Decentralized Finance

Decentralized Exchanges (DEX)

Instructors: Dan Boneh, **Arthur Gervais**, Andrew Miller, Christine Parlour, Dawn Song





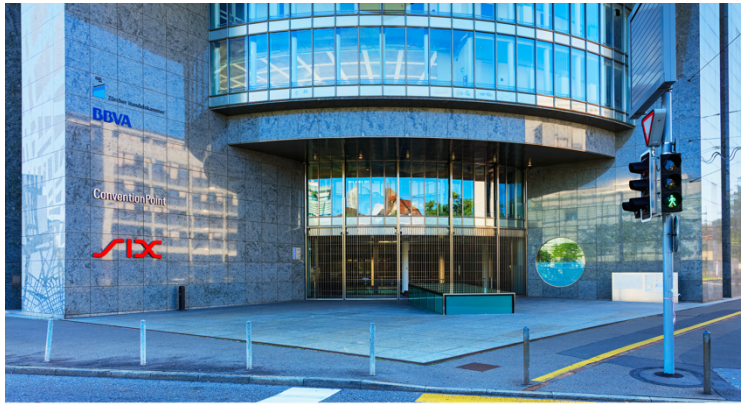
Stanford University

Imperial College London

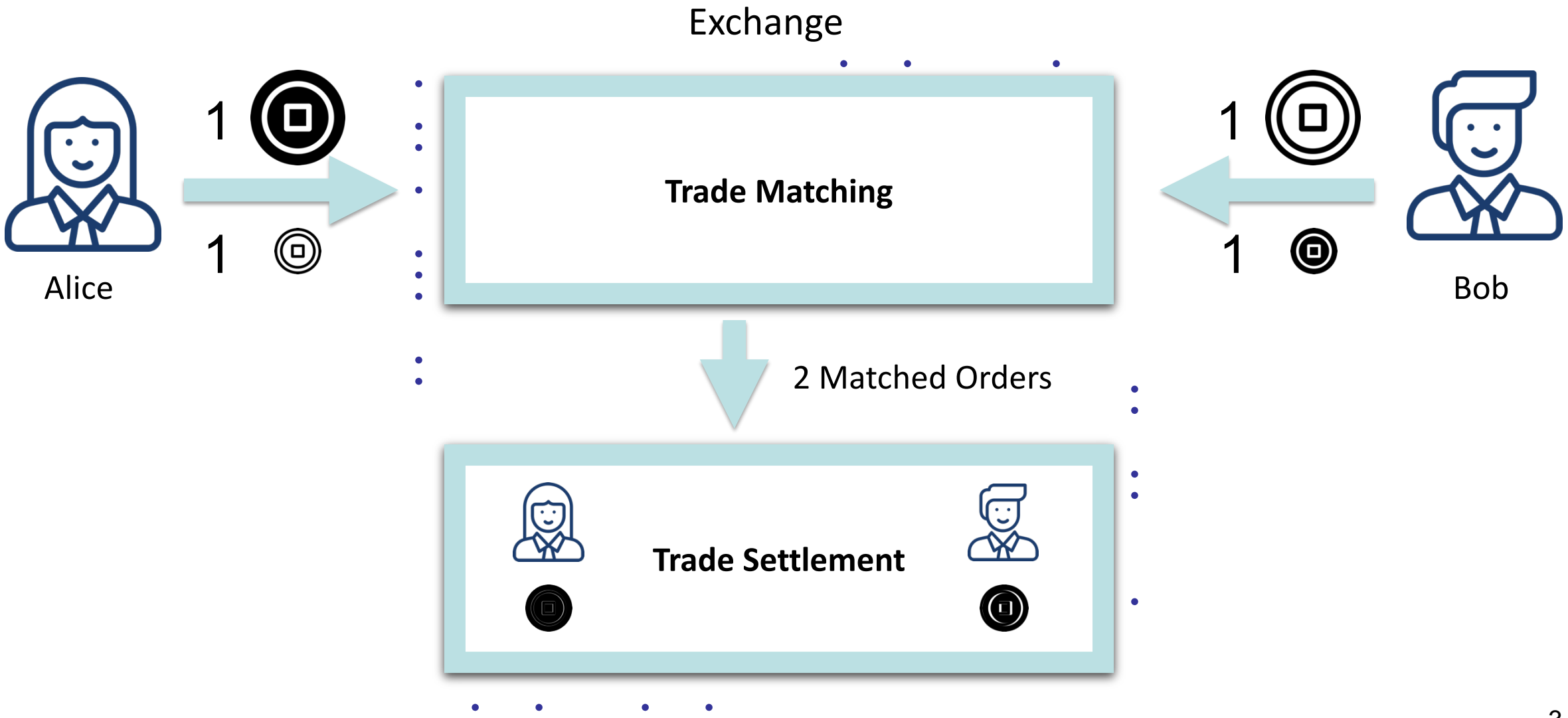
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Berkeley UNIVERSITY OF CALIFORNIA

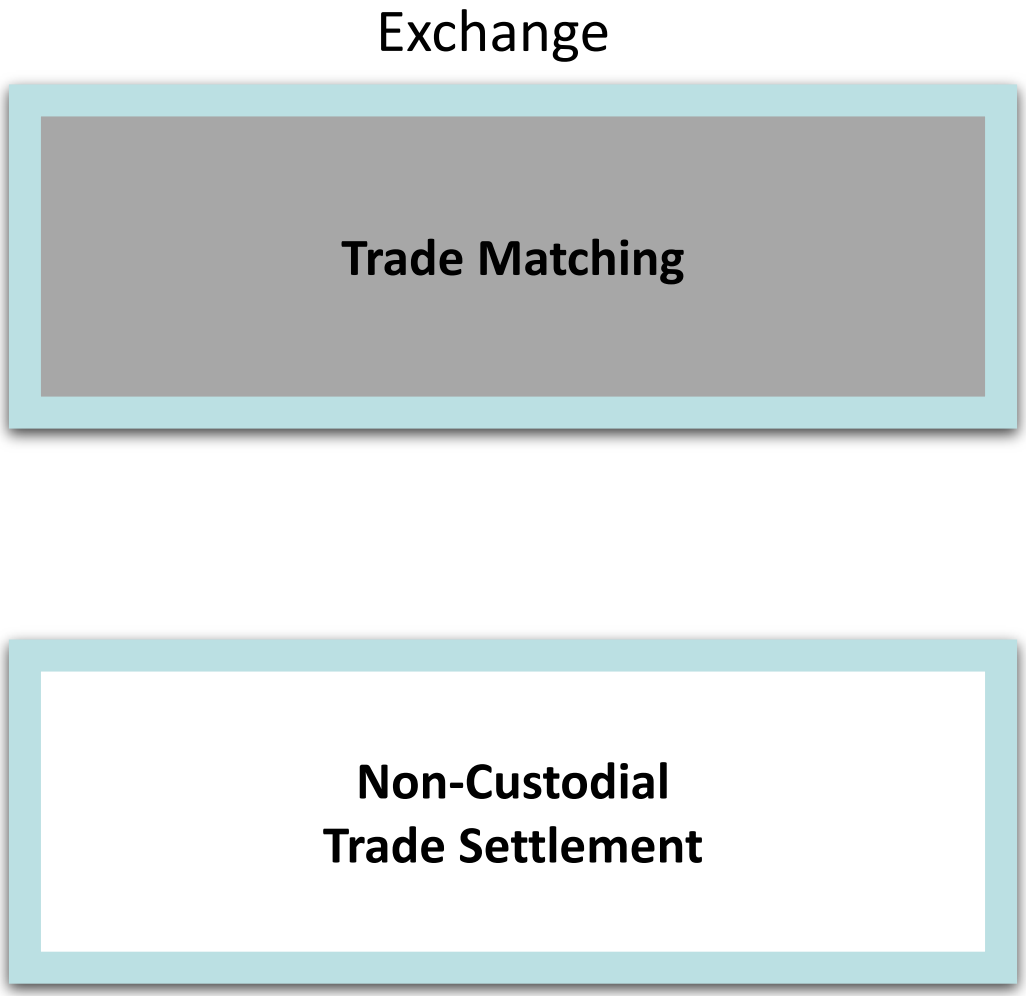
Financial Exchanges



Financial Exchanges 101



Trade Matching Models



Order Book

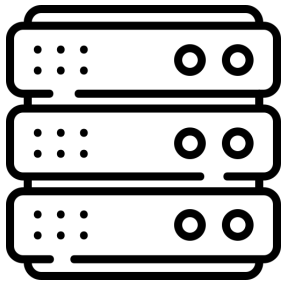
这里Market size是指在特定价格水平基类的买单/卖单数量

order book里的“ 深度 ”表示每一个价格乘以对应的数量来进行加总。 深度越深，则市场流动性越好

Two Order Book Models

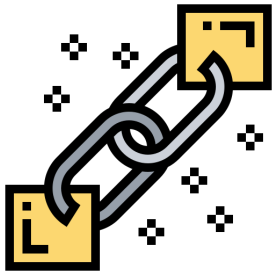
Server
中心化服务器

- Fast matching
- No fees for canceled orders
- No censorship resistance
- Exchange front running



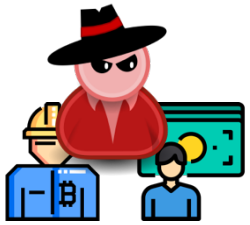
传统交易所中也容易发生front-running，并且不像在Defi中，传统交易所中的front-ning是看不到攻击者的，

On-Chain

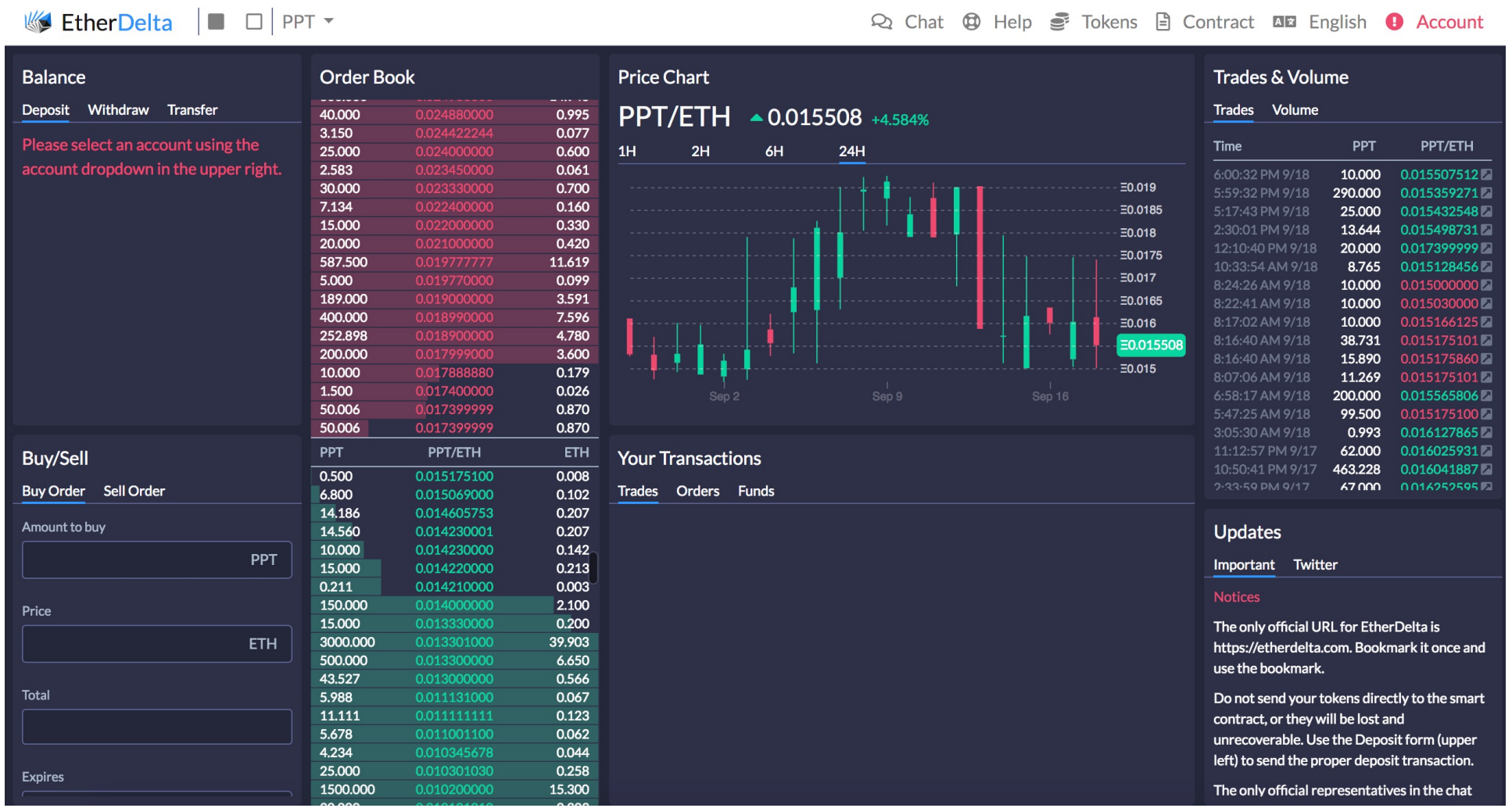


- Censorship resistance
- Robust
- Slow matching
- Blockchain fees for orders
- Miner/trader front running

但是存在MEV



EtherDelta


EtherDelta
PPT
Chat
Help
Tokens
Contract
English
Account
Balance
Deposit
Withdraw
Transfer
Please select an account using the account dropdown in the upper right.
Buy/Sell
Buy Order
Sell Order
Amount to buy
PPT
Price
ETH
Total
Expires
Order Book
40.000 0.024880000 0.995
3.150 0.024422244 0.077
25.000 0.024000000 0.600
2.583 0.023450000 0.061
30.000 0.023330000 0.700
7.134 0.022400000 0.160
15.000 0.022000000 0.330
20.000 0.021000000 0.420
587.500 0.019777777 11.619
5.000 0.019770000 0.099
189.000 0.019000000 3.591
400.000 0.018990000 7.596
252.898 0.018900000 4.780
200.000 0.017999000 3.600
10.000 0.017888880 0.179
1.500 0.017400000 0.026
50.006 0.017399999 0.870
50.006 0.017399999 0.870
PPT PPT/ETH ETH
0.500 0.015175100 0.008
6.800 0.015069000 0.102
14.186 0.014605753 0.207
14.560 0.014230001 0.207
10.000 0.014230000 0.142
15.000 0.014220000 0.213
0.211 0.014210000 0.003
150.000 0.014000000 2.100
15.000 0.013330000 0.200
3000.000 0.013301000 39.903
500.000 0.013300000 6.650
43.527 0.013000000 0.566
5.988 0.011131000 0.067
11.111 0.011111111 0.123
5.678 0.011001100 0.062
4.234 0.010345678 0.044
25.000 0.010301030 0.258
1500.000 0.010200000 15.300
Price Chart
PPT/ETH 0.015508 +4.584%
1H 2H 6H 24H
Ξ0.019
Ξ0.0185
Ξ0.018
Ξ0.0175
Ξ0.017
Ξ0.0165
Ξ0.016
Ξ0.015508
Ξ0.015
Sep 2
Sep 9
Sep 16
Your Transactions
Trades
Orders
Funds
Trades & Volume
Trades
Volume
Time PPT PPT/ETH
6:00:32 PM 9/18 10.000 0.015507512
5:59:32 PM 9/18 290.000 0.015359271
5:17:43 PM 9/18 25.000 0.015432548
2:30:01 PM 9/18 13.644 0.015498731
12:10:40 PM 9/18 20.000 0.017399999
10:33:54 AM 9/18 8.765 0.015128456
8:24:26 AM 9/18 10.000 0.015000000
8:22:41 AM 9/18 10.000 0.015030000
8:17:02 AM 9/18 10.000 0.015166125
8:16:40 AM 9/18 38.731 0.015175101
8:16:40 AM 9/18 15.890 0.015175860
8:07:06 AM 9/18 11.269 0.015175101
6:58:17 AM 9/18 200.000 0.015565806
5:47:25 AM 9/18 99.500 0.015175100
3:05:30 AM 9/18 0.993 0.016127865
11:12:57 PM 9/17 62.000 0.016025931
10:50:41 PM 9/17 463.228 0.016041887
Updates
Important
Twitter
Notices
The only official URL for EtherDelta is https://etherdelta.com. Bookmark it once and use the bookmark.
Do not send your tokens directly to the smart contract, or they will be lost and unrecoverable. Use the Deposit form (upper left) to send the proper deposit transaction.
The only official representatives in the chat

LOB DEX: Lessons Learned

order book模式的交易所

- Advantages:
  - No KYC/AML 身份认证和反洗钱
  - No fees paid to the exchange 注意，说的是不需要交手续费给交易所。并不是不交
  - No impermanent loss (explained later in AMM)

- Disadvantages:
  - Fees for deposit, withdraw, trade creation/cancel
  - Slow execution
  - Not fully decentralized (mediating server)

中介服务器

Settlement Layer 结算层

Exchange

Trade Matching

Non-Custodial
Trade Settlement

Why do we need DEX?

Alice is rich
(aka a “whale”)

Alice wants to provide her money to traders to earn fees

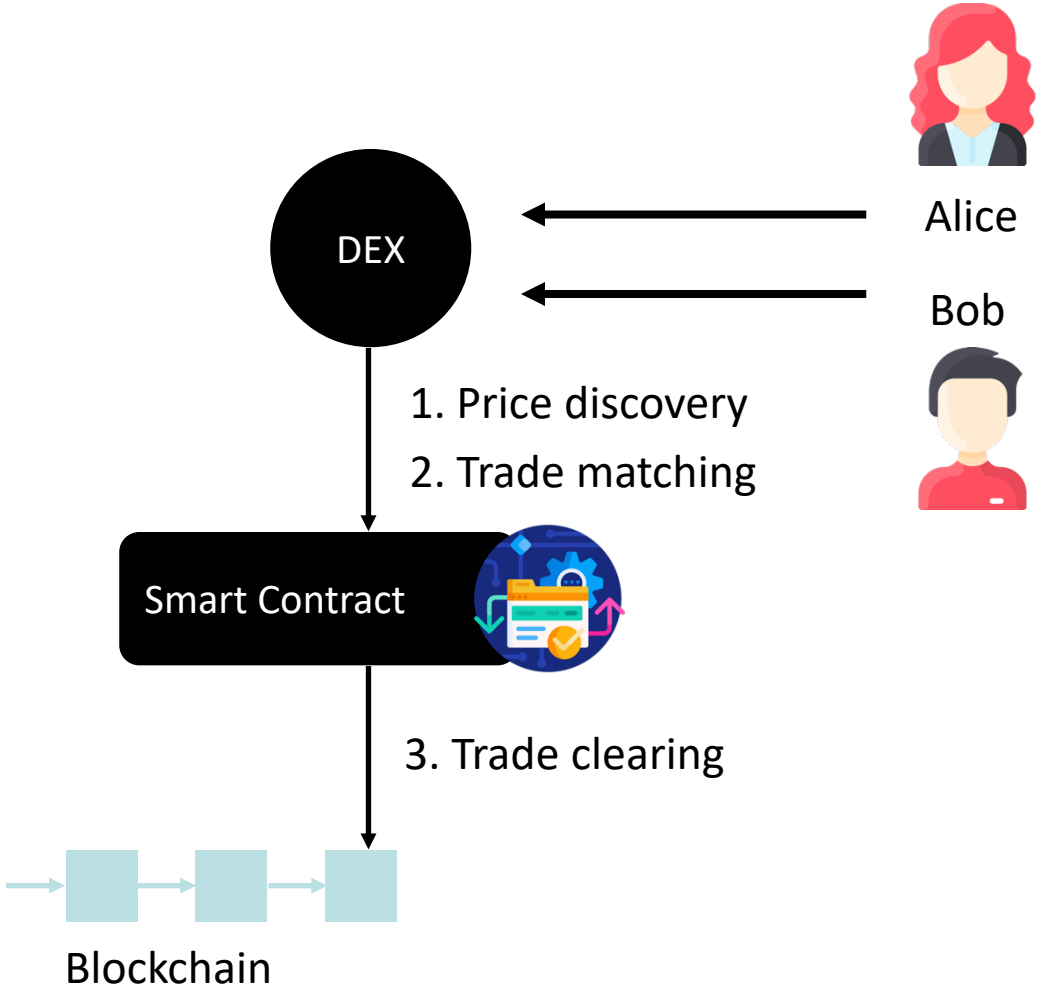
..but has to trust someone to manage her money

Bob is nifty trader

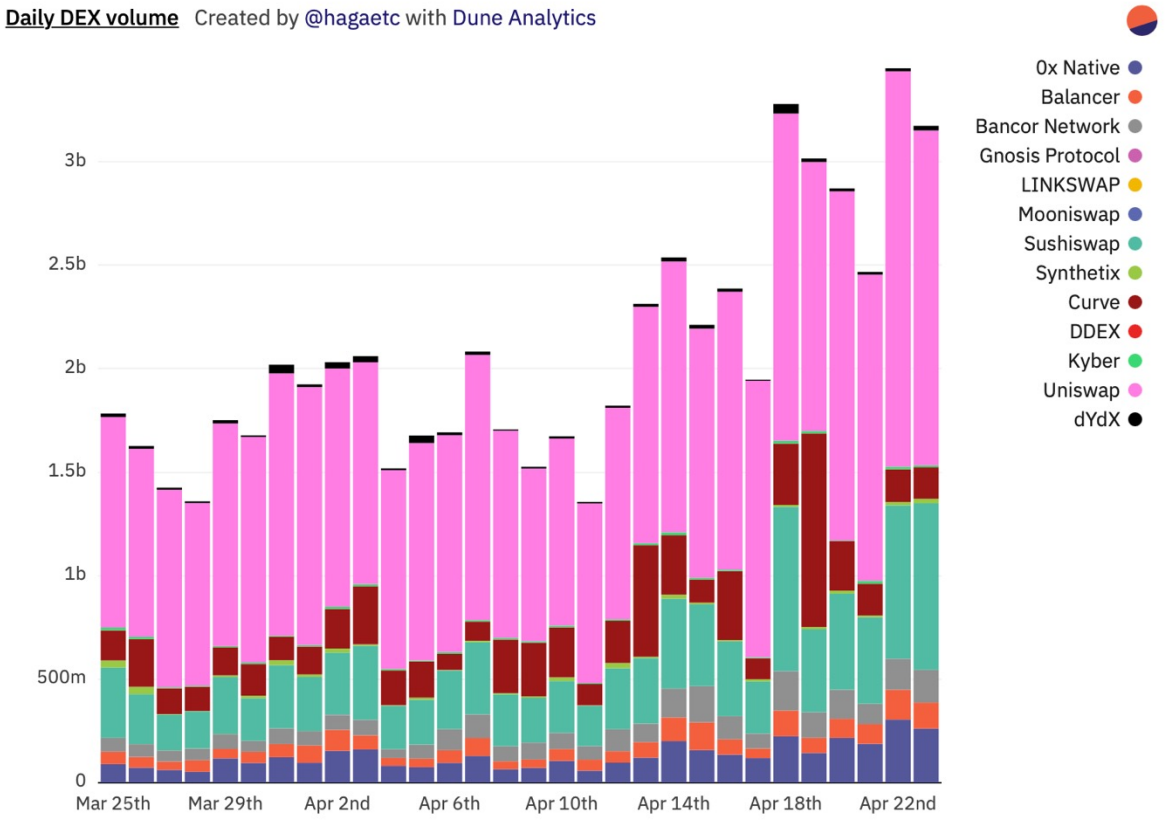
Bob wants to buy the latest coins

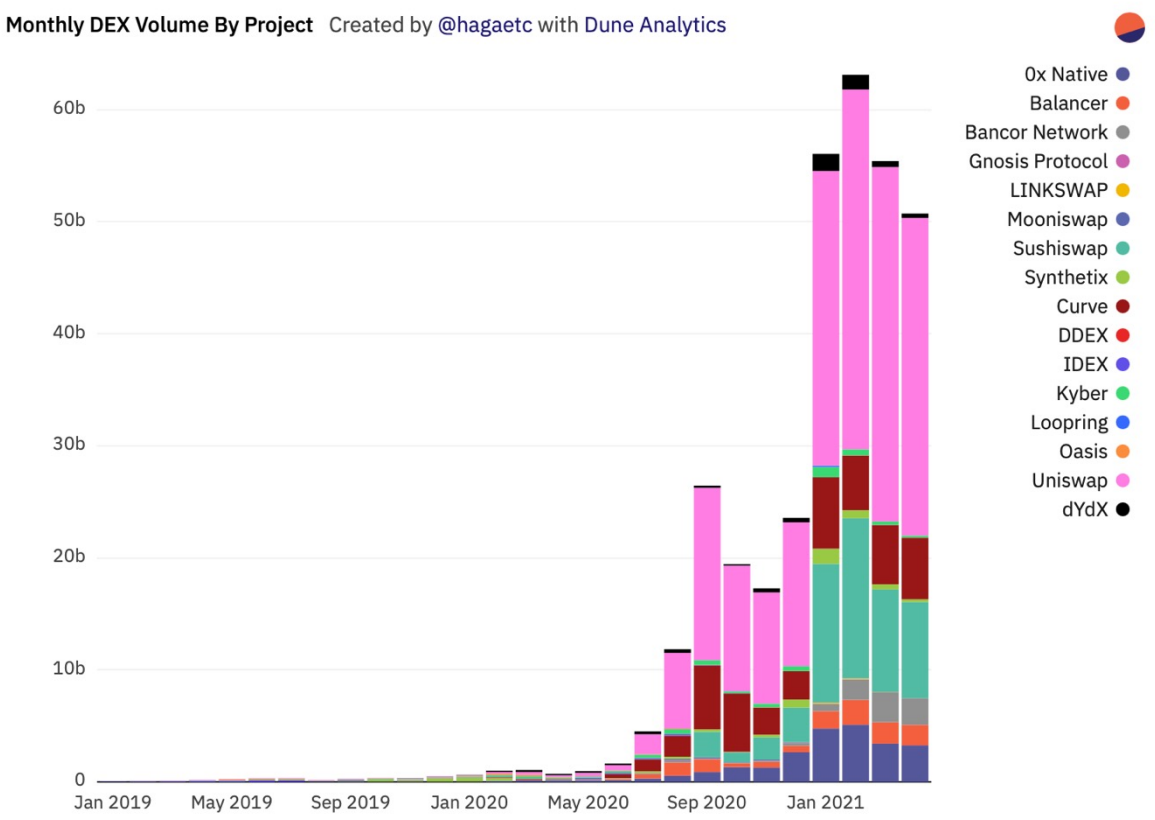
..but struggles to find a trusted source to buy

DEX System Architecture



DEX trading volume





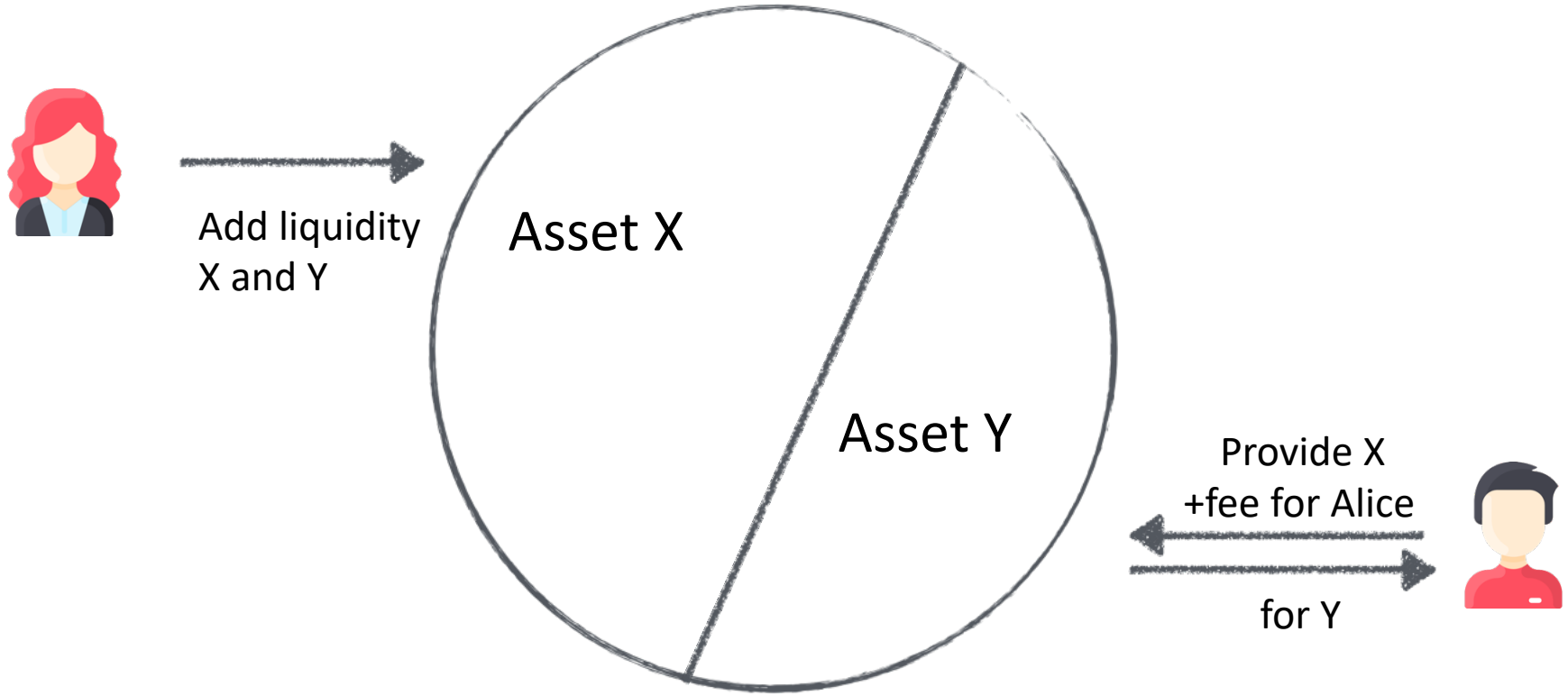
Daily Volume:
- DEXes: 3.5B
- Binance: 49B
- Nasdaq: 234B

Source:
https://defiprime.com/dex-volume
http://www.nasdaqtrader.com/Trader.aspx?id=DailyMarketSummary
https://coinmarketcap.com/rankings/exchanges/


Automated Market Maker
https://defi-learning.org

Liquidity Pool

Idea: Let a smart contract do the market making.



smart contract pool

AMM – Automated Market Maker

Idea: Let a smart contract do the market making.

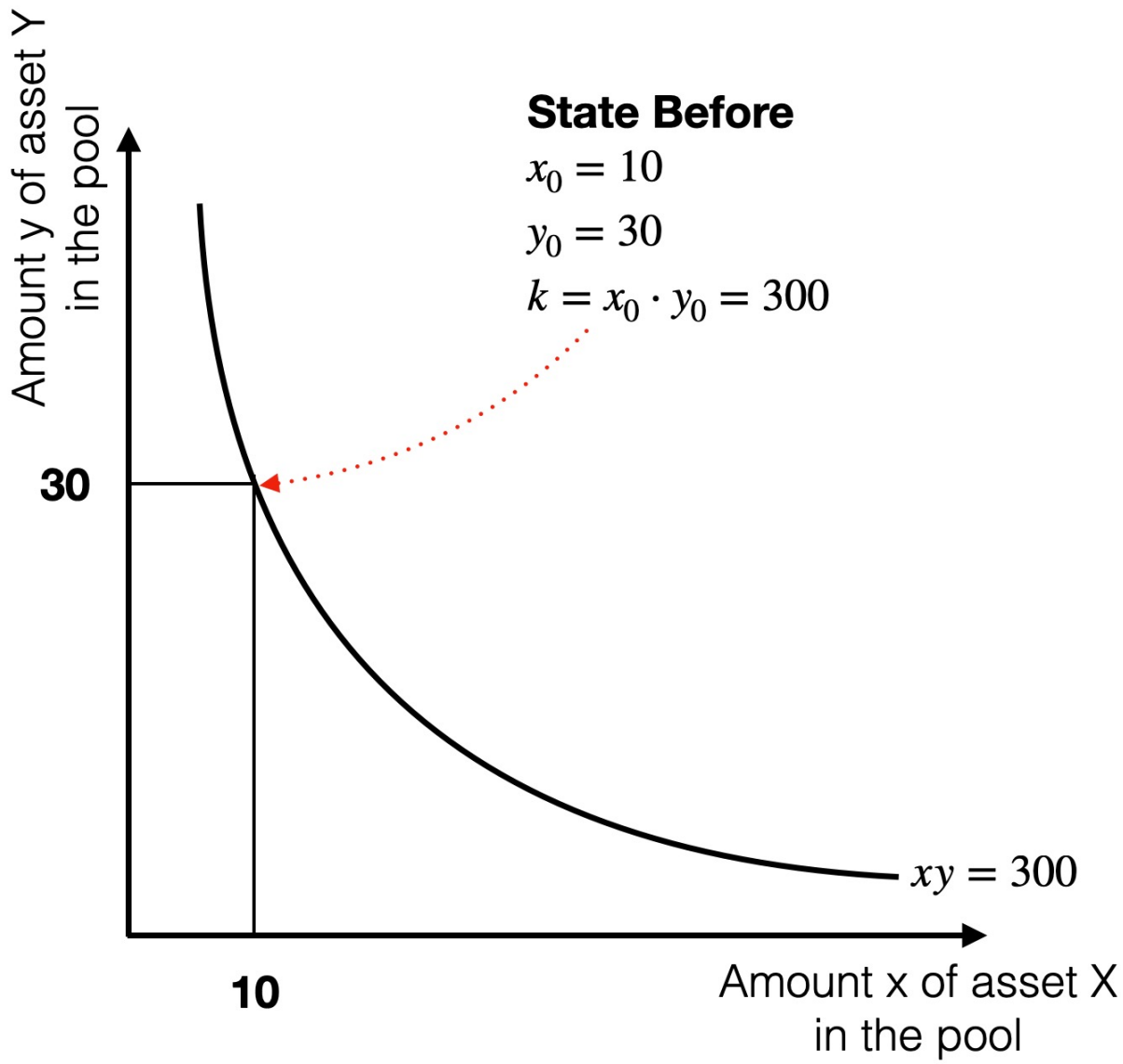
$$x \times y = k$$

- x: Asset X quantity
- y: Asset Y quantity
- k: constant

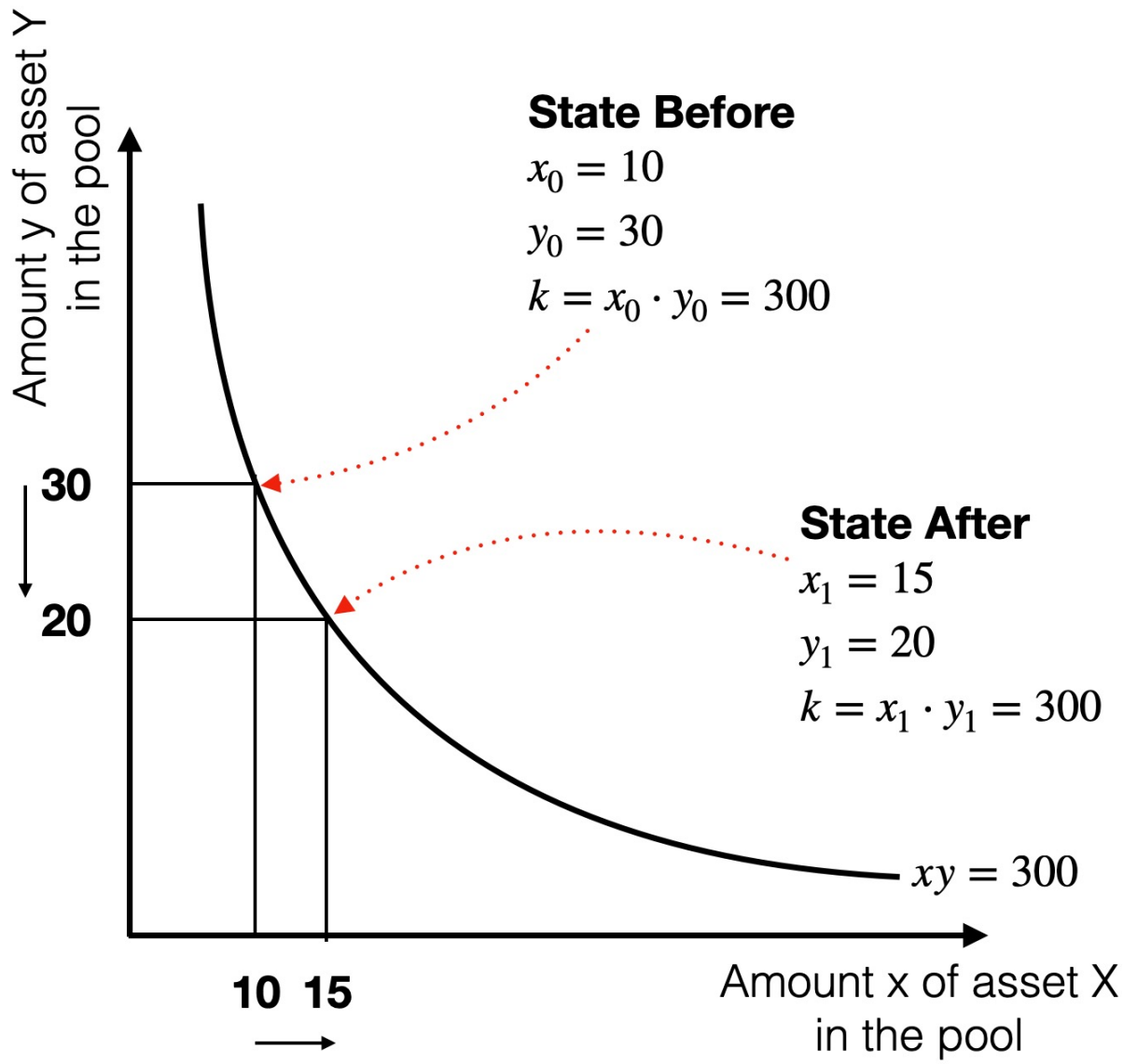
Properties:

- Instant liquidity, irrespective of the trade size
- Purchase of asset X increases price of X and decreases the price of Y
- Ratio of asset X and Y sets the price
- Known as Constant Product (CP) AMM

AMM Example

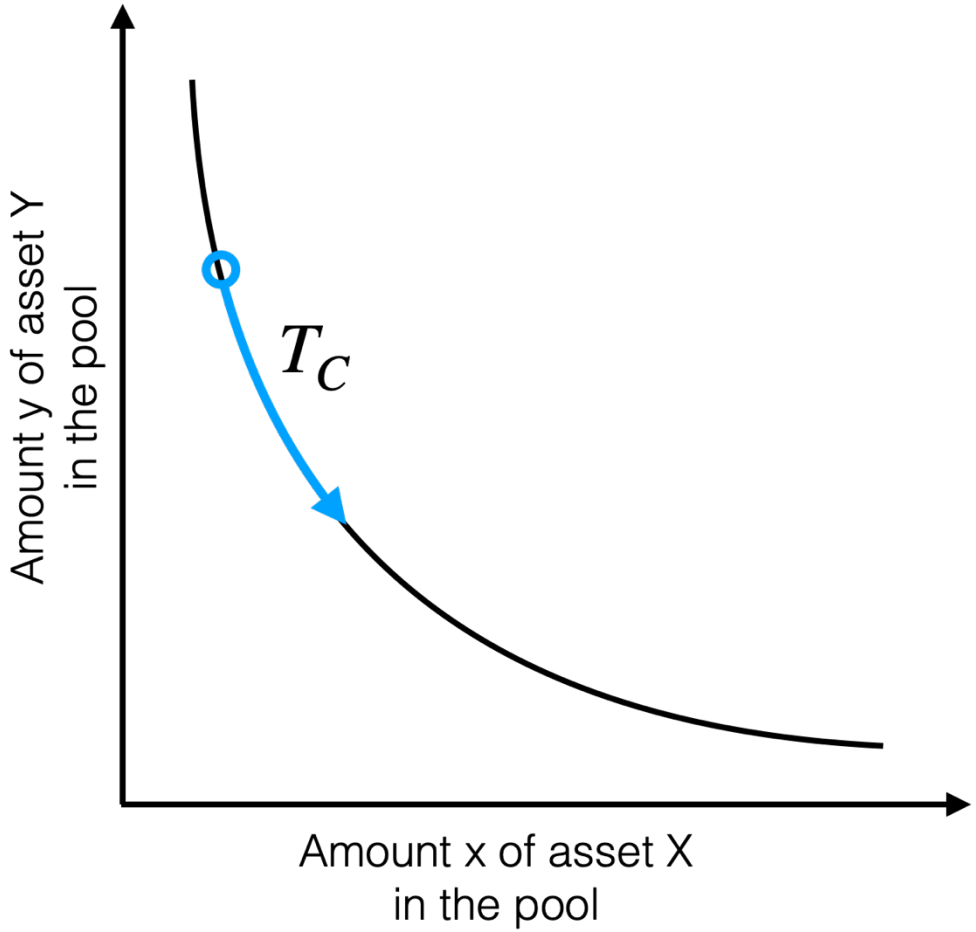

Amount y of asset Y
in the pool
State Before
$x_0 = 10$
$y_0 = 30$
$k = x_0 \cdot y_0 = 300$
30
$xy = 300$
10
Amount x of asset X
in the pool

AMM Example

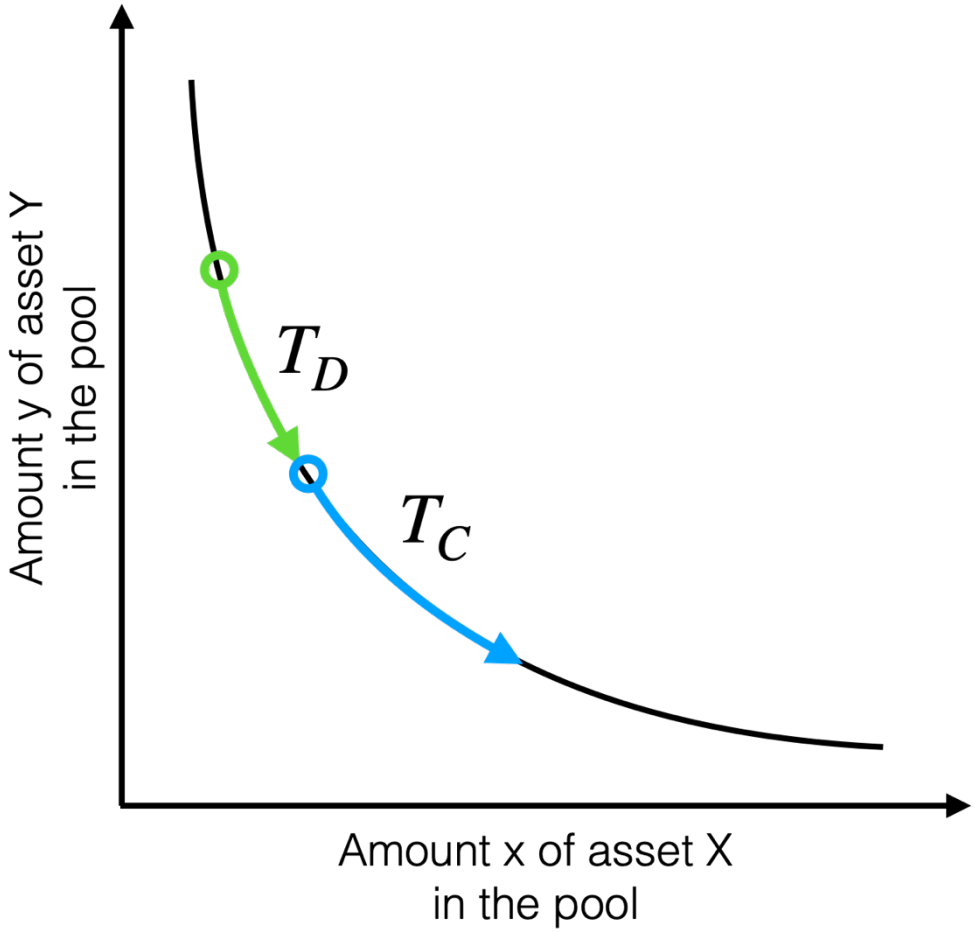

Amount y of asset Y
in the pool
State Before
$x_0 = 10$
$y_0 = 30$
$k = x_0 \cdot y_0 = 300$
30
20
State After
$x_1 = 15$
$y_1 = 20$
$k = x_1 \cdot y_1 = 300$
$xy = 300$
10 15
Amount x of asset X
in the pool

Expected Slippage

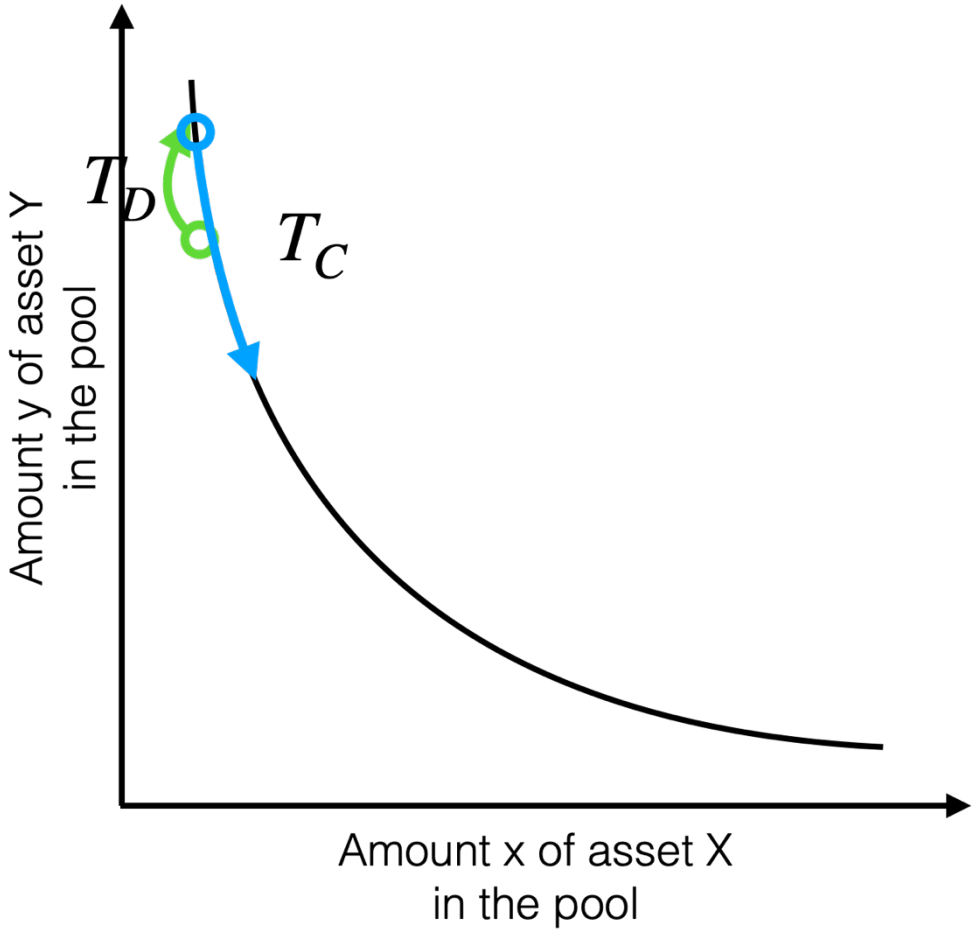
The expected increase or decrease in price based on the trading volume and available liquidity.



Unexpected Slippage → Worse Execution Price



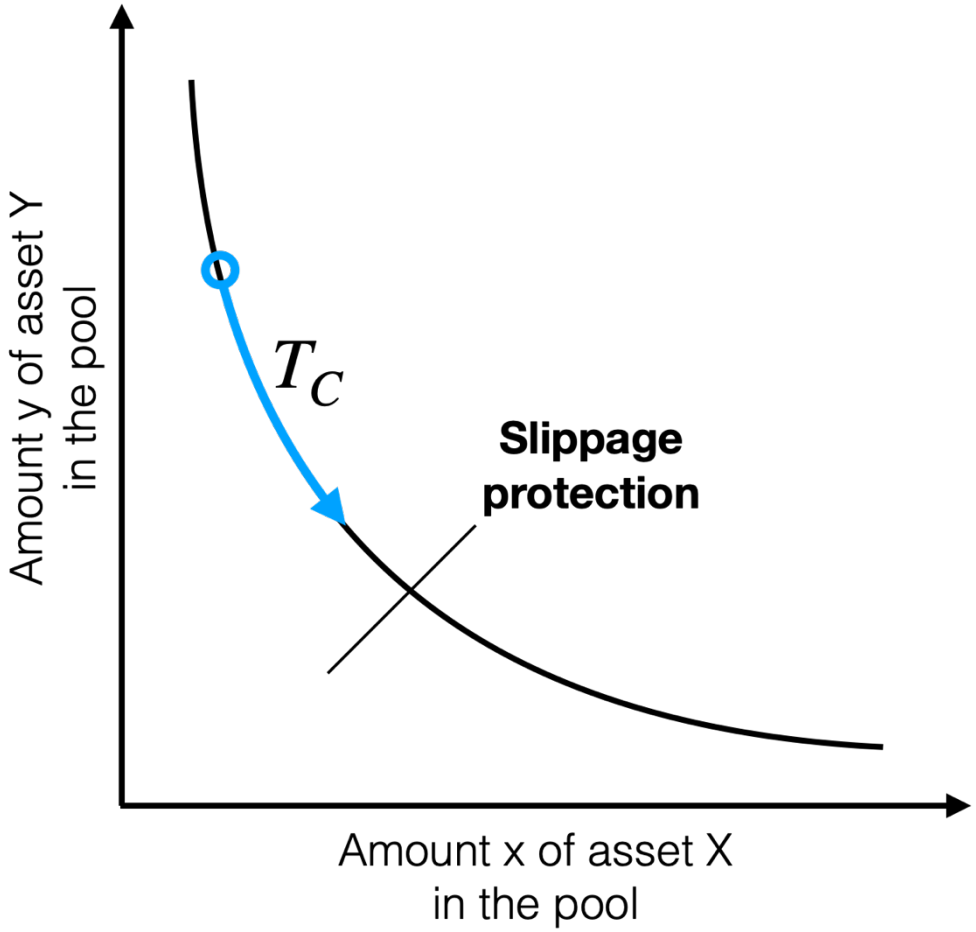
Unexpected Slippage → Better Execution Price



Slippage Protection

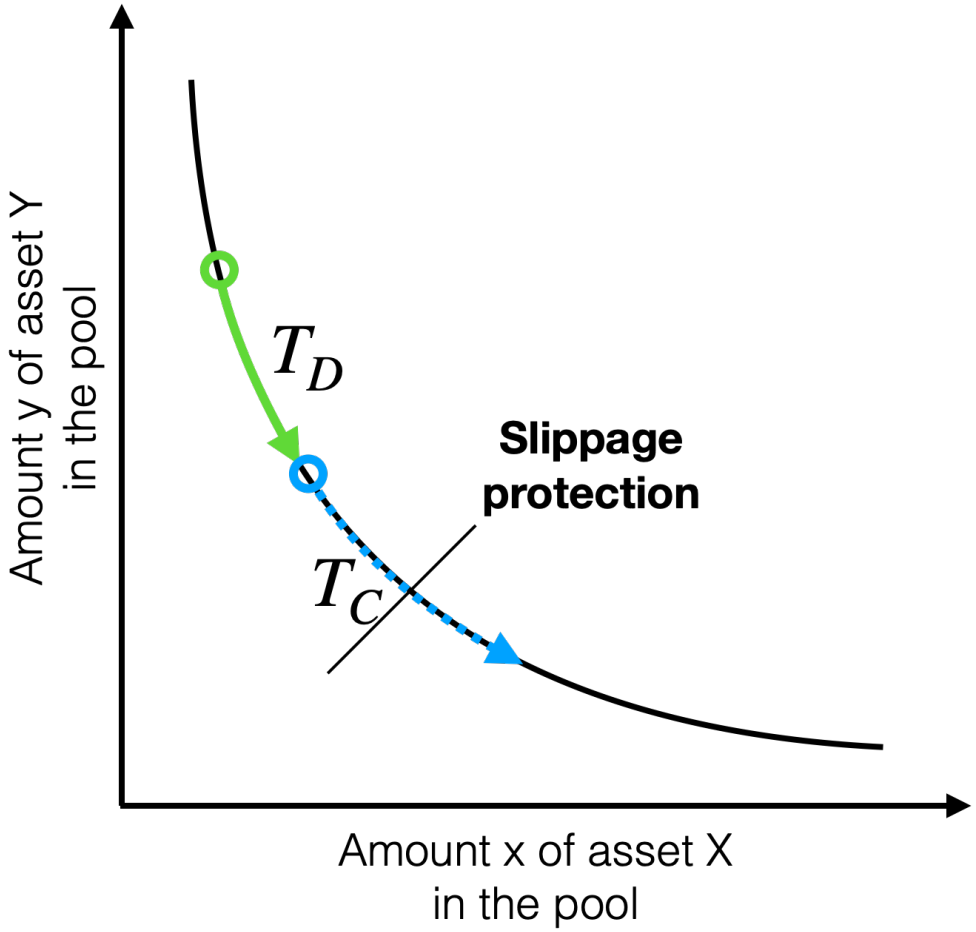
滑点保护

Configures a slippage protection threshold to prevent unacceptable slippage



Slippage Protection

A transaction **fails** when crossing the slippage limit.



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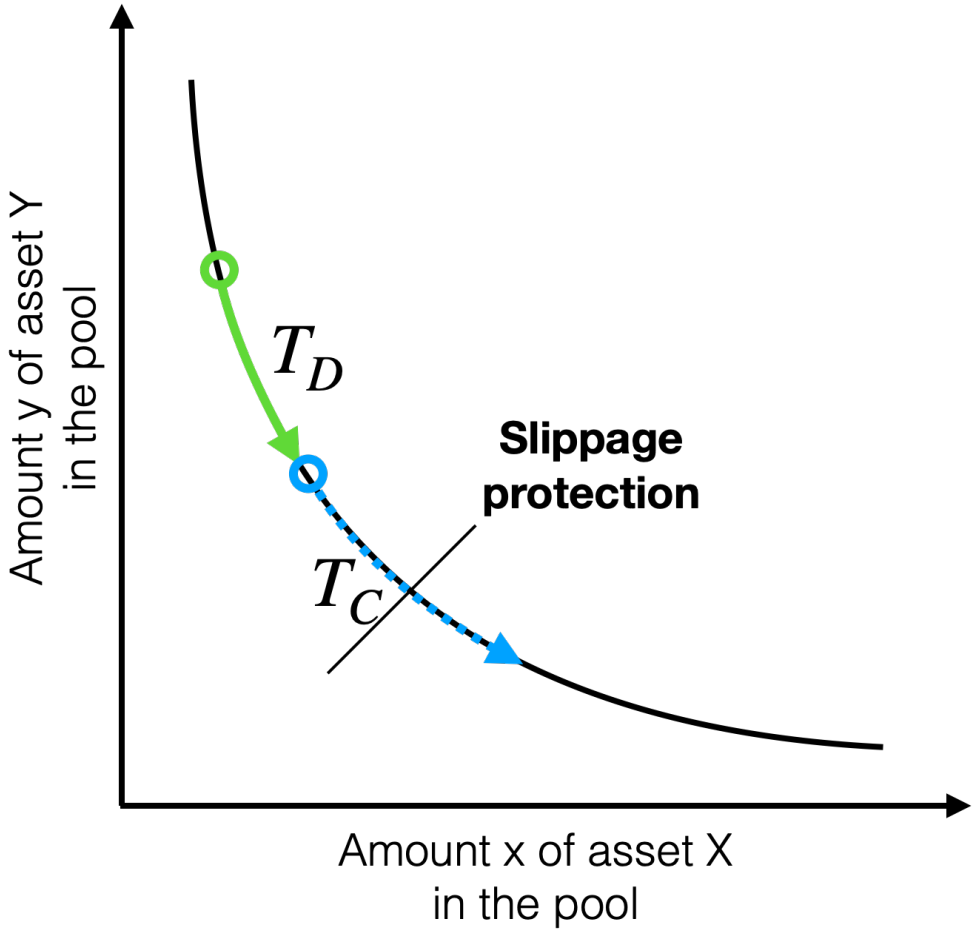
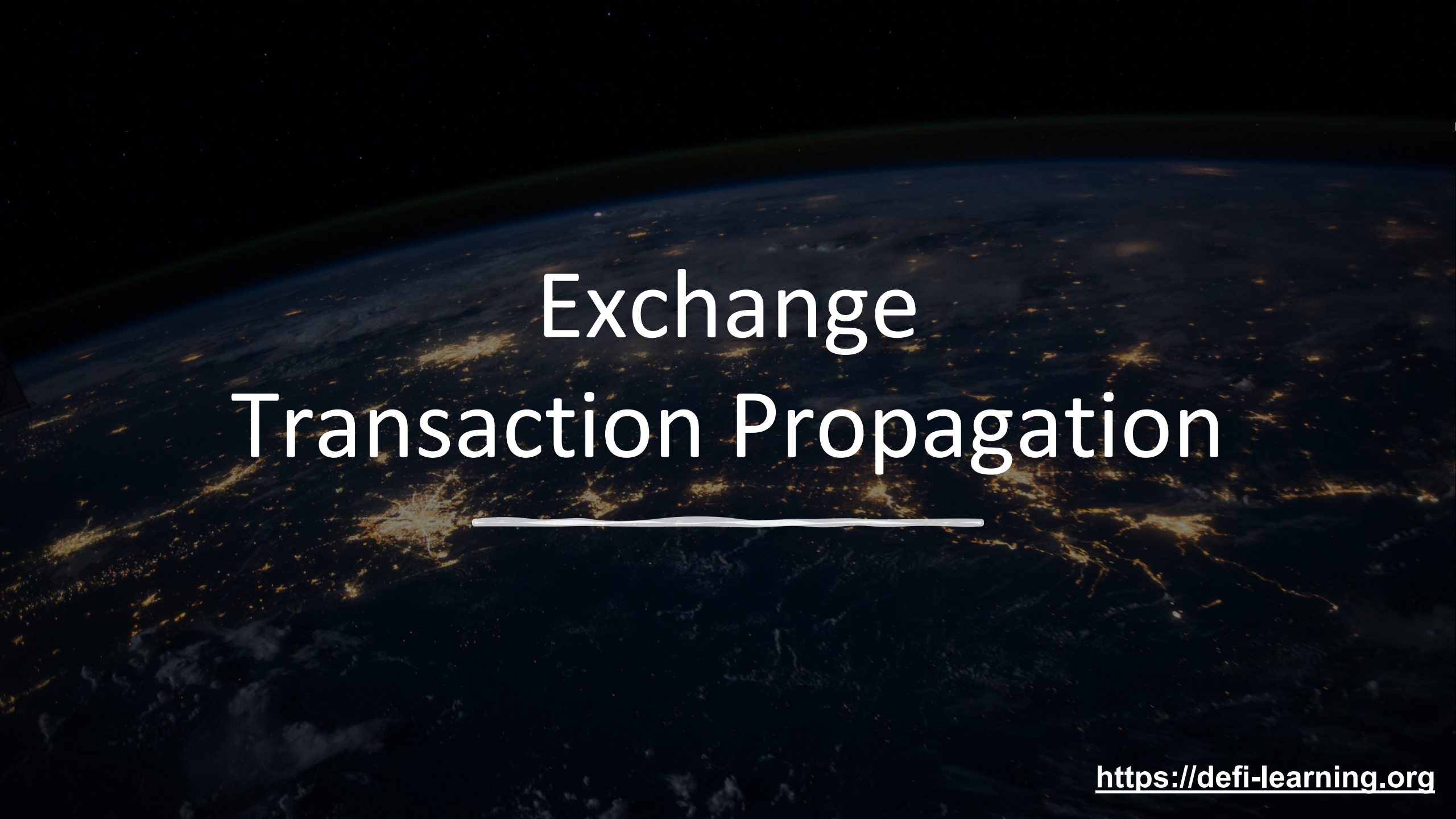


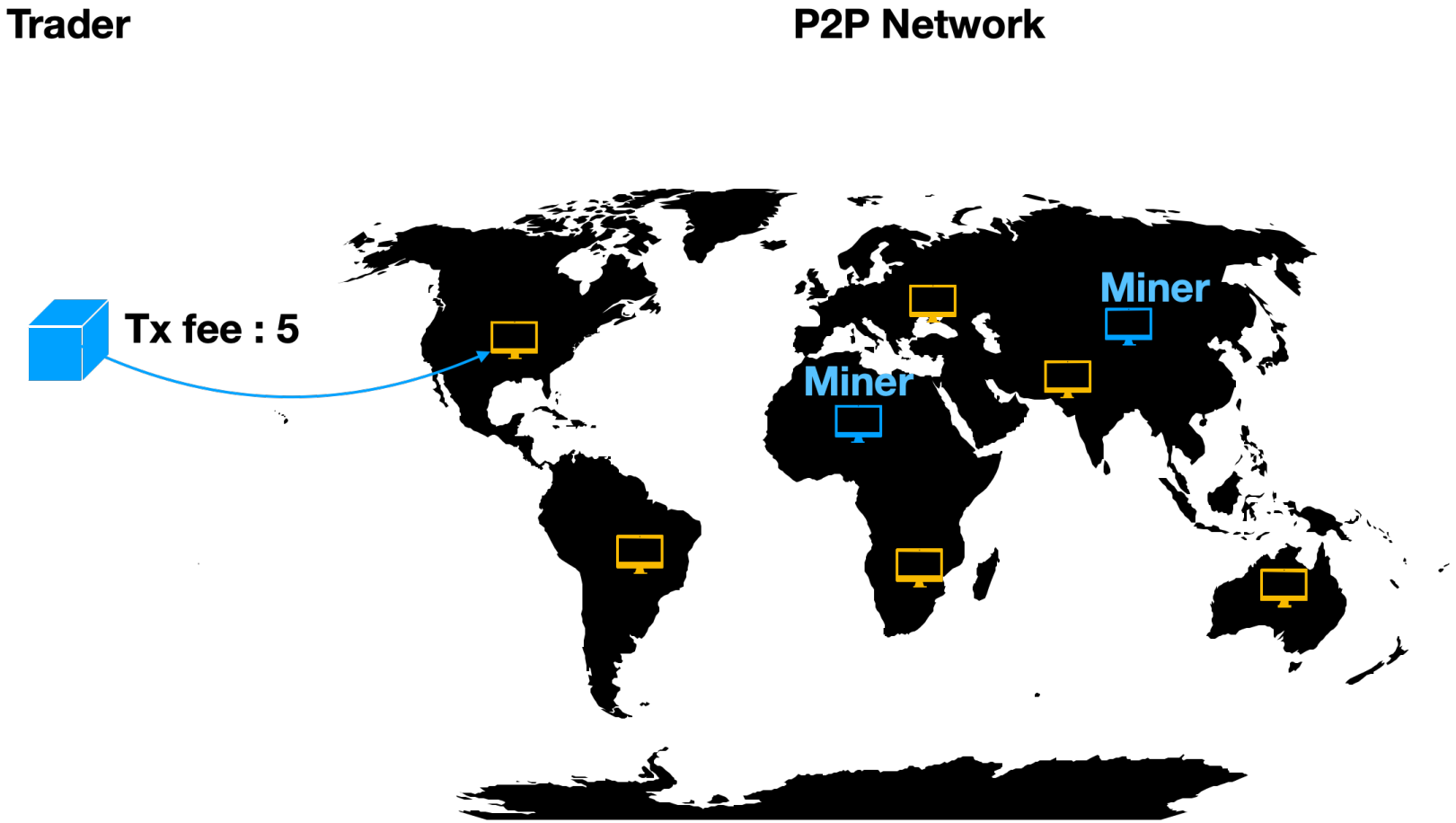
Pros and Cons of an AMM

- (+) No Order Book maintenance
  - But arbitrage required 需要套利
- (+) Simple implementation for CP AMM
  - Low gas costs
- (-) Danger of impermanent loss/coin de-peg 币价脱钩
  - Total loss of funds possible
- (-) High slippage for low liquidity markets
  - Please do observe your slippage tolerance 注意你的滑点容限
- (-) Users vulnerable to sandwich attacks
  - See security lecture

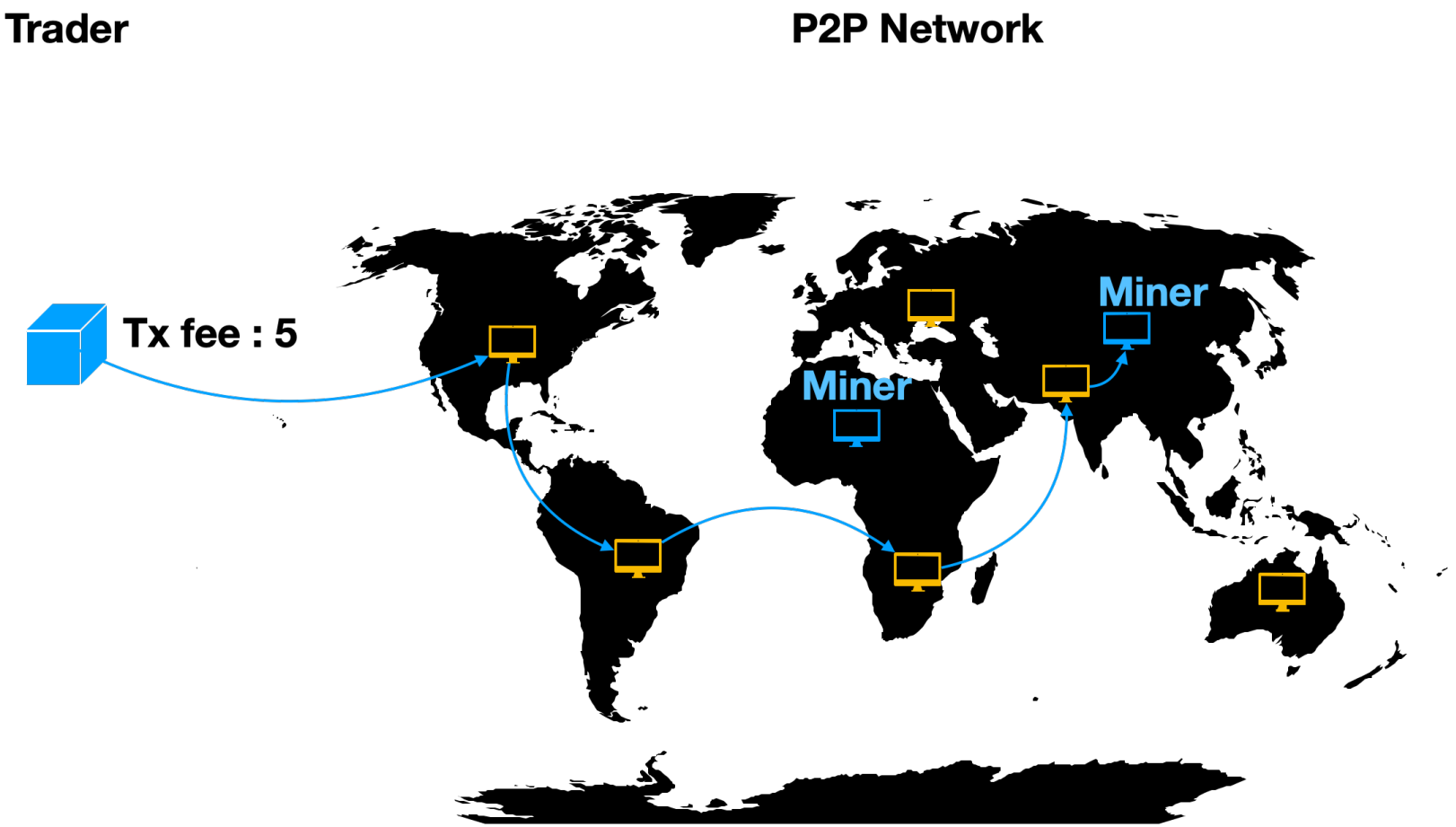


https://defi-learning.org

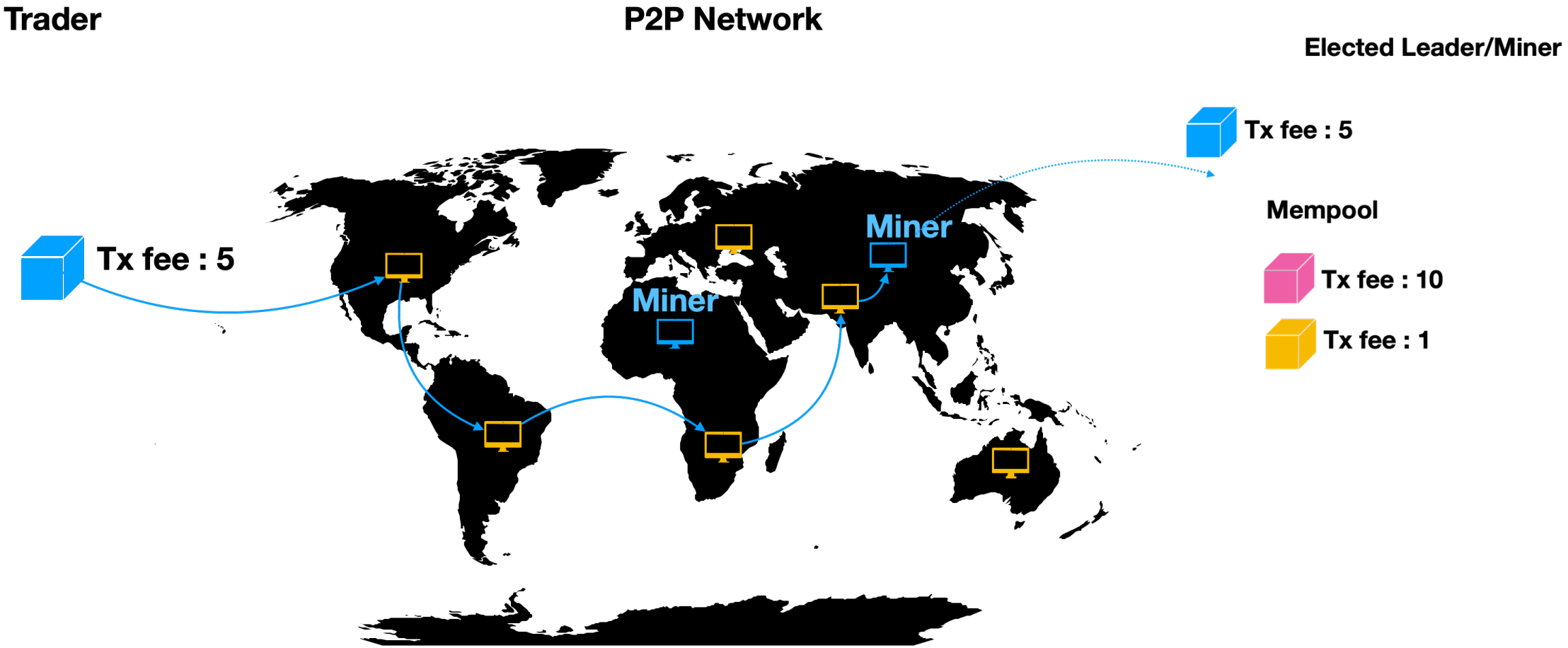
Exchange Transaction Propagation



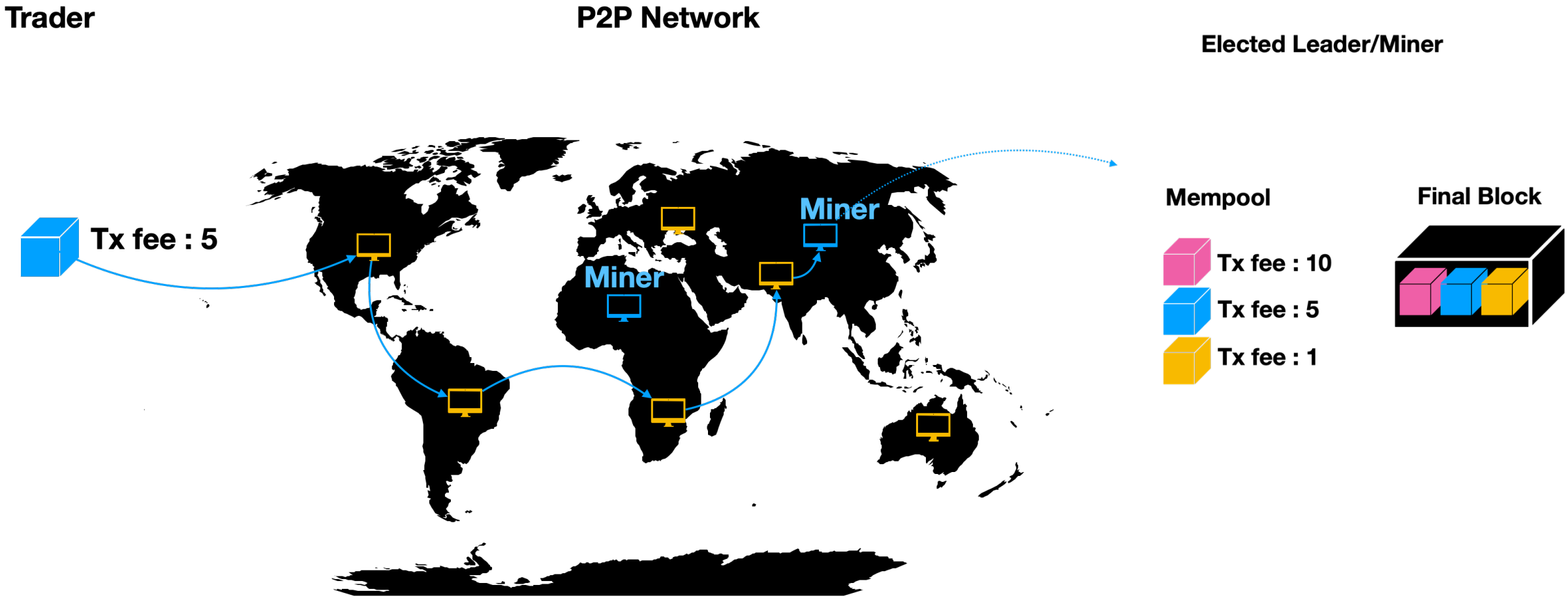
Exchange Transaction Propagation



Exchange Transaction Propagation

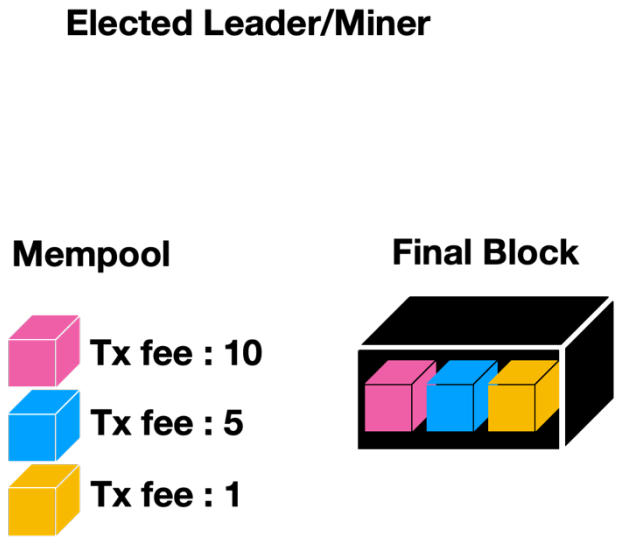


Exchange Transaction Propagation



Exchange Transaction Propagation

- Asynchronous Blockchain P2P Network
  - Best effort propagation
  - Transparency
  - High-Frequency Trading



- Inclusion based on a fee auction
  - Price Gas Auction (PGA)
    - On the public P2P network
  - Sealed Bid Gas Auction (SGA)
    - On centralized network relay services

实际上就是让用户的出价保密。避免竞价策略

flag


Pegged and Stablecoin AMM
https://defi-learning.org

Pegged/Stablecoin Swap

USDC USDT DAI

USD derivatives

WBTC renBTC sETH stETH

Pegged coins

- Three Stablecoin Types
  - Reserve-based 基于储蓄的
  - Collateral-based
  - Algorithmic

锚定

Pegged/Stablecoin Swap

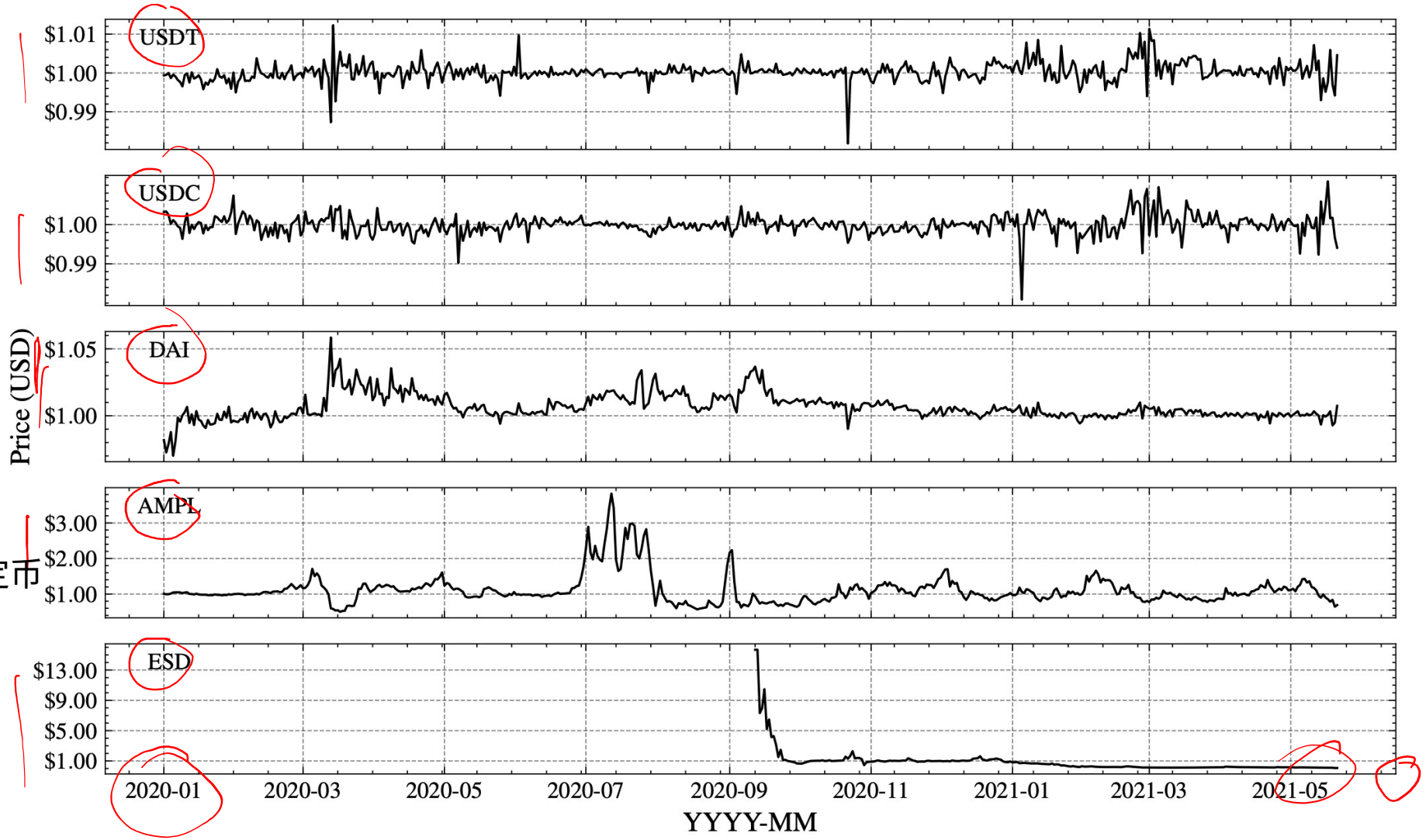
基于储备

基于储备

基于抵押

算法稳定币

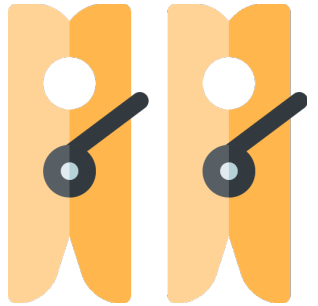
算法稳定币



Pegged/Stablecoins

同时变化

- Pegged/Stablecoin prices move in expectation together
  - The exchange rate should ideally remain 1 to 1
  - A default CP AMM is not optimized for such case



优/缺点

- Stablecoin AMM pros/cons:
  - (+) Better prices for bigger volumes (i.e. more liquidity)
  - (-) Potentially higher gas costs
  - (-) Danger of a de-peg of a stablecoin

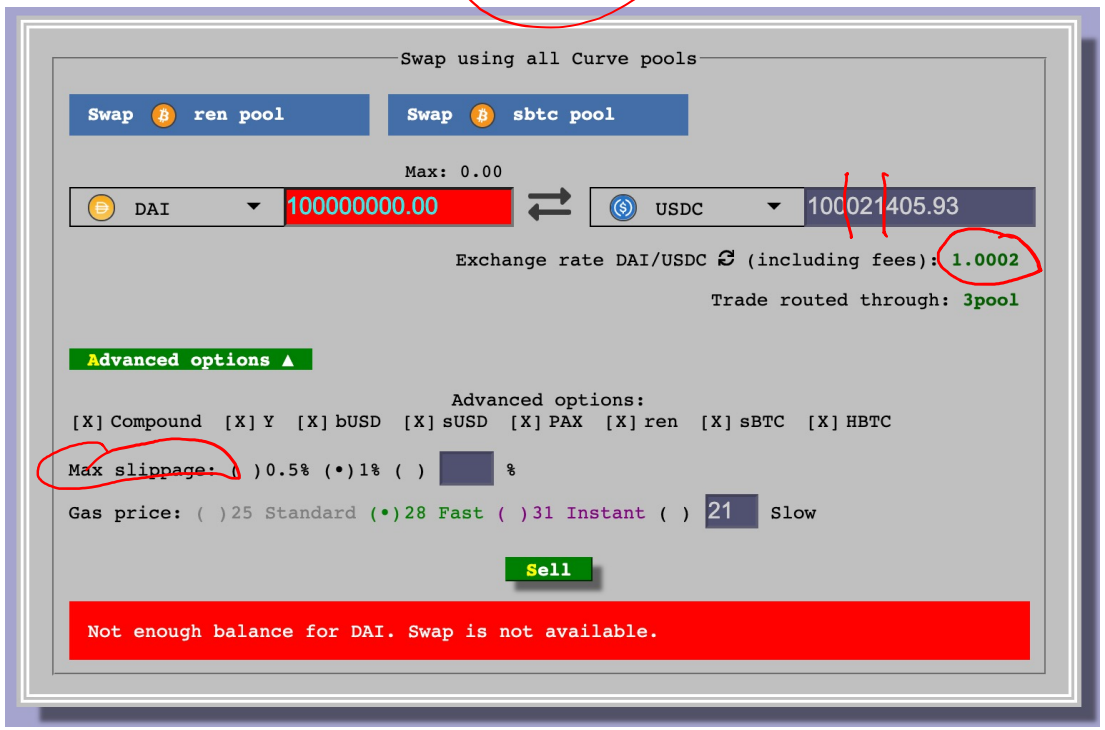
相对于AMM，稳定币的流动性较差

脱钩风险

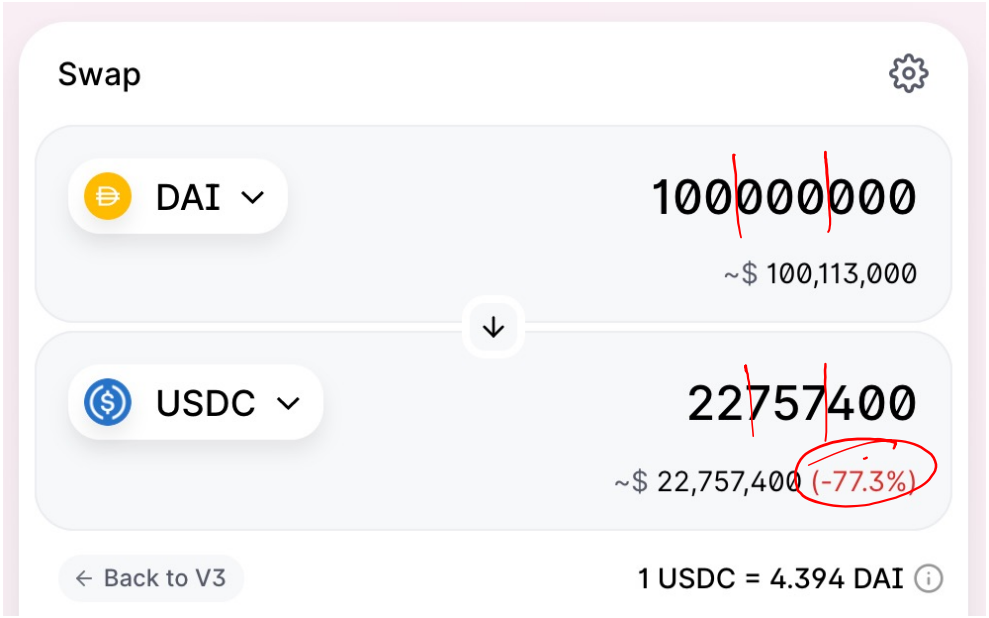
Pegged/Stablecoin Swap

Curve

Curve的主营就是稳定币、锚定资产



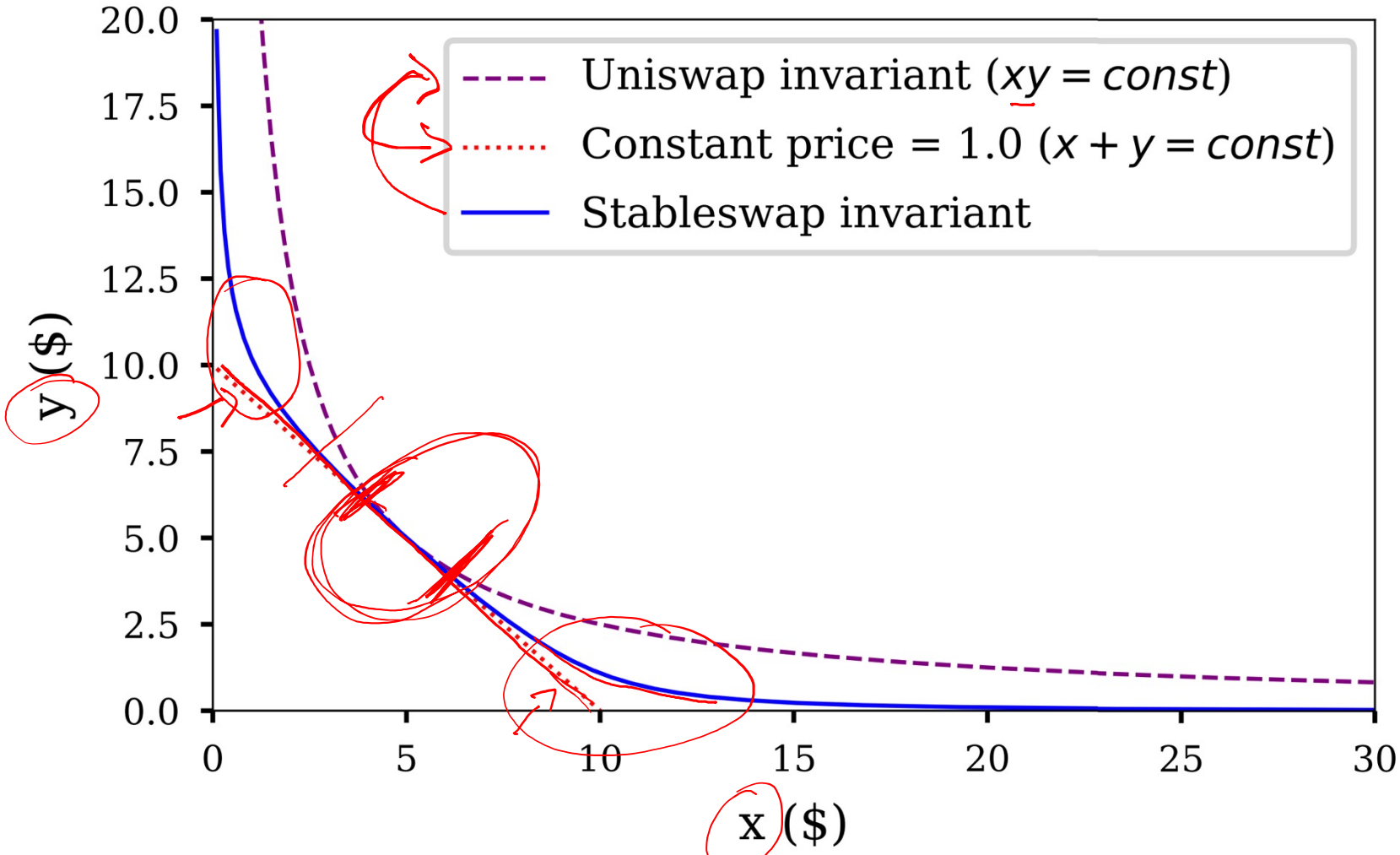
Uniswap



- Significant liquidity differences among exchanges
  - Here an example for a 100M USD swap from DAI to USDC

Price Curve

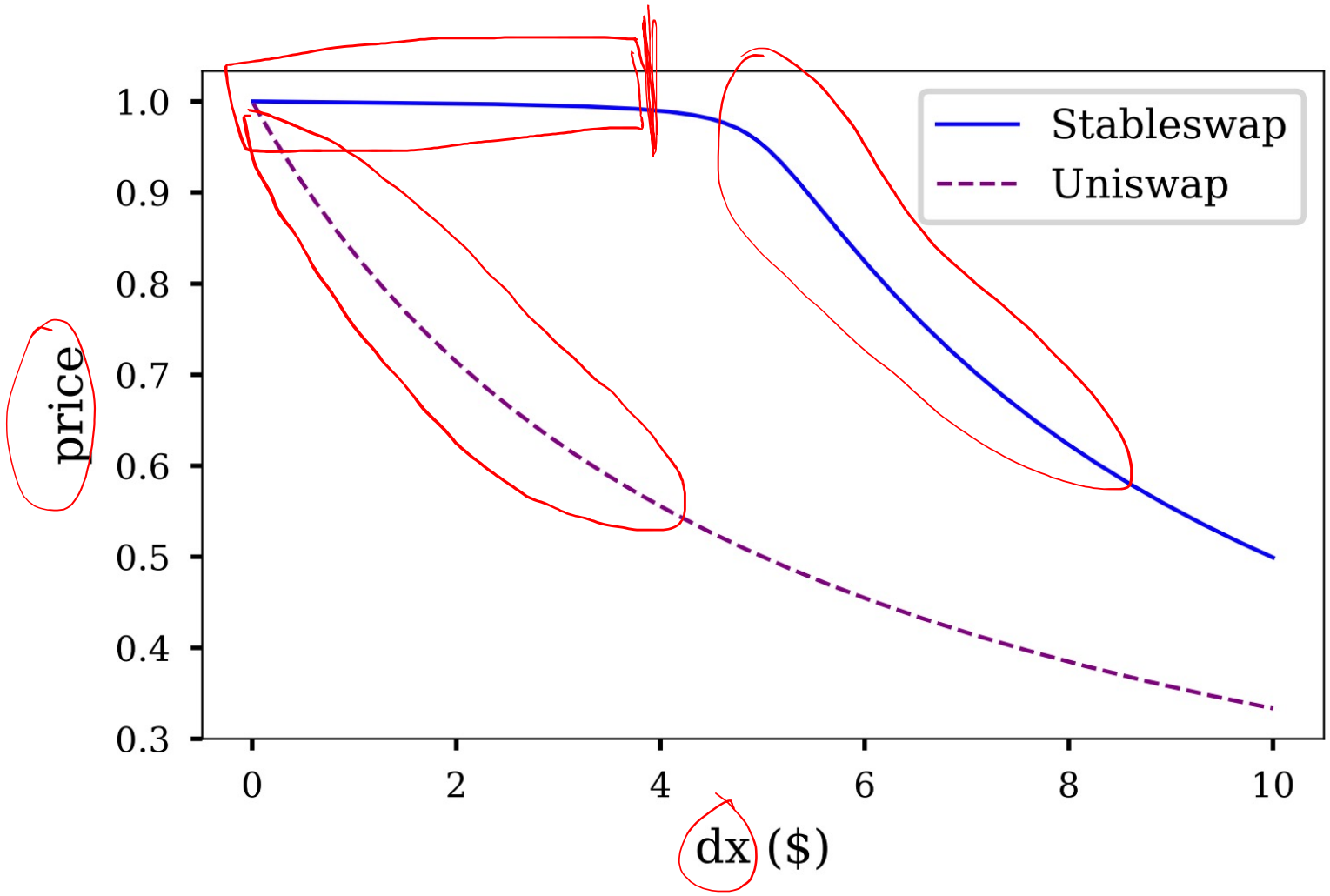
Stableswap (aka Curve Finance)



initially,
x = 5
y = 5

Slippage Comparison

Stableswap (aka Curve Finance)



What happens if a coin de-pegs?

What happens if a coin gets blacklisted?

AMM Whitepaper

- Check out the whitepapers of different projects
  - These are not peer-reviewed academic works
  - Be aware of possible missing items/nuances
  - Projects do not always disclose the full details

项目方

mooc老哥：如果想要深度的了解Defi,并且想要了解好什么是去中心化稳定币，你都需要深度的去理解和学习Curve

- Curve:
  - https://curve.fi/files/stableswap-paper.pdf
  - https://curve.fi/files/crypto-pools-paper.pdf

mooc老哥说:curve是整个Defi中最最重要的协议，没有之一

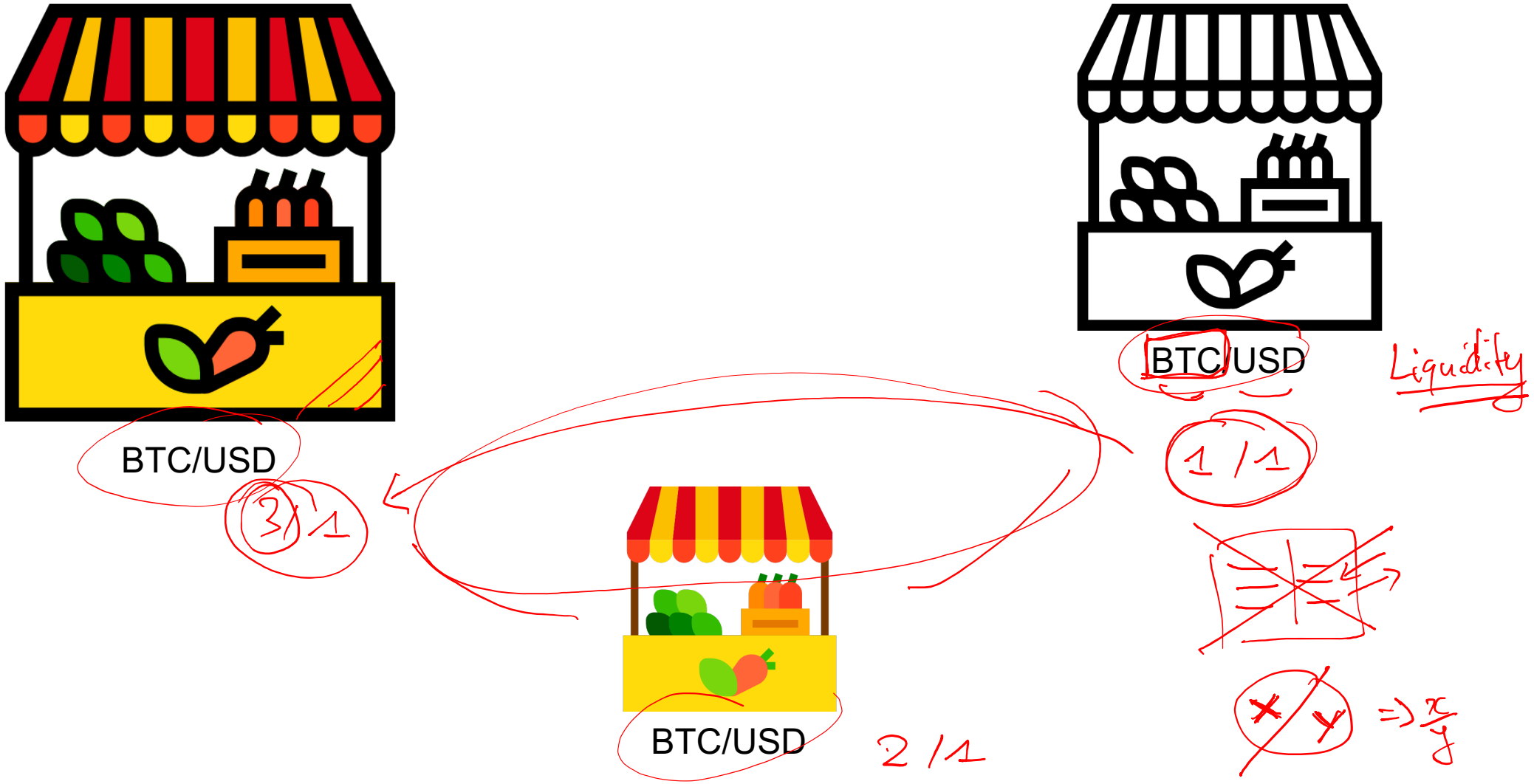
- Uniswap:
  - https://uniswap.org/whitepaper.pdf
  - https://uniswap.org/whitepaper-v3.pdf

AMM Arbitrage

自动做市商套利

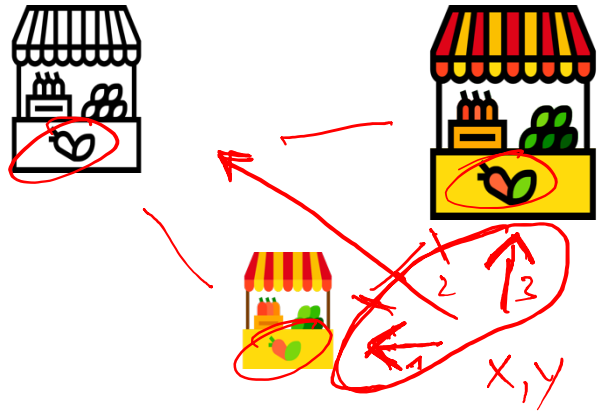
https://defi-learning.org

Arbitrage



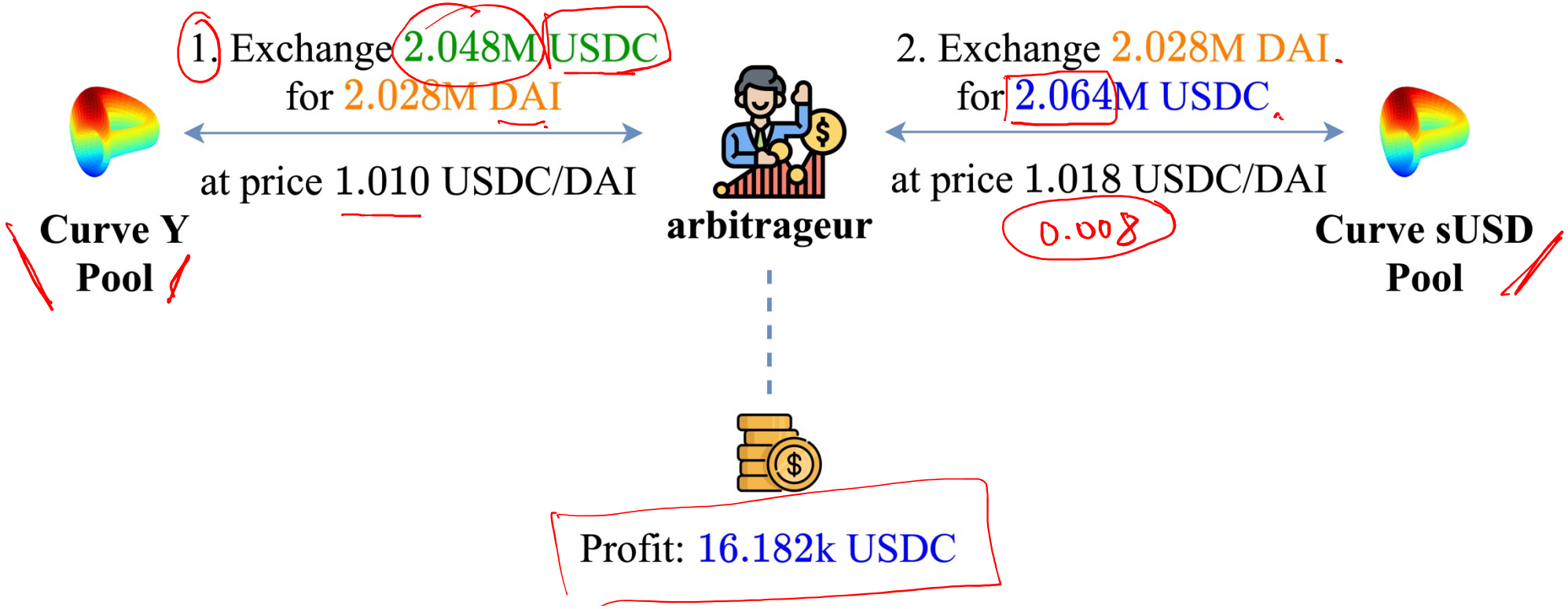
Arbitrage

- Multiple Markets with
  - the same assets X and Y
  - different prices for X and Y

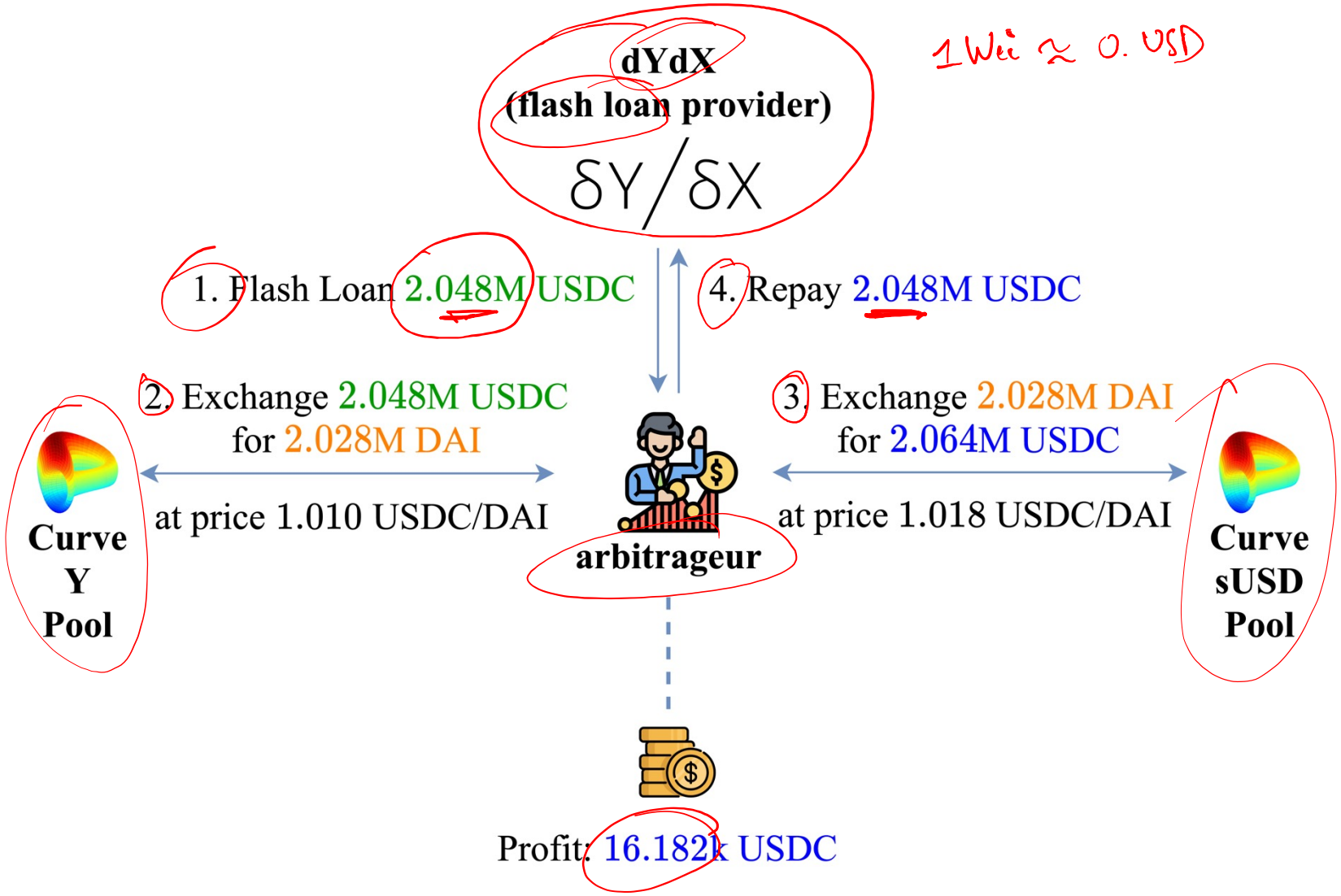


- Prices are synchronized by “arbitrageurs”
  - Profit from the price difference
    - Also referred to as “spread” 差额
  - Requires to perform at least one transaction

Arbitrage on two markets



Arbitrage (with Flash Loan)



AMM Impermanent Loss

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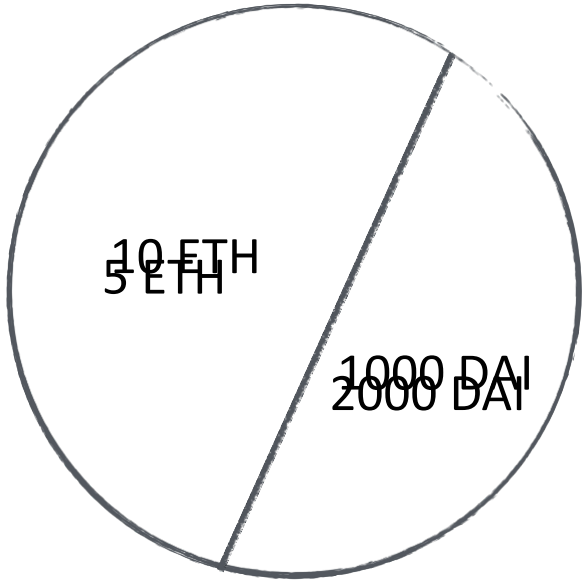
Impermanent Loss Example

2. Price increase of ETH
1 ETH == 400 DAI

1 ETH == 100 DAI

1. Add liquidity
1 ETH, 100 DAI
== 200 USD
== 10% of pool



ETH/DAI Pool

ETH

for DAI

Arbitrage

Realisation of IL:
1 ETH + 1 USD == 500 USD
→ Alice lost 100 USD

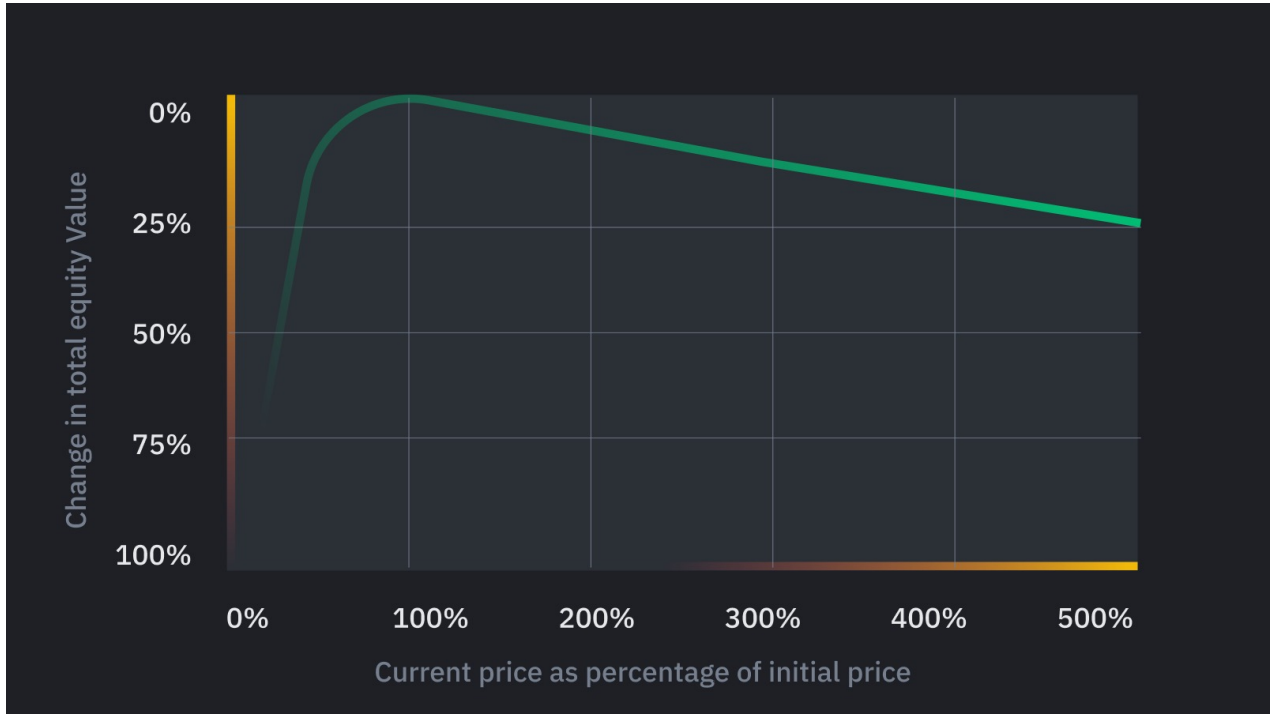
3. Withdraw liquidity
10%== 0.5 ETH, 200 DAI
== 400 USD

Impermanent Loss

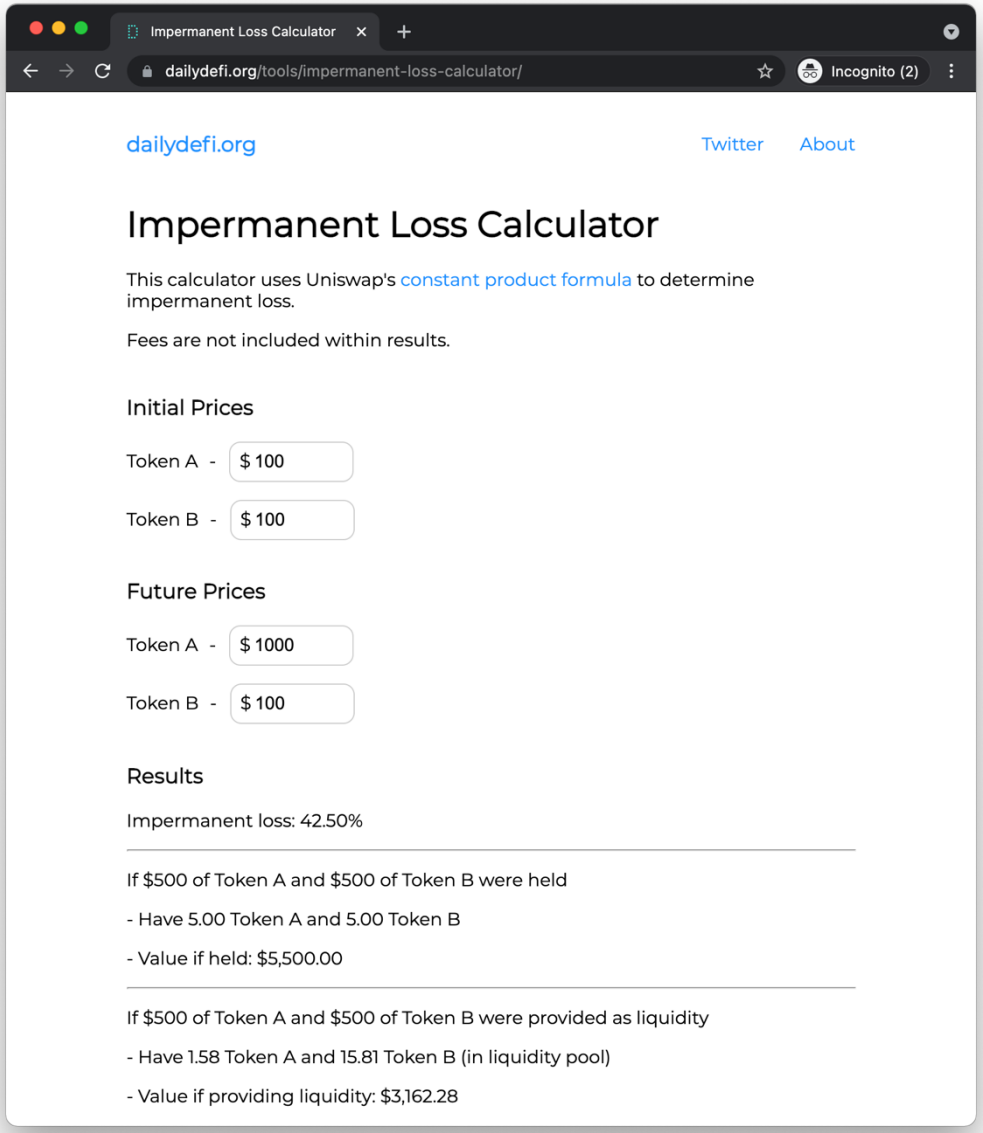
如果计算是直接按照之前比例和之前总份额来算的话。 那么这样流动性的头矿看起来就没啥了呀？
(ps.反思其中 trick，这里还是不懂， 看看uniswap和，curve白皮书)

- Impermanent == not permanent
  - Realized upon withdraw only!
  - It can result in total loss
    - Trading fees may compensate
    - Liquidity mining may compensate
    - Similar to a de-peg of a Stablecoin
- Possible Solutions
  - Challenging
  - Change of the bonding curve

无常损失之所以会导致总损失，主要是因为流动性池内资产比例的变化和市场价格波动。在资产价格大幅波动时，无常损失可能会显著增加，导致 LP 的实际收益低于他们通过直接持有这些资产所能获得的收益，从而产生总损失。



Impermanent Loss Calculator




AMM Liquidity Mining
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Liquidity Mining == Incentive

- 2 Types of rewards in DeFi Pools
  - Trading fees (e.g. 0.03% in Curve)
  - Liquidity Mining rewards 现阶段，流动性挖矿甚至比交易费更来钱

- Liquidity Mining
  - An incentive to provide liquidity to a pool
  - Proportional rewards in terms of liquidity 部分奖励
  - Can be added/removed anytime
  - Retrospective airdrops possible → address history is valuable

存在空投的可能性

Liquidity Mining 流动性挖矿

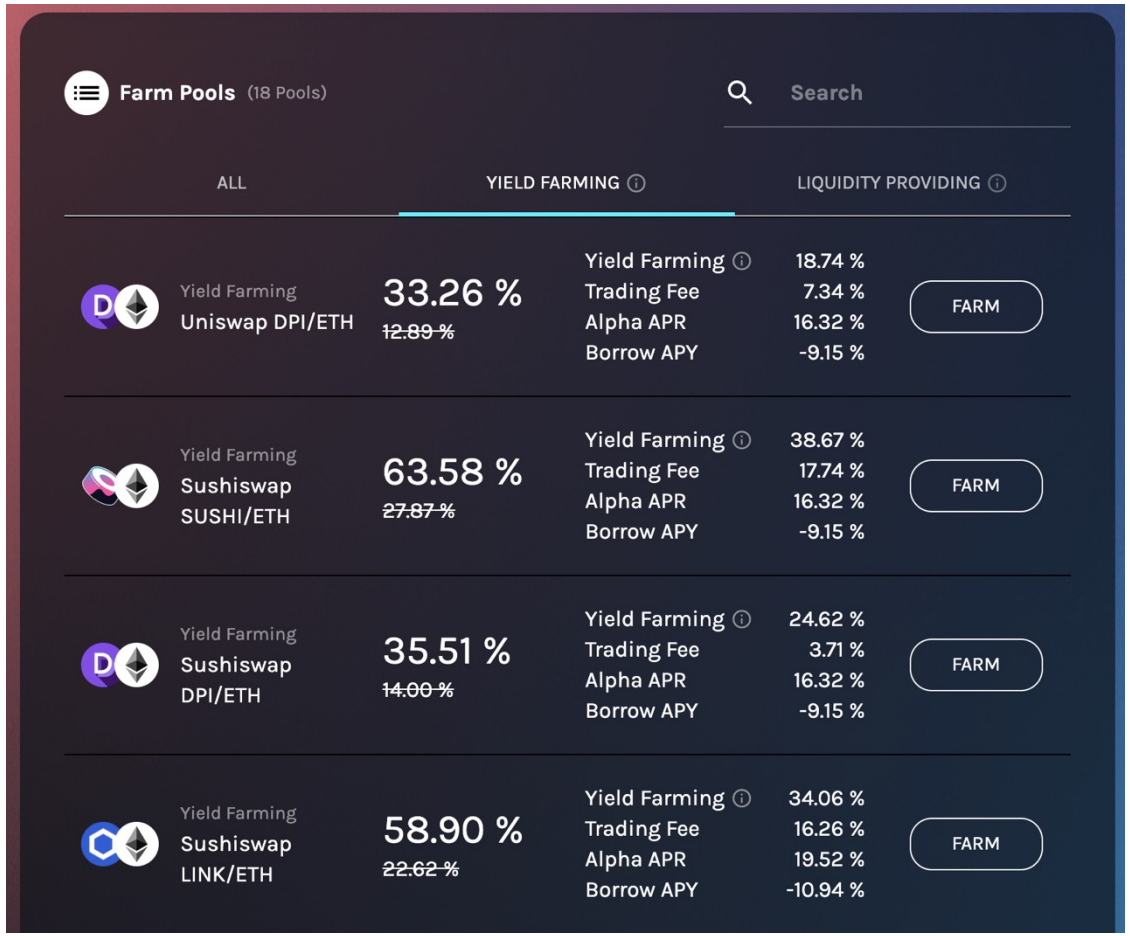
Curve

Curve pools

Pool	Base APY	Rewards APY	Volume ▼
tricrypto CRYPTO V2 [?] USDT + wBTC + WETH	3.73%	+2.04%→5.11% CRV	$28.7m
3pool USD DAI + USDC + USDT	0.63%	+3.14%→7.84% CRV	$120.3m
sUSD USD DAI + USDC + USDT + sUSD	0.57%	+2.59%→6.48% CRV +1.78% SNX	$12.5m
ren BTC renBTC + wBTC	0.41%	+5.84%→14.59% CRV	$9.9m
ironbank USD cyDAI + cyUSDC + cyUSDT	4.11%	+4.68%→11.70% CRV	$7.7m
bbtc BTC BBTC + sbtcCrv	0.36%	+2.60%→6.51% CRV	$6.9m
busdv2 USD BUSD + 3Crv	0.89%	+5.25%→13.13% CRV	$6.7m
lusd USD LUSD + 3Crv	0.58%	+4.90%→12.25% CRV	$5.6m
sbtc BTC renBTC + wBTC + sBTC	0.36%	+4.67%→11.67% CRV	$5.1m
tbtc BTC tBTC + sbtcCrv	0.81%	+13.77%→34.42% CRV	$4.6m

See All Pools

Alpha Homora v2



DEX Aggregator

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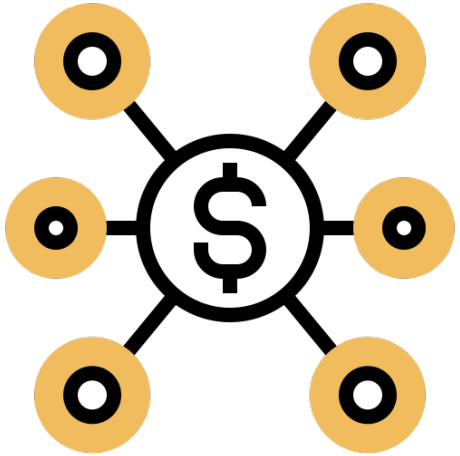
聚合器

DEX Aggregator

- Users may ask
  - Where do I get the best price for a trade?
  - Where is the deepest liquidity?

人力很难捕捉到最好的价格点

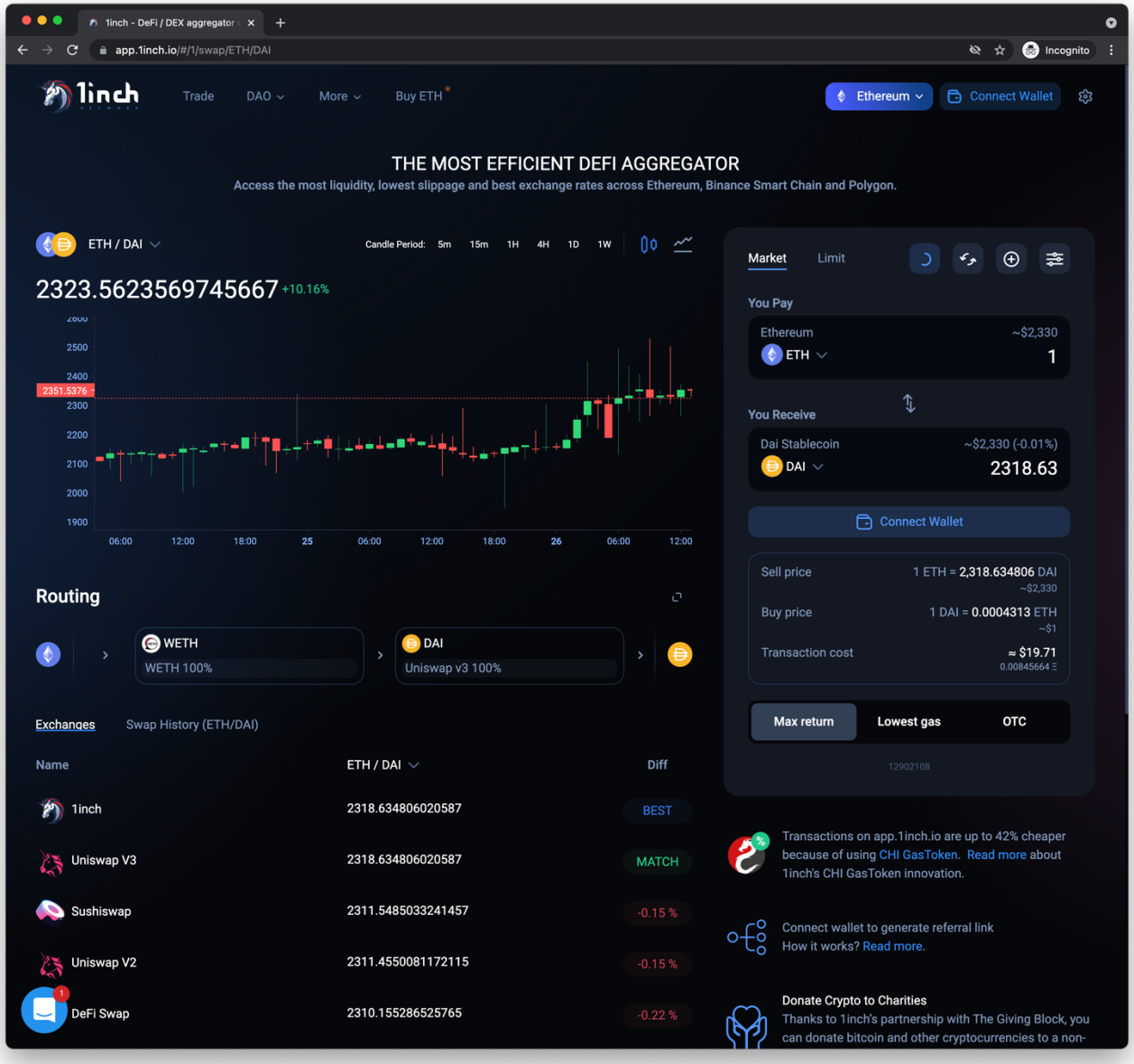


- Two types of aggregators
  - Off-chain aggregator (1inch, paraswap)
    - (+) Can spawn multiple chains, very flexible
    - (-) Operator can front-run users
  - On-chain aggregator (swapswap)
    - (+) atomic routing & arbitrage
    - (-) unlikely to efficiently cover 4+ exchanges

但是像这里， 具体聚合器是怎么工作的喃？ 仅仅只是多路的聚合吗？ 那为什么还can spawn multiple chains

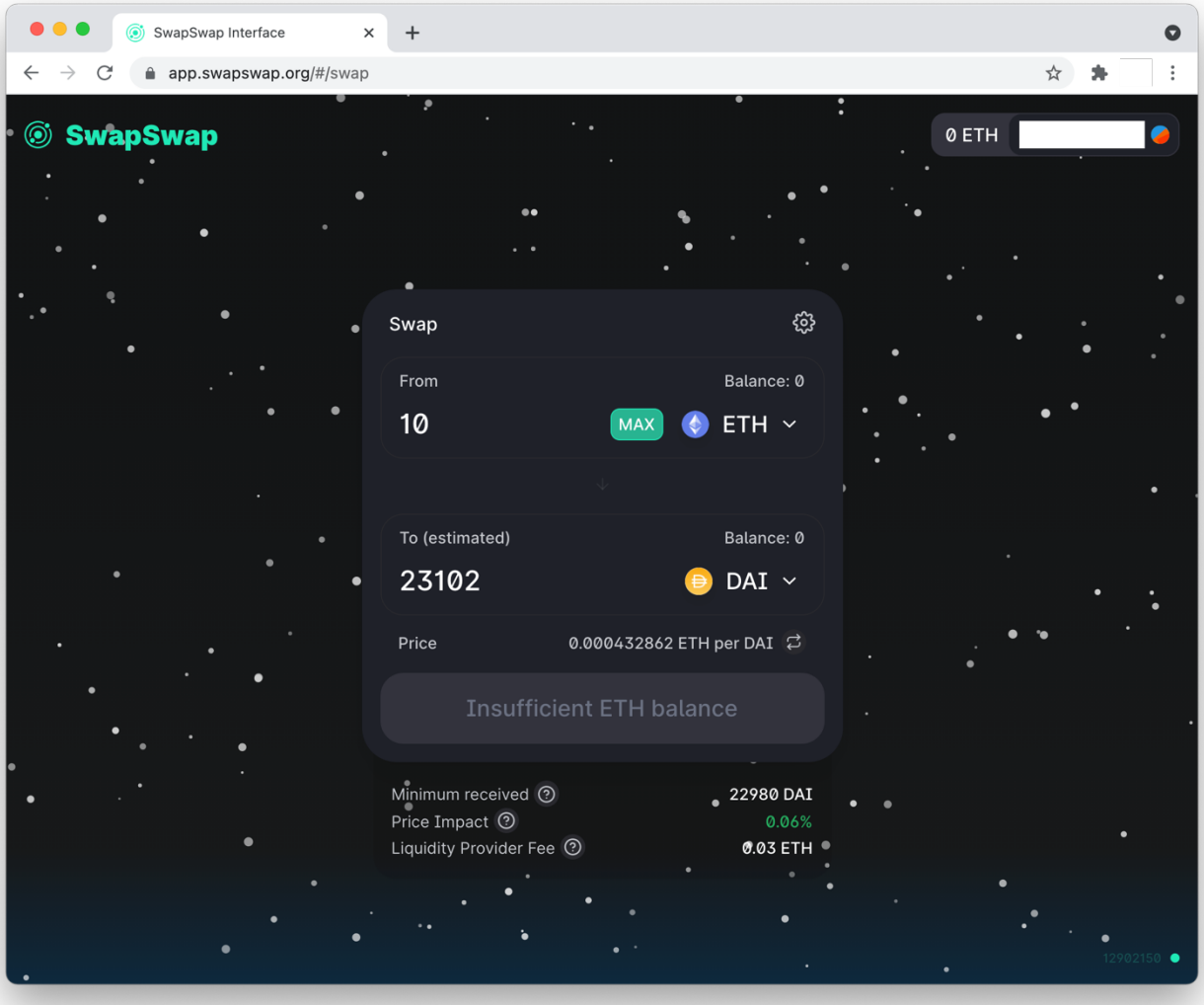
1inch

- Aggregates many DEX
  - Very verbose UI for users
- Routing
  - Explains which route taken
  - No arbitrage performed



SwapSwap

- Aggregates 2 DEX
  - Uniswap and Sushiswap
  - No UI change for the user
- Routing & Arbitrage
  - Routes a swap if the smart contract deems routing profitable
  - Performs arbitrage with flash loans if deemed profitable by the smart contract




How to detect trading opportunities in DeFi?
未决，后续认真花时间去弄
https://defi-learning.org

How to detect arbitrage/profitable opportunities?

- Bellman Ford Algorithm

有待手动实现一下bellman Ford算法

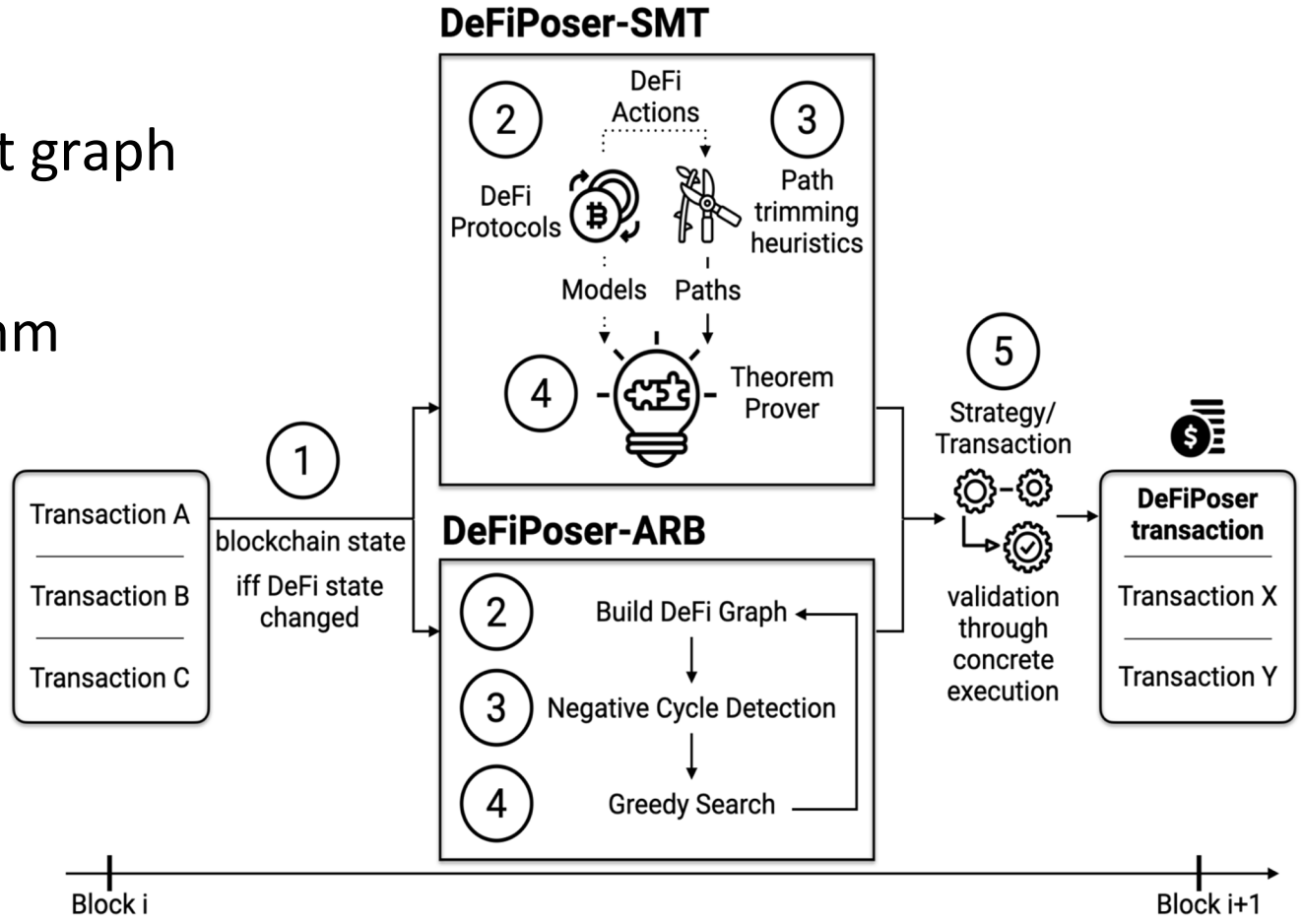
  - Negative cycle detection
  - Works among multiple markets
  - Used in traditional finance and DeFi

- Theorem Solver (SMT)
  - Needs to encode the DeFi model
  - Apply heuristics for path pruning

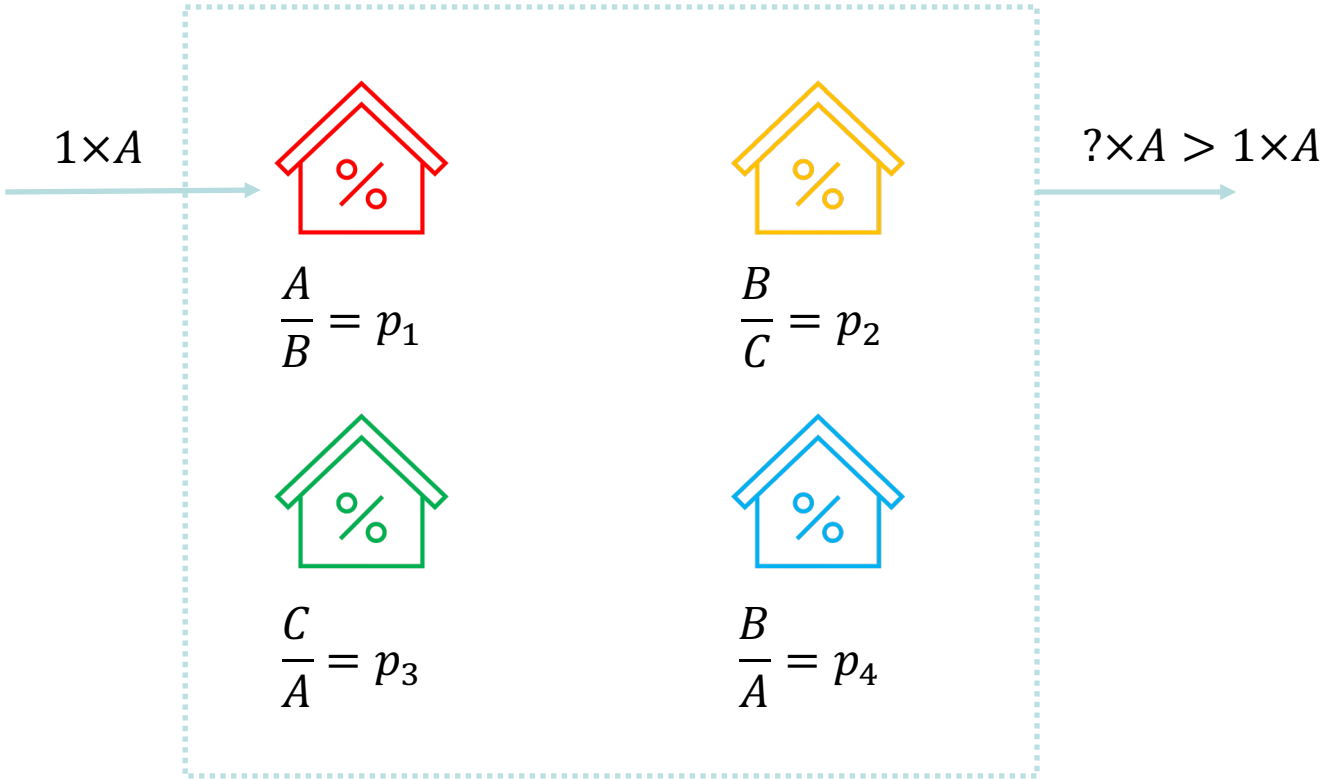
启发式算法 路径修剪

DeFiPoser-ARB and DeFiPoser-SMT [S&P'21]

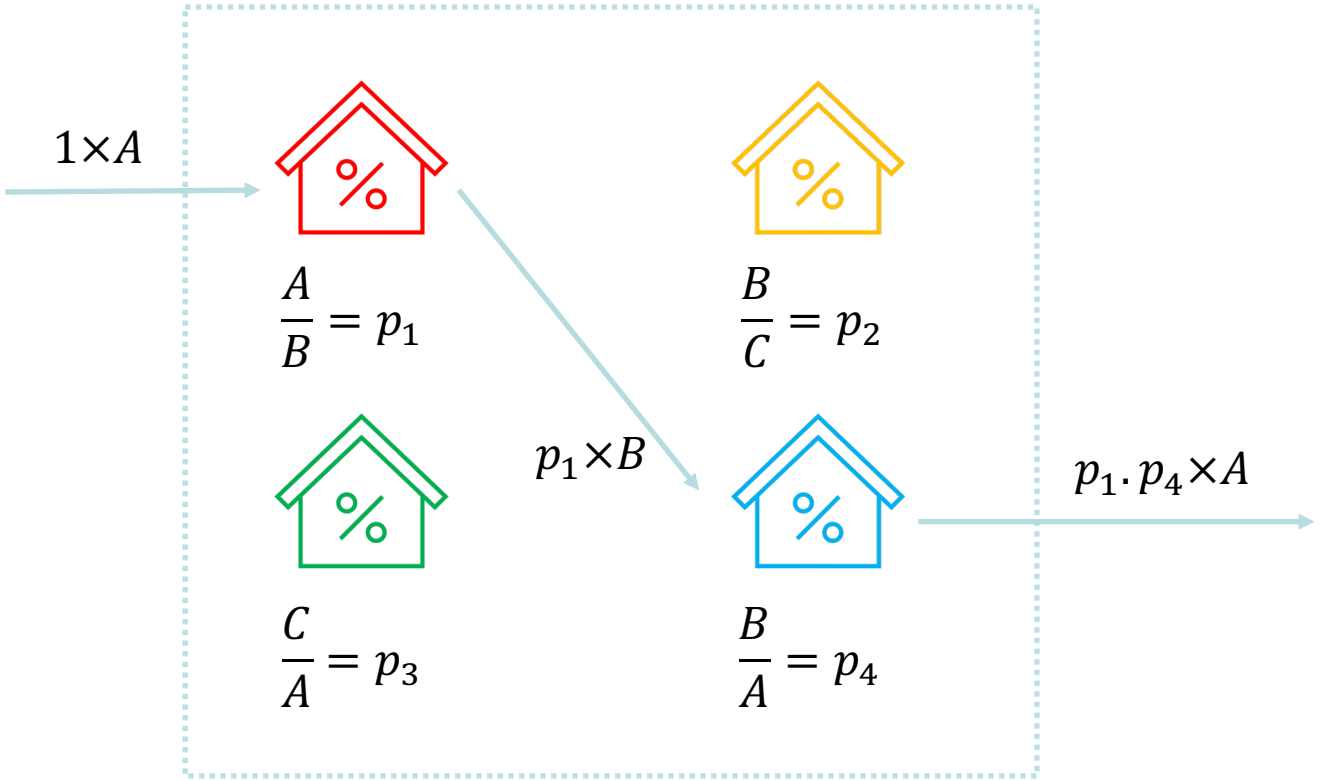
- DeFiPoser-ARB
  - builds a directed DeFi market graph
  - identifies negative cycles
  - Bellman Ford-Moore algorithm
- DeFiPoser-SMT
  - state transition model
  - prunes search space
  - theorem prover



DeFiPoser-ARB



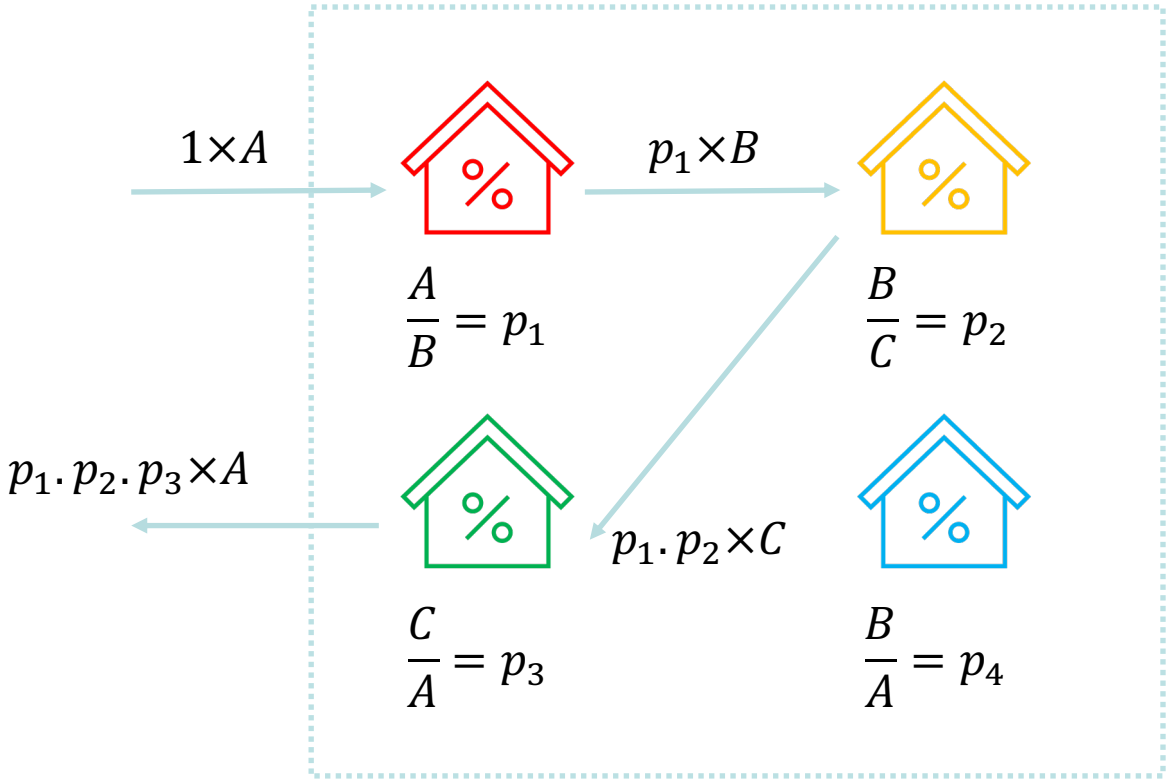
DeFiPoser-ARB



Profitable condition

$p_1 . p_4 > 1$

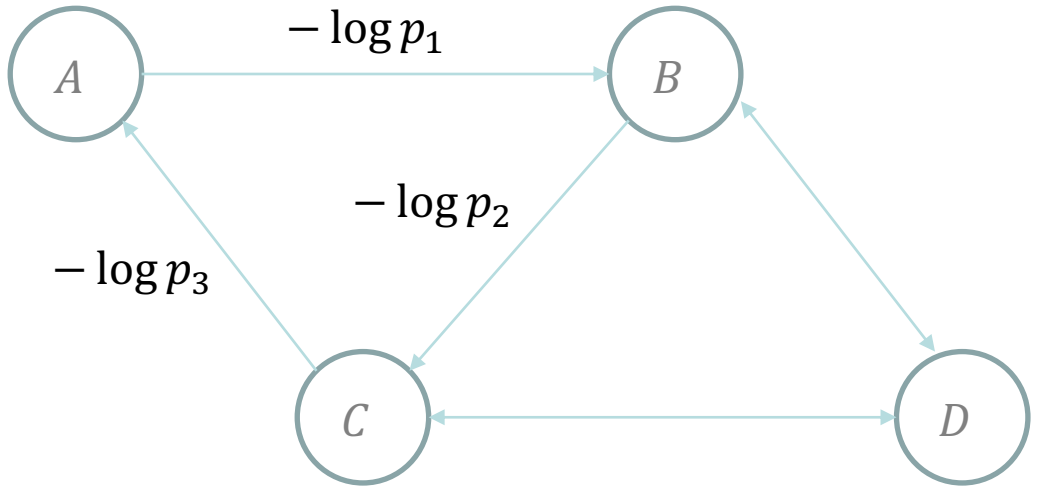
DeFiPoser-ARB



Profitable condition

$p_1 . p_2 . p_3 > 1$

DeFiPoser-ARB



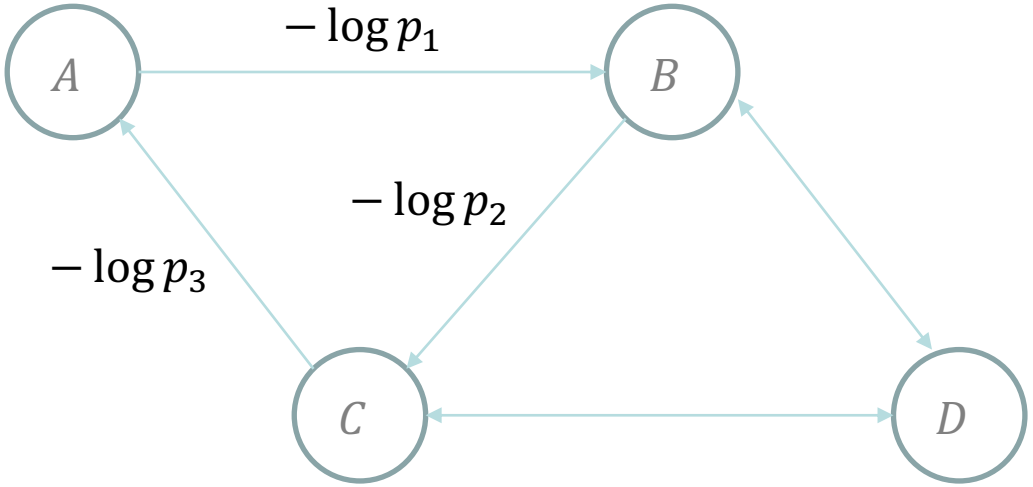
Profitable condition

$p_1 . p_2 . p_3 > 1$

$\Updownarrow$

$(-\log p_1) + (-\log p_2) + (-\log p_3) < 0$

DeFiPoser-ARB



$$\prod_i p_i > 1$$

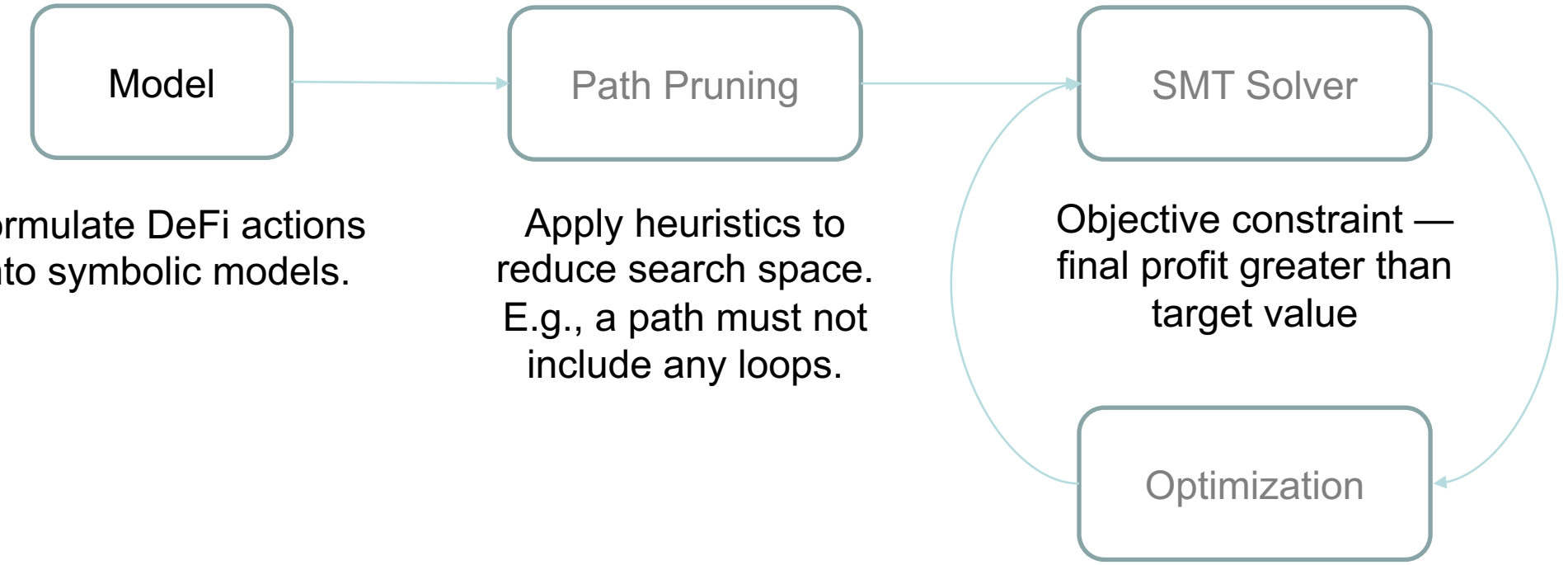
$$\Updownarrow$$

$$\sum_i (-\log p_i) < 0$$

BellmanFord-Moore algorithm

$O(|N^2| \cdot |E|)$

DeFiPoser-SMT



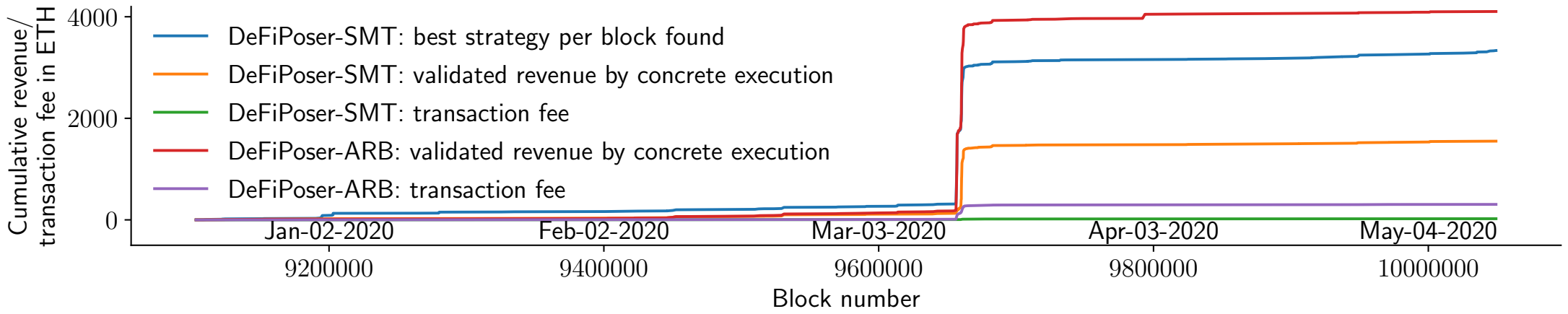
Formulate DeFi actions into symbolic models.

Apply heuristics to reduce search space. E.g., a path must not include any loops.

Objective constraint — final profit greater than target value

Apply a binary search to find the optimal value.

DeFiPoser Evaluation



- 96 actions on Uniswap, Bancor, MakerDAO, total of 25 assets
- Block 9100000 (Dec-13-2019) to 10050000 (May-12-2020)
- Validation by concrete execution
  - Weekly revenue estimate:
    - DeFiPoser-ARB: 191.48 ETH (76,592 USD)
    - DeFiPoser-SMT: 72.44 ETH (28,976 USD)

这里ARP使用收益比SMB更好

Bellman Ford vs. SMT

	DeFiPoser-ARB	DeFiPoser-SMT
Path generation	Bellman-Ford-Moore, Walk to the root; No acyclic paths	Pruning with heuristics; Any paths within the heuristics
Path selection	Combines multiple sub-paths	Selects the highest revenue path
Manual DeFi modeling	Not required	Required
Captures non-cyclic strategies	No	Yes (e.g., bZx)
Optimally chosen parameters	No	Yes (subject to inaccuracy of binary search)
Maximum Revenue	81.31 ETH (32,524 USD)	22.40 ETH (8,960 USD)
Total Revenue (over 150 days)	4,103.22 ETH (1,641,288 USD)	1,552.32 ETH (620,928 USD)
Lines of code (Python)	300	2, 300