Gearbox

Generalized Leverage Protocol

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Abstract

Gearbox aims to enhance capital efficiency in DeFi with the introduction of Credit Accounts - a new primitive for leveraged interactions with other DeFi protocols. Credit Accounts are isolated smart contracts with specific whitelisted actions and assets. Such an architecture ensures a higher degree safety of both the user funds and the borrowed funds per account, through liquidation of a user's Credit Account portfolio under a certain health factor threshold. Overall, Gearbox provides users and DeFi protocols access to leverage, which could be applied to margin trading, leveraged farming, leveraged CDPs, and many other financial instruments.

1 Introduction

DeFi space has been growing at an incredible rate with the TVL reaching 136 bln USD [1]-[2] and Metamask user base reaching 5M monthly active users [3]. And while one of the premises of DeFi is to be as composable as possible, there are still a lot of idle assets in the protocols and unutilized capital. Not only that, but user-side over-collateralization is a huge bottleneck for capital efficiency, which is why many have been looking at credit facilitation to enable undercollateralized loans [4] [5].

Gearbox enables leveraged interactions with external DeFi protocols in a composable manner. Instead of going for credit scoring and reputation systems, Gearbox introduces Credit Accounts - a new DeFi primitive which allows users to execute financial orders without accessing funds on it, such as that account acts as collateral for different leveraged operations.

It can be thought of as similar to a centralized exchange where users may borrow funds for margin trading within the platform, but with the exception that Gearbox protocol does so in a fully composable manner and functions cross-platform. The leverage made available to users could be utilized across DeFi applications, be it farming on Curve and Aave, trading on Uniswap and Sushiswap, options on Opyn, Hegic, Oiler, and other platforms; as well as other interactions based on the allowed list [6] [7].

We would like to note that there are a number of great projects working on the market. Alpha Homora's leveraged farming has achieved $600mln in TVL enabling up to 9x leverage [8]. Meanwhile, Iron Bank has reached $823mln in TVL and is now integrated in Yearn, Alpha Homora [9],[10]. Recently launched Kashi by Sushiswap is attempting to enable margin trading too, but in a siloed manner. dYdX and Perpetual Protocol [11] also enabled leveraged trading, facilitating over $57M [12] and $200M [13] daily volume respectively just months after their launch.

While dYdX lets you leverage trade and Alpha Homora lets you leverage farm, Gearbox let's you leverage-interact with any whitelisted protocol. Through a generalized primitive, Gearbox allows margin trading, lending, farming, and anything else you can do on any other protocol. So to draw the difference, the interactions through Gearbox are also related to margin, but they happen across protocols in a composable manner [16], rather than in siloed pools or AMMs.

2 Credit Account as a new DeFi primitive

A Credit Account is a new DeFi primitive which allows users to perform leveraged interactions with any whitelisted DeFi protocol. It's made possible by holding user funds and margin funds (borrowed) on an isolated smart contract, which can execute whitelisted user operations but don't provide direct access to funds on the Credit Account itself.

This opens up an opportunity for users to get leverage, keeping the overall funds on Credit Accounts, and allowing them to perform interactions with different DeFi protocols while debt is secured by the total funds on the Credit Account.

2.1 Credit Account as collateral

As mentioned above, funds held on Credit Accounts are used as collateral for the debt, and users can operate these funds by sending financial orders to Credit Accounts. To mitigate possible risks, operations available to users are restricted by two policies:

- **Allowed contracts list**. Users can interact through Credit Accounts only with contracts from this list to mitigate risks that funds will be sent to vulnerable smart contracts.
- **Allowed tokens list**. This allows managing risks of swapping funds to highly-volatile assets whose price could drastically fall after a swap and before a liquidation would take place.

Both policies are managed by governance.

2.2 Balance sheet

Let's consider Credit Account's holdings as a balance sheet: on the asset side it keeps allowed tokens, and on the liability side it keeps initial user funds and borrowed funds.

Each Credit Account has an underlying (borrowed) asset denomination. Once opened, it can't be changed. For example, a DAI-denominated Credit Account always stays in DAI, and the same goes for any other asset. The ratios of assets traded into can be calculated by converting these assets on an account to the underlying denominated one. As such, all actions performed within one Credit Account can be seen as a cross-margin position, while interactions between different Credit Accounts can be classified as isolated margin.

Total value represents the Credit Account's balance in the underlying asset.

$$TV(t) = \sum c_i(t) * p_i(t), \tag{1}$$

where c_i - balance of i-th asset in Credit Account, p_i - price of i-th asset calculated in underlying asset from price oracle.

On the other side, a Credit Account has liabilities which are equal to the sum of borrowed amount $b(t)$, interest accrued $b_I(t)$ and initial funds. The debt is secured while

$$TV(t) > b(t) + b_I(t) + f(t), \tag{2}$$

where $f(t)$ is fees paid to protocol.

2.3 Portfolio quality and health factor

In the previous section we demonstrated a simple equation (2) to understand if the loan is secured or not. But a liquidation on the blockchain takes time, so we need a buffer between total value and liabilities, to make sure that protocol is overcollateralized even in a case of drastic price drops. To ensure this gap **Threshold weighted value** is used:

$$TWV(t) = \sum c_i(t) * p_i(t) * LT_i, \tag{3}$$

where LT_i - liquidation threshold, the constant showing the maximum allowable ratio of Loan-To-Value for the i-th asset. There LT_i can be imagined as a reciprocal of the overcollateralization ratio for the i-th asset. Liquidation threshold depends on volatility of i-th assets priced in underlying assets: the higher volatility, the less value LT has. Also it is necessary to notice that protocol calculates LT for underlying asset by formula

$$LT_U = 100\% - l_p - f_l, \tag{4}$$

where l_p - liquidation premium, f_l - liquidation fee.

The determination of the correct parameters for liquidity thresholds and defining and correct assessment of market risk are crutial for the robustness of protocol - these decisions should be made by governance. Fortunately, similar credit risk assessment techniques are already used in various lending protocols and we can draw on their experience [17], [18].

TWV later is used to understand the quality of Credit Accounts portfolio (or **Health factor**):

$$H_f(t) = \frac{TWV(t)}{b(t) + b_I(t)}, \tag{5}$$

Credit Accounts can be liquidated if $H_f < 1$. More details of how liquidation works will be provided in the Liquidation section.

2.4 Repaying debt

There are two possible options to close a Credit Account. The first option is to repay the debt D and withdraw all funds from the Credit Account to the user's wallet.

$$D(t) = b(t) + b_I(t) + A_f(t) \tag{6}$$

Another option is to close the Credit Account. In this case, all assets will be converted to the underlying asset using the default swap protocol. These funds are used to repay debt $D(t)$ while all remaining funds are returned to the user. Closing a Credit Account is not permitted if $TV(t) < b(t) + b_I(t) + A_f(t)$.

2.5 Liquidation

If the health factor H_f falls below 1, a Credit Account can be liquidated by anyone. In this case, liquidator pays

$$A_l(t) = TV(t) * (1 - l_p) \tag{7}$$

and the protocol transfers all assets from the Credit Account to the liquidator account. The amount of funds returned to the pool after a liquidation is calculated as

$$A_p(t) = \min\{A_l(t), b(t) + b_I(t) + f_l(t)\}, \tag{8}$$

where the liquidation fee f_l is calculated as (12).

All funds remaining after this operation are returned to Credit Account's owner:

$$R(t) = \max\{0, A_l(t) - A_p(t)\}. \tag{9}$$

So, we can get PnL from protocol's point of view:

$$PnL(t) = A_p(t) - b(t) - b_I(t). \tag{10}$$

If $PnL > 0$ protocol and liquidity providers earn money, the protocol mints additional LP tokens and sends them to the Treasury. Otherwise, the protocol uses the Treasury's funds as an Insurance pool to protect LPs from losses (details in next sections).

2.6 Protocol fees

Gearbox charges protocol fees on the following operations:

- if the Credit Account is closed by the user, the spread between borrow rate and deposit rate is accrued to the protocol treasury:

  $$A_f(t) = (TV(t) - b(t) - b_I(t))f_p + b_I(t)f_s, \tag{11}$$

  where f_s - share of accrued interest, f_p success fee.

- if Credit Account is liquidated, the protocol accrues a liquidation fee, calculated as

  $$f_l(t) = TV(t)\tilde{f}_l, \tag{12}$$

  where $\tilde{f}_l$ is liquidation fee constant.

These fees will be collected to the Treasury. All constants are defined by governance.

2.7 Debt management

Gearbox protocol provides 3 options to manage debt: increase collateral size by transferring money directly to Credit Accounts, increase borrowing amount and repay loan (last one will be described in Pools section).

Users can borrow funds from the pool (increase borrow amount), if after this transaction, his $H_f \geq H_{fmin}$, which represents the lowest bound allowed for increased borrowing. H_{fmin} equals H_f which is set at opening Credit Account with max allowed leverage factor L_{max}:

$$H_{fmin} = LT_U * \frac{L_{max} + 1}{L_{max}} \tag{13}$$

To compute maximum amount which can be borrowed at t, you can use following formula:

$$db_{max}(t) = (b(t) + b_I(t))\frac{H_f(t) - H_{fmin}}{H_{fmin} - LT_U}. \tag{14}$$

3 Pools

Capital is required to provide margin to Credit Accounts. Therefore, there are Liquidity Pools: anyone can become a liquidity provider by depositing funds in the Liquidity Pool. In the future, Gearbox could even pull funds from other lending platforms instead of acting as an isolated liquidity pool, thus increasing capital efficiency and composability in DeFi.

Gearbox uses approach taken in DeFi lending protocols for building its Pools [14], [15], where the interest rate provided to LPs depends on the pool utilization ratio - the higher the utilization, the higher interest rate.

3.1 Interest rate model

It is important to note that the borrow rate in a pool depends on the pool utilisation parameter and is computed independently. It uses a linear interest rate model, similar to Aave's methodology.

To calculate the pool's logic, we use expected liquidity $EL(t)$ (the amount of money which should be in the pool if all users close their Credit Accounts and return debt) and cumulative index $CI(t)$ (which is an aggregated variable that shows the value of borrowed money) variables. They are calculated as

$$EL(t_n) = EL(t_{n-1}) + B(t_{n-1})r(t_{n-1})(t_n - t_{n-1}), \tag{15}$$

$$CI(t_n) = CI(t_{n-1})(1 + r(t_{n-1})(t_n - t_{n-1})), \tag{16}$$

where $B(t)$ represents total borrowed amount without accrued interest rate, $B(t) = \sum b_j$, $r(t)$ is the borrow rate paid by borrowers, t_n - current timestamp, t_{n-1} - timestamp of last borrow rate update.

Later $EL(t)$ is used to calculate borrow rate as

$$r(t) = \begin{cases} r_0 + \frac{B(t)+B_I(t)}{U_* EL(t)}\left(r_1 - r_0\right), & B(t) + B_I(t) \leq U_* EL(t) \\ r_1 + \left(\frac{B(t)+B_I(t)}{EL(t)} - U_*\right)\frac{r_2 - r_1}{1-U_*}, & B(t) + B_I(t) > U_* EL(t), \end{cases} \tag{17}$$

where $r_0,\ r_1,\ r_2,\ U_*$ are constants defined by governance.

3.2 Liquidity providing and Diesel(LP) tokens

LP tokens in Gearbox protocol are called Diesel tokens. Diesel token holders accrue interest by providing capital to Credit Accounts, which in turn act as borrowers. Diesel tokens are ERC20 token standard and provide composability features to LPs. The Diesel rate is the internal rate for diesel tokens which is used to mint or burn them. It is calculated as

$$d(t) = \begin{cases} \frac{EL(t)}{ds(t)}, & \text{if diesel supply } ds(t) > 0 \\ 1, & \text{otherwise.} \end{cases} \tag{18}$$

Every time someone adds liquidity to the pool, it mints L/d diesel tokens (LP tokens) and returns them to the liquidity provider. There L is the amount of provided liquidity, d - current diesel rate.

And vice versa, when liquidity provider wants to remove liquidity, they send A_{LP} diesel tokens to pool (which are burned by the pool) and get

$$\frac{A_{LP} EL(t_n)}{ds(t_n)} \tag{19}$$

underlying tokens.

3.3 Repaying debt and collecting fees

When a Credit Account is repaid, the protocol calculates resulting profit and loss from borrowing as $PnL = b_r - b - b_I$, where b_r - returned funds, b_I - interest paid. Then the pool's borrowed amount is updated as $B(t_n) = B(t_{n-1}) - b_r$. Let $PnL \geq 0$. This case means that the returned value is more than the borrowed amount plus interest accrued. Interest accrued is already included in expected liquidity. At this point, the protocol keeps all funds in the pool

$$EL(t_n) = EL(t_{n-1}) + PnL \tag{20}$$

and mints $\frac{PnL}{d(t_n)}$ diesel tokens to the treasury fund.

3.4 Pool insurance

Gearbox's Treasury accrues fees in LP tokens as described in the previous section. This has several outcomes:

- Increases capital lent out in the protocol, as the protocol keeps its own funds in pools too
- Treasury funds earn interest
- Treasury funds can be used as an automatic insurance pool with the goal of covering black swan events (details in next paragraph)

To clarify the last point, let's consider a case when a Credit Account is closed with negative PnL. This would mean that a Credit Account does not have enough funds to repay the debt + interest (late liquidation due to drastic price drop, ethereum network congestion, etc). These cases are very rare, but a known case is the March 2020 MKR issue with keepers where the system became undercollateralized. In such cases, the pool automatically uses treasury funds as insurance and burns diesel tokens to keep diesel rate on the same level.

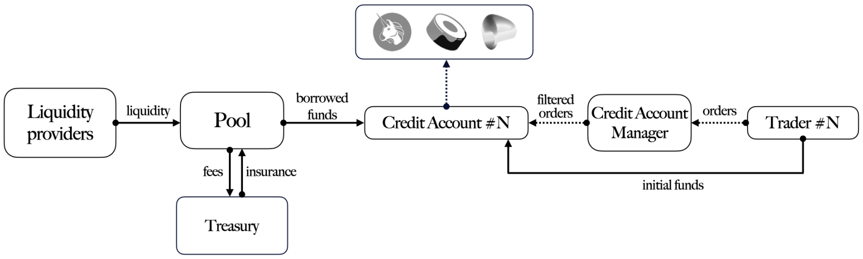
$$dTB = \min\left(TB, \frac{|PnL|}{d(t_n)}\right), \tag{21}$$

where TB - treasury balance.

This design keeps diesel token rate on the same level in the cases where portfolio value falls below debt size. Governance can make the decision to swap Diesel tokens to underlying assets, decreasing exposure of accrued protocol fees to insurance.

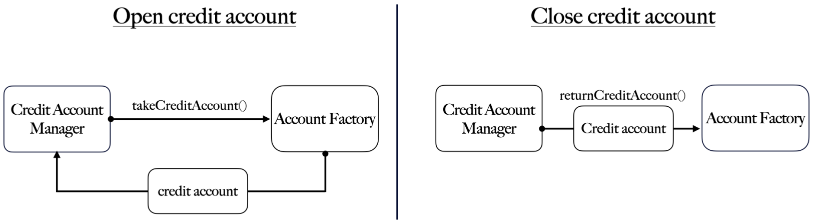
4 Implementation

Gearbox protocol has a flexible, adaptable, and scalable architecture. The core business logic is encapsulated in the core layer which supports operations for both protocol sides. It allows connecting customized pools with Credit Account managers without changing the internal codebase, and thus simplifying the integration process.



4.1 Reusable Credit Accounts

Reusable Credit Accounts are an innovative technology that makes Gearbox gas-efficient and reduce economic sense for hacker attacks. Credit accounts act as isolated smart-contracts that eliminate multiple overhead operations of keeping and updating internal user's balances. It creates minimal overhead for market operations (i.e. swapping on Uniswap). Isolated smart-contract usage requires huge deployment costs from the user and usually creates newcomer barriers. In Gearbox, users "rent" deployed Credit Account contracts from Account Factory, use them and then return.



Each time a user opens a Credit Account, the protocol takes a pre-deployed Credit Account smart contract from the Account Factory. When a user closes a Credit Account, the protocol returns it to the Account Factory and can reuse it. If the Account Factory has no pre-deployed contracts and a user opens a new Credit Account the protocol covers the deployment costs in the same transaction.

4.2 Integrations

The goal of Gearbox is to be integrated with existing and new protocols in an open source manner and provide leverage across many user bases. The architecture allows integration on both sides, both by protocols that are interested in granting leveraged access to their operations as well as by protocols that could provide supply-side lending liquidity like Aave, Compound, etc.

The integration process looks pretty simple: it is required to inherit an abstract contract (Credit Account Manager or Pool) and add specific business logic with set parameters. To be integrated with deployed contracts, the integration should be approved by Gearbox DAO.

Simple integration processes open up new opportunities for collaborations with other protocols, providing leverage to their operations and making Gearbox protocol composable. Overall, Gearbox aims to increase capital efficiency in the DeFi space.

5 Use cases

Credit Account as a generalized credit account DeFi primitive can be used to build a lot of applications on top of it:

- **Margin trading**. Traders can use Credit Accounts to create leverage positions. Their portfolio is custodied in a Credit Account as collateral. Credit Account Managers regulate a list of assets available shorting/longing, list of available AMMs for traders, etc.
- **Leveraged yield farming**. Farmers can get funds from the pool and direct them to staking contracts.
- **Leveraged derivative tokens**. Credit Accounts can be utilized to build x2/x4 leveraged tokens that later can be available on existing AMMs. Only a smart contract is required with pretty simple logic: it receives stablecoins from users (DAI, USDC etc), opens a Credit Account with leverage x2/x4 and buys long-asset for all of its assets (for example, ETH). As a result, this Credit Account's portfolio value behaves like a x2/x4 leveraged position, so the smart contract can tokenize this Credit Account by minting ERC-20 x2/x4 leveraged tokens and sending them to the user-issuer.
- **Options**. To implement options on top of Credit Accounts, the logic described above could also be used, but with one difference. A smart contract should use flexible leveraging while opening a Credit Account: it should get $d/p * K$ loan from pool, where d - issuer's deposit amount, p current long-asset price, K - option strike value.

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