

defi

October 22, 2021

1 Decentralized Finance (DeFi)

1.1 Literature

- Harvey, Ramachandran and Santoro: DeFi and the Future of Finance, 2021. ([Online version HERE](#))

1.2 Material and codes

- Github
-

```
[1]: # Imports
import os
import requests
import pandas as pd
import matplotlib.pyplot as plt
```

1.3 Main problems to solve:

- Data integrity (cryptography)
- Decentralization (incentives aka mining)

2 + 2

2 Previously on ...

- Blockchain technology
-
- ERC-20

3 HASH Algorithm

A unique representation of information that does not trace back to the information.

4 Decentralized Exchange (DEX)

Paradoxically, crypto assets might live in a decentralized world, the majority of their trading (currently) does not.

4.1 Types of markets (exchange mechanisms)

1. Order book → typical exchange
2. Request for quote → over the counter (OTC)
3. Automated Market Making (AMM) → liquidity pools

4.2 Protocol

Traditionally, laws, regulators and the exchanges themselves create rules, in order to facilitate:

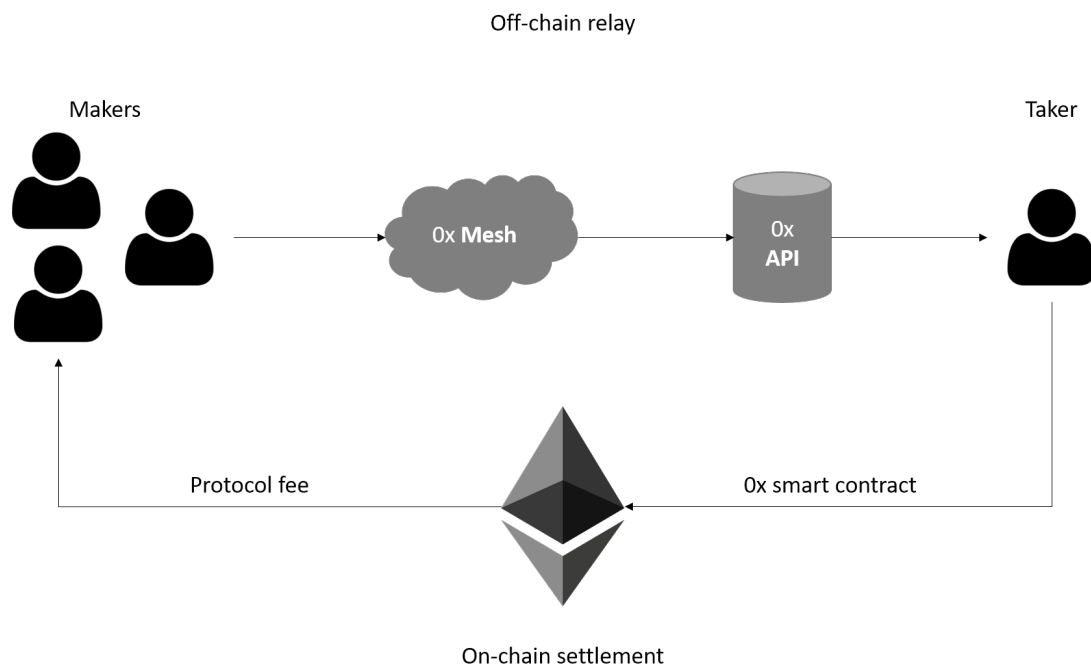
- Price exploration
- Agreement to trade
- Trade settlement

A DEX protocol is a **set of audited smart contracts** that replaces the traditional set of rules.

This is a example of footnote1. Another footnote2.

footnote 1 footnote 2

DAI is a stablecoin cryptocurrency which aims to keep its value as close to one United States dollar as possible through an automated system of smart contracts on the Ethereum blockchain.



```
[2]: response = requests.get('https://api.0x.org/swap/v1/prices?sellToken=DAI')
response = response.json() if response.status_code == 200 else response.
↳ status_code
pd.DataFrame(response['records'])
```

```
[2]:      symbol      price
0    WETH    4001.929043782100320133
```

1	ZRX	0.917641315772504736
2	USDC	0.689899153981396268
3	USDT	0.661581829911861702
4	WBTC	61560.589644867161342771
5	UNI	24.312684869908536949
6	MKR	2512.556554212391754602
7	SNX	9.527336986146130157
8	LINK	27.137650729868938301
9	SUSD	0.97124180910927937
10	TUSD	0.952546621031764651
11	SUSHI	10.324309410168912091
12	AAVE	312.313458446841969298
13	YFI	33868.145919124902607466
14	BAT	0.313574070908672533
15	KNC	1.479566704891018609
16	BNT	4.169685479421263629
17	BAL	20.973807730255136236
18	COMP	314.874871253604602093
19	ETH	4001.929043782100320133

```
[3]: # Request tokens that are currently available
response = requests.get('https://api.0x.org/swap/v1/tokens')
response = response.json() if response.status_code == 200 else response.
    ↳ status_code
available_tokens = pd.DataFrame(response['records'])
available_tokens
```

```
[3]:
```

	symbol	address	name \
0	ETH	0xeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee	Ether
1	WETH	0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2	Wrapped Ether
2	ZRX	0xe41d2489571d322189246dafa5ebd1f4699f498	0x Protocol Token
3	DAI	0x6b175474e89094c44da98b954eedeac495271d0f	Dai Stablecoin
4	USDC	0xa0b86991c6218b36c1d19d4a2e9eb0ce3606eb48	USD Coin
..
98	REP	0x221657776846890989a759ba2973e427dff5c9bb	Augur
99	SETH	0x5e74c9036fb86bd7ecdcb084a0673efc32ea31cb	sETH
100	STAKE	0x0ae055097c6d159879521c384f1d2123d1f195e6	xDAI Stake
101	TBTC	0x8daebade922df735c38c80c7ebd708af50815faa	tBTC
102	1INCH	0x111111111117dc0aa78b770fa6a738034120c302	1INCH

	decimals
0	18
1	18
2	18
3	18
4	6
..	...

```
[103 rows x 4 columns]
```

```
[4]: WETH_address = '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2'
# Extract a random order from the
response = requests.get(f'https://api.0x.org/orderbook/v1/orders?
↳makerToken={WETH_address}&page=1&perPage=1')
response.json() if response.status_code == 200 else response.status_code

[4]: {'total': 58,
      'page': 1,
      'perPage': 1,
      'records': [{'order': {'signature': {'signatureType': 3,
      'r': '0x8e1b66ec6229abf194eff93e55caef16232f64d4b74c15a9a1bb8907f1a9df33',
      's': '0x1f2a8482c6dd4c93a430e93b58b231362648dcf6a576ad98dba14a3514858ba8',
      'v': 28},
      'sender': '0x0000000000000000000000000000000000000000000000000000000000000000',
      'maker': '0xfc2f592ed0e0447c6c0e75350940fc069c2ba1e6',
      'taker': '0x0000000000000000000000000000000000000000000000000000000000000000',
      'takerTokenFeeAmount': '0',
      'makerAmount': '10000000000000000000000000000000000000000000000000000000000000000',
      'takerAmount': '1559896092778183786496',
      'makerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2',
      'takerToken': '0x1f9840a85d5af5bf1d1762f925bdaddc4201f984',
      'salt': '1634913816937',
      'verifyingContract': '0xdef1c0ded9bec7f1a1670819833240f027b25eff',
      'feeRecipient': '0x0000000000000000000000000000000000000000000000000000000000000000',
      'expiry': '1634913858',
      'chainId': 1,
      'pool':
      '0x000000000000000000000000000000000000000000000000000000000000000017'},
      'metaData': {'orderHash':
      '0x052748a9ed87f3859f45fe270f70b2096fbb395999288e930db2bf1db91bb81d',
      'remainingFillableTakerAmount': '1559896092778183786496',
      'createdAt': '2021-10-22T14:43:37.603Z'}}}]}
```

```
[6]: total_makerAmount = 0

for record in response['records']:
    total_makerAmount += int(record['order']['makerAmount']) / 10**18

total_makerAmount
```



```

'takerAmount': '401076099036260937000',
'fillData': {'tokenAddressPath':
['0x6b175474e89094c44da98b954eedeac495271d0f',
'0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2'],
'router': '0xf164fc0ec4e93095b804a4795bbe1e041497b92a'},
'source': 'Uniswap_V2',
'sourcePathId':
'0x3fe06c187b6afc96b90abb907c9b2531ae08337181d175394a8d3df1eaa98aab',
'type': 0}],
'allowanceTarget': '0xdef1c0ded9bec7f1a1670819833240f027b25eff',
'sellTokenToEthRate': '3990.34943023518559556',
'buyTokenToEthRate': '1'}

```

5 Order book

```

[8]: base_address = '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2' # WETH
      qoted_address = '0x6b175474e89094c44da98b954eedeac495271d0f' # DAI

      response = requests.get(f'https://api.0x.org/orderbook/v1?
      ↳baseToken={base_address}&quoteToken={qoted_address}&perPage=1000')
      order_book = response.json() if response.status_code == 200 else response.
      ↳status_code
      order_book

```

```

[8]: {'bids': {'total': 3,
'page': 1,
'perPage': 1000,
'records': [{'order': {'signature': {'signatureType': 3,
'r': '0x0c5af4c37a7cde9c42d1431ba595b8d889e1948045902be87eec37ecfc66965e',
's': '0x23cf8301bf6ff23dd25137c3ea39a40dd7e7e003ad17aa06db27a0cf82d644c7',
'v': 27},
'sender': '0x0000000000000000000000000000000000000000000000000000000000000000',
'maker': '0x6c2d992b7739dfb363a473cc4f28998b7f1f6de2',
'taker': '0x0000000000000000000000000000000000000000000000000000000000000000',
'takerTokenFeeAmount': '0',
'makerAmount': '217710373368871216218112',
'takerAmount': '54403884365129449472',
'makerToken': '0x6b175474e89094c44da98b954eedeac495271d0f',
'takerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2',
'salt': '1634913811953',
'verifyingContract': '0xdef1c0ded9bec7f1a1670819833240f027b25eff',
'feeRecipient': '0x0000000000000000000000000000000000000000000000000000000000000000',
'expiry': '1634913839',
'chainId': 1,
'pool':
'0x000000000000000000000000000000000000000000000000000000000000000017'}},

```

```

    'metaData': {'orderHash':
'Ox1ec25f25378fa7a9f0ad15e7a6ce9f7abfd20fae6f5b503f12d6972163323719',
  'remainingFillableTakerAmount': '54403884365129449472',
  'createdAt': '2021-10-22T14:43:33.128Z'}},
  {'order': {'signature': {'signatureType': 3,
    'r': '0x2e4760ce93a7c5c6147c3d23b2e9f60202eedb0d0cc1513665b001ee45e20ed0',
    's': '0x5af3603e2837bf5f1862d61d5f9a08255f2ed5571a726bc7f3bf854db56d3f13',
    'v': 28},
    'sender': '0x0000000000000000000000000000000000000000000000000000000000000000',
    'maker': '0x6c2d992b7739dfb363a473cc4f28998b7f1f6de2',
    'taker': '0x0000000000000000000000000000000000000000000000000000000000000000',
    'takerTokenFeeAmount': '0',
    'makerAmount': '21858823777616685236224',
    'takerAmount': '54626613205944311808',
    'makerToken': '0x6b175474e89094c44da98b954eedeac495271d0f',
    'takerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2',
    'salt': '1634913833654',
    'verifyingContract': '0xdef1c0ded9bec7f1a1670819833240f027b25eff',
    'feeRecipient': '0x0000000000000000000000000000000000000000000000000000000000000000',
    'expiry': '1634913861',
    'chainId': 1,
    'pool':
'Ox000000000000000000000000000000000000000000000000000000000000000017'}},
    'metaData': {'orderHash':
'Ox59a635aa6a58a535f016b7ad5313237496f12b8204cb9fc4f59190047820a2ee',
  'remainingFillableTakerAmount': '54626613205944311808',
  'createdAt': '2021-10-22T14:43:54.586Z'}},
  {'order': {'signature': {'signatureType': 3,
    'r': '0x5b46c692b643728849f35861db9c44e987280f6da1af18ebe35f5a118bae7a47',
    's': '0x5509583f76f8e96133f52072fcf5a444738f6cb3119cd113fe8ba255c33ad524',
    'v': 28},
    'sender': '0x0000000000000000000000000000000000000000000000000000000000000000',
    'maker': '0x6c2d992b7739dfb363a473cc4f28998b7f1f6de2',
    'taker': '0x0000000000000000000000000000000000000000000000000000000000000000',
    'takerTokenFeeAmount': '0',
    'makerAmount': '215735178449193978036224',
    'takerAmount': '53943211657721839616',
    'makerToken': '0x6b175474e89094c44da98b954eedeac495271d0f',
    'takerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2',
    'salt': '1634913825715',
    'verifyingContract': '0xdef1c0ded9bec7f1a1670819833240f027b25eff',
    'feeRecipient': '0x0000000000000000000000000000000000000000000000000000000000000000',
    'expiry': '1634913853',
    'chainId': 1,
    'pool':
'Ox000000000000000000000000000000000000000000000000000000000000000017'}},
    'metaData': {'orderHash':

```



```

'0xdd79315bb20fa90636e172a2985a70f58e259a0857763eb40ff79b1ba4bddfac',
  'remainingFillableTakerAmount': '53943211657721839616',
  'createdAt': '2021-10-22T14:43:47.900Z'}]]},
'asks': {'total': 4,
'page': 1,
'perPage': 1000,
'records': [{'order': {'signature': {'signatureType': 2,
  'r': '0xb5b20c6dac5a1095ad80e12600dc0ff976ee89cef4ba106de02ea1891c7d1022',
  's': '0x5a5b2c080478549eb15830c18f360d941692fe42f4f60808adcc9ffe2147435e',
  'v': 28},
  'sender': '0x0000000000000000000000000000000000000000000000000000000000000000',
  'maker': '0x174a2921d14d7898825701144f79c51b4b0e2337',
  'taker': '0x0000000000000000000000000000000000000000000000000000000000000000',
  'takerTokenFeeAmount': '0',
  'makerAmount': '10000000000000000',
  'takerAmount': '300000000000000000',
  'makerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2',
  'takerToken': '0x6b175474e89094c44da98b954eedeac495271d0f',
  'salt': '1632856730347',
  'verifyingContract': '0xdef1c0ded9bec7f1a1670819833240f027b25eff',
  'feeRecipient': '0x0000000000000000000000000000000000000000000000000000000000000000',
  'expiry': '1664479130',
  'chainId': 1,
  'pool':
'0x0000000000000000000000000000000000000000000000000000000000000000'},
  'metaData': {'orderHash':
'0x15681e5d86e7a29e0f794588ea9154a71696eb0ba72faabf7298ec62f254bf3e',
  'remainingFillableTakerAmount': '0',
  'createdAt': '2021-09-28T19:18:59.600Z'}}},
{'order': {'signature': {'signatureType': 3,
  'r': '0xf4ec387ab30b42de3e92411235d6283c61a54d02d02147f5abd4d1122962ba46',
  's': '0x029f9bfc9a1b8f6de78d5f28dac6770346210c365190ad46c87b25308005b5d3',
  'v': 27},
  'sender': '0x0000000000000000000000000000000000000000000000000000000000000000',
  'maker': '0x6c2d992b7739dfb363a473cc4f28998b7f1f6de2',
  'taker': '0x0000000000000000000000000000000000000000000000000000000000000000',
  'takerTokenFeeAmount': '0',
  'makerAmount': '1000000000000000000',
  'takerAmount': '40267181866124201426944',
  'makerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2',
  'takerToken': '0x6b175474e89094c44da98b954eedeac495271d0f',
  'salt': '1634913825638',
  'verifyingContract': '0xdef1c0ded9bec7f1a1670819833240f027b25eff',
  'feeRecipient': '0x0000000000000000000000000000000000000000000000000000000000000000',
  'expiry': '1634913853',
  'chainId': 1,
  'pool':

```



```

'metaData': {'orderHash':
'0xfe06e58747fd94422f2f86ae35119d48cf9c6fd631310d743cef6002e7bd23d6',
'remainingFillableTakerAmount': '40284555132393008136192',
'createdAt': '2021-10-22T14:43:54.586Z'}}]]}}

```

Let us analyze the order book in a human friendly format from a **price taker perspective**.

Bid, i.e. the price at which the **taker sells WETH** for USD

```

'makerToken': '0x6b175474e89094c44da98b954eedeac495271d0f', # DAI being sold by the maker
'takerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2', # WETH being sold by the taker
'makerAmount': '17323698973795344711680', # Amount of DAI being sold by the maker
'takerAmount': '4585635752723798528', # Amount of WETH being sold by the taker

```

Ask, i.e. the price at which the **taker buys WETH** for USD

```

'makerToken': '0xc02aaa39b223fe8d0a0e5c4f27ead9083c756cc2', # WETH being sold by the taker
'takerToken': '0x6b175474e89094c44da98b954eedeac495271d0f', # DAI being sold by the maker
'makerAmount': '10000000000000000000', # Amount of WETH being sold by the maker
'takerAmount': '38006811467435057610752', # Amount of DAI being sold by the taker

```

We could quote prices (and volumes) in WETH or DAI, here we use DAI, hence,

\$

$$Price = \frac{\text{Amount in quoted currency (e.g. DAI)}}{\text{Amount in base currency (e.g. WETH)}} \quad (1)$$

\$

```

[9]: quotes = []

for q in order_book['bids']['records']:
    if q['metaData']['remainingFillableTakerAmount'] != '0':
        # Quote: DAI received per WETH
        price = int(q['order']['makerAmount']) / int(q['order']['takerAmount'])
        # Volume in DAI (DAI is stored as bigint with 18 decimals)
        volume = int(q['order']['makerAmount']) / 10**18
        quotes.append(('Bid', price, volume, f'>>> One WETH pays ${price:.2f}$␣
↳DAI'))

for q in order_book['asks']['records']:
    if q['metaData']['remainingFillableTakerAmount'] != '0':
        # Quote: DAI paid per WETH
        price = int(q['order']['takerAmount']) / int(q['order']['makerAmount'])
        # Volume in DAI (DAI is stored as bigint with 18 decimals)
        volume = int(q['order']['takerAmount']) / 10**18
        quotes.append(('Ask', price, volume, f'>>> One WETH costs ${price:.2f}$␣
↳DAI'))

quotes = pd.DataFrame(quotes, columns=['Side', 'Price in DAI', 'Volume in DAI',␣
↳'Price taker perspective'])
quotes.sort_values(by='Price in DAI', inplace=True)

```

```
quotes
```

```
[9]: Side Price in DAI Volume in DAI Price taker perspective
2 Bid 3999.301707 215735.178449 >>> One WETH pays $3999.30$ DAI
1 Bid 4001.497163 218588.237778 >>> One WETH pays $4001.50$ DAI
0 Bid 4001.743183 217710.373369 >>> One WETH pays $4001.74$ DAI
3 Ask 4026.718187 40267.181866 >>> One WETH costs $4026.72$ DAI
4 Ask 4028.141817 140984.963586 >>> One WETH costs $4028.14$ DAI
5 Ask 4028.455513 40284.555132 >>> One WETH costs $4028.46$ DAI
```

6 Submitting an order

7 Drawbacks

- Front-running

```
[10]: # This is just generating the HTML and PDF version of the script.

# jupyter nbconvert vdt.ipynb --to slides --post serve --SlidesExporter.
↪ reveal_scroll=True
local_dir = %pwd
os.system(f'jupyter nbconvert {local_dir}/vdt.ipynb --to html')
# Generate PDF
os.system(f'jupyter nbconvert {local_dir}/vdt.ipynb --to pdf')
```

```
-----
NameError                                Traceback (most recent call last)
<ipython-input-10-e3ac1649b7a5> in <module>
      3 # jupyter nbconvert vdt.ipynb --to slides --post serve --SlidesExporter
↪ reveal_scroll=True
      4 local_dir = get_ipython().run_line_magic('pwd', '')
----> 5 os.system(f'jupyter nbconvert {local_dir}/vdt.ipynb --to slides
↪ --SlidesExporter.reveal_scroll=True')
      6 # Generate PDF
      7 os.system(f'jupyter nbconvert {local_dir}/vdt.ipynb --to pdf')

NameError: name 'os' is not defined
```