Ammalgam Litepaper

By Will Fey, April 2022

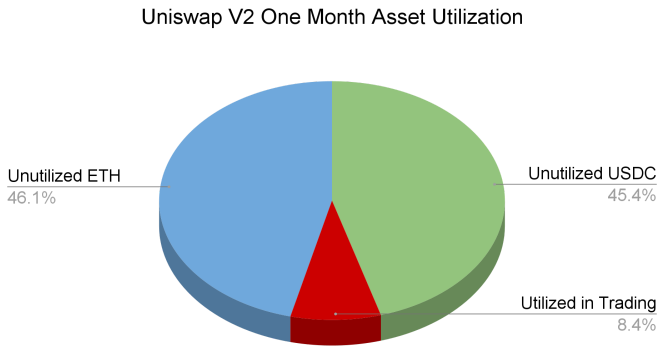
Introduction

Ammalgam is an automated market maker that significantly increases capital efficiency and functionality compared to existing AMMs and current compositions of lending and trading protocols. Two novel concepts create these improvements. First, by adding the ability to lend and borrow to traditional AMM pools, Amalgam creates Dual Purpose Pools ("DP pools"). DP Pools allow liquidity providers ("LP") to compound returns by utilizing their deposit for both lending and trading simultaneously. This allows LPs to multiply their active assets that are earning fees and consolidate their capital into one protocol. Market makers that want to hedge their exposure to one asset now can do so without a second protocol to source their debt. Ammalgam allows LPs both a consolidation of capital into one protocol and a higher yield for that capital. Higher yields come without any additional gamma risk introduced by Uniswap V3 concentrated liquidity. These enhancements solve two problems we call the split capital and split fee inefficiencies.

Second, the implementation of timelocks for high risk loan withdrawals and liquidations eliminate a common exploit of lending protocols. An increasing number of lending protocols are getting exploited using flash loans or using a large sum of capital to manipulate lending valuations in order to withdraw excessive amounts of debt or liquidate positions prematurely [R2020, R2021, R2022]. By implementing an appropriate time lock, Ammalgam can loosen the accuracy assumptions of the price oracle by calculating windows of variance in price from the external market. Without sacrificing security, this structure creates the ability to rely on the trading pools as an internal oracle for lending valuation, and removes the need for external dependencies for asset pricing.

AMM Capital Efficiency Problem

Uniswap V2 only utilizes a small fraction of assets based on the high and low prices of an asset during a given time [AZSKR21]. As can be seen in the chart below showing one month of ETH-USDC pool activity, this is very inefficient:



Concentrated liquidity was introduced in V3 to enable better capital efficiency for LPs. However, this comes with a number of trade offs. For instance, when you concentrate your positions, you increase both your fees and impairment loss risk. Additionally, the use of NFT interferes with the composability of V3 by making it more difficult for other protocols to value each unique NFT. V2 AMM tokens are fungible and can easily be valued. Lastly, users looking for better returns in V3 also have the additional risk, cost, time, and effort of concentrated impermanent loss, management, and monitoring of ranges as prices fluctuate.

Improvements

Regardless of what market makers love about Uniswap V2 and V3, DP Pools unlock the best of both versions. Passive users can set it and forget it with better capital efficiency. More advanced users can achieve the same goals of concentrated liquidity using leverage, but at a fraction of the cost of using a separate lending pool or protocol. This combination is unlike anything currently available in this domain.

Improved Capital Efficiency

Current attempts to combine lending and trading utilize separate asset pools for the liquidity which results in capital inefficiencies. Regardless of protocol structure, when using separate pools, liquidity and yields are split in a less than optimal way.

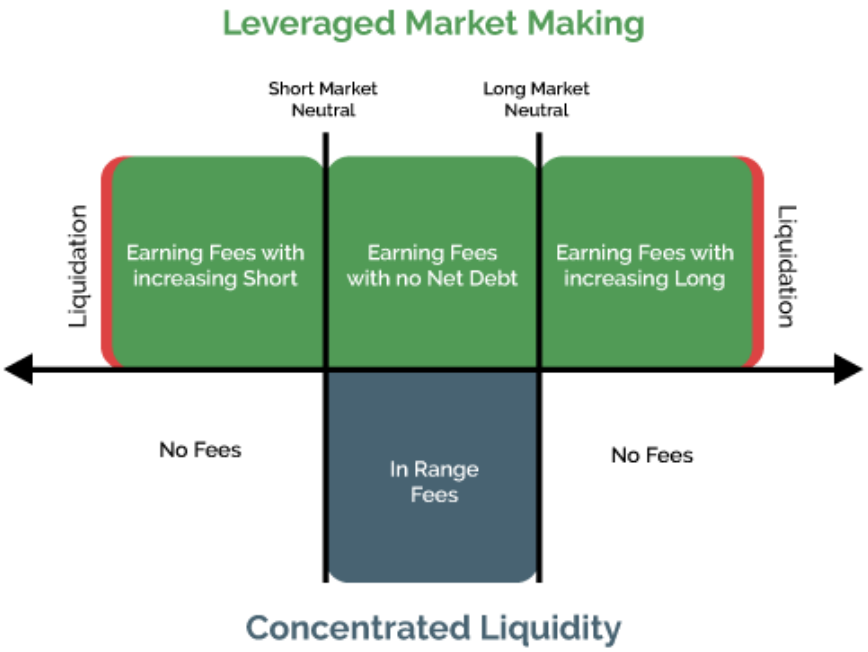
When a market maker utilizes a lending protocol to borrow assets in order to leverage their market making using AMM tokens as collateral, they have to pay fees to another LP for supplying those assets (“Split Fees”). Using DP pools, leveraged market makers can borrow from the same pools to which they are supplying liquidity. This results in their cost being reduced since they only pay the spread between supply earned on their collateral and borrow paid on their debt.

Other AMMs attempt to improve capital efficiency by lending out unutilized reserves on a different lending protocol. In this case, some assets are earning lending fees and some assets are earning trading fees but not all assets are earning both lending and trading fees (“Split

Capital"). DP Pools allows LPs to earn lending and trading fees on all assets, eliminating the inefficiencies of piecemealing the structure together through separate pools.

Leveraged Liquidity vs Concentrated Liquidity

In Ammalgam, market makers can apply leverage to achieve the same enhanced fees available with Unsiswap V3's Concentrated Liquidity. In many ranges, the yields for supplying assets will exceed the costs for borrowing and further enhance fee capture with respect to concentrated liquidity. The use of leverage to produce the same ranges as concentrated liquidity has a few trade offs.

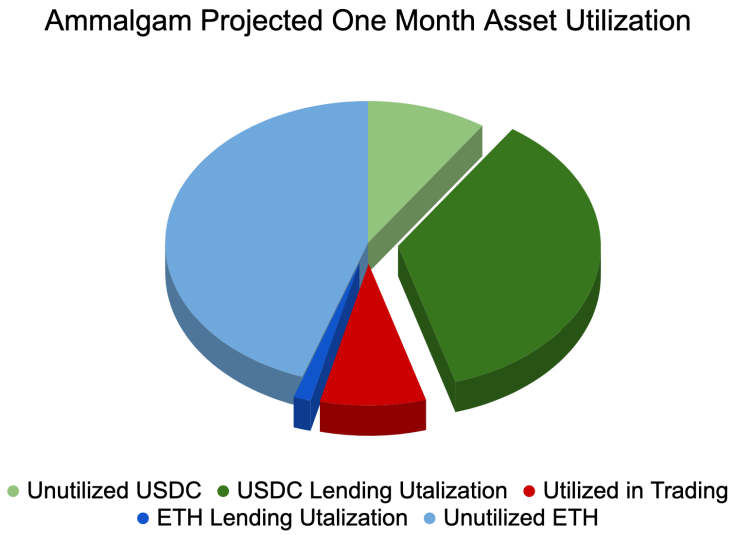


Concentrated liquidity earns fees as long as the price remains in range. Using leverage to replicate that same range, fees do not stop accruing when prices leave the equivalent V3 range. Leveraged market making starts to create a short or long when leaving the concentrated liquidity range. As the short or long increases in size, loan to value thresholds are approached. Once those thresholds are crossed, the leveraged market making position will be liquidated.

Replicating tighter ranges using leverage will increase lending costs. The same formulas presented in the Uniswap V3 white paper can be used to calculate the needed leverage to replicate any concentrated range. These formulas are extracted in the Supplementary section at the end of this paper .

When lending utilization rates of one asset are much higher than another, the supply and borrow rates of the higher utilized assets will exceed those of the other. At this point, leveraged market making can pay a premium by leveraging the underutilized asset and supplying the over utilized asset. This can generate lending yields for leveraged market makers with a neutral or short on the underutilized asset.

Improved Capital Efficiency for Passive Market Makers



Concentrated Liquidity and Leveraged AMM take time, effort, and expense to set ranges, monitor price fluctuations, and pay gas for rebalancing. For those that prefer a passive market making strategy, DP pools give LPs better yields through the additional lending revenue without any of the added risks of concentrated or leveraged liquidity. Unlike other protocols that lend out a portion of unutilized assets to a separate lending protocol, DP Pools earn the market supply rate on all deposits allowing LPs to maximize return on investment.

Enhanced Features

Short any Asset

A number of lending protocols have set out to allow market access to short tokens. However, market participants still are missing access to short most assets outside of what is available on protocols like Compound and Aave. This is due to the compounding risk factors of listing more assets. Kashi isolates this risk by pairing assets but lacks sufficient incentives to attract the necessary liquidity. Ammalgam allows market participants to open short positions on any asset listed in a pool. Since these pools are permissionless to create, assets can be shorted as quickly as they are being launched. DP Pools enhance LP incentives and ensure ample liquidity for shorting assets. Contrast this with current lending paired pools like Kashi which only offer lending rates that, in practice, do not attract sufficient liquidity (“Insufficient Incentives").

Delta Neutral and Short Market Making

Some market makers will want to provide liquidity to an AMM pair but not want to have exposure to both assets. To neutralize their exposure, they will borrow the unwanted asset on a lending platform. Using Ammalgam, delta neutral market making can be achieved without

having to borrow from a separate platform. A market maker simply borrows the assets they do not want exposure to, or borrows in excess of what they deposit to create a short position.

Unlike concentrated liquidity, market makers can earn fees without exposure to both assets. When borrowing all of one asset, the market maker would pay the rate of borrowing minus the rate of supplying that asset. Since borrowing rates will always exceed supply rates, this does have its costs, but once again the cost of the spread is much more capital efficient than paying the entire borrowing rate using another lending protocol ("Split Fees").

Market Maker Hedging Using a Third Pool Proportional Debt Token

Squeeth has been identified as a useful tool to hedge impermanent loss of market making due to its positive curvature [C2021, L2022]. Another way to create positive curvature to hedge AMM risk is to borrow AMM tokens [TAEK2021]. This was a useful feature of CREAM before it was exploited. However, it was an expensive hedge as borrowers paid both interest and the expansion of value of those tokens created from the collection of trading fees. Ammalgam will additionally issue a debt token that represents a share of a portion of the pair of assets. The token's asset composition will fluctuate its composition proportionally to the AMM pool's portion of each asset as prices fluctuate. Regardless of where a market maker supplies assets, they can utilize Ammalgam's proportional debt tokens to hedge their exposure. These tokens will cost the average of the supply rates of the underlying tokens but exclude the growth of AMM shares resulting from trading fees. This hedge is available to any pair just by the opening of that pair's pool on Ammalgam.

Market Maker User Experience Enhancements

A variety of financial utilities can be achieved by utilizing distinct lending and trading protocols. A market maker providing assets to a trading platform can achieve a market neutral position by borrowing the assets to make the market from a lending platform. A short can be opened by borrowing an asset from a lending platform and then selling it on a trading platform. Since DP pools enable both lending and trading in one protocol, these utilities can not only be set up in one protocol, but also in one transaction. Users can short an asset at their specified leverage and the platform will transfer the collateral, borrow and sell the asset getting shorted. A market neutral market maker position can be opened by supplying one asset, borrowing the other, and depositing into the AMM. Similarly, a leveraged AMM position can be set up in one transaction taking the users desired leverage, transferring the users assets and borrowing the desired leverage and depositing all the assets into the AMM pool which would be used as collateral for the loans.

Existing Composition of Trading and Lending Solutions

A number of lending protocols have complemented AMMs by allowing AMM deposits to be used as collateral for borrowing, or by allocating unutilized trading assets to be lent out in an attempt to improve capital efficiency. Other lending protocols utilize AMM pools to allow users to modify their loan to value ("LTV") ratio by (a) unwinding or lowering their risk or (b)

leveraging or increasing a short or long position (Aave's use of Paraswap). Each existing composition of lending and trading add their respective benefits and features, but also fall short of what can be accomplished using *DP Pools*. These shortcomings can be described as Split Capital, Split Fee and Inefficient Incentives:

Split Capital Inefficiency

Split Capital Inefficiency is when capital allocations are split between two financial functions. Specifically in this case, fees are earned for either trading or lending. This distribution attempts to increase capital efficiency by allowing unused assets to earn fees that wouldn't be possible with a vanilla version automated market maker (Uniswap V2). However, this distribution is inefficient because assets are typically earning trading fees or lending fees, but do not earn trading and the maximum available lending fees concurrently. An example of this would be Balancer Boosted pools which take a portion of AMM deposits and deposits them in Aave. Thus, there is an opportunity to significantly increase efficiency by using the additional LP deposits not earning lending fees.

Uniswap V3 could actually be categorized in this same way according to Hayden [A2021]:

Here, Hayden suggests combining lending and trading by allocating some assets to market making that would be earning higher fees due to concentrated liquidity and the rest to lending. The higher market making fees might be equivalent to the fees earned if all assets were deposited into a V2 pool, but lending is only earned on a portion of assets, not all.

Split Fee Inefficiency

Split Fee Inefficiency for LPs is when a set of financial features is utilized by multiple protocols thereby splitting earned fees for each function. If a trade liquidity provider attempts to

borrow assets to leverage their trade liquidity they pay interest fees to another party for borrowing those assets. Whereas with Ammalgam, the LPs are increasing yield by earning the fees that are currently going to third party pools.

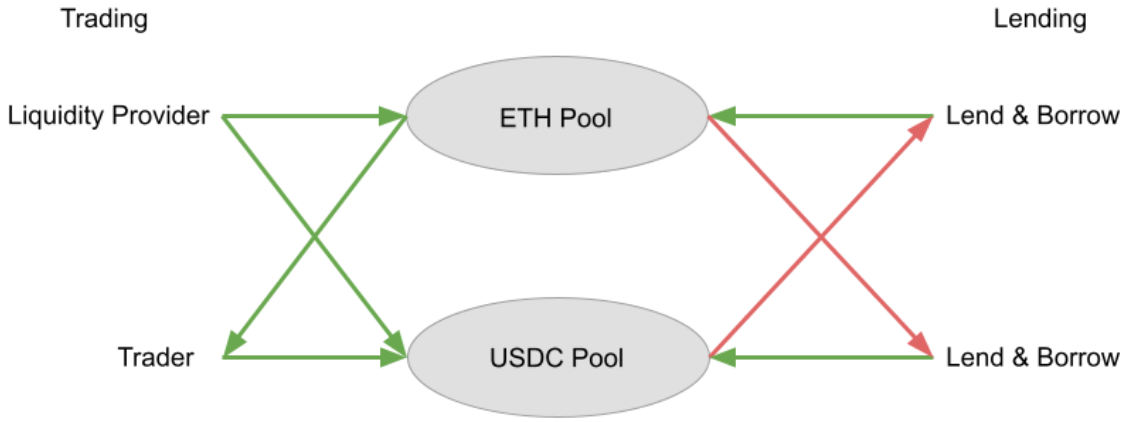
For example, Aave AMM, Alpha Homera and C.R.E.A.M enabled AMM LP tokens to be used as collateral, but the fees for debts were still paid to separate pools specifically dedicated to lending. Since fees for borrowing go to separate pools leveraging AMM using these platforms can be expensive and even infeasible.

Insufficient Incentives

Insufficient incentives for liquidity providers lead to low liquidity in a lending platform. If liquidity is insufficient, the purpose of the platform is restricted to the bounds of the insufficient liquidity. SushiSwap's lending platform, Kashi, enabled permissionless lending pools by isolating risks in one to one token pairs rather than the traditional many to many lending protocols. This isolated risk means that any asset can be borrowed and thus shorted. Unfortunately, only about a dozen pairs have sufficient liquidity (more than six figures of values) to be borrowed. The lending yields from these pools is an insufficient incentive for LPs to provide the liquidity required to open larger shorts. AMM pools of these same asset pairs are sufficiently able to attract more meaningful liquidity for their purposes. By combining both lending and trading using DP pools, the trading incentives will drive sufficient incentives for LPs to provide liquidity to allow for meaningful shorts of any asset.

Dual Purpose Pools

As shown above, Split Capital, Split Fees and insufficient incentives are primarily created by trying to combine separate pools from different protocols to facilitate both trading and lending. DP Pools accomplish this same result using one pool and thereby multiplying returns, thus significantly increasing capital efficiency.



This new pool allows liquidity providers to earn fees for trading and lending. Trading liquidity providers can also leverage their deposits to scale the fees they earn without using multiple protocols. This leverage creates lower slippage for traders causing a multiplicative

network effect to more trading volume and additional liquidity. Since leverage is sourced from borrowing from the same pools holding deposits, interest is both paid and earned for debt and collateral, respectively.

The following table compares how Ammalgam improves upon each of the described inefficiencies compared to popular combined AMM/Lending protocol solutions:

Inefficiency Category	**Dapps**	**LP Trading Fees**	**LP Lending Fees**	**Leverage**	**Shorting**
Dual Purpose Pool	Ammalgam	Full	Full	Yes	Yes
Split Capital	Balancer Boosted	Full	Partial	No	No
Split Fees	Aave AMM, Alpha Homera	Full	None	Yes	No
Split Fees	Aave with Paraswap	None	Full	Yes	Whitelisted assets
Insufficient Incentives	Kashi	None	Full	Yes	Low liquidity

DP Pool Debt Limits

Typical limits on lending platforms can reach up to around 80% LTV for high confident assets and decrease for low confident assets. LTV ratios are critical risk factors to platforms that allow many to many collateral and debt pairings. Ammalgam's debt pairs are limited to a one to one relationship within each given AMM pair. This isolates the risk to the pool itself and allows for a simpler risk model that can be scaled to more assets.

Dual purpose pool LTV debt limits work differently than traditional lending platforms for a trading liquidity provider. This is because the trading liquidity provider is borrowing the same assets they deposited. Debts of one asset only become risks when they exceed the collateral of that same asset. Thus, LTV is calculated using the net of one asset (the supply minus the borrow) with relation to the net of the other asset. If there is not a net debt of either asset, leverage is unlimited with the consequence of a tighter range bounded by liquidation risk if the price fluctuates out of that range.

Possibility of Exhaustion of Actual Assets

Allowing users to borrow assets directly from DP Pools leads to the possibility that one asset is depleted. The quantity of each asset in the reserves are used to quote prices for traders. A price could be quoted on trade that would exhaust the actual reserves of the purchased asset.

Handling this exhaustion of assets can be done in one of two ways. One option is to allow the trade and payout the available assets. Then, give the users an interest earning deposit (essentially an IOU token) equal to the remaining balance of the unavailable trade amount which could be paid back once the assets became available. The other option is simply to not allow any trade beyond the actual reserves.

In the example above, the IOU token credited to the trader is accounted for separately. This is because it is deposited strictly for the purpose of borrowing as it has not been matched with an equivalent amount of desired token required for it to be considered trading liquidity. If a market condition can lead to this case, it may never revert. In this case the IOU tokens may not hold the same value as the underlying asset. A separate pool of the IOU token to the underlying token might be used to allow holders to trade to the underlying token at a premium. These IOU tokens open a number of edge cases that add complexity that might be better to address by not fulfilling trades beyond what assets are available in the pool and depending on market pressure to attract additional liquidity of the exhausted asset.

Exhaustion of assets is expected to be rare and, if occurring, short-lived given typical market forces. As one asset becomes more scarce in a pool, the variable lending rate would increase to a value that would incentivise the market to provide more of that asset to the pools reducing the risk of asset depletion.

Oracle Manipulation

To help mitigate price manipulation, especially from flash loans, Ammalgam introduces a time lock of at least one block for any action that would introduce a new debt or liquidation. This time lock of one block ensures that any flash loan debt must be repaid before the timelock period has ended. This requirement eliminates the use of flash loans to overstate collateral and debts.

A time lock period of one block does not cover all the possible exploits. Price manipulation is a trivial task given sufficient capital with respect to pool reserves, however, its cost increases over time. Arbitrage becomes possible when two markets deviate in price. In this case, arbitrageurs can profit by shrinking the gap between the external market and the manipulated pool. The longer arbitrageurs can extract profit, the more expensive it is to maintain the manipulation.

The value of an exploitation of a lending protocol can also be measured based on the size of the price manipulation. In the case of Compound, a 30% increase in the price of DAI resulted in an estimated $4 million premium for a liquidator [R2020].

By comparing the potential payout of an artificial price change to an attacker, and the time it would take for the attacker to maintain the artificial price, we can find an acceptable time period to lock a withdraw or liquidation to ensure that the price conditions are not artificial, or if they are artificial, the attacker will lose more than he earns.

The incentive mechanisms for liquidations are also adjusted to better align incentives between the protocol and the liquidator. In the case that the asset being provided has an inflated value due to manipulation, liquidators can earn both the premium and the inflated valuation of the collateral with respect to the asset being provided. Instead liquidations should be sourced from the AMM itself and provide liquidators with a fee for finding the insolvent position that would cover both the gas of the transaction and enough to make the effort worthwhile. Self funded liquidations will repay the insolvent debt from the pool using a swap as discussed in Liquidations.

Summary

Ammalgam's unique composition of lending and trading using DP pools enhances capital efficiencies by generating additional fees for LPs compared to current AMM options and to piecing multiple transactions together across multiple protocols. All of this utility can be unlocked for liquidity providers in a single transaction maximizing the simplicity of the user's experience. Combining the power of DP Pools with Internal Time Lock Oracles provides a platform where transacting results in deeper liquidity in the DeFi market overall and improved fees for traders with improved functionality and without sacrificing composability.

Reference

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Supplementary

Conversion from Concentrated Liquidity to Leveraged Liquidity

The following formula from Uniswap V3 builds from $x \cdot y = k$ to define the quantity of each asset x and y as the price fluctuates when using concentrated liquidity in the range between prices p_a and p_b and using $k = L^2$:

$$(x + \frac{L}{\sqrt{p_b}})(y + L\sqrt{p_a}) = L^2 \text{ (2.2)[AZSKR21]}$$

When using leverage to replicate concentrated liquidity ranges, the required debt x_d and y_d of each asset x and y can be defined as:

$$x_d = \frac{L}{\sqrt{p_b}} \; and \; y_d = L\sqrt{p_a}$$

Using formulas $\Delta x = \Delta \frac{1}{\sqrt{P}} L$ (6.16) the following can be extracted using (p_0, x_0) and $(p_b, 0)$

$$L = \frac{x_0\sqrt{p_0 p_b}}{\sqrt{p_b} - \sqrt{p_0}}$$

Therefore our required debt is

$$x_d = \frac{x_0\sqrt{p_0}}{\sqrt{p_b} - \sqrt{p_0}} \; and \; y_d = \frac{x_0\sqrt{p_0 p_b p_a}}{\sqrt{p_b} - \sqrt{p_0}}$$

Using these formulas, any concentrated range can be constructed with leverage. Additionally, the quantities of assets x and y held by leveraged market makers as prices fluctuate is defined by the same curves used to define concentrated liquidity.