank deposits are essentially debts to depositors;

[11]Modern banking emerged from the benches (*banca* in Italian) of Venice goldsmiths (*c.* CE 400) [17].

[12]The Sumerian economy (*c.* 2500 BCE) consisted primarily of temple complexes, using the silver shekel (*weight equivalent to one bushel of barley*) as its basic monetary unit. Temple workers received a total of 60 shekels (*portions of barley*) per month, distributed in equal rations twice per day. In this sense money was not a product of commercial transactions, it was created by bureaucrats for resource accounting [66].

[13]In Mesopotamian marketplaces prices were calculated in silver, but most transactions were based on credit and settled in barley during harvest periods [65].

[14]Credit is derived from the Latin *credere*, meaning *to trust.*

[15]The total number of coins in circulation (*i.e.*, quantity) rather than the total weight of metal they contained (*i.e.*, quality) fundamentally determined price levels. For the great majority of routine market transactions, coins exclusively functioned as tokens of value [36][46].

respective account balances are primarily secured by government bonds held by the banking system, supplemented by private sector debt. The issuance of money is not an exclusive privilege of government, but merely one of its functions as the predominant buyer of commodities and services. For instance, government currency is a promise to pay, and to subsequently redeem, like all other money [37]. State-issued money is nominally a public debt, albeit one that is not *expected* to be paid. Instead, the government promises to accept its own money for payments to itself (*e.g.*, taxes or public fees). Consequently, the basis of commercial enterprise is the perpetual cycle of credit and debt creation, and their serial cancellation. Any transaction essentially involves the exchange of a commodity for a credit. When a sale occurs, a credit is earned; in contrast, a purchase originates a debt—*there is no medium of exchange* [37]. Credit is not merely a byproduct of commercial transactions; it is definitive purchasing power.

2.3 Decentralization and trust

The original Bitcoin whitepaper presented an innovative method for implementing a novel form of commodity money. Bitcoin adheres to the traditional utility narrative wherein an intrinsically[16] valuable item reaches monetary precedence due to *inter alia,* rarity, and durability. However, such a characterization is inaccurate; money necessitates both a creditor and a debtor—a principle that is fundamentally incompatible with Bitcoin. Consequently, trading a bitcoin is equivalent to exchanging a commodity. From this perspective, bitcoins and comparable decentralized cryptocurrencies are generally not well classified as money. Instead, they function as digital commodities—analogous to gold or silver—serving as store of value assets. While bitcoins are not money in the formal sense; they unquestionably possess monetary value, but they are not money *per se*.

However, blockchain-based stablecoin assets such as Tether (USDT) or USD Coin (USDC) serve as proxies for bank money. A USDT token practically represents credit within the Tether platform, thus resembling an indirect bank deposit [68]. Although USDT functions on decentralized ledgers, administration of the Tether platform and the USDT token contract are both explicitly centralized. Holding USDT ostensibly maintains a claim against the Tether organization, and accepting USDT as payment implies confidence in the quality of its debts. In this sense, Tether has created genuine, digital bank money—albeit stablecoin issuers are merely implementations of shadow banks. Stablecoins operating with this model are clearly not decentralized cryptocurrencies like Bitcoin or Ether, yet they are *definitively* money.

The innovation of decentralized finance (DeFi) has catalyzed the development of alternative,

[16]No distinction is made between physical and digital assets, acknowledging renown cryptocurrency polymath Nick Szabo: “No value, utility, or function of a good is any more ‘*intrinsic*’ than any other.” [67].

smart contract-based stablecoins such as Dai (DAI) and Liquity USD (LUSD) [45][47]. These protocols allow cryptocurrency commodities (*e.g.*, Ether) to be pledged as collateral to issue reciprocol stablecoin token assets. Within this framework, a smart contract essentially operates as a margin account, facilitating the borrowing of dollars (*e.g.*, DAI or LUSD) against collateral. This mechanism of originating credit secured by depositor assets is the epitome of money creation. Given that stablecoins like DAI and LUSD are administered by autonomous smart contracts, they embody novel forms of decentralized money.

The value of a currency unit does not measure of the value of an object, but instead the value of counterparty (*i.e.*, the nominal debt issuer) trust, whether it be a government, an individual, or a smart contract. Assessing this underlying liability is the most crucial factor in the practical adoption of a financial medium. Consequently, to mitigate inherent credit risks *ex-ante*, various methods of collateralization have been developed since the inception of money.

3 Collateral utilization

Collateral is the fundamental component of all financial market structures, affecting commerce and exchange worldwide. The most consequential collateral market is international lending, secured by underlying securities, commodities, and myriad liquid assets. The strategic utilization of collateral is a ubiquitous catalyst for liquidity creation, augmenting the efficiency of global pecuniary operations. In this context, effective collateral management is crucial for both the future expansion and stability of the comprehensive financial ecosystem.

3.1 Secured transaction models

Assets that permit title transferability and have systematic pricing are potentially qualified as collateral resources. Consequently, **c**ollateral management is diverse and structurally complex, dependent upon the objectives of a transaction and its counterparties. The primary models of collateral-secured transactions consist of:

- cash borrowing
- repurchase agreements (repos)
- securities borrowing
- over-the-counter (OTC) derivatives
- central counterparty (CCP) derivatives
- central bank market operations

These transactions exhibit variance in both size and duration—determinative factors in assessing their respective collateral quality, limitations, and inherent risk. From these various models, functional collateral requirements can be derived for a generalized application.

Cash borrowing Secured cash loans constitute debt products in which creditors lend cash over a specified duration against the perfection of collateral. Directly originated, non-corporate lending spans a broad spectrum of industries and financing modalities, utilizing collateral assets such as residential and commercial mortgages, vehicle loans, credit card debt, and movable property (*e.g.*, inventory and equipment). To augment credit availability, financial institutions commonly convert illiquid financial assets into marketable securities. Contractual debt-related cash flows can also be isolated and securitized as bonds, pass-through securities, or collateralized debt obligations (CDOs). These securities are often divided into tranches or re-classified into varying levels of subordination predicated on expected cash flows. Consequently, in contrast to traditional unsecured corporate bonds, assets created within a securitization are *credit enhanced*—their credit quality is elevated beyond that of the original unsecured debt or the underlying asset pool.

Repurchase agreements Repo contracts function as bilateral financial arrangements wherein one party sells assets such as government treasury bonds for cash, while simultaneously committing to repurchase same at a predetermined price in the future. From an economic perspective, a repo contract can be considered a short-term, interest-bearing loan with the implied interest rate reflected in the difference between the sale and repurchase price. The repo market is integral[17] to enabling efficient borrowing for institutions that own securities (*e.g.*, banks, broker-dealers, hedge funds) while offering an opportunity for parties with surplus cash (*e.g.*, money market and mutual funds) to generate returns with minimal risk exposure [27].

Repo markets provide commercial banks a low-risk method to leverage their liquid assets by sourcing cash in the federal funds market, capitalizing on the relatively higher rates in the repo or foreign currency (FX) market. In contrast, insurers, pension funds, money market funds, and corporations utilize repos as a prudent method to allocate their cash reserves. Notably, the cash buyer (*i.e.*, the lender) receiving a security as collateral may further deploy that security in subsequent repo transactions. This capacity to re-hypothecate collateral allows hedge funds to escalate leverage for arbitraging pricing discrepancies and providing market liquidity [13]. However, the increasing complexity of cash management, coupled with cyclical fluctuations of repo lending volume can induce excessive system volatility.

[17]Repo market funding reaches \$3-4 trillion of daily aggregate transaction value [61].

Securities borrowing Conventional securities lending encompasses a short-term loan of stocks or bonds in return for pledged collateral. This transaction economically resembles a repo agreement, particularly when collateralized by cash. These contracts are primarily employed to acquire specific securities, enabling firms to establish short positions, implement hedging strategies, and provide market liquidity. Primary providers of collateral securities are investment firms, pension funds, central banks, and insurance companies. Securities lending transactions are typically administered by a third-party intermediary (*e.g.*, a custodian bank) bridging the agent and principal. Custodian banks also facilitate asset securitization and trading, often leveraging asset-backed commercial paper (ABCP) conduits. ABCP is collateralized by a variety of financial assets, funded via off-balance sheet (*i.e.*, shadow banking) residential mortgages, commercial loans, collateralized debt obligations, and credit card loans [1]. Notably, ABCP programs have been implicated as a primary catalyst of financial crises, underscoring the systemic risks associated with these instruments in periods of market stress [42].

Over-the-counter derivatives Predicated on underlying assets, indices, or interest rates, derivative contracts are mechanisms for hedging price movements, increasing exposure to price fluctuations, and providing access to otherwise inaccessible or illiquid markets. Standardized derivatives are listed on exchanges, whereas more complex and idiosyncratic products (*e.g.*, interest rate contracts and credit default swaps) are traded bilaterally over the counter (OTC). Collateral is increasingly used in derivative transactions to mitigate counterparty credit exposure.

Both the exchange-traded and the OTC derivative markets are primarily driven by the originate-to-distribute model—a method of packaging various securitized products including asset-backed securities (ABSs), collateralized debt obligations (CDOs), asset-backed commercial paper (ABCP), and structured investment vehicles (SIVs). Subsequently, these securities are often partitioned into marketable tranches of varying risk-return profiles. The inherent characteristics of the derivatives market harbor the potential to disseminate systemic risk in a highly leveraged manner—a position in a derivatives contract yields a more pronounced exposure compared to that originating from the underlying asset itself [56]. OTC markets are characterized by elevated levels of customization and consequently illiquidity, limited transparency, substantial market concentration and interconnectedness, and a lack of comprehensive regulation.

Central counterparty derivatives Fundamental to most exchange relationships is the credit support extended by clearing entities to facilitate the settlement process. In the instance of OTC derivatives cleared through a central counterparty (CCP), parties on both sides of a trade are required to contribute margin (*i.e.*, collateral) to the CCP as a prudential measure. The interposition of the CCP in the clearing process alleviates the need for bilateral counterparty credit lines among clearing members. Typical members involved in the derivative settlement chain include prime brokers, custodian banks, clearing banks, and interdealer brokers (IDBs). For non-IDB bilateral clearing and settlement, there are inherent risks and resiliency issues: (*i.*) upon trade execution, counterparty credit risk emerges—should one party fails to meet its obligations, replicating the trade will incur additional cost[18], (*ii.*) credit arrangements associated with clearing relationships are inherently uncommitted, and unexpected alterations in credit terms or funds availability will disrupt the settlement process, (*iii.*) defaults result in significant capital exposure for entities in the clearance and settlement chain, (*iv.*) managing defaults by market participants other than CCPs varies and may lack transparency, introducing additional, uncertain complexity into the settlement scheme [7]. These financial vulnerabilities render the entire ecosystem more susceptible to shocks; losses incurred by one participant can rapidly accumulate within the interconnected network [58].

Central bank market operations Central banks have comprehensive mandates that encompass an array of objectives, from the implementation of monetary policy to the preservation of payment systems. Each central bank establishes its own infrastructure and operational scheme dedicated to collateral and credit management. In particular, these standards[19] impose certain processes on institutions engaged in providing collateral or procuring liquidity [8].

Repo transactions are the primary instrument deployed by most central banks to control short-term interest rates and effectuate their monetary strategies. When a central bank intends to suppress interest rates, it purchases eligible collateral using a reverse repo, injecting cash into the banking system. In contrast, when a central bank sells assets with a repurchase agreement it drains cash reserves. U.S. Treasury bonds are the predominant form of collateral due to their creditworthiness and liquidity, however, settlement obligations for cash Treasury trades are not fungible (*i.e.*, delivery of a specific security is required) which introduces funding risk. Additionally, substantial gross volumes assume potential intraday and overnight exposure under certain scenarios [14]. For instance, if a participant maintains a long versus short, duration-weighted position, the associated closeout costs due to counterparty default may exceed the net valuation of the portfolio. Ultimately, the complex and interdependent nature of collateral operations underscores the complex functionality and associated risks of central banks in their management of monetary policy.

[18]For trades cleared bilaterally without inter-broker dealer involvement, the buyer and seller remain exposed to counterparty credit risk throughout t+0 and overnight into t+1 [14].

[19]Most regulatory frameworks accept cash, central government debt securities, and covered bonds; debt securities issued by credit institutions, corporate bonds, and asset-backed securities are accepted mainly in central bank frameworks; equities, bank guarantees, and gold are often acceptable for CCP margin collateral and for non-centrally cleared OTC derivatives [25][26].

3.2 Structural elements

Collateral-secured transactions encompass a broad range of size, duration, and frequency, involving an array of counterparties. As demonstrated, these models generally lack interoperability and exist autonomously—predominantly due to idiosyncratic risks of the collateral utilized within a transaction framework. The onerous task of assessing and segregating these risks is highly specific to each type of asset; inevitably this complexity precipitates cost and operational inefficiencies throughout the entire lifecycle of a secured transaction. Modern collateral management is implemented by analyzing its structural elements—the verification, perfection, and enforcement of collateral interests.

3.2.1 Asset verification

The creation of collateral or security interests within financial systems present diverse challenges accompanied by significant cost. For physical assets, comprehensive verification processes are required to ensure their existence, evaluate their condition, and determine their appraised market value. For intangible and dematerialized assets, additional verification measures are necessary to confirm their existence within designated accounts, often involving third-party custodians or government agencies. Measuring asset liquidity represents a crucial aspect of collateral management; the facility in which assets can be converted into cash is a primary determinant of collateral suitability. This complexity extends further due to the lack of universal consensus on what constitutes a high-quality asset. Moreover, the quality of collateral assets is subject to intertemporal variation due to market idiosyncrasies, shocks, or issuer dynamics. Unpredictability in market-wide conditions and exchange rates further compounds the challenges associated with collateral management, even for positions that are markedly overcollateralized [11].

The simplest form of securitization involves establishing an enforceable interest in an underlying asset. Successful securitizations are contingent on standardized and predictable collection rates derived from assets like mortgages, chattel paper, leases, and accounts receivable. However, in jurisdictions where the collection of loans or enforcement of liens is less formulaic, securitization offers only limited cross-border actuarial benefits. Verifying new forms of collateral is also complicated, as the risk assessment of proposed assets is necessarily comprehensive. Moreover, not all market participants possess an equal pricing capacity; information sensitivity becomes especially pronounced for speculative assets, as specialized counterparties may have disparate access to information. For example, credit claims and covered bank bonds are increasingly utilized as collateral, but the complexity involved in mobilizing credit claims depreciate their utility as a marketable asset class [30]. Ultimately, asset verification contraints severely diminish collateral fluidity and versatility.

3.2.2 Collateral perfection

Perfecting a security interest ensures that a lender has rights to collateral *vis-a-vis* other creditors and third-party purchasers according to a standard set of priority rules. The perfection process involves (*i.*) establishing a preferential claim (*e.g.*, filing a lien) and (*ii.*) demonstrating its existence. Security assets are typically registered within custodian accounts to ensure their traceability and facilitate the recognition of ownership rights.

An essential factor beyond identifying perfected collateral is discerning its degree of rehypothecation. The practice of collateral re-use is widespread, especially in margin accounts, which dramatically increases interdependence (*e.g.*, collateral chains) within financial markets. Rehypothecation also introduces uncertainties regarding the ultimate ownership and accessibility of collateral in the event of default. This was particularly evident during previous financial crises when investment banks employed off-balance sheet (*i.e.*, shadow banking[20]) securitizations to finance mortgages while hedging risk through off-balance sheet credit default swaps [55][57]. These conventional methods significantly impair collateral transparency—complicating collateral assessment and potential coordination among creditors. As a result, perfecting collateral is a dynamic process that often requires continuous monitoring of counterparty financials.

3.2.3 Enforcement and settlement

The conversion of collateral interests is non-trivial, requiring the seizure of assets and their subsequent liquidation. This contributes to a prolonged and expensive enforcement process—seizing the collateral is merely the initial phase of enforcing a security interest. For custody of digital balances, assets must be transferred to a compatible account, while tangible property often needs to be physically relocated. Following its acquisition, collateral must be sold in the secondary market, which frequently yields an abated recovery of proceeds due to immediate liquidity constraints and subsequent slippage. Moreover, legal procedures associated with enforcing collateral interests are subject to delays, increasing the risk of asset depreciation.

During stressful periods, cash investors are often reluctant or unprepared to take possession of collateral, preferring instead to withdraw funding if a counterparty is perceived as uncreditworthy. Further, once collateral is seized, its liquidation creates an expectancy of fire sales which can amplify and transmit systemic risk. Counterparties facing default may engage in preemptive asset sales to raise liquidity, prompting other investors to divest collateral and initiate broader sales. This vicious cycle raises concerns of contagion, and borrowers are compelled to liquidate holdings, precipitating a rapid devaluation of similar assets across other portfolios [41].

[20]Credit issuance by non-bank financial institutions (NBFIs) not subject to traditional banking regulations is estimated at over $50 trillion [28].

3.3 Limitations and inefficiencies

Secured credit transactions are invariably encumbered due to the restrictions of creating, perfecting, and enforcing an underlying collateral interest. These utilization processes are replete with systemic operational and financial inefficiencies which reduce resource transparency. Consequently, collateral quality assessment is limited, often with only discretionary reference to rehypothecation and varying debt seniority. Insufficient collateral standards constrain collateral fluidity and the ability to interchangeably capitalize assets between counterparties or jurisdictions. This lack of versatility often exposes collateral indirectly to alternative assets in unexpected ways, abstracting the correlation and accumulation of unintended exposures. The resulting leverage and liquidity risk incurred in this manner has far-reaching implications extending throughout the global economy.

4 Digital credit issuance

Prudential collateral management is critically valuable; facilitating efficient liquidity (*i.e.*, money) creation can directly reduce interest rates, stimulate investment, and foster increased productivity. Secured credit capitalizes the network of global commerce—the intrinsic role of collateral thereby accelerates the creation and velocity of money. Digital credit issued through a transparent and extensible process has the potential to enable faster, cheaper, and more efficient economic transactions.

4.1 Decentralized finance and assurance

Distributed networks uniquely allow for independent recording of state via open validator sets and distributed convergence mechanisms. By mitigating fraud and information asymmetry, these networks provide a model form of transaction assurance (*i.e.*, transaction authenticity), with trivial verification cost. A decentralized collateral protocol can secure financial transactions, granting all participants the ability to transparently verify diverse assets and their ancillary status. Analogous to its application in traditional finance, collateral has become the epicenter of the DeFi ecosystem—total value locked (TVL) serves as the primary metric for indexing the relevance of an application or settlement layer. Evolving from conventional financial products and services, DeFi facilitates a variety of applications such as money markets, derivatives, and exchanges. These products promote resilience and stability by utilizing smart contracts to transparently convey collateral operations (*i.e.*, verification, perfection, and settlement). Despite inevitable liquidations and market dislocations, premium DeFi platforms (*e.g.*, Compound, Aave) have demonstrated sound performance, absent in protocol debt, shortfalls, or loss mutualization—an unrealistic achievement for their centralized counterparts.

4.1.1 Collateral implications

Modern collateral management is complex, encompassing a diverse array of assets and counterparties. Ensuring intertemporal transparency is critical to alleviate many of the fundamental concerns in assessing quality collateral (*e.g.*, market constraints, actual utilization, and hypothecation). Moreover, as systems have digitized, interoperability deficits and incompatibility issues among asset types and perfection mechanisms have proliferated. Beyond the collateral prerequisites, the efficient operation of financial markets relies heavily on well-defined clearing and settlement processes which accommodate transactional heterogeneity. The emergence of new decentralized networks offers model platforms for these functionalities; leveraging open databases conclusively improves transparency for asset definition, ownership, and quality. Through standardized protocol interactions, assets and their consolidated state can be independently verified and administered with nominal expense.

Assets represented on an open and decentralized ledger are characterized by their verifiability, publicly discernible liquidity, and invariant accessibility. These features promote increased collateral versatility throughout global markets, circumventing the ambiguities associated with rehypothecation structures and shadow finance. The resulting capitalization persistently reduces systemic fragility and uncertainty, particularly in times of market stress. A DeFi primitive is requisite to record and replicate resource data, rendering collateral positions both interpretable and transmissible.

4.2 Anvil protocol

Anvil is a system of Ethereum-based smart contracts that manages collateral and issues fully secured credit. A primary example is a letter of credit (LOC), analogous to a paper bank cheque drawing verified funds, providing an economic guarantee of payment. A user deposits collateral assets (*e.g.*, WETH or USDT) into the Anvil vault contract (§5.1) to create a LOC for a credited asset amount (*i.e.*, the LOC value). The protocol supports LOCs issued by distinct accounts as well as multi-party collateral pools (§5.2). Individual LOCs expire at a specified time but are extendable by the creator indefinitely; pool-based LOCs are designed for perpetual duration with time-delayed withdrawals. There are no LOC creation or interest fees at the protocol level.

A LOC can only be redeemed or cancelled by the designated beneficiary account. The beneficiary generates a `releaseLOC` signature to expire the LOC or a `redeemLOC` signature to acquire the credited assets at a specified recipient address. This account can be a smart contract solely responsible for generating gasless signatures, authorizing redemption to separate accounts. To provide the credited asset upon a `redeemLOC` request, the protocol allows a LOC to be converted (§5.3.1) whereby collateral assets are exchanged for proportionate credited assets. Conversions are implemented in a method consistent with liquidation processes of prevailing money market platforms. A primary feature of the protocol is that beneficiaries never acquire or possesses the underlying collateral; credited assets are transferred *in specie* to the recipient address.

Anvil incorporates the governance model pioneered by Compound Labs and Open Zeppelin [12][50] (§5.4), with all protocol operations managed by the ANVL token. This framework ensures that the protocol parameters (*e.g.*, token support, limits, and collateral factors) are determined and supported via decentralized governance.

4.2.1 Transparency and composability

Anvil enhances collateral fluidity by removing ambiguities pertaining to the state of resources and their re-use, maintaining distinct LOCs for reserved assets. This configuration assures the effective provision of high-quality collateral, free of indefinite encumbrance, or credit enhancement. Once an asset is reserved within the Anvil vault, it cannot be transferred until the LOC is redeemed, released, or expired—eliminating risk of protocol default from rehypothecation.

Vault collateral functions are fully accessible to any third-party contract once authorized via the governance process. Decentralized governance also ensures conservatism in supported assets and their respective parameters, minimizing intermediary-induced information asymmetry costs (*i.e.*, specialization in assessment), and removing operational barriers associated with collateral types, particularly in cross-border utilization. This process ensures the safe overcollateralization of LOCs and circumvents the need for traditional counterparty risk assessment. Since collateral enforcement and settlement is not required, Anvil effectively abstracts credited assets from underlying collateral—only the LOC value is pertinent to the beneficiary. Through its continuous accessibility, the protocol also minimizes transactional risks due to operational inefficiencies or unavailability linked to borrowers and centralized counterparties. Clearing functions (*i.e.*, redemptions) are decentralized, absolving dependence on counterparties prone to operational obstructions (*e.g.*, delays resulting from software issues, legal review, or clerical errors). Asset conversions are market-based and occur in real time, superseding protracted offline procedures that conventionally span weeks or even months for appropriate asset disposition.

The entirety of LOC operations is fully transparent and publicly discernable. Anvil essentially serves as a comprehensive ledger of publicly hedged assets, removing risks intrinsic to both private and commercially-operated registry services. Decentralized governance strengthens collateral parameters and ensures liquidity, mitigating contagion risk and the rapid mark-downs of collateral assets. However, LOCs maintain their efficacy even during economic downturns, since counterparty creditworthiness is irrelevant—credited assets are sufficiently secured by senior perfection.

4.2.2 Secured credit primitive

Anvil is a unified protocol for asset provision, designed explicitly for safety, simplicity, and composability as a primitive building block in the development of other applications. This modularity can address the current limitations of DeFi collateral utilization which systematically isolates each protocol or consensus layer. For instance, assets secured within the Anvil vault may collateralize LOCs for non-automated acceptance across any application, irrespective of consensus mechanism. The vault operations for collateral pools may also function as a proxy validation strategy analogous to re-staking protocols. Efficiency may be derived further from inherently productive collateral, establishing a safe, endogenous, positive-yield approach to utilizing assets. This structure maximizes capital efficiency while mitigating security risks associated with dynamic collateral allocation (*e.g.*, providing assets to multiple smart contracts). Moreover, the basic primitive supports a diverse spectrum of use cases, ranging from crypto-specific operations to payments and even traditional finance.

Asset bridging Utilizing LOCs within smart contracts has the potential to facilitate immediate cross-platform transactions. If a bridge application—as a beneficiary—recognizes LOCs, assets can be issued on an alternate ledger prior to an input (*i.e.*, deposit) transaction reaching economic finality. This mechanism is particularly capital efficient for arbitrage since Anvil imposes neither initiation nor maintenance fees. LOCs can also secure deposit or withdrawal transactions on layer 2 (L2) implementations which often feature non-trivial consensus challenge periods. In instances where a platform integrates Anvil LOCs, immediate, on-demand asset transfers can be safely executed.

Counterparty credit Upon LOC creation, the beneficiary (*e.g.*, an individual or smart contract) can promptly credit an account balance on a protocol or exchange; assets are guaranteed to be transferred upon demand. LOCs can be accepted on centralized exchanges to secure instant deposits for immediate trading or more efficient liquidity provision. While a beneficiary exchange would have unrestricted claims to credited assets, collateral is publicly discernable to validate previous non-misappropriation of user assets. Additionally, external custody providers may utilize beneficiary multi-signature accounts to provide assurance against illegitimate claims.

Payments LOCs offer security for both online and in-store digital payment transactions. Given their extensible duration, LOCs can accommodate asset transfers that achieve economic finality either rapidly or over extended periods. Any tokenized asset can potentially be supported, providing integration flexibility for acceptance and compliance. Further, LOCs can serve as a more efficient method for collateralizing purchases on a credit-based payment network with subsequent batched settlement. Concurrently, passive vault assets can be effectively used to issue an array of collateralized stablecoin products for direct payments or augmenting protocol economics through inherent yield.

4.2.3 Further extensibility

The core protocol is designed with minimal features and a focus on composability for smart contract integration. Future development may include smart contracts to enable offchain collateral management and protocol interactions on behalf of other accounts (*e.g.*, traditional debit and credit cards). This provides a practical implementation of onchain credit issuance for individuals or groups, enabling user discretion in collateralizing their own transactions. Similarly, collateral re-staking to secure other smart contracts, protocols, or Anvil-issued stablecoins may be extended from the core vault contract. Generalizable LOC states may also be constructed as a custom non-fungible token to further support direct wallet integration and more efficient metadata consumption. Seamless cross-chain collateral management deployed natively on L2 networks is also of immediate consequence.

Market evolution A universal and composable collateral system offers immediate applications in both decentralized and traditional finance. The protocol is designed as a universal primitive to support any asset type, including tokenized real-world assets (RWA) and traditional collateral assets such as corporate bonds, equities, and government treasury bills—all currently issued on Ethereum Virtual Machine (EVM) compatible blockchains [10][63]. Moreover, international exchanges are actively trading tokenized equities, futures, and options; these advancements advocate the potential adoption of decentralized models within traditional capital markets. This evolution would complement the structure of foreign currency exchange (FX), the most liquid financial market in the world operating within an entirely decentralized market absent a physical existence, centralized ownership, or management [30]. This framework epitomizes a naturally efficient market, negating the need for fees and commissions associated with clearing houses or redundant operations. This model promotes a hybrid system, centralizing issuance while decentralizing verification and authorization processes. Such an approach will decrease data inconsistencies, eradicate centralized clearing, and compress aggregate transaction costs. Additionally, participants benefit from direct access to the primary market, facilitating earlier detections of systematic risks and potential counterparty failures. Within this context, Anvil can become a trustless primitive to secure traditional collateral transactions across any tokenized asset class.

5 Contracts

The Anvil protocol is designed as a minimum functionality primitive, prioritizing security, simplicity, and extensibility. Central to this framework is the modular `CollateralVault` contract which is responsible for storing and managing collateral assets.

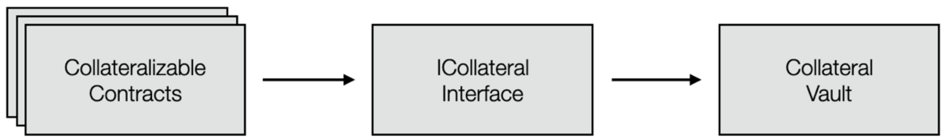

Figure 1: Anvil architecture

The ancillary `DelayedExitStakePool` and `LetterOfCredit` contracts issue secured credit by utilizing vault assets. For prescriptive security, the protocol architecture distinctly partitions collateral from the logic administering its access.

5.1 Collateral vault

The `CollateralVault` enables smart contracts to initiate secured credit transactions utilizing account deposits. The vault implements the `ICollateral` interface to expose collateral operations (*e.g.*, deposit, withdrawal, balance query, and contract approval). Accounts may invoke logic of an approved contract to call `CollateralVault` indirectly through the `ICollateral` interface [24].

Collateralizable permission For a contract to interact with `CollateralVault` on behalf of an account, it must be authorized by the respective account and the vault contract owner. If approval is revoked subsequent to collateral reservation, the contract transitions to a decrement-only state; the contract may then only claim or release assets.

Collateral reservation The vault maintains separate balances for available and reserved collateral associated with each account. The `reserveCollateral` method is used to generate a `CollateralReservation`, authorizing a collateralizable contract to claim designated assets. Once a reservation has been created, it may only be claimed, released, or modified by the origination contract. When `releaseCollateral` is called, the resources associated with a specific `CollateralReservation` are released, purging the corresponding reservation from the contract state. The function `modifyCollateralReservation` acts on an existing `CollateralReservation`, replicating the logic of `reserveCollateral` and `releaseCollateral` for increasing and decreasing collateral respectively. While the reserve, release, and modify operations regulate available and reserved balances, the total account collateral remains constant.

When `claimCollateral` is called: (*i.*) the requested portion of the reserved collateral is transferred to the beneficiary, (*ii.*) a protocol withdrawal fee is debited from the reserved collateral, (*iii.*) the reserved balance is decremented by the entirety of the reservation, (*iv.*) any surplus post-claim collateral reverts to the available balance, (*v.*) the `CollateralReservation` data is deleted from the contract state. The caller has discretion in denoting a partial claim; the reserved balance decreases by the aggregate of the liability, and the `CollateralReservation` state updates to reflect the residual reserved amount.

Collateral operations Collateral vault assets are limited to ERC-20 [21] tokens included within the `collateralTokens` list. Both `depositToAccount` and `withdraw` functions accept a destination address field for smart contract extensibility. Assets may be transferred between `CollateralVault` accounts without incurring protocol withdrawal fees by calling `transferCollateral`. This also enables `CollateralVault` accounts to pool assets for a mutual `CollateralReservation`; invoking the `poolCollateral` function consolidates assets within the contract balance (§5.2). When assets are subsequently released from a pool, the `transferCollateral` function returns assets to the respective account balance (§5.2.1).

Contract owner The `CollateralVault` contract extends the Ownable [51] contract module to facilitate the management of various parameters. It can be upgraded by authorizing the owner to manage accounts of `permittedCollateralUpgradeContracts` within the vault contract state. An account can invoke the `upgradeAccount` vault function to transfer collateral balances to whitelisted `permittedCollateralUpgradeContracts` addresses without incurring the vault withdrawal fee. To ensure backward protocol compatibility, every `permittedCollateralUpgradeContracts` must implement the `ICollateral` interface, validated via the ERC-165 [22] `supportsInterface` method.

Configurable fields The `CollateralVault` contract applies the `collateralTokens` list which comprises ERC-20 token addresses eligible for deposit. Each asset has a `maxUsedAsCollateral` constraint that is managed via governance. If a decrease in operational limits precipitates an account or the protocol to become non-compliant, a decrement-only state is enforced for that specific collateral asset until the aggregate limits are met. The `collateralizableContracts` list identifies contracts that are authorized to access the `ICollateral` interface of `CollateralVault`. The field `withdrawalFeeBasisPoints` denotes the fee associated with removing collateral from `CollateralVault`. For claimed collateral, the protocol uses the `withdrawalFeeBasisPoints` value at the time its `CollateralReservation`. The initialized value is `50` basis points, with a hard-coded `1000` maximum to deter exploitative governance scenarios.

The `permittedCollateralUpgradeContracts` list contains contracts to which available collateral balances can be migrated without incurring the `withdrawalFeeBasisPoints` fee. The contract owner has the authority to invoke `withdrawFromProtocolBalance` to remove non-account-associated balances to addresses specified by governance.

5.2 Time Based Collateral Pool (TBCP)

The `TimeBasedCollateralPool` enables assets from multiple accounts to be collectively pooled for mutual collateral reservations. Third parties may configure and deploy instances of the TBCP contract as required for intended credit operations.

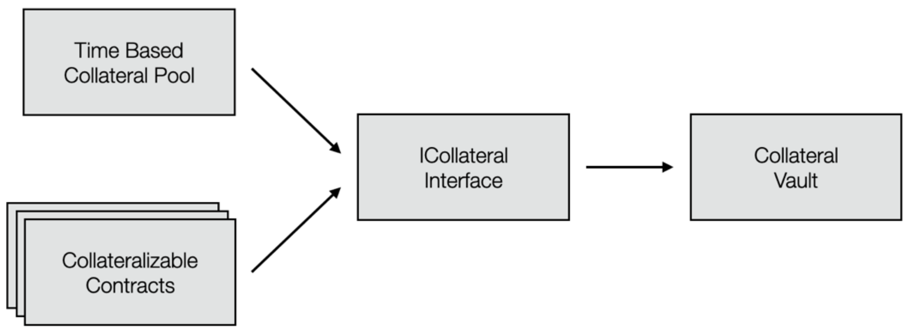

Figure 2: Time Based Collateral Pool architecture

An account supplies assets to a `Collateral Pool` and receives pool units proportional to its total balance. Pool units are associated with each account in the `TimeBasedCollateralPool` contract. To ensure predictable and efficient pool withdrawals, staked collateral is subject to time-based exit periods.

5.2.1 Supply operations

The `stake` function operates on `CollateralVault` account balances to allocate assets to a specified collateral pool. Similarly, the `unstake` operation permits an account to initiate the withdrawal process of supplied assets. Upon the completion of the unstaking process, tokens are disassociated (*i.e.*, not claimable) from the pool contract and `releaseEligibleTokens` may be called to release assets to the respective `CollateralVault` balance. Alternatively, `stakeReleasableTokensFrom` enables an account to directly convert disassociated assets into staked collateral within an alternative pool. Similar to the `LetterOfCredit` contract (§5.3), the beneficiary may call the `claim` function to receive any amount of supplied assets.

Pool units Within the contract state, pool units serve as an accounting mechanism to facilitate the management of supplied collateral. The amount of account-specific collateral within a pool is represented as: `accountUnits * poolTokens / totalPoolUnits`.

Unstake process Withdrawing staked assets from a pool requires a time-delay process to maintain stability and predictability. This process consists of: (*i.*) an account calls `unstake` to initiate the unstake period, (*ii.*) the unstake operation completes after the pre-determined time delay, (*iii.*) the account calls `releaseEligibleTokens` to transfer unstaked tokens to its `CollateralVault` balance or `stakeReleasableTokensFrom` for reallocation within an alternate pool.

The `TimeBasedCollateralPool` unstaking time delay provides assurance to beneficiaries that collateral is reserved over distinct time periods. If collateral providers indiscriminately remove pool assets, a beneficiary cannot assume collateral utility over any risk duration from time `T` to time `T + t`. To provide this certainty, accounts are required to provide withdrawal intent at least `t` prior to release; the period `t` is defined as a configurable `epoch` within the TBCP contract. All operations within `TimeBasedCollateralPool` are segmented into the epoch in which they occur, represented as a sequential integer initialized upon contract deployment.

Configurable Fields The `TimeBasedCollateralPool` contract requires `epoch` time period and the `ICollateral` contract address to be fixed on deployment. Default `claim` destination account, token-based `claim` destination account overrides, and administration members (*e.g.*, owner, claimant, and claim router) are all subsequently configurable.

5.3 Letter of Credit

Using the `CollateralVault`, the `LetterOfCredit` contract reserves collateral to issue a LOC, claims collateral upon LOC redemption, and releases collateral after a LOC expires.

The Anvil LOC comprises two elements: the collateral asset, which secures the LOC, and the credited asset, which represents its redeemable value. The protocol supports LOC issuance independent of the collateral and credit asset types. For instance, WETH may serve as the collateral for a LOC redeemable in WETH, USDT, or USDC. When both asset types match (*e.g.*, WETH/WETH) this case is defined as a converted LOC (cLOC). If the assets differ (*e.g.*, WETH/USDT) this is represented as an unconverted LOC (uLOC). Irrespective of the format, the critical aspect of every LOC is the inerrant redeemability of its full credited value. To mitigate potential market volatility all uLOCs require sufficient overcollateralization. Liquidity must be available for collateral-asset-to-credited-asset conversion, guaranteeing beneficiaries invariably receive the credited asset. The `LetterOfCredit` contract facilitates a proxy mechanism to convert the collateral assets under conditions of either impending under-collateralization or beneficiary redemption.

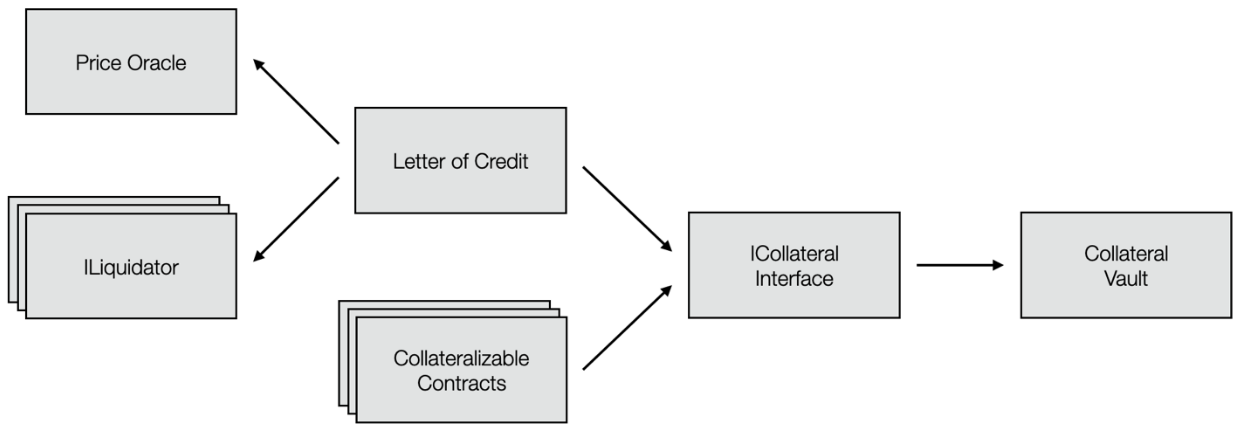

Figure 3: Letter of Credit architecture

The `LetterOfCredit` contract is responsible for LOC issuance and management, utilizing the `ICollateral` interface for collateral access. To support uLOCs, the contract leverages the `PriceOracle` for external price verification and the public `ILiquidator` interface to facilitate condition-based conversions. The `PriceOracle` provides `LetterOfCredit` with externally validated prices sourced from an offchain oracle. Onchain price update data is provided on demand for LOC operations, consuming an opaque array of bytes representing the oracle price update payload.

5.3.1 LOC operations

The `LetterOfCredit` contract exposes various functions to directly modify LOC states.

Create The `createLOC` function can be called by any account for which `LetterOfCredit` can successfully invoke the configured `ICollateral` contract `reserveCollateral` function. To issue a LOC the transaction must contain the collateral and credited asset values, the beneficiary address, and future expiration date. Modifiable protocol constraints pertain to collateral-credited asset pairs, limits, and expiry. For a uLOC, solvency is critical; the maximum allowable ratio between collateral and credited asset values (*i.e.*, collateral factor) is regulated pairwise. A risk factor is computed from the current credited-to-collateral value ratio, expressed as a percentage relative to the collateral factor. LOCs with higher risk factors have a greater possibility of liquidation. During uLOC creation, `PriceOracle` is queried for asset prices, providing updated values from transaction calldata to the oracle contract. Consequently, a uLOC creator must convey a valid offchain oracle price update for inclusion within the creation transaction. After a LOC has been created, it is redeemable for the credited value until it is released or reaches expiration.

Redeem To effectuate LOC redemption, the beneficiary may call `redeemLOC` and pass the specific LOC identifier and intended recipient address to the `LetterOfCredit` contract. For a cLOC, the credited asset is claimed from the `ICollateral` interface and transferred to the recipient address. The redemption sequence is identical for a uLOC, except that collateral assets first require conversion. Due to potential operational or security efficiencies, a beneficiary may publish an authorization signature to allow external accounts to proxy LOC redemption. For partial LOC redemption, a custom asset amount can be specified when calling the `redeemLOC` function. In instances of partial redemption, both collateral and credited asset balances are decremented proportionally; if conversion is not required, only the requisite collateral facilitating the redemption and withdrawal fee is used.

Cancel When `cancelLOC` is successfully called the corresponding LOC becomes invalid, removing its collateral reservation. In the case of an unconverted LOC, the `LetterOfCredit` contract utilizes `ICollateral` to invoke `releaseAllCollateral`. If the LOC was previously converted, the credited amount is transferred directly to the LOC creator since assets were already removed from the `CollateralVault`.

Extend An account may prefer to extend the duration of an existing LOC rather than allowing it to expire. The function `extendLOC` is callable by the LOC creator to submit an expiration date that surpasses the existing record, provided it does not exceed the `maxLocDurationSeconds` limit.

Modify The prevailing exchange rate between the collateral and credited assets can fluctuate significantly. The LOC creator may be inclined to supply additional collateral to mitigate conversion risk or withdraw collateral for more efficient asset utilization. To realize these adjustments, the creator may call `modifyLOCCollateral`, provided the consequent risk factor remains within `LetterOfCredit` limits.

Convert The `convertLOC` function translates active uLOCs into cLOCs. This method may be invoked by the LOC creator to mitigate future exchange risk and return residual collateral. It may also be called publicly if the LOC risk factor meets or exceeds the collateral factor (*i.e.*, the LOC is convertible). It is critical to ensure solvency in this scenario—collateral assets must be promptly converted into credited assets. The `LetterOfCredit` contract performs the following conversion sequence: (*i.*) refreshes the `PriceOracle` using the provided update and computes the proportionate collateral asset necessary for conversion (*ii.*) claims the requisite collateral from the `ICollateral` interface while simultaneously releasing any remainder, (*iii.*) accepts the collateral in lieu of the credited assets, (*iv.*) updates the LOC state to converted. When a uLOC is converted, the credited assets are retained within the LOC contract pending their release or redemption. Within this process, the liquidator acts as an exchange interface, supplying the credited assets to the `LetterOfCredit` contract as replacement for the collateral assets. To ensure real-time conversion of LOCs, incentive premia are set by governance to maintain protocol stability. For example, with a `5%` incentive, the liquidator can remove collateral equivalent to `105%` of credited asset value from the `LetterOfCredit` contract. Providing a valid `ILiquidator` to the `convertLOC` function is not required, since the caller is allowed to perform the liquidation itself. In this instance the account approves the `LetterOfCredit` contract to transfer the credited asset and assigns `address(0)` to the `ILiquidator` parameter. Subsequently, the `convertLOC` function swaps the collateral and credited assets with the caller.

Signature-based execution The public functions `convertLOC`, `redeemLOC`, and `releaseLOC` may be invoked when provided cryptographic authorization. For example, the LOC creator is permitted to sign a gasless authorization payload and disseminate it to third parties for execution. The corresponding liquidator incentive ensures the invocation of these public functions upon receipt of a valid signature hash. The required value is the structured data hash signature of the populated struct by the account authorized to call the function [23].

Contract owner The `LetterOfCredit` contract also extends the Ownable contract to administer contract parameters. Although the owner can modify configurable fields, the `LetterOfCredit` contract is non-upgradeable, ensuring unaltered contract logic and LOC structure. An upgraded version of the `LetterOfCredit` contract—or any other type of collateralizable contract—may ultimately be deployed to utilize the `CollateralVault` through the `ICollateral` interface subject to governance approval. Additionally, for long-term optionality the `PriceOracle` contract may be upgraded through the standard governance process.

Configurable Fields LOC operation events require an oracle price update with the parameter `maxPriceUpdateSecondsAgo` restricting the allowable period. The `maxLocDurationSeconds` field sets the maximum duration of an active LOC from its creation or extension. Collateral and credited asset pairs are indexed via `assetPairCollateralFactors`; both the collateral factor and liquidation incentives are configurable. The collateral factor and liquidator incentive are applied upon LOC creation; any subsequent updates to `assetPairCollateralFactors` do not affect existing LOCs.

Supported assets for `LetterOfCredit` are maintained within `creditedTokens`, which also configures `globalMaxInUse` for each credited asset.

5.4 Governance

Anvil has adopted the OpenZeppelin Governor [50] contracts to manage `CollateralVault`, `TimeBasedCollateralPool`, and `LetterOfCredit` contracts. All contracts are deployed with configurable parameters, allowing prudential adjustments as additional market data becomes available to ensure protocol safety. Voting control of all updates and modifications will be administered using the ANVL token.

6 Summary

Background

- Money originated as an abstract *measure* of value in order to settle debts
- Money is discernably not a commodity but merely an accounting tool
- Money is a socio-economic construct—a *credit* constituted by social relationships
- Credit issuance and its derivatives account for the second largest global financial market
- Collateral is the basis for credit issuance and the subsequent creation of money
- The verification, perfection, and enforcement of security interests are complex and costly
- Collateral utilization is limited and inefficient due to lack of structural transparency

Anvil

- Collateral is the foundational component of *both* traditional finance and DeFi
- DeFi provides transparency to verify assets and their condition (*e.g.*, encumbrances)
- DeFi removes collateral management complexity (*e.g.*, rehypothecation uncertainty)
- Anvil is a Ethereum-based protocol designed for composability and extensibility
- Anvil is analogous to a protocol bank that issues secured credit (*i.e.*, money)
- A letter of credit (LOC) is a payment mechanism that provides economic assurance
- Anvil issues variable duration LOCs that guarantee credited assets on demand
- Third parties can deploy time based collateral pools for large-scale transaction assurance
- Anvil LOCs have no creation, maintenance, or interest fees
- Creditors do not take ownership of collateral and are unexposed to liquidation
- Only the LOC value is relevant to beneficiaries, base collateral is effectively abstracted
- Anvil can enable instant token bridging, CEX deposits, and payments
- Yield-generating collateral assets provide a safe positive-return approach to utilization
- Anvil ultimately provides safe, efficient, and versatile collateral utilization
- Protocol governance is performed by the ANVL token

7 References

[1] T. Adrian, B. Begalle, A. Copeland, A. Martin. Repo and Securities Lending. *Federal Reserve Bank of New York* 529, 2011.

[2] S. Bell. The Role of The State and the Hierarchy of Money. *Cambridge Journal of Economics*, 149-163, 2001.

[3] S. Bell, J. Henry. Hospitality versus Exchange: The Limits of Monetary Economies. *Review of Social Economy*, 203-226, 2001.

[4] E. Bleiberg. The Economy of Ancient Egypt. *Civilizations of the Ancient Near East* 3, 1373-1385, 1995.

[5] S. Bond. The Coinage of the Early Roman Empire. *Greece & Rome* 4, 149-159, 1957.

[6] M. Bordo. Money, Deflation and Seigniorage in the Fifteenth Century. *Journal of Monetary Economics* 18, 1983.

[7] D. Bowman, J. Louria, M. McCormick, M. Styczynsk. The Cleared Bilateral Repo Market and Proposed Repo Benchmark Rates. *FEDS Notes*, 2017.

[8] W. Buiter, A. Sibert. How the Eurosystem's Treatment of Collateral in its Open Market Operations Weakens Fiscal Discipline in the Eurozone. *In Fiscal Policy and the Road to the Euro*, 29-60, 2006.

[9] C. Cipolla. Currency Depreciation in Medieval Europe. *The Economic History Review* 15, 413-422, 1963.

[10] Citi Global Perspectives and Solutions. Money, Tokens, and Games. https://ir.citi.com/gps.

[11] S. Claessens, H. Tong, I. Zuccardi. Did The Euro Crisis Affect Non-Financial Firm Stock Prices Through a Financial or Trade Channel? *IMF Working Paper* 11, 227, 2011.

[12] Compound Labs. The Money Market Protocol. https://compound.finance/documents/Compound.Whitepaper.pdf.

[13] A. Copeland, D. Duffie, A. Martin, S. McLaughlin. Key Mechanics of the U.S. Tri-Party Repo Market. *FRBNY Economic Policy Review* 18, 2012.

[14] A. Copeland, I. Davis, E. LeSueur, A. Martin. Lifting the Veil on the U.S. Bilateral Repo Market. *Federal Reserve Bank of New York*, 2014.

[15] J. Curtis, W. Hallo. Money and Merchants in Ur III. *Hebrew Union College Annual* 30, 103-139, 1959.

[16] M. Dandamaev. Wages and Prices in Babylonia in the 6th and 5th Centuries. *Altorientalische Forschungen* 15, 53-58, 1988.

[17] G. Davies. A History of Money. *University of Wales Press*, 2002.

[18] M. DeCecco, Monetary Theory and Roman History. *The Journal of Economic History* 45, 809-822, 1985.

[19] W. Dubberstein. Comparative Prices in Later Babylonia (625-400 B.C.). *American Journal of Semitic Languages* 56, 20-43, 1939.

[20] P. Einzig. Primitive Money in its Ethnological, Historical, and Economic Aspects. *Oxford*, 1966.

[21] Ethereum Improvement Proposal 20: ERC20 Token Standard. https://eips.ethereum.org/EIPS/eip-20.

[22] Ethereum Improvement Proposal 165: Standard Interface Detection. https://eips.ethereum.org/EIPS/eip-165.

[23] Ethereum Improvement Proposal 712: Typed Structured Data Hashing and Signing. https://eips.ethereum.org/EIPS/eip-712.

[24] Ethereum Improvement Proposal 1820: Pseudo-introspection Registry Contract. https://eips.ethereum.org/EIPS/eip-1820.

[25] European Central Bank. Eligible Assets for EU Banking. https://www.ecb.europa.eu/paym/coll/assets/html/index.en.html.

[26] European Central Bank. Collateral Eligibility Requirements. https://www.ecb.europa.eu/pub/pdf/other/collateralframeworksen.pdf.

[27] M. Fleming, K. Garbade. The Repurchase Agreement Refined: GCF Repo. *Current Issues in Economics and Finance* 9, 2003.

[28] Financial Stability Board. Shadow Banking: Strengthening Oversight and Regulation. https://www.fsb.org/wp-content/uploads/r_111027a.pdf.

[29] O. Goelet. Fiscal Renewal in Ancient Egypt: Its Language, Symbols, and Metaphors. *Debt and Economic Renewal in the Ancient Near East*, 277-307, 2002.

[30] C. Goodhart. The Two Concepts of Money: Implications for the Analysis of Optimal Currency Areas. *European Journal of Political Economy* 14, 407-432, 1998.

[31] D. Graeber. Debt: The First 5,000 Years. *Melville House*, 2012.

[32] P. Grierson. The Debasement of the Bezant in the Eleventh Century. *Byzantinische Zeitschrift* 47, 379-394, 1954.

[33] J. Henry. The Social Origins of Money: The Case of Egypt. *Department of Economics California State University*, 2004.

[34] C. Humphrey. Barter, Exchange and Value: An Anthropological Approach. *Cambridge University Press*, 1992.

[35] G. Ingham. Money is a Social Relation. *Review of Social Economy* 54, 243- 275, 1996.

[36] A. Innes. What is Money? *The Banking Law Journal* 30, 377-408, 1913.

[37] A. Innes. The Credit Theory of Money. *The Banking Law Journal* 31, 151-168, 1914.

[38] International Monetary Fund. World Economic Outlook Update. https://www.imf.org/en/Publications/WEO/Issues.

[39] Investment Company Institute. Money Market Fund Assets. https://www.ici.org/research/stats/mmf.

[40] C. Kaplanis. The Debasement of the Dollar of the Middle Ages. *The Journal of Economic History* 63, 768-801, 2003.

[41] A. Koch, S. Ruenzi, L. Starks. Commonality in Liquidity: A Demand-Side Explanation. *The Review of Financial Studies* 29(8), 1943–1974, 2016.

[42] F. Keane. Securities Loans Collateralized by Cash: Reinvestment Risk, Run Risk, and Incentive Issues. *Federal Reserve Bank of New York Current Issues* 19, 2013.

[43] G. Knapp. The State Theory of Money. *Macmillan*, 1924.

[44] L. Kurke. Coins, Bodies, Games, and Gold: The Politics of Meaning in Archaic 16 Greece. *Princeton University Press*, 1999.

[45] R. Lauko, R. Pardoe. Liquity: Decentralized Borrowing Protocol. https://docs.liquity.org/documentation/resources.

[46] R. Lopez. The Dollar of the Middle Ages. *The Journal of Economic History* 11, 209-234, 1951.

[47] Maker DAO. The Maker Protocol: MakerDAO's Multi-Collateral Dai (MCD) System. https://makerdao.com/en/whitepaper.

[48] K. Menger. On the Origin of Money. *Economic Journal* 2, 239-55, 1982.

[49] P. Onge. How Paper Money Led to the Mongol Conquest: Money and the Collapse of Song. *The Independent Review* 22, 223-243, 2017.

[50] Open Zeppelin. Governance Contract. https://docs.openzeppelin.com/contracts/4.x/api/governance.

[51] Open Zeppelin. Ownable Contact. https://github.com/OpenZeppelin/openzeppelin-contracts/access/Ownable.sol.

[52] J. Pickering. The History of Paper Money in China. *Journal of the American Oriental Society* 1, 136-142, 1844.

[53] M. Powell. Identification and Interpretation of Long-Term Price Fluctuations in Babylonia: More on the History of Money in Mesopotamia. *Altorientalis Forschungen* 17, 76-99, 1990.

[54] M. Powell. Money in Mesopotamia. *Journal of the Economic and Social History of the Orient* 39, 224-242 ,1996.

[55] Z. Pozsar. Shadow Banking: The Money View. *Office of Financial Research* 14, 4, 2014.

[56] M. Roe. The Derivatives Market's Payment Priorities as Financial Crisis Accelerator. *Stanford Law Review* 63, 539, 2011.

[57] M. Singh, J. Aitken. The Role of Rehypothecation in the Shadow Banking System. *International Monetary Fund Working Paper* 10, 172, 2010.

[58] Office of Financial Research. Non-Centrally Cleared Bilateral Repo. https://www.financialresearch.gov/the-ofr-blog.

[59] S. Smith. A Pre-Greek Coinage in the Near East. *Numismatic Chronicle* 5(2), 176-185, 1922.

[60] P. Spufford. Money and its Use in Medieval Europe. *Cambridge University Press*, 1988.

[61] Securities Industry and Financial Markets Association. Asset Backed Securities Statistics. https://www.sifma.org/resources/research/us-asset-backed-securities-statistics.

[62] D. Shotter. Coinage in Roman Imperial Policy. *Greece & Rome* 25, 156-168, 1978.

[63] Siemens. Press Release: Siemens Issues First Digital Bond on Blockchain. https://press.siemens.com/pressrelease/siemens-issues-first-digital-bond-blockchain.

[64] J. Smithin. What is Money? *Routledge*, 2000.

[65] D. Snell. Ledgers and Prices: Early Mesopotamian Merchant Accounts, *Yale Eastern Research* 8, 1982.

[66] R. Sweet. On Prices, Moneys, and Money Uses in the Old Babylonian Period. *University of Chicago*, 1958.

[67] N. Szabo. Bit Gold: Towards Trust-Independent Digital Money. http://szabo.best.vwh.net/bitgold.html.

[68] Tether Limited. Tether: Fiat Currencies on the Bitcoin Blockchain. https://tether.to/en/whitepaper.

[69] G. Thomson. Studies in Ancient Greek Society: The Prehistoric Aegean. *Citadel Press*, 1949.

[70] A. Vasiliev. History of the Byzantine Empire. *Blackwell*, 1952.

[71] A. Wallace. Image and Authority in the Coinage of Augustus. *The Journal of Roman Studies* 76, 66-87, 1986.

[72] R. Wallace. The Origin of Electrum Coinage. *American Journal of Archaeology* 91, 385-397, 1987.

[73] O. Zervos, M. Jessop. The Earliest Coins of Alexander the Great. *The Numismatic Chronicle*, 166-190, 1982.