Morpho

Optimizing Decentralized Liquidity Protocols

Paul Frambot*
Institut Polytechnique de Paris

Mathis Gontier Delaunay
Télécom SudParis

Vincent Danos†
École Normale Supérieure

Adrien Husson†
INRIA

Katia Babbar†
University of Oxford

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Abstract

Morpho enhances current DeFi liquidity protocols. The aim is to offer a suite of products to make supplying and borrowing operations in DeFi more efficient and seamless. The first building block proposed is a novel, Pareto-improving, interest rate mechanism built on top of existing protocols. The Morpho Protocol allows for better rates on both sides of the market whilst preserving the same liquidity and liquidation guarantees for everyone.

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*Corresponding author, please direct any enquiry to contact@morpho.xyz
†Visiting Academic

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1 Motivation

Over the past ten years, blockchain technologies have not only enabled innovation in the space of money transfers but have, most importantly, provided the means to re-imagine the entire financial ecosystem. Today, blockchains like Ethereum, the largest DeFi platform, enable developers from anywhere in the world to create open services that previously were the exclusive playground of financial intermediaries such as banks, exchanges, insurances, asset managers, hedge funds, etc. Decentralized Finance or DeFi, encompasses an ensemble of independent, open, transparent, and composable technological bricks as pieces of self-executable code, providing open access to a new set of financial primitives available to all. Removing intermediaries not only reduces bias but also lowers the cost of the global financial infrastructure, eventually decreasing the overall costs to end-users. Morpho's mission is the democratization of interest rate services, ensuring access to profitable, convenient, and secure supplying and borrowing for all.

Since the "DeFi Summer" in 2020, novel protocols have emerged enabling users to execute financial operations in a decentralized fashion such as the secured supplying and borrowing of crypto-assets with Compound [LH19] or Aave [Tea20]. The growth in the market size of these protocols has been astonishing and has far exceeded the tens of billions[1]. However, looking at the historical data of supply versus borrow rates of the main DeFi protocols, there is a pain point for both sides of the market: borrow rates are high compared to very low supply rates.

Let's take the Compound Protocol as an example:

[1] As of September 2021, over $ 45 billion combined

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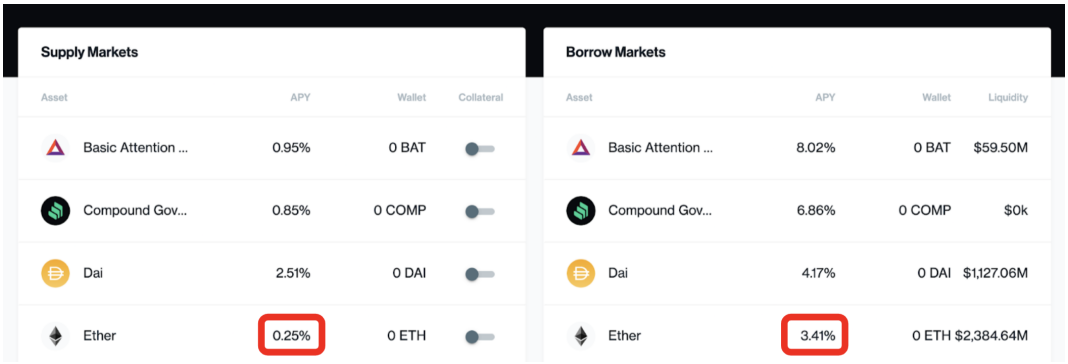


Figure 1: APY spread in app.compound.finance

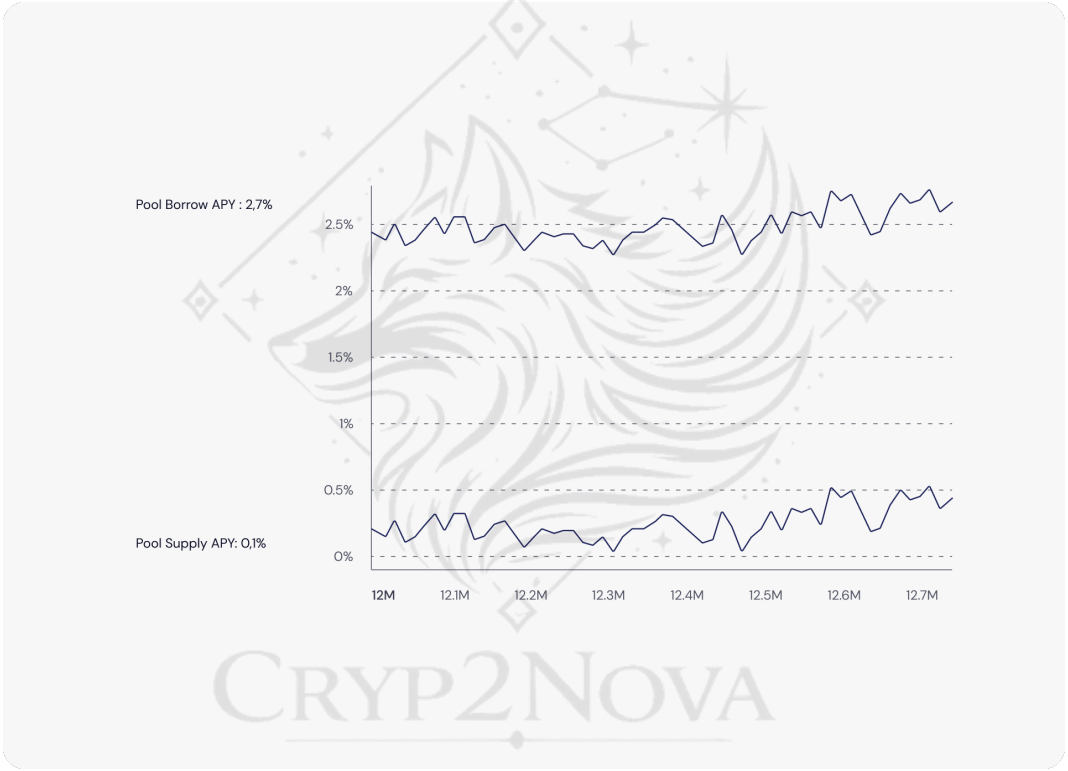


Figure 2: APY spread of Compound on ETH over 500k Ethereum blocks

For Ether, an average supply APY (β_s) of 0.1% and an average borrow APY (β_b) of 2.7% are observed[2].

Example 1.1 *Assume that Alice supplies 1000 DAI and Bob borrows 1000 DAI on Compound. After a year, Alice only earned 1 DAI while Bob paid 27 DAI. Both parties may also get some COMP rewards tokens, but we will omit these for now.*

This example is quite counter-intuitive at first as one can expect DeFi to remove the middle man and to create Peer-to-Peer (P2P) positions where Alice earns exactly what

[2]This is an average over 500k Ethereum blocks, which represents approximately 90 days

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Bob is paying. So why are these APYs not unique and set at a mid-rate of 1.4%, which would be advantageous to both parties?

Example 1.2 *In such a scenario where Alice would supply 1000 DAI and Bob would borrow 1000 DAI on Compound. After a year, Alice would have earned 14 DAI while Bob would have paid 14 DAI.*

Compound is relying on a Peer-to-Pool model where suppliers deposit their liquidity in a common pool and get tokenized vouchers in return, known as cTokens[3]. Any borrower can supply collateral to access liquidity from this pool. When repaying their position, borrowers pay some interest that also goes into the pool. Notice that under this model, positions do not have a fixed term and that suppliers are not competing with each other: the interest paid is shared amongst all suppliers, proportionally to the amount supplied. In practice, suppliers are committing much more capital to the pool than is ultimately utilized. Large amounts of capital thus remain unused in the pool and mechanically, the experienced supply APY is lower than the borrow APY. The equation that drives the supplying and borrowing rates is well documented in the Compound protocol[4]:

$$\begin{cases} \beta_b = A * U + B \\ \beta_s = \beta_b * U * (1 - R) \end{cases}$$

where:

A = Slope of the borrowing rate curve.
U = Utilization rate of the pool.
R = Reserve factor.
B = Intercept of the borrowing rate curve.

Thus, the spread is given by:

$$\beta_b - \beta_s = (A * U + B) * (1 - U * (1 - R))$$

The slope and intercept of these curves are often adjusted by Compound's governance. Once these parameters have been established, the spread is fully determined by the above equation.

- The utilization rate U of the pool is the percentage of the liquidity that is borrowed. All suppliers provide liquidity to a pool for a few borrowers. The interests paid by a borrow are evenly shared amongst all suppliers as they do not compete in the Compound pool.

- The Compound reserve factor R: a fee going to a DAO-controlled vault to pay for different protocol actions like refunds or to fund contributors like Compound Labs. The fee is usually a percentage of the APY [5].

[3] In Aave, cTokens are replaced by aTokens

[4] Note that in practice, Compound supply rates are affine by piece functions that change slope after passing a certain utilization threshold. To simplify, we only considered one slope, as it does not change the following results

[5] As of September 2021, between 7% to 25% of the interest rate

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The spread between APYs is intentional, as keeping utilization rates below 100% enables users to both withdraw current funds or borrow new funds at any time. This interesting property is sometimes referred to as the "liquidity" of the money market. The design choice of this "pool model" keeps suppliers and borrowers motivated whilst preserving the liquidity of positions.

However, this model has proven very inefficient as suppliers are not competing with each other. Moreover, one may also remark that rates are not decided by the offer and demand of the market but are biased by A and B parameters, chosen by the platform. A natural idea would be to build some sort of order book to register every position in a P2P fashion.

This very concept was tackled at first by some other protocols like ETHLend [Tea18]. There was effectively no spread between Suppliers and Borrowers under that protocol, who were directly matched in a P2P fashion. However, the protocol was much less flexible and fungible than a pool. According to Aave, ETHLend was indeed more efficient in terms of rates but the lack of liquidity of those P2P term loans was greatly limiting their use. Today, a DeFi user would rather generate a permanent yield in a pool, with minimal supervision needed, than seek an improved yield which can be unreliable due to high gas costs paid for every transaction. The lack of liquidity in P2P protocols like ETHLend could be due to the low level of adoption of DeFi protocols at the time. Or more importantly, the absence of professional market-makers able to manage P2P positions under the heavy constraints and costs of the Ethereum blockchain itself.

The Morpho Protocol leverages the composability and liquidity of the existing PLFs (Protocol for Loanable Funds [GWPK20, PWXL20]), such as Compound and Aave, and to create an efficient - yet liquid - P2P market of supply and borrow positions with near zero spread. In the previous ETH example, both sides of the market could use an APY within the spread, for example near 1.4%. Both sides win without taking riskier positions. In that regard, Morpho is a Pareto-improvement of current liquidity protocols.

Users eventually get permanent positions with self-adjusting rates, being, at best, the exact rate that the matched borrower is paying, and at worst, the rate of the PLF that Morpho falls back on. Morpho can therefore be described as a liquidity pool optimizer, where both borrowers and suppliers benefit from improved rates while preserving the same guarantees and the same liquidity.

The technical limitations of blockchain technology and the low adoption of DeFi in the early days have constrained many applications to employ sub-optimal models like the use of pools. Morpho's proximal goal is to address this inefficiency, hence empowering the end-user with the full potential of DeFi. Many DeFi projects are starting to address the problem of uncollateralized positions and/or the ability to provide real-world collateral. Morpho's longer-term goal is to build an efficient component that will rationalize the DeFi rates market and eventually be an integral part of the solution.

The paper is divided as follows. Section 2 of this paper introduces the Morpho Protocol, the mechanisms it leverages, and how it improves supply and borrowing rates with no loss of liquidity and no additional liquidation risks. Section 3 focuses on how Morpho matches suppliers with borrowers and introduces the Morpho token. Section 4 explains how this novel approach not only optimizes current protocols but

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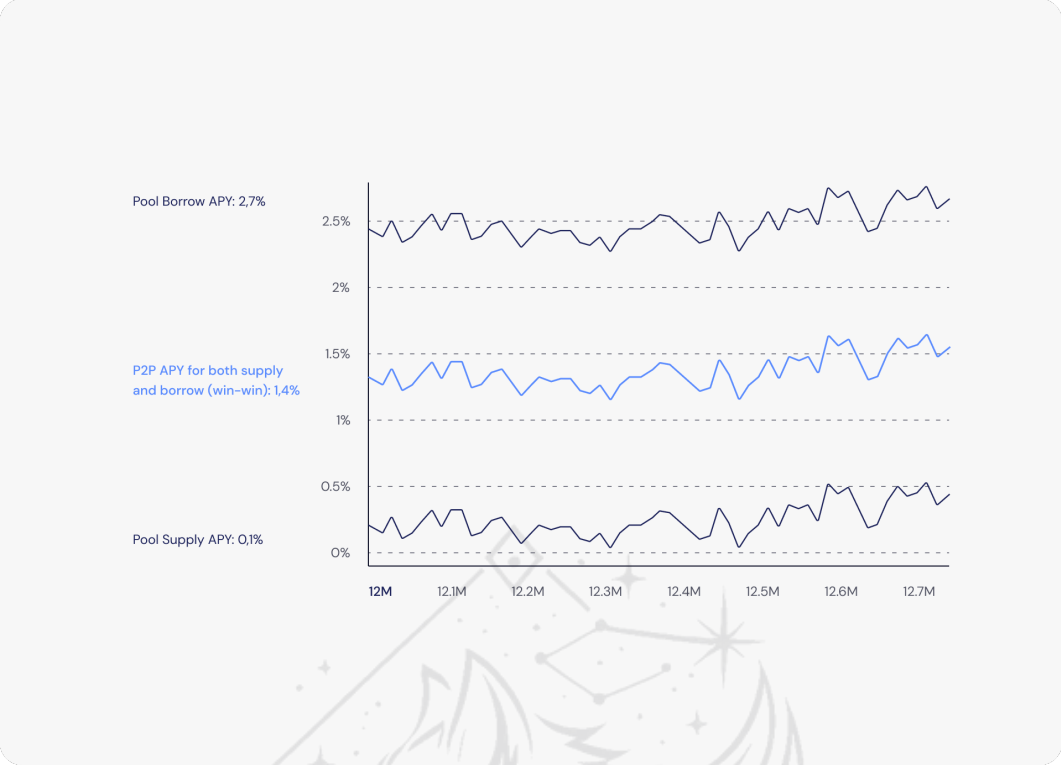


Figure 3: Compound rates compared to the Morpho P2P APY on ETH over 500k Ethereum blocks.

also builds the foundations to evolve alongside technical improvements of the underlying blockchain itself. Morpho is a first self-contained step to a new economic space for DeFi: competitive liquidity markets. Section 5 will finally discuss the position of Morpho in the DeFi space and its use cases.

2 The Morpho Protocol

This is a simplified introduction to the Morpho Protocol. We are currently working on a fully detailed Yellow Paper and hope to release it in 2022.

2.1 High-level description

In this section, it is assumed that the Morpho Protocol is only integrated into the Compound Protocol and is then called Morpho-Compound. However, it should be noted that Morpho is compatible with any other PLF like Aave and is then called Morpho-Aave.

From a user point of view, Morpho-Compound operates very similarly to Compound: users can supply, withdraw, borrow and repay assets with the same liquidity as Compound. Liquidators can liquidate undercollateralized credit lines according to the same collateral factors and the same price oracles as Compound. One should not experience any different from what they are used to, except that the rates are more interesting. Morpho-Compound acts as a proxy between the user and Compound. Let's

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take a brief look at how the assets flow in this setting.

- Supply tokens: the user just supplies tokens to Morpho (Step 1 in the picture). In the background, the protocol will deposit them on Compound (Step 2) and mint cTokens (Step 3). Morpho will hold on to the cTokens and use them later to move the positions out of the Compound pool (Steps 4 to 7).



Figure 4: A supplier deposits liquidity to Morpho

- Borrow tokens: the user first provides some collateral, say BAT tokens, with the same collateral factors as in Compound and triggers the borrow function (Step 4). In the background, the protocol first triggers the matching engine, linking one or many suppliers in the Morpho Protocol to the borrowing required. Next, Morpho uses the cTokens of the matched suppliers to move their liquidity out of Compound's Pool (Steps 5 and 6) and give it to the borrower (Step 7). At this point, the position has moved from Pool-To-Peer to Peer-To-Peer and both the borrower and the suppliers involved are getting better rates. Note that the debt can be matched with only a part of a supplier deposit if it is small, or with the deposits of multiple suppliers in the other case.



Figure 5: A borrower takes liquidity from Morpho

Notice that during the P2P position, users are out of the pool and thus seamlessly have a P2P position with a utilization rate of 100%. Since Morpho moves the positions out of Compound when the borrower requires a match, the matched supplier does not need to share the rewards with the rest of the pool. Thus, coming back to the example for rates on ETH, there is a win-win with near 1.4% for both the supply and borrow APY, instead of an underlying 0.1% for the supplier and 2.7% for the borrower on Compound.

Example 2.1 *Assume that Alice is the first Morpho user and she decides to supply 1 ETH to the protocol and that 1 ETH = 200 cETH at this moment. If no one else uses Morpho, after one year, Alice has earned 0.001 ETH as if she were directly in*

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Compound. Now, let's consider that Bob borrows 1 ETH through Morpho after providing BAT as collateral. The two users will be matched P2P and during a year, Alice would earn close to 0.014 ETH instead of 0.001, and Bob would only pay close to 0.014 ETH instead of 0.027. Note in this whole process, Bob and Alice do not need to execute additional transactions compared to Compound, the matching is done automatically by Morpho.

2.2 Same liquidity, same guarantees, improved rates

Morpho is a hybrid interest rate mechanism that combines Peer-to-Peer and Peer-to-Pool matching of liquidity protocols. It is built in such a way that, if someone is not finding any counterpart via the P2P mechanism, Morpho falls back onto Compound by depositing the user's funds in its smart contract. Under this configuration, Compound is considered as the supplier of last resort: the user is at least as economically rewarded as they would be by simply using Compound.

2.2.1 Liquidity

One may ask how Morpho ensures the full liquidity of the market in very specific scenarios like a supplier that wants to exit a P2P position where its capital is fully borrowed. The main idea is that in every scenario where the Morpho user would not be able to leave, there is a fallback to Compound.

Example 2.2 *Assume that Alice and Bob are the only users of Morpho. Alice supplied 1 ETH while Bob borrowed it with some DAI as collateral. After a year, they paid/earned nearly 0.014 but Bob has not repaid the position yet. However, Alice wants her money back and triggers the withdrawal function. In this scenario, Morpho is going to borrow on Compound using Bob's DAI as collateral and give the borrowed ETH to Alice. Note that from this point onward, Bob's APY will be reset to Compound's rate: 2.7% but if Alice comes back, they would reconnect at near 1.4%.*

Remark that even in this scenario, the collateral of the borrowers can be matched P2P as well, whether its debt is matched P2P or on the pool. This is not intuitive at first, and quite a complex thing to understand and this is out of the scope of the White Paper and will be elaborated on in the Yellow Paper.

2.2.2 Liquidations

Morpho has its own liquidation mechanisms, but copies directly onchain the same parameters as the underlying pool it relies on. The protocol mechanically has the same collateral factor, liquidation conditions, and price oracles that it fetches on-chain. In this way, the liquidation guarantees for users are the same as on the underlying PLF.

One may remark that Morpho's contract itself sometimes has a borrow position on the underlying pool, but Morpho can only be liquidated if its position, which is an aggregate of all of Morpho's users positions, is eligible for liquidation. To prevent this Morpho's users will be liquidated when possible, ensuring the safety of the position of Morpho itself on the pool.

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2.2.3 Improved rates

To recap, a supplier will have at least the net APY of Compound (supply APY + COMP rewards). However, if the protocol finds a private match with a borrower, the user will upgrade to what we call the "P2P APY". The P2P APY is a win-win APY for both suppliers and borrowers, it could be the average of supply and borrow net APY. Note that during strong incentivization programs, PLFs can use liquidity mining to reduce this spread or even invert it. This scenario is tackled in 2.5.

Let's illustrate one scenario for the supplier and for the borrower.

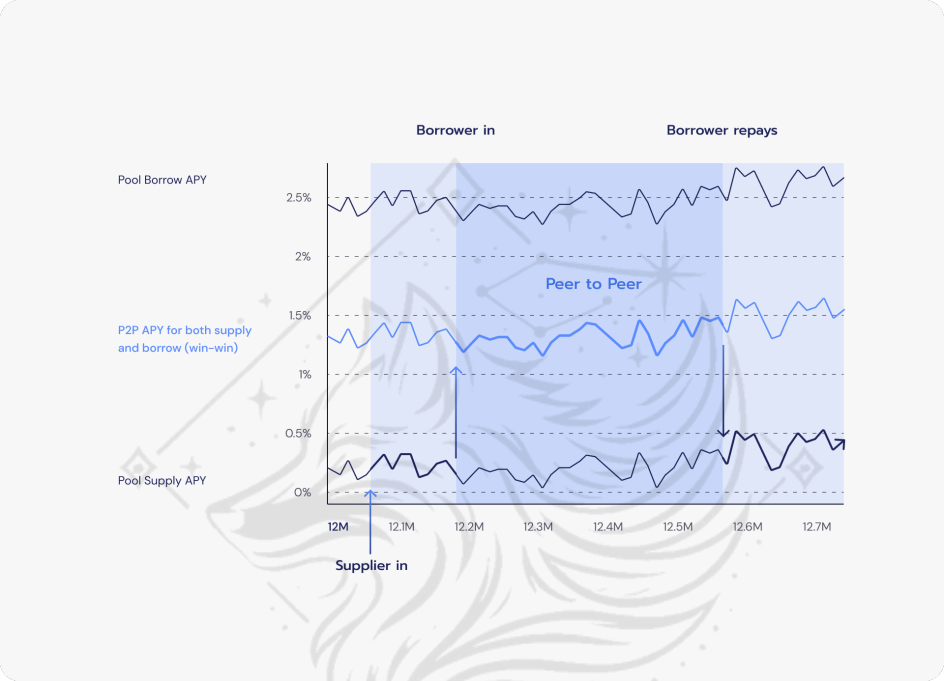


Figure 6: APY of a supplier using Morpho

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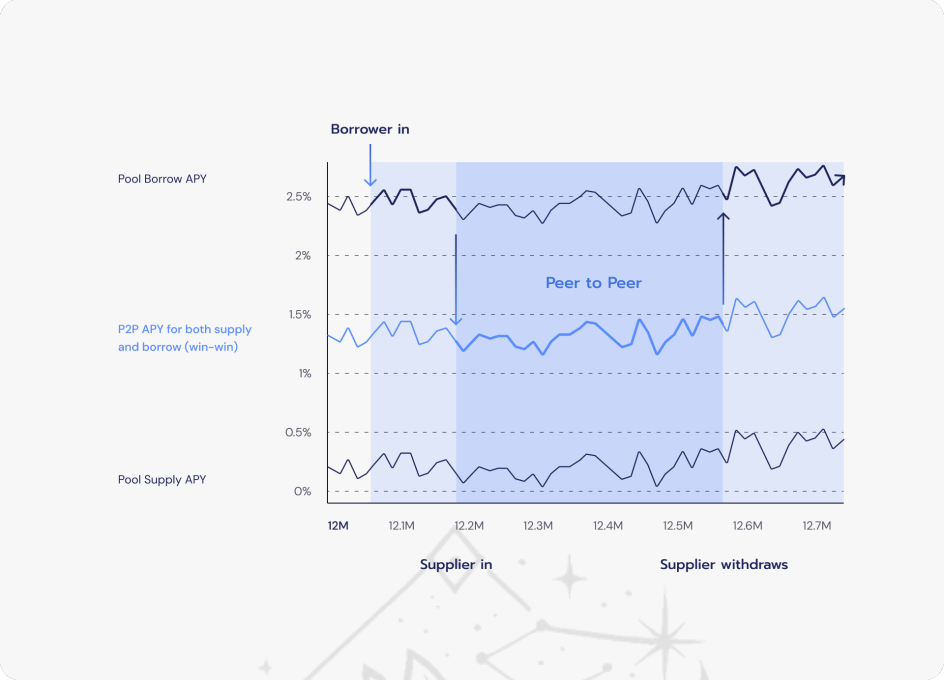


Figure 7: APY of a borrower using Morpho

As can be seen, when a P2P match is created or ended, the user jumps from experiencing a Compound rate to the optimized P2P APY offered by Morpho. Many questions arise. How do we track the P2P APY, and how is it chosen? There is often an imbalance between the number of suppliers and borrowers, how to select who will be matched? Is the matching engine fully scalable?

2.3 P2P tracking mechanics

The supply balance and the borrowing are each split into two variables: *onPool* and *inP2P*. Indeed, either the liquidity or borrow request of the user has been matched, and they benefit from the P2P APY, or not, and the supply/borrow position is on Compound.

For the *onPool* case, when the user's liquidity has been supplied or borrowed on Compound, Morpho uses Compound variables to keep track of the balances increase. For suppliers, deposits are stored in cTokens units: in this way, the yield generated by supplying on Compound is taken into account.

The *inP2P* case was inspired by cTokens mechanisms from current liquidity protocols. Morpho introduces a unit called 'p2pIndex', whose underlying value grows over time, and which will be used to describe the "on Morpho" debt (both for suppliers and borrowers). Its value is linked to the unit of the token by the variable $p2pIndex$ according to the following formula :

$$valueInUnderlying = valueInP2PUnit \times p2pIndex$$

The variable $p2pIndex$ is updated according to the mid-rate yield per block via an internal function, which is called each time a user calls a function that needs to do the conversion to this unit. Note that the complexity is constant.

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Example 2.3 *Assume 1 ETH = 200 cETH. Alice comes first and supplies 1 ETH to Morpho, her supply balance becomes:*

$$\begin{cases} onPool : 200\, cETH \\ inP2P : 0\, p2pETH \end{cases}$$

Now Bob borrows 1 ETH. Assume that, at this moment, 1 ETH = 100 p2pETH. Alice's supply balance becomes:

$$\begin{cases} onPool : 0\, cETH \\ inP2P : 100\, p2pETH \end{cases}$$

Note that Bob shares the same numbers for his borrowing balance. A year later, if the mid-rate remains 1.4%, the price of p2pETH should be approximately 1 ETH = 98.6 p2pETH.

Note that in current PLFs there is a great imbalance between the volume of loanable funds compared to the volume of demand. This is done on purpose as liquidity pools need more suppliers than borrowers to work. This is not the case with Morpho which could have much more borrowers than suppliers and still be fully liquid and working. Moreover, in Morpho, this imbalance is not necessarily in favor of suppliers since rates are very different.

Indeed, the imbalance is highly dependent on market conditions and thus on the P2P APY itself. One may remark that the P2P APY positioned in the middle in the examples is an arbitrary choice and should be flexible to reflect supply and demand eg. taking a rate closer to the supply APY of the PLF instead of the actual middle to attract more borrowers. Without having to build a complete competitive interest rates market, as in 4., some flexibility can be easily introduced to the P2P APY by updating it according to market conditions.

2.4 The matching engine

P2P positions on Morpho benefit from a 100% utilization rate, which means that, in terms of volume, there is as much supply as borrow demand. This is a key difference from other pool-based PLF where there is a lot more loanable liquidity than borrow demand, inducing low utilization rates of their pool and thus creating the APY spread.

Most of the time, there will be an imbalance between supply and demand in Morpho. For example, one can expect n units of suppliers trying to match k units of borrowers with $n > k$ (or vice-versa). The protocol needs to select k happy suppliers to enjoy the P2P APY and the $n - k$ others will be put on the PLF. The module in the code responsible for choosing and matching the k users will be referred to as the matching engine.

There are many alternative ways to design a matching engine: a FIFO queue (First-In-First-Out), a volume sorted queue, uniformly random choice amongst users waiting in the pools, ... To design Morpho, different parameters may be taken into account:

- Economic Efficiency: Maximize matched volumes.
- Gas Efficiency: Minimize gas, avoid dust problems.[6]

[6] Dust is defined as very small amounts.

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- Simplicity: A passive user or contract should be able to benefit from Morpho simply supplying/borrowing.
- Fairness: The use of Morpho should benefit as many users as possible.

One might think that efficiency is gained to the advantage of a small club of suppliers that are matched. This is not quite the case. The contention here is that the way the interest rate market is run at the moment in DeFi disincentivizes the demand for liquidity on the borrowing side. With Morpho in place, more borrowers show up and the entire cash-flow market grows. Moreover, as described in 2.3, the P2P APY will self-adjust according to offer and demand and thus attract even more users!

One could also imagine that this matching engine requires to loop over the number of users and thus can't be scalable with the constraints of the blockchain. The Morpho algorithm does use a loop to iterate through users. The idea is that Morpho's gas cost is chosen by the DAO, which sets how many matches are done for each user. When there is no gas for matching left, the algorithm falls back to the pool for the remaining amount. This ensures the full scalability of Morpho

Finally, remark that Morpho is fully onchain. The Yellow Paper shall provide the full description of this algorithm.

2.5 Token Incentives and inverted spreads

Compound or Aave are currently undergoing very strong liquidity mining programs as they emit large amounts of their native tokens AAVE or COMP to incentivize users onto their respective protocols. If the user is not in a P2P position (i.e. the user is placed in a pool), Morpho transfers all the rewards to guarantee at least the same rates as Compound.

Often, liquidity mining rewards can reduce the net APY (APY+rewards) spread or even invert it, i.e. APY borrow $<$ APY supply, as can be seen in the following picture.

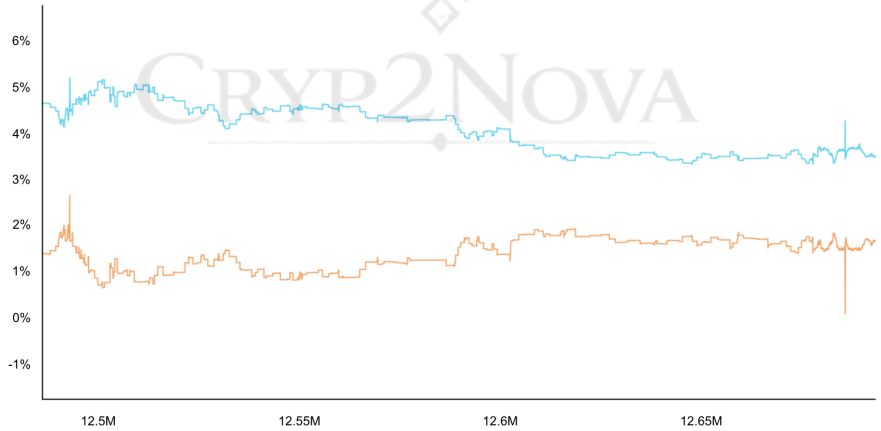


Figure 8: Net borrow APY (orange) and net supply APY (blue) for DAI over 150k Ethereum blocks

In this scenario, Morpho guarantees at least the liquidity mining inflated APY, but it will be less likely to have a strictly better APY. Moreover, one may remark that a

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user could have to deal with three different kinds of tokens in the same platform: the underlying token, the pool token, and the Morpho Token.

To solve those problems, Morpho could let the user trade their accumulated COMP or AAVE to Morpho Tokens with the Morpho DAO when they claim their rewards. By doing so, the user gets a bonus of Morpho Tokens, which is given out from Morpho's own incentive program. Remark that Morpho thus accumulates AAVE and COMP, which makes sense as it may want to have a say in the governance of the pool it relies on.

To summarize, two regimes can be distinguished for Morpho:

- The spread of the PLF is not inverted: Morpho moves supply and borrowing positions in and out of the PLF to get improved APYs as described in 2.1 In the long term, this scenario will be the most likely.
- The spread of the PLF is inverted: Morpho and the user can trade claimed rewards from COMP/Aave to Morpho Tokens, incentivizing users by providing a bonus.

The user is hence better off using Morpho in every scenario.

2.6 Sustainability and Reserve factor

The Morpho protocol is a common good initiative aiming at providing users with the best interest rates to supply and borrow crypto-assets. Like any software system, Morpho will need a cash flow to maintain and update its algorithm until it has fully matured into a convenient and optimal service for all. To do so, a small fee is taken in the protocol. The fee is a cut of the improvement made by Morpho compared to the pool it optimizes.

3 A metamorphosis into DeFi's next generation

Morpho is not only a new way to supply and borrow with more profitable rates, but it is also the first step towards a much broader financial opportunity, yet to be tackled in DeFi: competitive interest rate markets. In this section, we present the mechanics by which Morpho opens the door to this new space, and how it could progressively evolve into a much more general and efficient interest rate machine is discussed. As of September 2021, there are three steps in the envisioned evolution of the protocol: creating liquidity pool optimizers (Caterpillar), progressively introducing active liquidity in PLFs (Chrysalis), and finally enabling a fully competitive, independent, and optimal interest rate service in DeFi (Butterfly).

3.1 Caterpillar

Caterpillar is the first chapter of Morpho's evolution. It is the implementation of the protocol described in part 2.1.: enabling suppliers to be automatically moved out of the pools to go for an efficient P2P model whenever there is a borrower available and to fall back to the underlying pool when there is no match. Concretely, Caterpillars will

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be a set of multiple smart contracts, each optimizing a liquidity pool on one chain. For example, Morpho-Aave on Polygon, Morpho-Aave on Ethereum, Morpho-Compound on Ethereum, ...

3.2 Chrysalis

Caterpillars are great but they have one weakness, the pool. If the pool is not liquid anymore, the Caterpillar is not liquid as well. Taking a step back, we realize that in traditional and decentralized finance, liquidity can either come from idle pools or from activity, where market makers constantly put the liquidity where it is the most needed.

Similarly to Uniswap V3 [AZS+21], one solution would be to give the user the flexibility to choose between different P2P APYs (eg. the mid-rate, a rate a bit lower but still inside the spread, a rate a bit higher but still inside the spread)

On this observation, it appears that Caterpillar could become a Chrysalis, by accepting active users and posting liquidity promises at certain rates, within the spread of the pool. Concretely, Morpho will rely less and less on the pool, but the latter would still be a supplier/borrower of last resort. you can think of chrysalis as an order book of finite size, closed by the underlying liquidity pool.

3.3 Butterfly

A final approach would be to let the suppliers choose their own rate, inside or outside the spread.

Recall that some protocols already tried P2P competitive positions a few years ago but were not so successful because of the very low liquidity of suppliers. Indeed, the Ethereum blockchain is possibly not widespread nor efficient enough for professional market makers to create this liquidity. Pools were created to solve this problem, ensuring a continuous experience for the user. However, Morpho solves this issue by piggybacking on other protocols: if a supplier cannot find a match in the book, Morpho matches them with the underlying pool!

Assuming, that blockchain technology will be mature and efficient enough to address a larger audience, Morpho would rely less and less on PLFs. At some point, one can assume that it will not need an underlying PLF anymore and thus can stop relying on the liquidity pools, choosing its own course.

Under that incarnation, Morpho will probably appear as a more general kind of order book where every proposed position is connected in an instant, automatic and efficient way.

The composable order book of Mangrove [Tea21a] enables liquidity providers to tap into the whole DeFi ecosystem as their back-end infrastructure. Morpho Labs has been working closely with the Mangrove team to develop the Morpho Protocol. It turns out that Morpho's Butterfly version can reuse the matching engine of The Mangrove. Suppliers publish their overnight (δ) offers on an A/B book where an offer is a triple (N_A, N_B, r) with N_A the number of As asked as collateral, N_B the number of Bs lent, r the percentage increment required for payback at $t_1 = t_0 + \delta$.

A key difference with this mechanism is that the rate will no longer be computed by the platform as a Pareto-improvement on Compound's borrow and supply APY spread, but will emerge as naturally defined competitively by the suppliers.

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Upon a match, a contract is created between the parties (there may be multiple at the same time), following some collateral constraint like $\alpha_A v(N_A) \geq v(N_B)$. If either the collateral constraint is crossed, or the contract is still unpaid at $t \geq t_1$, it can be liquidated by a supplier.

4 Product Position: a liquidity protocol optimizer

Morpho's long-term goal is to make supplying and borrowing operations in DeFi more efficient and seamless. However, to start with, Caterpillar's scope is dedicated to Pareto-improving current PLF. You are using Compound? Consider Morpho-Compound. If you are using Aave, consider using Morpho-Aave, etc. By doing so, you will then improve the capital efficiency, and thus the APY, of your current positions, whilst preserving the same liquidity and the same guarantees.

One could distinguish two kinds of protocols in DeFi, financial primitives such as Uniswap, Aave, Curve, Compound, ... which provide essential bricks, and other protocols such as StakeDAO, ParaSwap, Yearn, Convex, ... that compose the primitives to build more complex and personalized products for the end-user, often taking trade-offs between risks and yields. Morpho is a middle layer between the two and is not comparable to the rest of the DeFi space.

Morpho optimizes the interest rate market, offering the same services as Compound or Aave with improved rates while guaranteeing the same liquidity and liquidation guarantees. It should be expected that rational users of Compound and Aave would eventually switch to the Morpho Protocol to enhance their yields. However Morpho is not a primitive itself, it is a primitive optimizer, an intermediate layer between primitives and end-user endpoints: Protocols (or individuals) using Aave should use the Morpho contract that connects to Aave to have better yields for their users without taking additional market risks!

Since 80% of Compound/Aave users are protocols. We can expect the same proportion for Morpho-Aave. Morpho is thus positioned at the bottom of DeFi's stack, right on top of the primitive.

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4.1 Use cases

Here is a list of non-exhaustive use cases to make the use of Morpho more concrete for the reader. Again, the main concept to remember is that wherever a pool-like Compound or Aave is used, you can use Morpho-Compound or Morpho-Aave instead.

4.1.1 Strategists

Many protocols like Yearn [Tea21b] or StakeDAO [BJ21] build strategies to maximize the earnings or minimize the costs of the users. Such protocols use Compound or Aave and thus can use Morpho-Aave or Morpho-Compound to generate even better returns without taking additional market risks.

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4.1.2 Aggregators

Aggregators constantly try to find the best rates between different supply or borrow markets. Remark that if Morpho-Compound is aggregated with Compound, an aggregator will never switch back to Compound. Moreover, Morpho's interfaces are the same for Morpho-Compound, Morpho-Aave, and others. An integrator will be much more friendly with a single interface rather than many. This way, one integrator can consider only having the Morpho optimizers aggregated.

4.1.3 Stablecoins

Decentralized stable coin protocols build strategies for their collateral to work. However, those strategies must be fully liquid so that the protocol can redeem the tokens and ensure the peg of the assets. That is why many of those build strategies on Aave are famous for being very liquid. With Morpho-Aave, protocols keep the same liquidity and improve their rates! Most stablecoin protocols provide substantial leverage for users supplying collateral in strategies. With Morpho in place as a strategy for a stablecoin, the yield optimization could be multiplied for the stablecoin protocol.

4.1.4 Individuals

Individuals can of course interact with Morpho on a front-end like compound.morpho.xyz. The ADMO, the association for the development of the Morpho DAO is also working to develop the use of Morpho Protocol and favor integration with end-user wallets.

One could simply supply assets to Morpho and start earning interests. A slightly more complex approach would be to borrow stable coins against other assets as collateral to put the borrowed tokens to work in yield farming protocols.

Sophisticated users also borrow to implement more complex strategies, like shorts or to build leveraged positions. Both of these kinds of users are likely to be interested in enjoying optimized rates for their trading strategies.

4.2 An additional layer of smart contracts

Morpho introduces new lines of code, connecting to existing protocols. One has to be fully aware of what that means when using the protocol. First, it induces an additional gas price when using Morpho-Compound rather than Compound. Second, Morpho is a new layer of smart contracts that is yet to be battle-tested in the market. The latter introduces additional hack risk for the user. Nonetheless, it should be noted that the most famous auditors in the world like Trail of Bits, Chainsecurity, or Spearbits each have or will soon audit Morpho Protocol. Finally, with the help of Certora, the Morpho Labs team is undergoing the formal proving of the protocol.

5 Conclusions

The Morpho Protocol takes on the challenge of improving the way current dominant DeFi liquidity protocols assign rates for suppliers and borrowers. Morpho does so by exploring DeFi's composability nature and combining cleverly the efficiency of earlier

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Peer-to-Peer protocols with the liquidity offered by Pool-to-Peer protocols. The resulting construct pleasantly optimizes rates while giving away none of the benefits enjoyed by the Pool-to-Peer protocols.

The current landscape for money markets in DeFi is noncompetitive for suppliers. By enhancing rates, Morpho advocates stronger adoption of the protocol by the borrowing side, overall increasing the trading activity of the market.

But, more efficient, fairer, and deeper interest rate markets are just the first step. With increased adoption of the protocol, Morpho serves as a stepping stone towards building competition in the DeFi rates market.

6 Acknowledgement

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7 Legal disclaimer

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References

[AZS+21] Hayden Adams, Noah Zinsmeister, Moody Salem, River Keefer, and Dan Robinson. Uniswap v3 core. *https://uniswap.org/whitepaper-v3.pdf*, 2021.

Archived copy · cryp2nova.com

[BJ21] Julien Bouteloup and Leopold Joy. Stake dao. *https://github.com/stake-capital/research/blob/master/Stake_Capital_DAO_Light_Paper.pdf*, 2021.

[GWPK20] Lewis Gudgeon, Sam Werner, Daniel Perez, and William J Knottenbelt. Defi protocols for loanable funds: Interest rates, liquidity and market efficiency. In *Proceedings of the 2nd ACM Conference on Advances in Financial Technologies*, pages 92–112, 2020.

[LH19] Robert Leshner and Geoffrey Hayes. Compound: The money market protocol. *compound.finance*, February 2019.

[PWXL20] Daniel Perez, Sam M Werner, Jiahua Xu, and Benjamin Livshits. Liquidations: Defi on a knife-edge. *arXiv preprint arXiv:2009.13235*, 2020.

[Tea18] ETHLend Team. Ethlend.io white paper - democratizing lending. *github.com/ETHLend/Documentation/blob/master/ETHLendWhitePaper.md*, February 2018.

[Tea20] Aave Team. Aave protocol whitepaper. *aave.com*, January 2020.

[Tea21a] Mangrove Team. The mangrove - a decentralized exchange protocol with reactive liquidity. *mangrove.exchange*, April 2021.

[Tea21b] YFI Team. Yearn finance. *https://docs.yearn.finance*, 2021.

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