Themis V2

White paper

April 2023

Motivation

The market size of Liquid Staking Derivatives (LSDs) has reached billions of dollars with the development of DeFi. These assets are created by different protocols for their respective service purposes, and are distributed across different blockchains.

Our mission is to unlock liquidity for these crypto-native assets. To achieve this goal, we are launching Themis Protocol V2 - a decentralized non-custodial liquidity protocol. The protocol provides two interest rate modes based on algorithms: variable and stable. There are many special designs in terms of capital efficiency, risk isolation, asset price tracking, and cross-chain liquidity. Most of these designs have been market-tested and code-reviewed for security. As the Themis roadmap progresses, we hope to realize our vision of building Themis Protocol into the cryptographic banking infrastructure of Web3.0.

We are motivated to solve current problems existing in lending protocols as follows:

- Security and asset diversity
- Capital efficiency and liquidity
- Decentralization and user experience
- Market permission and protocol community autonomy

The protocol design needs to have balance and make certain trade-offs. With community autonomy, we can gradually adjust these balances to their optimal state, making Themis one of the most popular DeFi protocols.

This white paper will elaborate on Themis Protocol V2 from important issues such as product architecture, asset risks, economic models, and development roadmap.

1. Product Architecture

The product architecture of Themis Protocol V2 mainly consists of three components - M0, M1, and the "Ve" voting custody mechanism, which are used to realize non-custodial liquidity pools, Yield Bearing Assets collateralized lending, and liquidity autonomy. The protocol's underlying design has incorporated efficient modes to improve capital utilization, isolation modes to enhance asset diversity, isolation layers for flexible risk control, and a Portal for cross-chain liquidity routing.

1.1. Non-Custodial Liquidity Protocol

Non-custodial liquidity protocol for the crypto-native community is an industry standard. Themis does not custody user assets, so there is no possibility of misusing user assets. A non-custodial liquidity protocol can provide a benchmark interest rate for all users of the protocol through algorithms, and create a money market. This model has been market-tested with the introduction of Compound and AAVE.

1.1.1. Asset Deposit/Collateralization/Borrowing/Liquidation

Users can deposit assets into the protocol's fund pool and receive tToken certificates. Assets that are allowed to be collateralized will be used as collateral by default, thereby providing users with borrowing privileges. After depositing multiple assets, these LTVs will accumulate, allowing users to borrow multiple assets. When users borrow assets, they generate debt tokens in the form of sTokens or vTokens.

- The assets deposited by users will be assigned a MaxLTV, which is the maximum debt value that can be borrowed based on the asset's value multiplied by the MaxLTV. The deposited assets will earn interest paid by other borrowers.
- sToken is a stable debt certificate generated when the user selects a stable interest rate, while vToken is a variable debt certificate generated when the user chooses a variable debt. Their algorithms are calculated based on usage rate. The interest rate of stable debt typically does not change after it is generated until rebalancing occurs due to insufficient liquidity. Variable debt changes in real-time based on usage rate.
- The assets deposited by users will be assigned a Liquidation Threshold. When the debt value/deposit value * liquidation threshold ≥ 100%, i.e. Loan Risk reaches 100%, the collateral will be liquidated.
- When each asset is liquidated, there is a certain price difference between its total value and the Liquidation Threshold. Based on this difference, the protocol will reward the liquidator with a Liquidation Bonus and reserve any remaining unliquidated assets for the user.

1.1.2Interest Rate Models

Liquidity risk materializes when utilization is high, and this becomes more problematic as U gets closer to 100%. To tailor the model to this constraint, the interest rate curve is split in two parts around an optimal utilization rate $U_{optimal}$. Before $U_{optimal}$ the slope is small after it begins rising sharply.

The interest rate R_t follows the model:

$$if\ U < U_{optimal}: \qquad R_t = R_0 + \frac{U_t}{U_{optimal}} R_{slope1} \tag{1}$$

$$if\ U \geq U_{optimal}: \qquad R_t = R_0 + R_{slope1} + \frac{U_t - U_{optimal}}{1 - U_{optimal}} R_{slope2} \tag{2}$$

In the borrow rate technical implementation, the `calculateCompoundedInterest` method relies on an approximation that mostly affects high-interest rates. The resulting actual borrow rate is as follows:

$$ActualAPY = (1 + TheoreticalAPY/secsperyear)^{secsperyear} - 1 \tag{3}$$

When $U < U_{optimal}$ the borrow interest rates increase slowly with the utilization

When $U \geq U_{optimal}$ the borrow interest rates increase sharply with utilization to above 50% APY if the liquidity is fully utilized.

Both the variable and stable interest models are derived from the formula above from the Whitepaper with different parameters for each asset.

Variable debts see their rate constantly evolving with utilization.

Alternatively, stable debts maintain their interest rate at issuance until the specific rebalancing conditions are met. In Themis V2 interest models are optimized by the new rate strategy parameter Optimal Stable/Total Debt Ratio to algorithmically manage stable rate.

$$if\ ratio < ratio_o: \qquad R_t = r_0 + \frac{ratio - ratio_o}{1 - ratio_o} R_{base} \tag{4}$$

1.1.3. Efficient Mode (E-Mode)

As there are situations where funds in the pool are of the same asset type, in order to improve capital efficiency, we have retained the efficient mode. When users activate this mode, the parameters of assets of the same type will change, i.e. their MaxLTV and Liquidation Threshold will increase while their Liquidation Bonus will decrease, in order to achieve efficient borrowing and lending of assets of the same type.

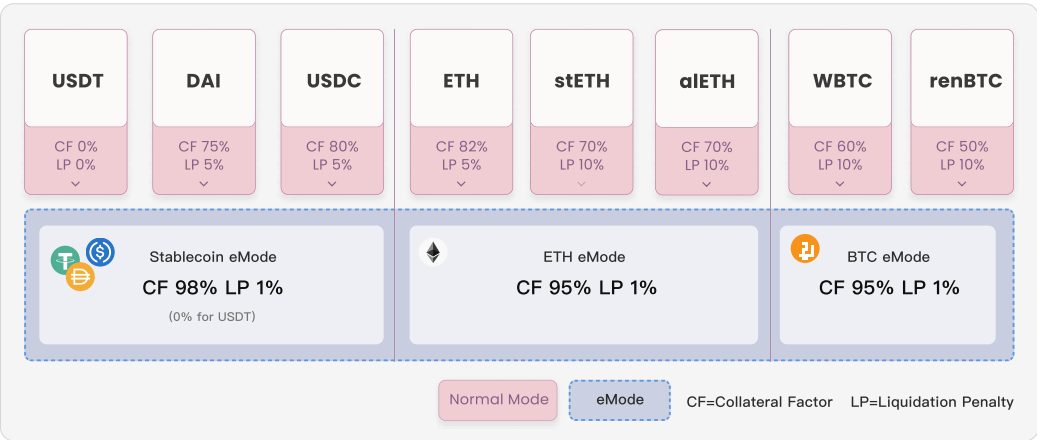

Figure 1. Efficiency Mode

1.1.4. Portal

Portal is a core feature that supports cross-chain liquidity of supply assets in Themis V2. By utilizing the unique design of tTokens, they can be destroyed on the source network while being immediately minted on the target network. The underlying assets can then be moved through bridging to pools in the target network with a delay. This has many implications on calculating interest rates and the security of the target network market.

From a design perspective, the protocol-level requires very few functionalities to support multiple portal implementations. The protocol only needs three additional functionalities:

- To mint unsupported tTokens,
- To provide support for unsupported tTokens, and
- To provide a whitelist mechanism for contracts that wish to utilize these functionalities.

In addition to these features, extra internal accounting is required for each reserved amount of unsupported tokens, and interest rate calculations need to be updated.

Minting unsupported tTokens will not affect the utilization rate of borrowers since no additional liquidity is provided [illegible]. However, it must be accounted for in the utilization rate of suppliers since the unsupported tTokens are accruing interest. To accommodate this situation, we calculate the utilization rate separately for lenders and borrowers, as follows:

$$debt_{total} = debt_{variable} + debt_{stable}, \qquad total_{liq} = debt_{total} + avail \tag{5}$$

$$util_{borrow} = \frac{debt_{total}}{total_{liq}}, \qquad util_{supply} = \frac{debt_{total}}{total_{liq} + unbacked} \tag{6}$$

As shown in Equation 6, increasing the unbacked value will reduce the supply utilization rate, thereby reducing the interest earned by liquidity providers, as their minted tokens are diluted. To offset this interest dilution, the reserve fund supporting the unbacked assets will charge a fee, which is accounted for in the liquidity index. This fee should cover the interest earned by minting tokens (please note that the accounting for the liquidity index will also redirect some interest back to the minted tokens), so in order to offset the interest earnings in terms of amount, it should satisfy:

$$Fee \geq \begin{cases} Interest & if\ amount \geq supply \\ Interest * \frac{supply}{supply - amount} & otherwise \end{cases} \quad (7)$$

Although the interest rate calculation is part of the core protocol, the protocol fee calculation used to cover the unbacked amount and fees comes from outside the core protocol. As delayed provisioning (through backUnbacked) and fee calculation are not enforced at the protocol level, governors should be cautious when approving bridge (port) access to portal functions in order to avoid potential risks caused from excessive minting.

1.2. Bond Collateralized Lending Protocol

Collateralized lending of Liquid Staking Derivatives (LSDs) is becoming one of the key services in DeFi in the future. Themis has supported Uniswap V3 NFT collateralized lending since its V1 version. In the V2 version, we will be compatible with more protocols and have optimized many designs to accommodate asset diversity and safer use of M0 liquidity. This includes isolation layers, isolation modes, parallel feed pricing strategy encapsulation, long-tail asset restriction parameters, and more.

1.2.1. Asset Collateralization/Lending/Liquidation

Assets in M1 can only be collateralized and borrowed against, and cannot be lent out as liquidity. However, they can still continue to earn income, including rewards, that originally were part of other protocols.

- collateralized assets are also allocated a MaxLTV, where Asset value * MaxLTV = the maximum amount of debt that can be borrowed.
- After borrowing assets, users will receive debt certificates s/vToken, which are linked to the interest rate curve and the utilization rate of M0 assets.
- Deposited assets are allocated a Liquidation Threshold. When Debt Value/Deposit Value * Liquidation Threshold ≥100%, i.e., when Loan Risk reaches 100%, the collateral will be liquidated.
- There is a certain price difference between the total value of each asset and the Liquidation Threshold when it is liquidated. Unlike M0, M1 does not have a Liquidation Bonus allocation, so the liquidator may earn the entire price difference.

1.2.2. Isolation mode

When assets are allocated in isolation mode, the assets that can be borrowed and lent are restricted. Most of the collaterals in M1 are in isolation mode. Isolation mode also limits the maximum amount of funds that can be borrowed and lent in the pool.

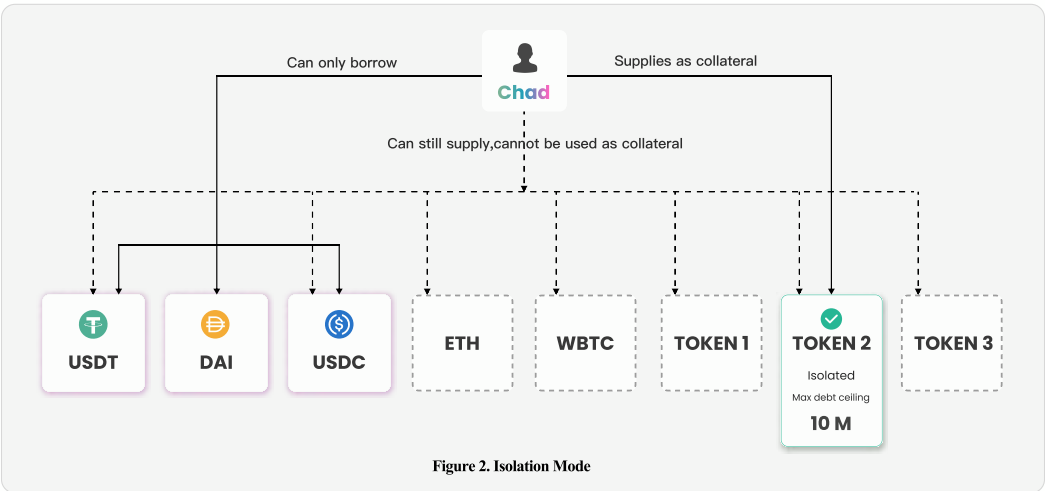

Figure 2. Isolation Mode

We'll give an example to illustrate the role of isolation mode in M1:

Suppose a user's collateral is a position in Uniswap V3 USDC/ETH 0.05%. Then they could borrow USDC, and ETH seems like a safer option. If this risk is acceptable, then other similar assets to USDC, such as DAI, USDT, and FRAX seem also acceptable. Similarly, other similar assets to ETH can also be acceptable. Suppose the liquidity of this position is only 10 million US dollars. Then suppose we set the borrowing limit at 10 million. Overall, this position may achieve leverage of up to 1.65x. However, individuals may create higher leverage ratios within it to increase their own transaction fee income.

1.2.3. Isolation layer

The design of the isolation layer is mainly to differentiate the use of M0 and M1. Since the collateral in M1 may come from different protocols, their risk assessment methods and pricing strategies may be different from other markets. However, to ensure that they can borrow sufficient liquidity, they need to borrow funds from M0, so several issues need to be considered:

- Under the premise of isolation mode, these collaterals also need to have debt separation from the user's collaterals in M0, and they do not interfere with each other during liquidation.
- Without invasive design, it needs to be compatible with assets such as ERC721/ERC1155/ERC3135 at the same time.
- Isolate the market of different protocols to avoid risk interference.
- Different protocol assets may have different pricing strategies, so a

scalable solution that is compatible with and linked to the chain oracle encapsulation is needed.

Since the debt token can be transferred under specific circumstances, we have designed an isolation layer using a low-perception approach for users, which is the sub-account system.

- All management permissions of the sub-account are under the main account. Users do not need to know the address of the sub-account, but the blockchain will record the behavior of this address.
- When enabling a protocol, a sub-account is automatically generated, collateralizing assets corresponding to the protocol. After borrowing other assets, only the collateral in the sub-account will be liquidated during liquidation events.
- Since most of the collateralized assets in the M1 market are LPs or LSDs, which may not be able to directly obtain Chainlink quotes, the pricing strategy for each M1 market is encapsulated in combination with Chainlink or TWAPs.
- The liquidation method of the sub-account can adopt a different liquidation approach than M0.

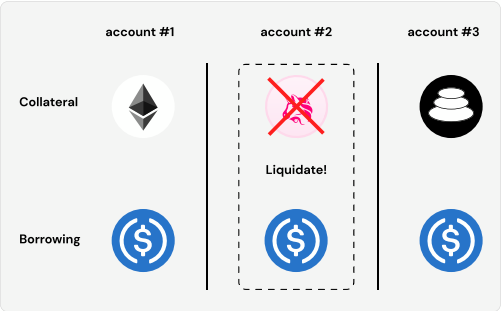

Figure 3. Isolation layer liquidation

1.3. Ve Voting Escrow Mechanism

The Ve voting escrow mechanism allows token holders to lock their tokens in a contract and, in return, receive voting weight equivalent to the locked tokens.

The core idea is to let token holders express their support and preference for an existing liquidity pool in the protocol by locking their tokens. Over time, these voting shares will gradually increase based on the lock duration; for example, if a token holder locks their tokens in the contract for a year, their voting share will be greater than that of another holder who locked for just a month.

The Ve voting escrow mechanism mainly consists of two parts: Locker and Gauge.

1.3.1 Locker

In practice, users need to lock their TMS into veTMS through a Locker. The locked veTMS typically consists of three parameters: the first is weighting factor, meaning the longer the lock duration, the greater the voting weight; the second is the minimum lock period, i.e., token holders must lock their tokens in the contract for at least a certain amount of time to obtain voting rights; the third parameter is used to adjust the issuance rate of voting shares to ensure system stability.

- veTMS is an NFT that can be managed through contracts, including weighting, splitting, merging, and transferring.
- After veTMS expires, all the TMS locked before can be redeemed.
- Holding veTMS alone will not generate any income; instead, it needs to be used for voting in Gauge to receive protocol revenue and reward bonuses.

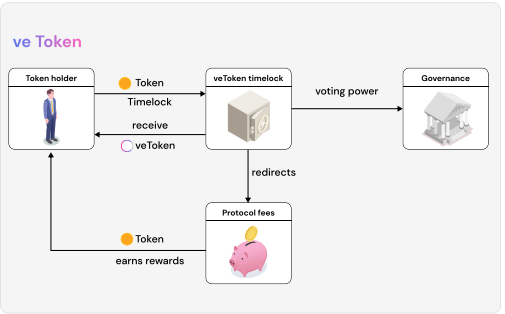

Figure 4. veToken earning process

Gauge is a voting platform where veTMS is used for voting, and the listed pools include all deposit, borrowing, collateral positions, and liquidity mining pools in Themis V2. Each pool has corresponding rewards, protocol revenue, and Bribes.

- First, each pool in Themis will generate a certain amount of protocol revenue based on the configured distribution. In each period, users can allocate this revenue by voting with their veTMS.
- In each period, Gauge will distribute rewards to all pools, and these rewards will be allocated according to the user's weight in the position. After holders of that position vote with their veTMS, the speed of receiving rewards can be accelerated, up to 2.5 times their original rate depending on the weight.
- Bribes are generally provided as additional subsidies by third parties. A pool can support up to eight reward types for providing extra rewards to users holding positions.

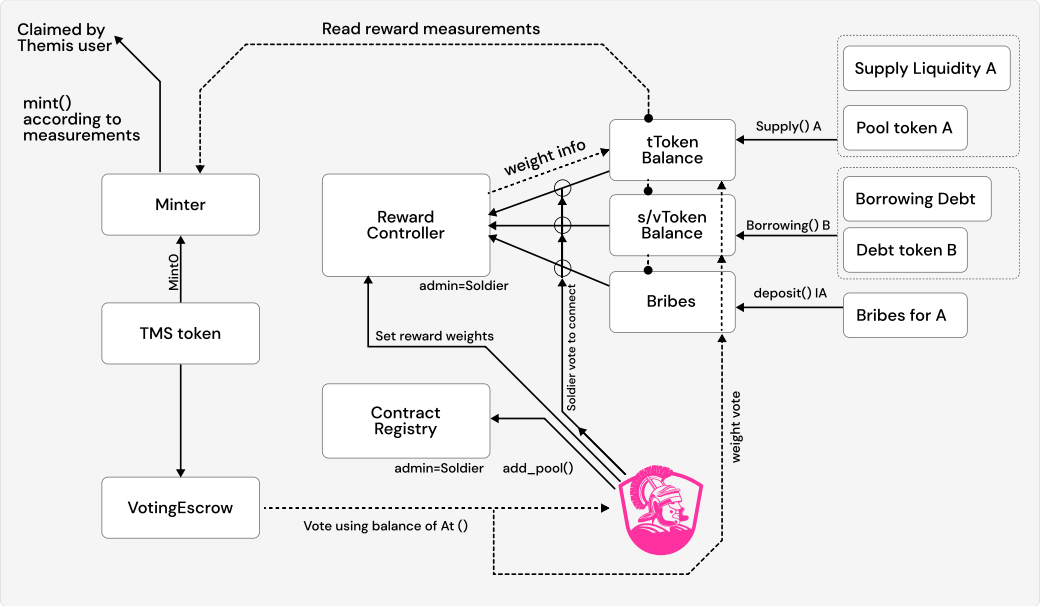

Figure 4. Reward Controller

In Themis V2, user deposits generate tTokens, and borrowing generates s/vToken vouchers. Therefore, when users Mint or Burn these tokens, the protocol deducts a certain fee as protocol revenue. 80% of the protocol revenue is shared with the Themis community, redistributed through Gauge. You must lock and forfeit the liquidity of your TMS governance tokens, which has three main benefits:

- **The community can vote to decide which liquidity pools the TMS token release should flow towards.**
- **They can earn staking rewards from the protocol revenue generated by Themis when providing or using liquidity.**
- **Increase staking rewards through token time-locking.**

One of the benefits of adopting the ve model is that it incentivizes holders to remove more TMS from the circulating supply by locking veTMS. With a lower circulating supply of tokens, this should stabilize the price and reduce long-term selling pressure. Additionally, in terms of protocol governance, liquidity growth for some pools can also be incentivized through voting to guide liquidity, thus achieving a certain degree of liquidity autonomy.

2. Assets Risk

This chapter mainly introduces the considerations for asset risk in the implementation of Themis V2, focusing on the three dimensions of asset safety, liquidity, and profitability. It covers asset pricing strategies, typical asset valuation logic, risk management parameters, and preventive measures.

2.1. Risk Management

This chapter mainly introduces the considerations for asset risk in the implementation of Themis V2, focusing on the three dimensions of asset safety, liquidity, and profitability. It covers asset pricing strategies, typical asset valuation logic, risk management parameters, and preventive measures.

Themis introduces many risk parameters and features to provide a high level of protection for the protocol, preventing potential bankruptcy risks.
Supply and borrowing caps: Themis V2 will allow configuration of borrowing and supply caps. This enables the protocol to regulate how much can be borrowed for each asset. Supply Caps limit the amount of an asset that can be provided to Themis. This helps reduce exposure to a particular asset and mitigates risks such as infinite minting or price oracle manipulation.

Fine-grained borrowing capacity control: Currently, various liquidity protocols do not allow reducing the borrowing capacity of an asset before liquidation occurs. This can cause significant constraints when the risk characteristics of an asset change (e.g., exposure to the asset cannot be reduced prior to liquidation). With fine-grained borrowing capacity control, Themis governance can reduce the borrowing capacity of any asset to 0% without affecting the borrowing ability of existing users (though liquidations of existing users may still be possible when necessary).

Risk administrators: Themis V2 allows entities to be whitelisted to unlock the ability to change risk parameters without requiring governance votes. These entities can be DAOs or automated agents that can build upon this functionality to automatically respond when certain invariants are breached.
Price oracle sentinel: The Sentinel feature is designed for L2 and M1's LSD design to address potential downtime of sequencers and liquidity attacks. It introduces a grace period for liquidations and prohibits borrowing in specific situations.

Variable liquidation shut-off factor: In Themis V2, partial liquidation of positions can be allowed, while M1 assets are restricted to full liquidation only, but it leaves room for future optimization.

2.2. Price Strategy

The asset pricing strategy of Themis V2 prioritizes obtaining quotes from trusted oracles, and we usually use Chainlink's price feeds for this purpose. However, some assets, particularly M1 assets, may not be able to obtain direct Chainlink price feeds. This means that their prices need to be quoted based on their liquidity changes. Although TWAPs are a good option, there are still risks involved because the TWAP quote is related to the liquidity of the asset trading pairs. Therefore, in principle, an additional layer of packaging is still required for asset pricing in Themis V2, i.e., using a watchdog system to monitor the underlying assets of the assets and combining them with Chainlink's price feeds to price assets.

2.1.1. Price Oracle Sentinel

Themis V2 introduces price oracle sentinels to alleviate some user experience issues that may arise in the second layer network.

Due to the characteristics of L2, for Themis V2 protocols and other systems that use price oracle sources, when the sequencer is shut down, the price source will not be updated (after all, they use trading). In fact, all the price developments that occurred during the entire downtime will be applied when the sequencer restarts. This uncertainty and the possibility of "slow flash crashes," combined with the fact that most ordinary users cannot directly queue L2 transactions on L1, led Themis to introduce a liquidation grace period. As long as the position does not significantly drop below the collateral value, it will enter a grace period from the time the sequencer is restarted until it can be liquidated. If the position drops below a threshold, it can be fully liquidated as it would be on L1. Note that the grace period is only activated when the sequencer experiences downtime, and users will not be allowed to borrow during this period.

2.1.2. Price Precaution Sentinel

Moreover, sentinels will also be used for instant borrowing and lending alerts for assets in M1. For LPs with two or more underlying assets, the quantity of their underlying assets pledged as collateral may change, which is usually used for flash loan attacks.

For example, when an ETH/DAI liquidity pool, consisting of ETH and DAI, is attacked by a flash loan, the attacker usually borrows a large amount of DAI to exchange for ETH. Due to the characteristics of AMM, the TWAP price of ETH in the liquidity pool will quickly decline, resulting in DAI being exchanged for less ETH. At this time, the high number of ETH in the collateral ETH/DAI will be considered to have a higher value during pledging, and thus let the attacker borrow more funds.

Sentinels can effectively defend against this situation. They check the instantaneous price of the collateral and the relative price difference in the LP, known as the Sentinel Price Gap, and prohibit borrowing and liquidation when it exceeds a threshold.

$$Access_{Borrowing} \begin{cases} reject, & if \ \frac{|Price_{oracle} - Price_{sentinel}|}{Price_{oracle}} \geq 0.1 \\ accept, & otherwise \end{cases} \quad (8)$$

When the Sentinel Price Gap parameter configured in the protocol is 0.1, the judgment condition is shown as formula (8).

In addition, since this interaction needs to be carried out under the premise of flash loan, setting a whitelist for flash loans can also effectively exclude this attack risk.

2.3. Decentralization

Themis V2 introduces Asset Listing Admins. The Listing Admin is a specific role that can be granted by Themis governance to allow different asset listing strategies. This will allow builders to create custom asset listing strategies which can be designed to bring true permissionless asset listing.

3. Tokenomics

Themis V2 will introduce a brand new tokenomics to gradually achieve protocol self-governance. This chapter includes the basic introduction, allocation purposes, and vesting rate of the TMS Governance Token.

3.1. TMS Governance Token

TMS Governance Token is mainly used for protocol governance, and it is a utility token.
Token ticker: TMS
Initial total supply: 800,000,000
Initial circulation ratio: 7.7%
Initial issuance network: Arbitrum

3.2. Allocation

800 million TMS tokens will be distributed as rewards to early stakeholders, cooperative protocols, ecosystem partners, teams, and the community. The distribution ratio is as follows:

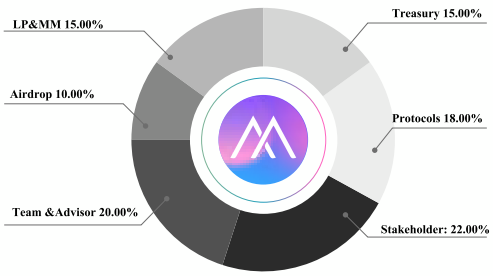

Figure 6. Initial TMS Allocation

3.3. Vesting Rate

The main stakeholders of a typical lending protocol (on Arbitrum network), including veTMS holders, LPs, users, and protocols, are all aligned by the ve(3,3) dynamics that determine TMS emissions.

veTMS holders — are incentivized to vote either for the highest borrowing volume pools (because the greater the volume, the greater the amount of fees produced as a result), or the ones being bribed by protocols seeking to bootstrap their liquidity. This allows these protocols to create their own fly wheel, if the token generates strong borrowing demand.
Suppliers and Borrowers — are incentivized with emissions driven by "Real Yield" based metrics.
Protocols — have access to a cooperation oriented collateral layer. They benefit from token utilization conditions for their tokens, and they can incentivize their liquidity via bribes offered to veTMS holders.

3.3.2. Emissions specifications

Weekly emissions (at inception): 4,000,000 $TMS
Weekly emissions decay: 1%
Weekly veTMS rebase: Up to 30%
Weekly developer wallet allocation: 2.5%
Emissions for Suppliers, Borrowers, MM & Staking: 67.5% (2.5% added from the dev allocation)

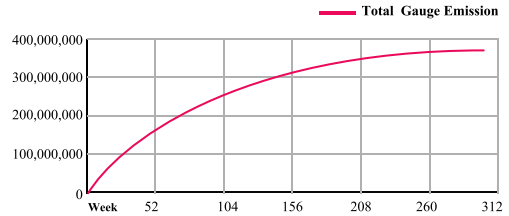

Figure 7. veToken earning process

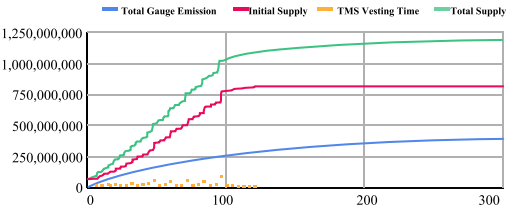

Figure 8. Vest and Emission in 300 weeks

4. Outlook

Themis is an open-source liquidity protocol and one of the bridges between liquidity protocols in future LSDFi. Through the lending capabilities of Themis V2, it becomes possible to achieve many DeFi ideas. It is difficult to define the definite direction of Themis's future development, but we can summarize our milestones and anticipate possibilities.

4.1. Milestones

In the past development, Themis has achieved NFT, UniswapV3 collateral borrowing, and pricing model designs for most mainstream DeFi protocols' LSD assets, as well as research on asset risks, which provides a solid foundation for us to release V2 product.

- August 2021: Release of Themis Uniswap V3 collateral borrowing whitepaper
- October 2021: Completion of seed round financing
- November 2021: Release of Dutch auction clearing design
- February 2022: Release of Themis V1, implementing Uniswap V3 collateral borrowing
- April 2022: Start designing Themis V2, introducing non-custodial liquidity pool design
- July 2022: Release of M0, M1 design thoughts
- September 2022: Design strategy for Arrakis, Balancer, Curve, and other assets
- August 2021: Release of Themis Uniswap V3 collateral borrowing whitepaper
- October 2021: Completion of seed round financing
- November 2021: Release of Dutch auction clearing design
- February 2022: Release of Themis V1, implementing Uniswap V3 collateral borrowing
- April 2022: Start designing Themis V2, introducing non-custodial liquidity pool design
- July 2022: Release of M0, M1 design thoughts
- September 2022: Design strategy for Arrakis, Balancer, Curve, and other assets

4.2. Roadmap

- Q2 2023: Release Themis Protocol V2 on Arbitrum and achieve collateral borrowing for Uniswap V3, Arrakis, Balancer, Curve, and Lido.
- Q3 2023: Achieve Fast Liquidity with Connext.
- Q4 2023: Achieve multi-chain deployment and implement cross-chain liquidity through portal.

For the protocol, since the implementation of features is not a very slow process, the future roadmap needs to be adjusted according to certain market conditions, but we will have several development directions:

- Open cooperation with more protocols and build an ecosystem.
- Gradually realize infrastructure capabilities in combination with ecosystem needs.
- Optimize user experience, achieve more convenient interaction, and lower blockchain perception.
- Create revenue through value-added services.