I. DeFi Deep Dive

Modules

1. **Credit and Lending**
   i. MakerDAO
   ii. Compound
   iii. Aave
2. Decentralized Exchange
3. Derivatives
4. Tokenization

Part III:

DeFi Deep Dive

1. Credit and Lending

(i) MakerDAO

(a) Creation of DAI

Credit/Lending: MakerDAO

Background

- As the name suggests, MakerDAO is a decentralized autonomous organization.
- The primary value-add is the creation of a crypto-collateralized stablecoin, pegged to USD called DAI. This means the system can run completely from within the Ethereum blockchain without relying on outside centralized institutions to back, vault and audit the stablecoin.
- Two token model: DAI = stablecoin and MKR = governance token

https://makerdao.com/whitepaper/White%20Paper%20-The%20Maker%20Protocol_%20MakerDAO%E2%80%99s%20Multi-Collateral%20Dai%20(MCD)%20System-FINAL-%20021720.pdf

Credit/Lending: MakerDAO

Mechanics of DAI

- DAI is generated as follows. A user can deposit ETH or other supported ERC-20 assets into a *Vault*.
- A Vault is a smart contract that escrows collateral and keeps track of the USD-denominated value of the collateral. No one owns the vault – it is an "contract account", as opposed to an EOA.
- The user can then mint DAI up to a certain collateralization ratio on their assets.
- This creates a "debt" in DAI that must be paid back by the Vault holder.

Credit/Lending: MakerDAO

Mechanics of DAI

- The DAI is the corresponding asset that can be used any way the Vault holder wishes.
  - Example 1: user can sell the DAI for cash
  - Example 2: use can use DAI to buy more of the collateral asset, and repeat the process, to create a levered position.
- Due to the volatility of ETH and most collateral types, the collateralization requirement is far in excess of 100% and usually in the 150-200% range.

Credit/Lending: MakerDAO

Collateralized debt position (CDP)

- The basic idea is not new; a homeowner in need of some liquidity can pledge their house as collateral to a bank and receive a mortgage loan structured to include a cash takeout.
- The price volatility of ETH is much greater than for a house and, as such, collateralization ratios for the ETH-DAI contract are higher.
- In addition, no centralized institution is necessary as everything happens within the Ethereum blockchain.

Credit/Lending: MakerDAO

Example

- Suppose an ETH owner needs liquidity but does not want to sell her ETH because she thinks it will appreciate.
- The situation is analogous to the homeowner who needs liquidity but does not want to sell her house.

Credit/Lending: MakerDAO

Example

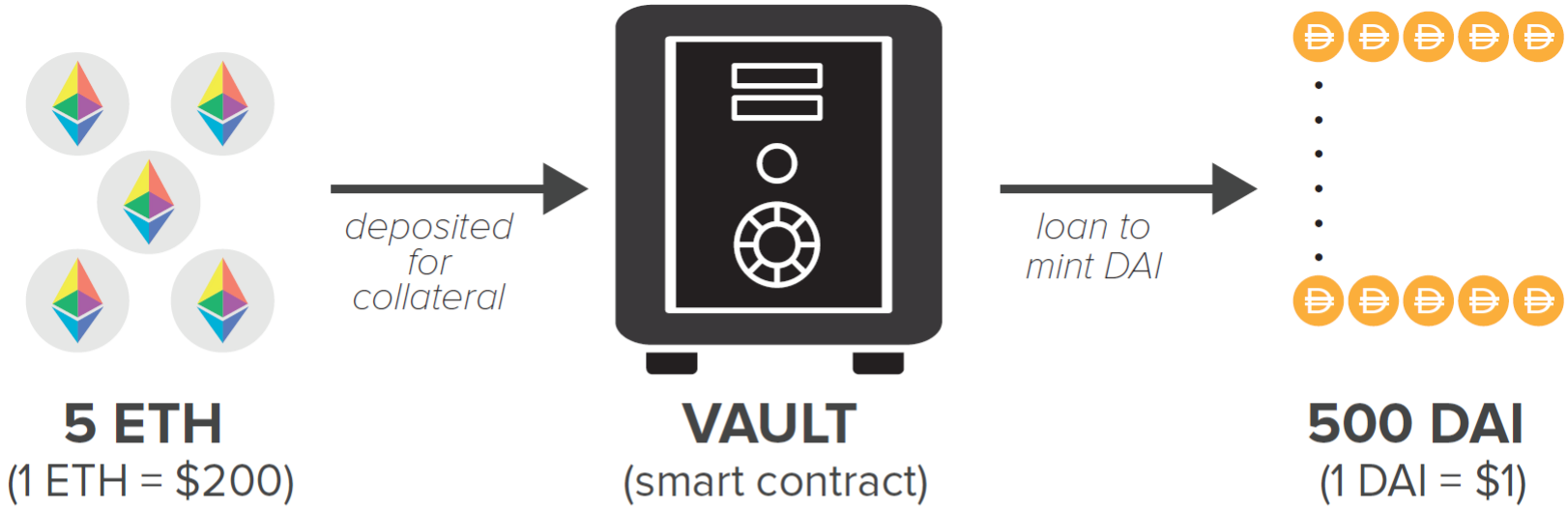
- Let's say an investor has 5 ETH at a market price of $200 (total value of $1,000).
- If the collateralization requirement is 150%, then the investor can mint up to 667 DAI ($1,000/1.5 with rounding).
- The collateralization ratio is set high to reduce the probability that the loan debt exceeds the collateral value, and for the DAI token to be credibly pegged to the USD, the system needs to avoid the risk that the collateral is worth less than $1=1 DAI.

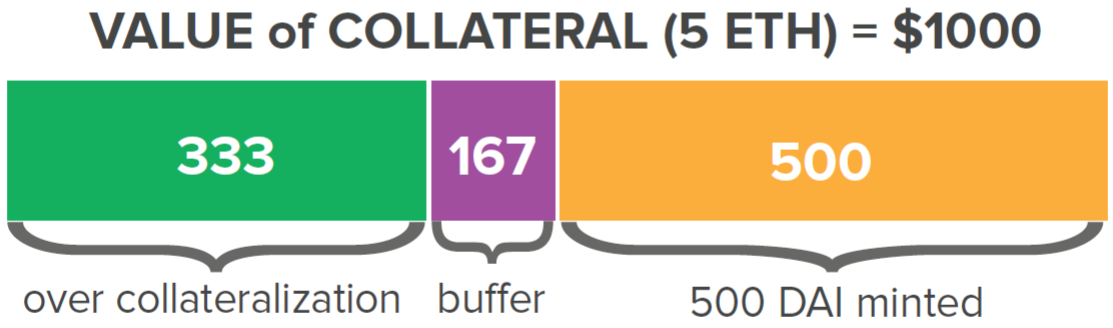
Credit/Lending: MakerDAO

Example

- Given the collateralization ratio of 1.5, it would be unwise to mint the 667 DAI because if the ETH ever dropped below $200, the contract would be undercollateralized, the equivalent of a “margin call”.
- We are using traditional finance parlance, but in DeFi there is no communication from your broker about the need to post additional margin or to liquidate the position and also no grace period.
- Liquidation can happen immediately.

Credit/Lending: MakerDAO





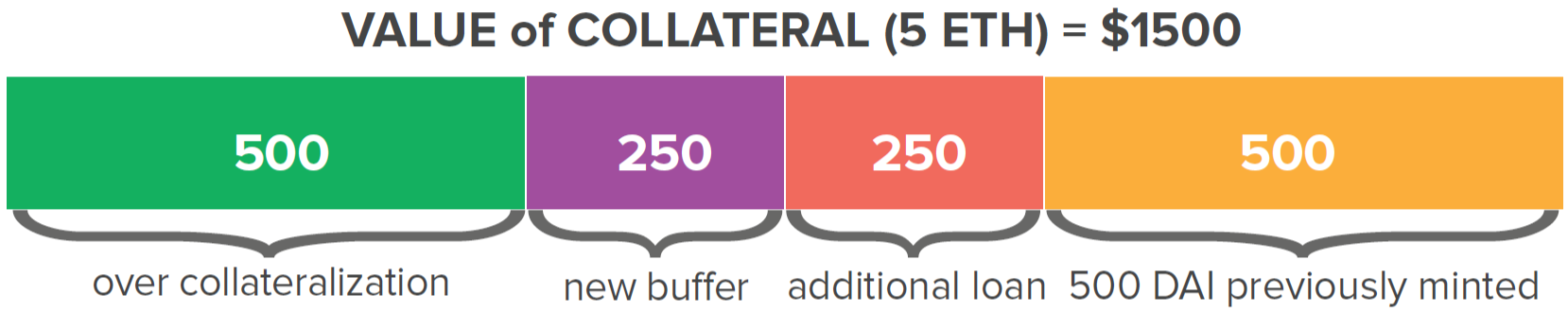
collateralization factor: **150%**
maximum loan: **1000/1.5 = 667 DAI**
actual loan: **500 DAI**

Credit/Lending: MakerDAO

Scenario 1

ETH appreciates 50% $200 —> $300

- Suppose ETH rises by 50% so collateral is worth $1,500.
- The investor can increase the size of her loan.
- To maintain the collateralization of 200%, the investor can mint an extra 250 DAI.



collateralization factor: **150%**
maximum loan: **1500/1.5 = 1000 DAI**
actual loan: **500 DAI** —> (ratio now 300%)
additional loan: **250 DAI**
new loan: **750 DAI** —> (ratio 200%)

Part III:

DeFi Deep Dive

1. Credit and Lending

(i) MakerDAO

(b) Liquidation

Credit/Lending: MakerDAO

Scenario 2

ETH depreciates 25% $200 —> $150

VALUE of COLLATERAL (5 ETH) = $750

collateralization factor: **150%**
maximum loan: **750/1.5 = 500 DAI**
actual loan: **500 DAI** —> (ratio now 150%)

- Suppose the value of the ETH drops by 25% from $200 to $150.
- In this case, the value of the collateral drops to $750 and the collateralization ratio drops to 1.5 ($750/1.5 = 500).

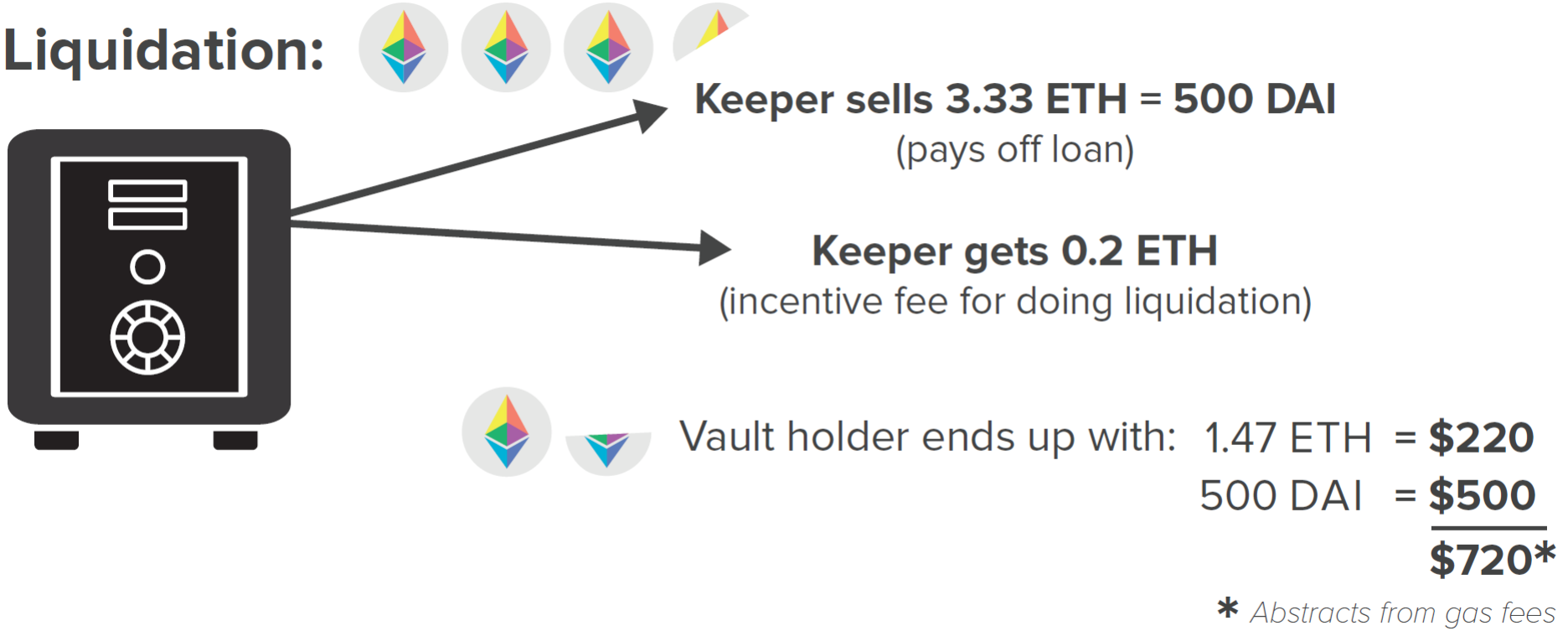
Credit/Lending: MakerDAO

Example

Suppose the value of the ETH drops by 25% from $200 to $150.

- The Vault user faces three scenarios.
  1. She can increase the amount of collateral in the contract (by, for example, adding 1 ETH).
  2. She can use the 500 DAI to pay back the loan and repatriate the 5 ETH. These ETH are now worth $250 less, but the depreciation in value would have happened irrespective of the loan.
  3. The loan is liquidated by a *keeper* (any external actor).

Credit/Lending: MakerDAO



- The keeper auctions the ETH for enough DAI to pay off the loan.
- 3.33 ETH are sold and 1.47 ETH returned to the Vault holder.
- Keeper gets incentive fee of 0.2 ETH
- Vault holder has 500 DAI worth $500 and 1.47 ETH worth $220.

Credit/Lending: MakerDAO

Stability forces

- Two forces in this process reinforce the stability of DAI.
  1. Overcollateralization.
  2. Market actions. In the liquidation, ETH are sold and DAI are purchased, which exerts positive price pressure on DAI.

Credit/Lending: MakerDAO

Maintaining the Peg

- The viability of the MakerDAO ecosystem critically depends on DAI maintaining a 1:1 peg to the USD.
- Various mechanisms are in place to incentivize demand and supply in order to drive the price toward the peg.
- The primary mechanisms are: the debt ceiling, stability fee, and DAI Savings Rate (DSR).
- These parameters are controlled by holders of the governance token Maker (MKR) and MakerDAO governance.

Credit/Lending: MakerDAO

Stability fee

- The Stability Fee is a variable interest rate paid in DAI by Vault holders on any DAI debt they generate.
- The interest rate can be raised or lowered (even to a negative value) to incentivize the generation or repayment of DAI to drive its price toward the peg.

Credit/Lending: MakerDAO

DAI Savings Rate (DSR)

- The Stability Fee funds the DSR, a variable rate any DAI holder can earn on their DAI deposit.
- The DSR compounds on a per-block basis. The Stability Fee, which must always be greater or equal to the DSR, is enforced by the smart contracts powering the platform.

Credit/Lending: MakerDAO

DAI Debt Ceiling

- Lastly, a smart contract–enforced DAI debt ceiling can be adjusted to allow for more or less supply to meet the current level of demand.
- If the protocol is at the debt ceiling, no new DAI is able to be minted in new Vaults until the old debt is paid or the ceiling is raised.

Credit/Lending: MakerDAO

Liquidation

- When a position is deemed to be under the liquidation ratio, a keeper can initiate an auction (sell some of the ETH collateral) to liquidate the position and close the Vault holder's debt.
- The *Liquidation Penalty* is calculated as a percentage of the debt and is deducted from the collateral in addition to the amount needed to close the position.

Credit/Lending: MakerDAO

Large drops in the value of collateral

- If the collateral drops so far in value that the DAI debt cannot be fully repaid, the position is closed, and the protocol accrues what is known as *Protocol Debt*.
- A buffer pool of DAI exists to cover Protocol Debt, but in certain circumstances the debt can be too great for even the buffer pool to cover.
- The solution involves the governance token MKR and the governance system.

Part III:

DeFi Deep Dive

1. Credit and Lending

(i) MakerDAO

(c) Governance

Credit/Lending: MakerDAO

Governance

- The MKR token controls MakerDAO.
- Holders of the token have the right to vote on protocol upgrades, including supporting new collateral types and tweaking parameters such as collateralization ratios.
- MKR holders are expected to make decisions in the best financial interest of the platform.
- Their incentive is that a healthy platform should increase the value of their share in the platform's governance.

Credit/Lending: MakerDAO

Global settlement

- For example, poor governance could lead to a situation where the buffer pool is not sufficient to pay back the Protocol Debt.
- In this case, newly minted MKR tokens are auctioned off in exchange for DAI and the DAI are used to pay back the Protocol Debt.
- This process is *Global Settlement*, a safety mechanism intended for use only when all other measures have failed.
- Global Settlement dilutes the MKR share, which is why stakeholders are incentivized to avoid it and keep Protocol Debt to a minimum.

Credit/Lending: MakerDAO

Decisions of MKR holders

- Votes by the MKR holders can change any of the parameters available on the platform, e.g., supporting new collateral types for Vaults
- MKR holders could also vote to pay themselves a dividend funded by the spread between the interest payments paid by Vault holders and the DAI Savings Rate.
- The reward of receiving this dividend would need to be weighed against any negative community response that might decrease the value of the protocol and the MKR token.

Credit/Lending: MakerDAO

Why DAI is attractive

- Importantly, users can purchase and utilize DAI without having to go through the process of generating it in a Vault—they can simply purchase DAI on an exchange.
- Therefore, users do not need to know the underlying mechanics of how DAI are created.

Credit/Lending: MakerDAO

Why DAI is attractive

- Holders can easily earn the DAI Savings Rate by using the protocol.
- More technologically and financially sophisticated users can use the MakerDAO web portal to generate Vaults and create DAI to get liquidity from their assets without having to sell them.
- It is easy to sell DAI and purchase an additional amount of the collateral asset to get leverage.

Credit/Lending: MakerDAO

Drawback of DAI

- DAI supply is always constrained by demand for ETH-collateralized debt.
- No clear arbitrage loop exists to maintain the peg.
- For example, the stablecoin USDC is always redeemable by Coinbase for $1, with no fees. Arbitrageurs have a guaranteed (assuming solvency of Coinbase) strategy in which they can buy USDC at a discount or sell it at a premium elsewhere and redeem on Coinbase.
- This is not true for DAI. Irrespective of any drawbacks, the simplicity of DAI makes it an essential building block for other DeFi applications.

Credit/Lending: MakerDAO

Traditional Finance Problem	**MakerDAO Solution**
Centralized Control: Interest rates are influenced by the US Federal Reserve and access to loan products controlled by regulation and institutional policies.	MakerDAO platform is openly controlled by the MKR holders.
Limited Access: Obtaining loans is difficult for a large majority of the population.	Open ability to take out DAI liquidity against an overcollateralized position in any supported ERC-20 token. Access to a competitive USD-denominated return in the DSR.
Inefficiency: Acquiring a loan involves costs of time and money.	Instant liquidity at the push of a button with minimal transaction costs.
Lack of Interoperability: Cannot trustlessly use USD or USD-collateralized token in smart contract agreements.	Issuance of DAI, a permissionless USD-tracking stablecoin backed by cryptocurrency. DAI can be used in any smart contract or DeFi application.
Opacity: Unclear collateralization of lending institutions.	Transparent collateralization ratios of vaults visible to entire ecosystem.

Part III:

DeFi Deep Dive

1. Credit and Lending

(ii) Compound

(a) What is Compound?

Credit/Lending: Compound

What is Compound?

- Compound is a lending market that offers several different ERC-20 assets for borrowing and lending.
- All the tokens in a single market are pooled together so every lender earns the same variable rate and every borrower pays the same variable rate.

Credit/Lending: Compound

Overcollateralization

- The concept of a credit rating is irrelevant, and because Ethereum accounts are pseudonymous, enforcing repayment in the event of a loan default is virtually impossible.
- For this reason, all loans are overcollateralized in a collateral asset different from the one being borrowed.
- If a borrower falls below their collateralization ratio, their position is liquidated to pay back their debt.
- The debt can be liquidated by a keeper. The keeper receives a bonus.

Credit/Lending: Compound

Collateralization ratios and factors

- The collateralization ratio is calculated via a *collateral factor*.
- Each ERC-20 asset on the platform has its own collateral factor ranging from zero to 90.
- A collateral factor of zero means an asset cannot be used as collateral.
- The required collateralization ratio for a single collateral type is calculated as 100 divided by the collateral factor.

Credit/Lending: Compound

Collateralization ratios and factors

- Volatile assets generally have lower collateral factors, which mandate higher collateralization ratios due to increased risk of a price movement that could lead to undercollateralization.
- An account can use multiple collateral types at once, in which case the collateralization ratio is calculated as 100 divided by the weighted average of the collateral types by their relative sizes (denominated in a common currency) in the portfolio.

Credit/Lending: Compound

Collateralization ratio is like a reserve multiplier

- The collateralization ratio is similar to a reserve multiplier in traditional banking, constraining the amount of “borrowed” dollars that can be in the system relative to the “real” supply.
- For instance, there is occasionally more DAI in Compound than is actually supplied by MakerDAO, because users are borrowing and resupplying or selling to others who resupply.
- Importantly, all MakerDAO supply is ultimately backed by real collateral and there is no way to borrow more collateral value than has been supplied.

Credit/Lending: Compound

Example

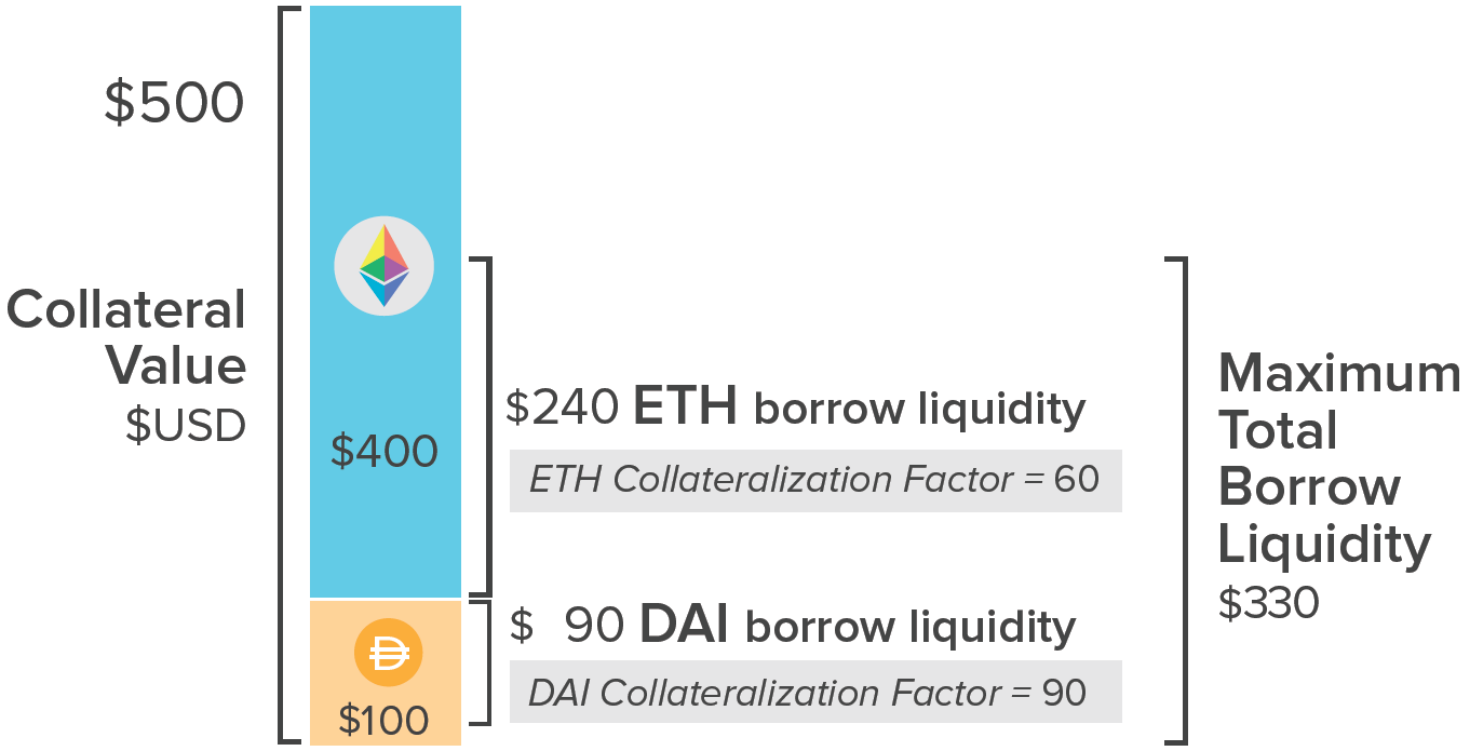
- An investor deposits 100 DAI with a collateral factor of 90.
- This transaction alone corresponds to a required collateralization ratio of 111%.
- Assuming 1 DAI = $1, the investor can borrow up to $90 worth of any other asset in Compound.

Credit/Lending: Compound

Example

- If she borrows the maximum, and the price of the borrowed asset increases at all, the position is subject to liquidation.
- Suppose she also deposits two ETH with a collateral factor of 60 and a price of $200/ETH.
- The total supply balance is now $500, with 80% being ETH and 20% being DAI. The required collateralization ratio is 100/(0.8*60 + 0.2*90) = 151%.

Credit/Lending: Compound



Collateralization Ratio

$$= \frac{\$500 \ \textit{collateral}}{\$330 \ \textit{borrow liquidity}} = 151\%$$

Also calculated as
100/(0.8x60 + 0.2x90)

Course III:

DeFi Deep Dive

1. Credit and Lending

(ii) Compound

(b) Supply and Borrow Rates

Credit/Lending: Compound

Supply and borrow rates

- The supply and borrow interest rates are compounded every block (approximately 15 seconds on Ethereum producing approximately continuous compounding) and are determined by the utilization percentage in the market.
- Utilization is calculated as total borrow/total supply.
- The utilization rate is used as an input parameter to a formula that determines the interest rates.
- The remaining parameters are set by *Compound Governance.*

Credit/Lending: Compound

Borrow rate formula

- The formula for the borrow rate generally is an increasing linear function with a y-intercept known as the *base rate* that represents the borrow rate at 0% borrow demand and a *slope* representing the rate of change of the rates.

Borrow rate = ***base rate*** + ***slope****utilization rate

- These parameters are different for each ERC-20 asset supported by the platforms.

Credit/Lending: Compound

Borrow rate formula

- Some markets have more advanced formulas that include a *kink*. A kink is a utilization ratio beyond which the slope steepens.
- These formulas can be used to reduce the cost of borrowing up to the kink and then increase the cost of borrowing after the kink to incentivize a minimum level of liquidity.

Credit/Lending: Compound

Supply interest rate formula

- Supply interest rate = (borrow interest rate x utilization ratio) so borrow payments can fully cover the supplier rates.
- The *reserve factor* is a percentage of the borrow payments not given to the suppliers and instead set aside in a reserve pool that acts as insurance in that case a borrower defaults.
- In an extreme price movement, many positions may become undercollateralized in that they have insufficient funds to repay the suppliers. In the event of such a scenario, the suppliers would be repaid using the assets in the reserve pool.

Credit/Lending: Compound

Example

- In the DAI market, 100 million is supplied and 50 million is borrowed.
- Suppose the base rate is 1% and the slope is 10%.
- At 50 million borrowed, utilization is 50%.
- The borrow interest rate is then calculated to be 0.5*0.1 + 0.01 = 0.06 or 6%.
- The maximum supply rate (assuming a reserve factor of zero) would simply be 0.5*0.06 = 0.03 or 3%.

Credit/Lending: Compound

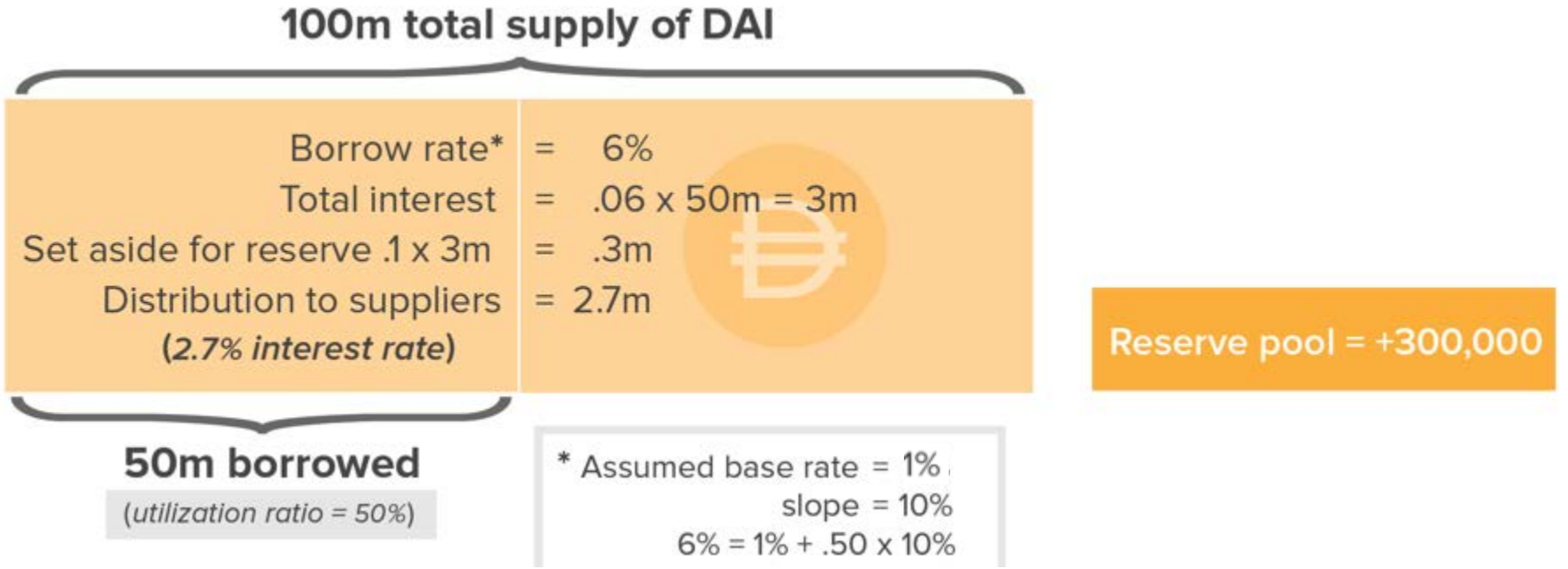
Example

- The borrow rate is not a marginal rate – it is a rate for all borrowers.
- For example, suppose an initial borrower does $25 million. The rate would be .25*0.1 + 0.01 = 3.5%.
- Then suppose another borrower enters the market with another $25 million loan.
- The rate increases to 6% for all borrowers.

Credit/Lending: Compound

Example

- If the reserve factor is set to 10, then 10% of the borrow interest is diverted to a DAI reserve pool, lowering the supply interest rate to 2.7%. 0.5*0.06*(1-0.10) = 0.027 or 2.7%.



Credit/Lending: Compound

Example

- Another way to think about the supply interest rate is that the 6% borrow interest of 50 million is equal to 3 million of borrow payments.
- Distributing 3 million of payments to 100 million of suppliers implies a 3% interest rate to all suppliers. With 10% diverted (300,000), then there is on 2.7 million of payments

Credit/Lending: Compound

Example with kink

- Suppose 100 million DAI is supplied and 90 million DAI is borrowed, a 90% utilization.
- The kink is at 80% utilization, before which the slope is 10% and after which the slope is 40%, which implies the borrow rate will be much higher if the 80% utilization is exceeded.

Credit/Lending: Compound

Example with kink

- The base rate remains at 1%.
- The borrow interest rate = 0.01 (base) + 0.8*0.1 (pre-kink) + 0.1*0.4 (post-kink) = 13%.
- The supply rate (assuming a reserve factor of zero) is 0.9*0.13 = 11.7%.

Credit/Lending: Compound

Advantages of Compound

- Unlock value of asset without selling it – like a home equity loan
- Easily engineer levered long or short positions
- Suppose you are bearish on price of ETH
  - Deposit stablecoin like USDC or DAI
  - Borrow ETH
  - Sell ETH for stablecoin
  - If price of ETH falls, you can use your stablecoin to buy (cheap) ETH to pay off debt

Credit/Lending: Compound

Advantages of Compound

- Levered positions are possible too
- Suppose you are bearish on price of ETH
  - Deposit stablecoin like USDC or DAI
  - Borrow ETH
  - Sell ETH for stablecoin
  - Deposit additional stablecoin from your sale
  - Borrow more ETH
  - Sell additional ETH for stablecoin
  - If price of ETH falls, you can use your stablecoin to buy (cheap) ETH to pay off debt

Part III:

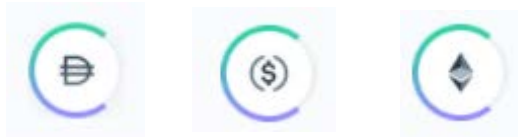
DeFi Deep Dive

1. Credit and Lending

(ii) Compound

(c) cTokens

Credit/Lending: Compound



cTokens

- The Compound protocol must escrow tokens as a depositor in order to maintain that liquidity for the platform itself and to keep track of each person's ownership stake in each market.
- A naive approach would be to keep track of the number inside a contract.
- A better approach would be to tokenize the user's share.
- Compound does this using a cToken, and this is one of the platform's important innovations.

Credit/Lending: Compound

cTokens are minted and burned

- Compound's cToken is an ERC-20 in its own right that represents an ownership stake in the underlying Compound market.
- For example, cDAI corresponds to the Compound DAI market and cETH corresponds to the Compound ETH market.
- Both tokens are minted and burned in proportion to the funds added and removed from the underlying market as a means to track the amount belonging to a specific investor.

Credit/Lending: Compound

cTokens can be traded

- Given interest payments continually accrue to suppliers, these tokens are always worth more than the underlying asset.
- cTokens can be traded on their own like a normal ERC-20 asset.
- Other protocols can seamlessly integrate with Compound simply by holding cTokens and allows users to deploy their cTokens directly into other opportunities, such as using a cToken as collateral for a MakerDAO Vault.
- Instead of using ETH only as collateral, an investor can use cETH and earn lending interest on the ETH collateral.

Credit/Lending: Compound

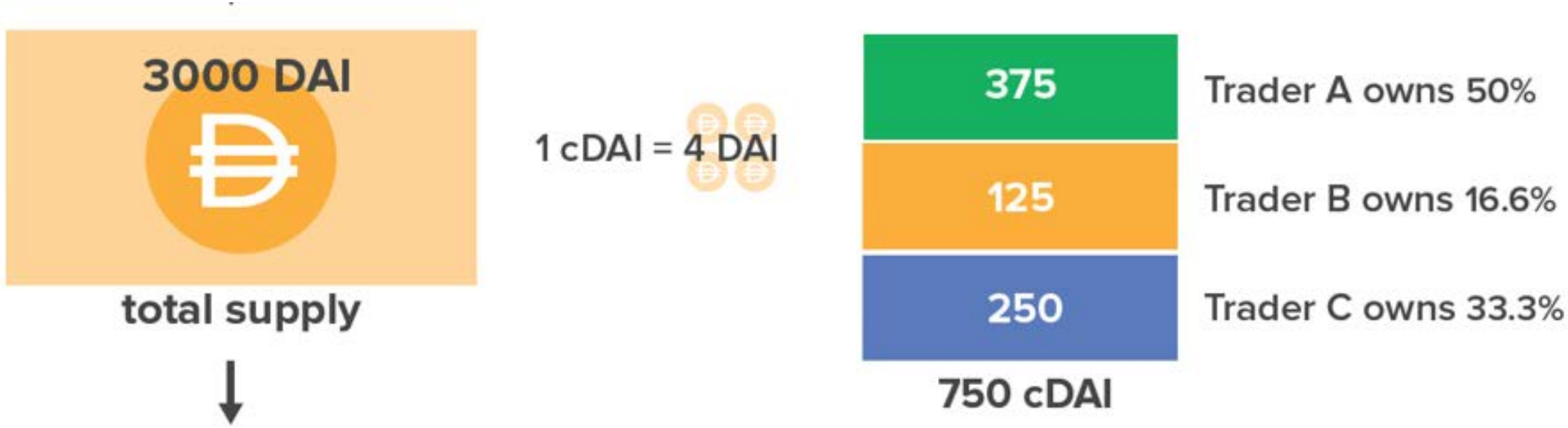
Example

- Assume there are 2,000 DAI in the Compound DAI market and a total 500 cDAI represents the ownership in the market; this ratio of cDAI to DAI is not determinative and could just as easily be 500,000 cDAI.

Credit/Lending: Compound

Example

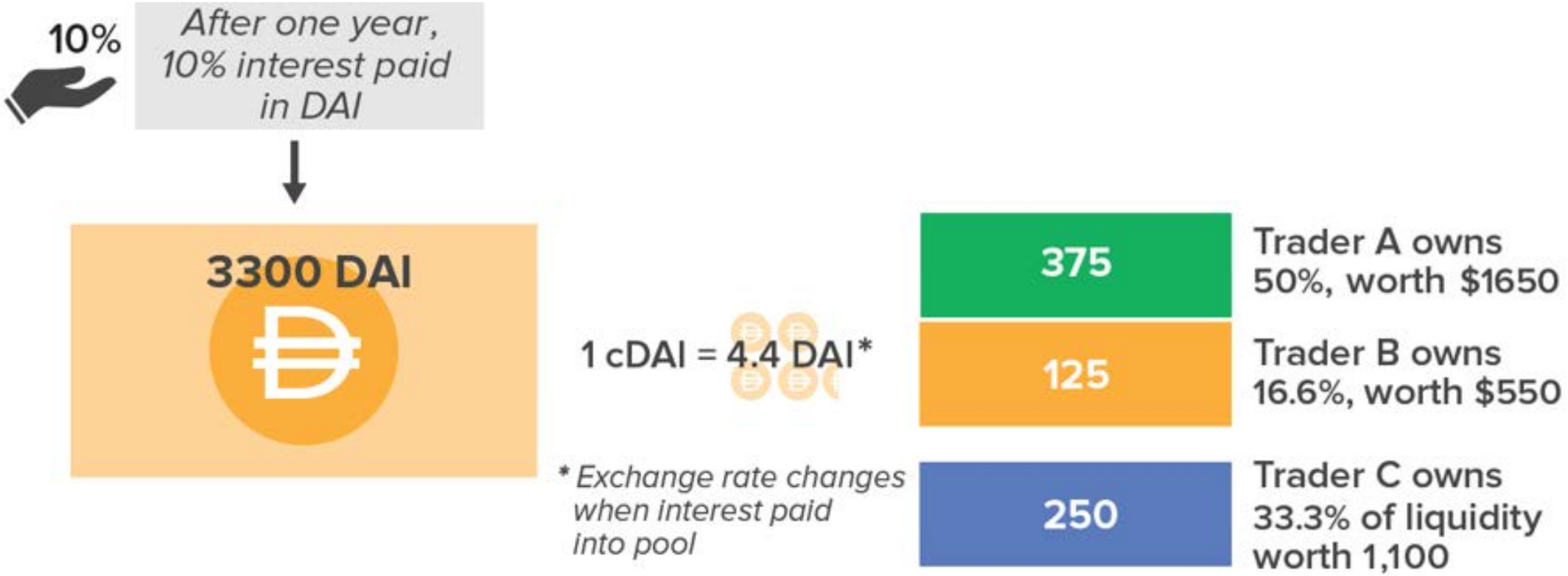
- If a trader comes in and deposits 1,000 DAI, the supply increases by 50% (and Compound mints 50% or 250 cDAI)



Credit/Lending: Compound

Example

- Currently, 1 cDAI = 4 DAI, but after interest accrues the ratio will change. Let interest = 10%, at year end, 3,300 DAI. Trader redeems 250 cDAI for 1,100 DAI



Credit/Lending: Compound

Example

- Note that the trader can deploy cDAI in the place of DAI so the DAI is not sitting idle but earning interest via the Compound pool.
- For example, the trader could deploy cDAI as the necessary collateral to open a perpetual futures position on dYdX or she could market make on Uniswap using a cDAI trading pair (discussed later).

Part III:

DeFi Deep Dive

1. Credit and Lending

(ii) Compound

(d) Governance

Credit/Lending: Compound

Governance parameters

- The many different parameters of Compound's functionality, such as the *collateral factor, reserve factor, base rate, slope,* and *kink*, can all be tuned.
- The entity capable of tuning these parameters is *Compound Governance*.
- Compound Governance has the power to change parameters, add new markets, freeze the ability to initiate new deposits or borrows in a market, and even upgrade some of the contract code itself.

Credit/Lending: Compound

Governance

- Importantly, Compound Governance cannot steal funds or prevent users from withdrawing.
- In the early stages of Compound's growth, governance was controlled by developer admins, similar to any tech startup.
- Technically, this meant that the first version of Compound was not fully decentralized

Credit/Lending: Compound

Governance parameters

- A strong development goal of Compound, as with most DeFi protocols, was to remove developer admin access and release the protocol to the leadership of a DAO via a governance token.
- The token allowed shareholders and community members to collectively become Compound Governance and propose upgrades or parameter tuning.
- A quorum agreement is required for any change to be implemented.
- The quorum rule is a majority of users each of whom holds with a minimum of 400,000 COMP (~4% of total eventual supply)

Credit/Lending: Compound

COMP token

- Compound implemented this new governance system in May 2020 via the COMP token.
- COMP is used to vote on protocol updates such as parameter tuning, adding new asset support, and functionality upgrades (similar to MKR for MakerDAO).
- On June 15, 2020, the 7th governance proposal passed which provided for distributing COMP tokens to users of the platform based on the borrow volume per market.

Credit/Lending: Compound

COMP token

- The proposal offered an experience akin to a tech company giving its own stock to its users.
- The COMP token is distributed to both suppliers and borrowers, and acts as a subsidization of rates.

Credit/Lending: Compound

COMP token

- With the release of the token on public markets, COMP's market cap spiked to over $2 billion.
- The price point of the distribution rate is so high that borrowing in most markets turned out to be profitable.
- This arbitrage opportunity attracted considerable volume to the platform, and the community governance has made and passed several proposals to help manage the usage.

Credit/Lending: Compound

Other platforms use Compound

- The Compound protocol can no longer be turned off and will exist on Ethereum as long as Ethereum exists.
- Other platforms can easily escrow funds in Compound to provide additional value to their users or enable novel business models.
- Easy, instant access to yield or borrow liquidity on different Ethereum tokens makes Compound an important platform in DeFi.

Credit/Lending: Compound

Fair lotteries

- PoolTogether is a no-loss lottery that deposits all user's funds into Compound, but pays the entire pool's earned interest to a single random depositor at fixed intervals.
- In most lotteries, 30-50% of the lottery sales are tagged for administrative costs and government or charitable use; hence, the expected value of investing $1.00 in a lottery is $0.50-$0.70.
- In a no-loss lottery, all sales are paid out and the expected value is $1.00.

Credit/Lending: Compound

Traditional Finance Problem	**Compound Solution**
Centralized Control: Borrowing and lending rates are controlled by institutions.	Compound rates are determined algorithmically and gives control of market parameters to COMP stakeholders incentivized to provide value to users.
Limited Access: Difficulty in accessing high-yield USD investment opportunities or competitive borrowing.	Open ability to borrow or lend any supported assets at competitive algorithmically determined rates (temporarily subsidized by COMP distribution).
Inefficiency: Suboptimal rates for borrowing and lending due to inflated costs.	Algorithmically pooled and optimized interest rates.
Lack of Interoperability: Cannot repurpose supplied positions for other investment opportunities.	Tokenized positions via cTokens can be used to turn static assets into yield-generating assets.
Opacity: Unclear collateralization of lending institutions.	Transparent collateralization ratios of borrowers visible to entire ecosystem.

Part III:

DeFi Deep Dive

1. Credit and Lending

(iii) Aave

(a) What is Aave?

Credit/Lending: Aave

What is Aave?

- Aave, launched in 2017, is a lending protocol similar to Compound.
- More tokens to supply and borrow are offered
- Importantly, the Aave lending and variable borrowing rates are more predictable, because unlike the volatile COMP token in Compound, no subsidy is involved.

Credit/Lending: Aave

Two markets

- The first is for more-conventional ERC-20 tokens similar to those of Compound, supporting assets such as ETH, USDC, and DAI.
- The second is specific to Uniswap UNI LP tokens (discussed later).
- For example, when a user deposits collateral into a Uniswap market, she receives an LP token as a *Liquidity Provider* that represents her ownership in the market.
- The LP tokens can be deposited in the Uniswap market on Aave to generate additional returns.

Credit/Lending: Aave

Flash loans

- Aave charges a fee of 9 basis points (bps) on the loan amount to execute a flash loan.
- The fee is paid to the asset pool and provides an additional return on investment to suppliers, because they each own a pro rata share of the pool.
- An important use case for flash loans is that they allow users quick access to capital as a means to refinance positions.

Credit/Lending: Aave

Example

- Assume the price of ETH is 200 DAI.
- A user supplies 100 ETH in Compound and borrows 10,000 DAI to lever up and purchase an additional 50 ETH, which the user also supplies to Compound.
- Suppose the borrow interest rate in DAI on Compound is 15% on Aave is 5%.
- The goal is to refinance the borrowing to take advantage of the lower rate offered on Aave, which is analogous to refinancing a mortgage, a long and costly process in centralized finance.

Credit/Lending: Aave

Example

- One option is to manually unwind each trade on Compound and re-do both trades on Aave to reconstruct the levered position, but this option is wasteful in terms of exchange fees and gas fees.
- A flash loan provides an attractive alternative

Credit/Lending: Aave

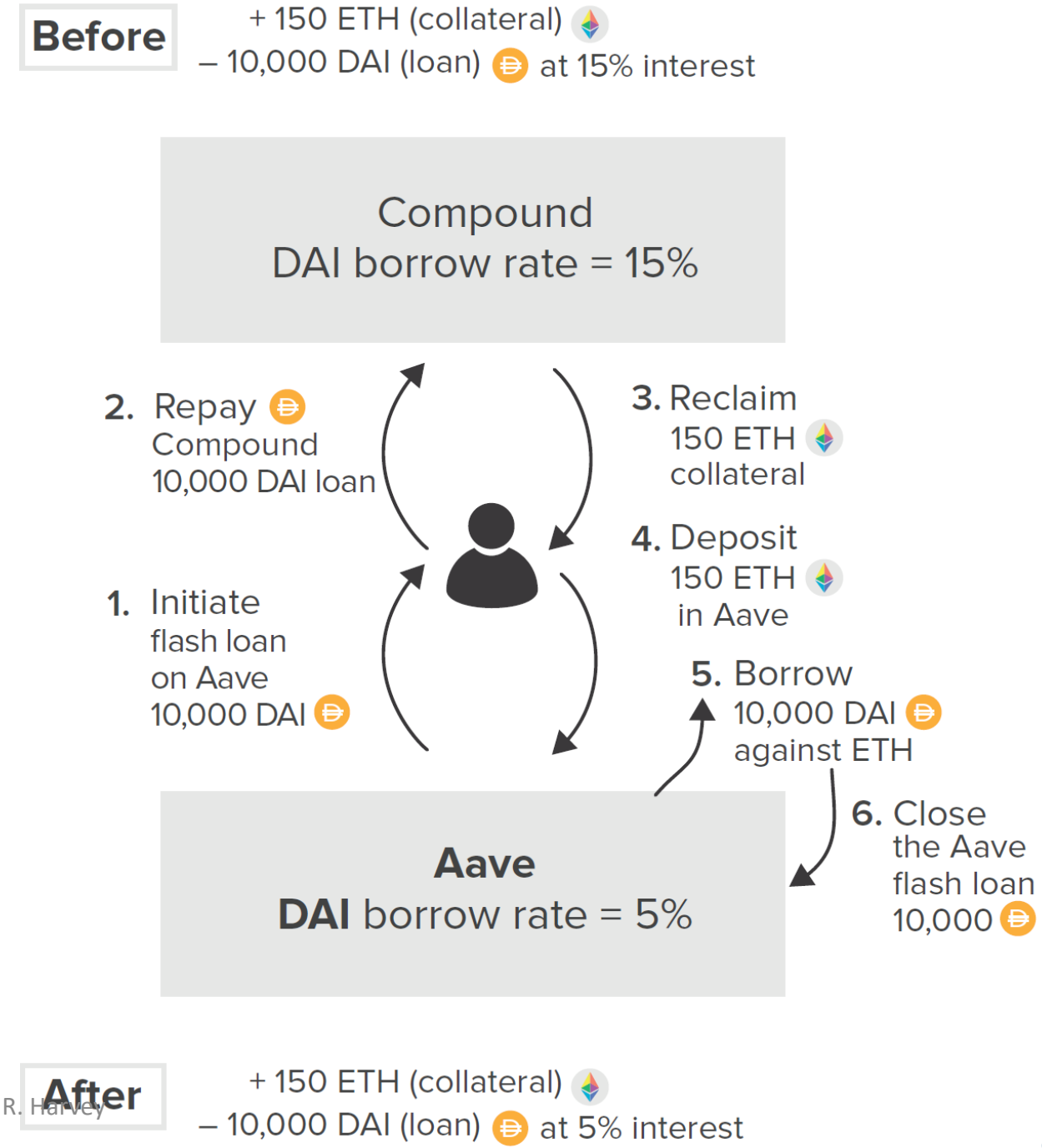
Example

- Take out a flash loan from Aave for 10,000 DAI,
- Use it to pay the debt on Compound,
- Withdraw the full 150 ETH from Compound
- Resupply to Aave, and (at 5% APR) against that collateral to repay the flash loan.
- The latter approach effectively skips the steps of exchanging ETH for DAI to unwind and rewind the leverage.

Credit/Lending: Aave

Example

- The flash loan is a single transaction
- A flash loan used to refinance a position allows for DeFi client applications that let users migrate a levered position from one dApp to another with the single push of a button.



Part III:

DeFi Deep Dive

1. Credit and Lending

(iii) Aave

(b) Stable Loans and Credit Delegation

Credit/Lending: Aave

Stable loan rate

- An Aave innovation (and as of this writing only available on Aave) is a “stable” rate loan.
- The choice of “stable” intentionally avoids the use of “fixed rate.”
- A borrower has the option to switch between the variable rate and the current stable rate.

Credit/Lending: Aave

Supply rate is not stable

- The supply rate is always variable, because under certain circumstances, such as if all borrowers left the market, it would be impossible to fund a fixed supply rate.
- The suppliers always collectively earn the sum of the stable and variable borrow interest payments minus any fees to the platform.

Credit/Lending: Aave

Stable rate is not a fixed rate

- The stable rate is not a fixed rate, because the rate is adjustable in extreme liquidity crunches and can be refinanced to a lower rate if market conditions allow.
- Also, some constraints exist around how much liquidity can be removed at a specific stable rate.
- Algorithmic stable borrowing rates provide value to risk-averse investors who wish to take on leverage without the uncertainty of a variable-rate position.

Credit/Lending: Aave

Credit delegation

- Aave is developing a *Credit Delegation* feature in which users can allocate collateral to potential borrowers who can use it to borrow a desired asset.
- The process is unsecured and relies on trust.
- This process allows for uncollateralized loan relationships, such as in traditional finance, and potentially opens up new sources of liquidity.
- The credit delegation agreements will likely have fees and credit scores to compensate for the risk of unsecured loans.

Credit/Lending: Aave

Credit delegation

- The delegator has sole discretion to determine who is an eligible borrower and what contract terms are sufficient.
- Credit delegation terms can be mediated by a smart contract.
- The delegated liquidity can be given to a smart contract, and the smart contract can use the liquidity to accomplish its intended function.
- The underlying benefit of credit delegation is that all loans in Aave are ultimately backed by collateral, regardless of whose collateral it is.

Credit/Lending: Aave

Example

- A supplier has a balance of 40,000 DAI in Aave earning interest.
- The supplier wants to increase their expected return via an unsecured delegation of their collateral to a trusted counterparty.
- The supplier likely knows the counterparty through an off-chain relationship, perhaps it is a banking client.

Credit/Lending: Aave

Example

- The counterparty can proceed to borrow, for instance, 100 ETH with the commitment to repay the asset to the supplier plus an agreed-upon interest payment.
- The practical impact is that the external relationship is unsecured because no collateral is available to enforce payment; the relationship is based essentially on trust.

Credit/Lending: Aave

Summary

- Aave flash loans offer extra returns to suppliers (incentives liquidity)
- Attracts arbitrageurs and other applications that require flash liquidity
- Stable borrow rates are compelling
- Credit delegation allows loan providers to take their own collateral in the form of nonfungible Ethereum assets, perhaps tokenized art or real estate not supported by the main Aave protocol.

Credit/Lending: Aave

Traditional Finance Problem	**Aave Solution**
Centralized Control: Borrowing and lending rates controlled by institutions.	Aave interest rates are controlled algorithmically.
Limited Access: Only select groups have access to large quantities of money for arbitrage or refinancing.	Flash loans democratize access to liquidity for immediately profitable enterprises.
Inefficiency: Suboptimal rates for borrowing and lending due to inflated costs.	Algorithmically pooled and optimized interest rates.
Lack of Interoperability: Cannot monetize or utilize excess collateral in a lending position.	Credit delegation allows parties to use deposited collateral when they do not need borrowing liquidity.
Opacity: Unclear collateralization of lending institutions.	Transparent collateralization ratios of borrowers visible to the entire ecosystem.