Decentralized Finance

Case Study: Uniswap

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Uniswap

- Decentralized exchange on Ethereum
  - >$10 billion volume per week, >$6 billion of tokens used as liquidity
- Permissionless
  - Anyone can create a trading pair for any two ERC-20 tokens
- Non-custodial
  - Nobody can shut it down or steal funds (unless the blockchain is compromised or the smart contracts have a bug)
- Censorship-resistant
  - Anyone who can send transactions on Ethereum can use it
Uniswap Mechanics

https://defi-learning.org
Uniswap Mechanics: Trading

function swap(uint amount0Out, uint amount1Out, address to, bytes calldata data) external;
Uniswap Mechanics: Trading

```
function swap(uint amount0Out, uint amount1Out, address to, bytes calldata data) external;
```
Uniswap Mechanics: Trading
Uniswap Mechanics: Adding Liquidity

Liquidity provider

Pool contract

```solidity
function mint(address to) external returns (uint liquidity);
```
Uniswap Mechanics: Removing Liquidity

Liquidity provider

Pool contract

function burn(address to) external returns (uint amount0, uint amount1);
Uniswap (v2) Math

https://defi-learning.org
Uniswap (v2) Math

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Uniswap (v2) Math

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```solidity
require(balance0Adjusted.mul(balance1Adjusted) >= uint(_reserve0).mul(_reserve1).mul(1000**2), 'UniswapV2: K');
```
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- Pool sends out as much USD as needed to return to the curve
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Uniswap Price Oracle

https://defi-learning.org
Many DeFi applications (like synthetics and lending protocols) depend on price oracles.

Uniswap can be used as this price oracle for ERC-20 tokens.

But just using the current price is vulnerable to a sandwich attack.

To mitigate this, Uniswap v2 and v3 track an accumulator that allows computation of a *time-weighted average price* (TWAP) over many blocks.
Time-Weighted Average Price using Uniswap V2

\[
\text{TWAP} = \frac{\text{priceCumulative}_2 - \text{priceCumulative}_1}{\text{timestamp}_2 - \text{timestamp}_1} = \frac{48,120 - 11,400}{1,583,535,828 - 1,583,532,228} = 10.2
\]

To calculate TWAP across an interval check `priceCumulative` and `block.timestamp` at the beginning and end of the interval.
Uniswap Mechanics: Price Oracle (v3)
Uniswap (v3) Math

https://defi-learning.org
Uniswap (v3) Math

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- Uniswap v3 allows liquidity providers to add **concentrated liquidity** within a specific price range.
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This is equivalent to translating the $xy = k$ curve down and to the left.
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Different liquidity providers can provide liquidity in custom ranges, which is all aggregated together into the same pool.
Uniswap (v3) Mechanics: Adding Liquidity

Liquidity provider

Pool contract

- deposit assets
- mint NFT
Links

- Uniswap v2 Whitepaper
  - https://uniswap.org/whitepaper.pdf
- Uniswap v3 Whitepaper
- The graphs above are interactive visualizations on Desmos
  - https://docs.uniswap.org/protocol/concepts/advanced/resources
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