THE BITCOIN TRANSACTION NETWORK

BITCOIN IN A NUTSHELL

HISTORY

- Invented by Satoshi Nakamoto (person or group of person), started in 2009
- The protocol is still evolving, the official *bitcoin core* is a GitHub repository, controlled by 5-10 individuals, on which anyone can propose contributions
  - Objectives: More efficient, faster, more secure, more anonymous,…

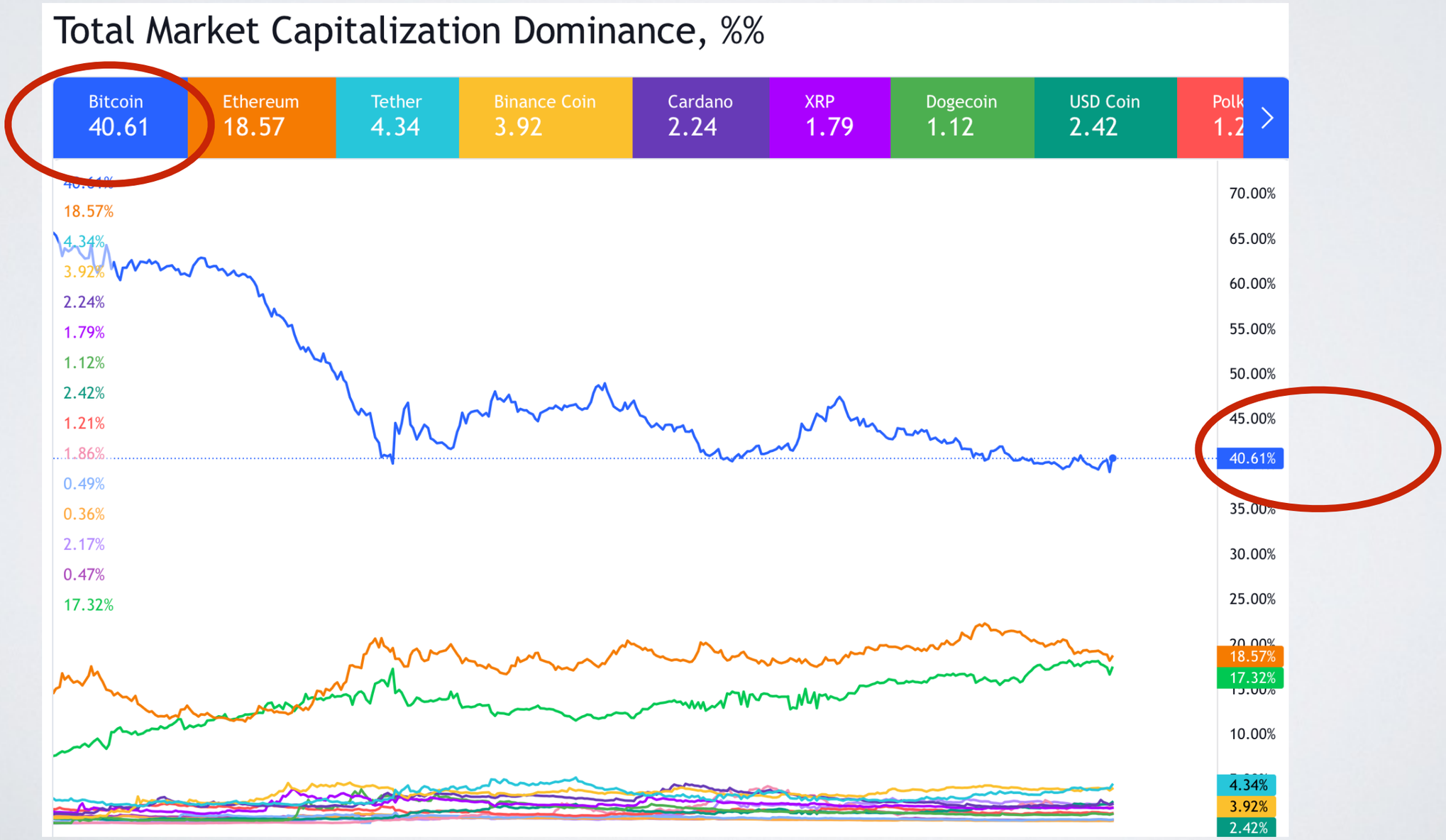
https://github.com/bitcoin/bitcoin

WHAT IS IT?

- A cryptocurrency
- A decentralized digital currency
  - No central authority (no central bank or state issue or guarantee the currency)
  - Cryptographic methods guarantee that no-one is cheating:
    - Issuing their own coins
    - Stealing coins
    - Etc.

IMPORTANCE

Bitcoin was the first cryptocurrency and is still has by far the highest Market capitalization. (Value of all existing coins)



SOME NUMBERS (2022)

- Bitcoins in existence(market cap) > $700 Billions
  - > Samsung, intel, mastercard, visa, LVMH
- Transactions per day > 300,000 (+L2, lightning etc.)
  - VISA: 150 million.
- Median transaction fee = $0,7
- Total value sent per day(without change) > $5 Billion
- Trading volume per day > Between $0.5 - 5 Billion
- Median transaction value = $600

DIGITAL LEDGER

- Bitcoin is based on a **blockchain**
  - Every transaction is stored in a *sequential database* (chain), a digital ledger.
    - Each new transaction is added at the end of the chain (in blocks)
    - Anyone can read everything in this chain
    - No-one can modify the older blocks in the chain
    - Adding a new element to the chain requires to solve a cryptographic problem

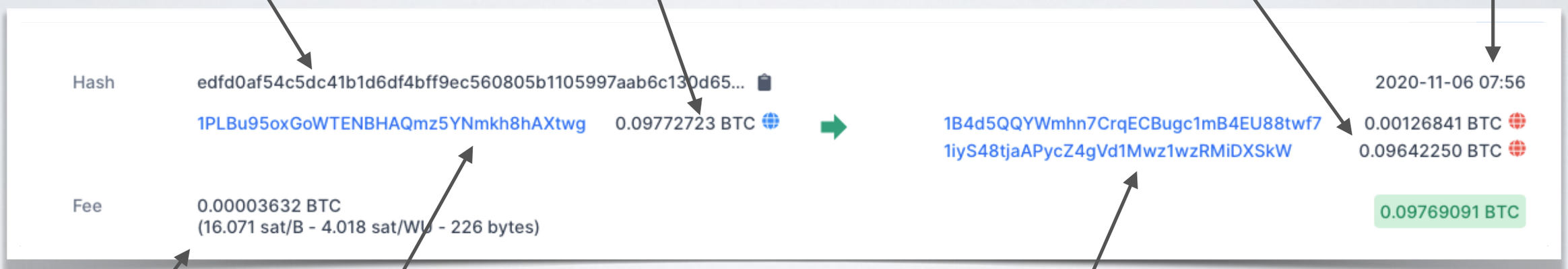
TYPICAL RECORD

Time of the transaction

Transaction identifier

Sum in input

Amounts sent



Transaction fee

Who is **sending**
(Bitcoin address)

Who is **receiving**
(Bitcoin addresses)

BITCOIN ANONYMITY

- Anyone can see all transactions=>We can study in details aggregated statistics
  - Evolution of numbers, amount of transactions, fees, etc.

- So can we track user's activity?
  - Pseudonimity=>no way to link **bitcoin address** to **identity**
  - Users can create multiple addresses easily
  - Multiple addresses of a same person can sometimes be associated
  - In practice:
    - Large actors (companies, …) are not anonymous
    - Individual users can hide what they are doing

BITCOIN MARKETS

- Bitcoin value in $ is fixed based on exchange markets
  - Trading, much as any other currency
  - Trade operations are usually not written in the blockchain, the bank virtually exchange between counts of its customers
- Transaction fees are decided based on another market
  - **Miners** use computation power to solve cryptographic problems to include transactions in the blockchain
    - They are paid by 1)newly created coins 2)transaction fee
  - Anyone is free to propose any transaction fee
    - Miners choose in priority transactions with higher fees

BITCOIN MARKETS

- What are bitcoin transactions?
  - Mining
  - Exchange between users?
  - Users buying services/products?
  - Trading?
    - No, not directly. Trading is done on exchange platforms and mostly handled internally
  - Gambling?
  - Exchange between "banks", i.e., wallet managers?
  - Money laundering?
  - L2 transactions ? (Tether, Ligthning, NFT, etc.)
- Detail is not known(yet)

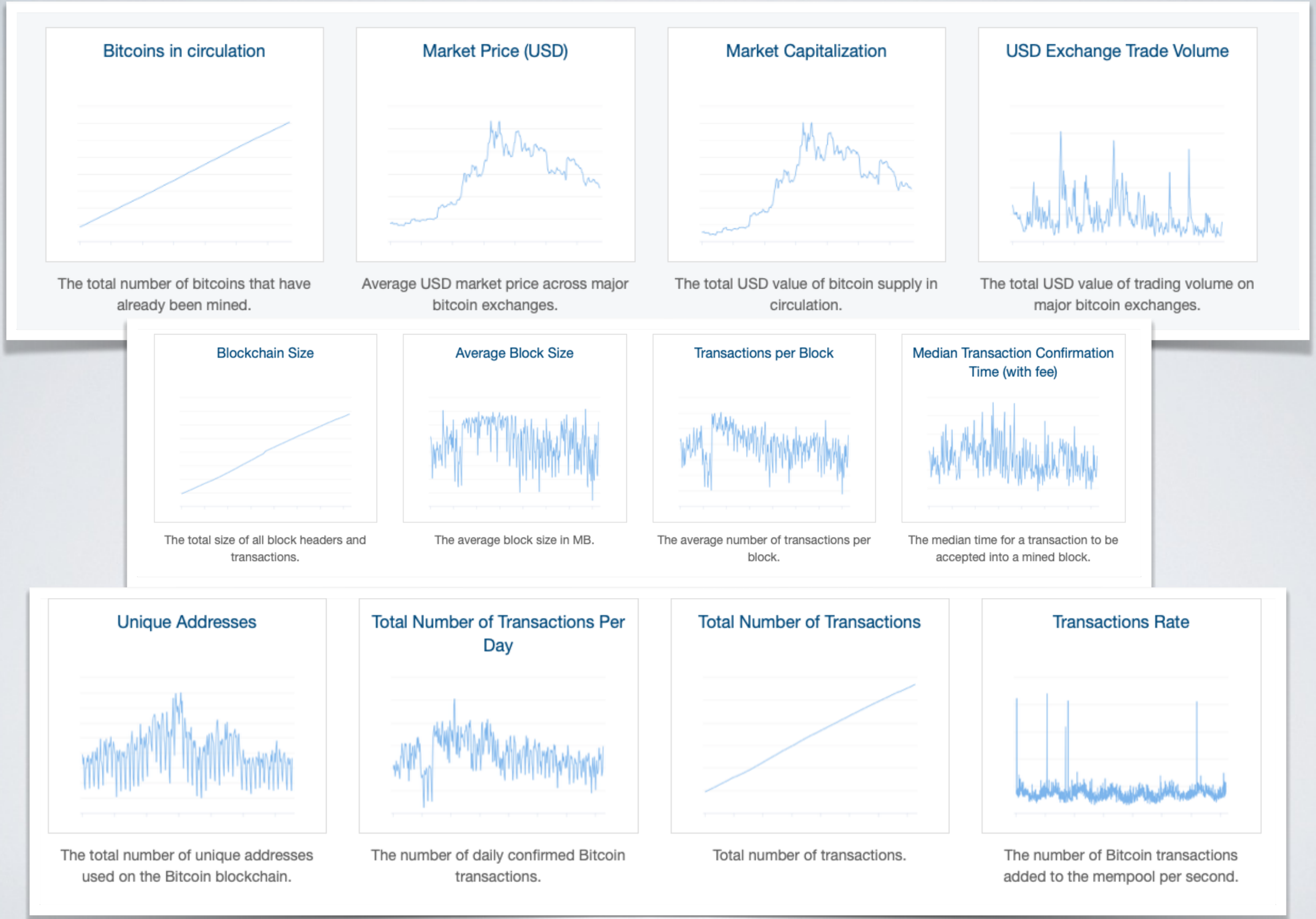
BITCOIN TRANSACTION NETWORK ANALYSIS

BITCOIN

- In this class, we are **not** interested in:
  - Cryptographic aspects
  - How the blockchain works
  - Governance of cryptocurrencies
  - Smart contracts
  - ICO

- What we are interested in:
  - Observing and understanding what is happening at the micro-level in one cryptocurrency (for this class, the largest one, Bitcoin) => **Look under the hood !**
  - How what is happening at the micro-level can be connected to what we observe at the macro-level (crisis, price fluctuation, macro-indicators…)

BITCOIN - MACRO LEVEL



https://www.blockchain.com/en/charts

BITCOIN - MACRO LEVEL

- This type of aggregated data is mostly identical to data you are used to in economy
- Can be studied with time series analysis (ARIMA, …)
- What is unique about Bitcoin:
  - We have all data about all transactions done using a given currency
  - We can use this information in relation with macro-level statistics
  - We can use it for new types of analysis

BITCOIN - DATA

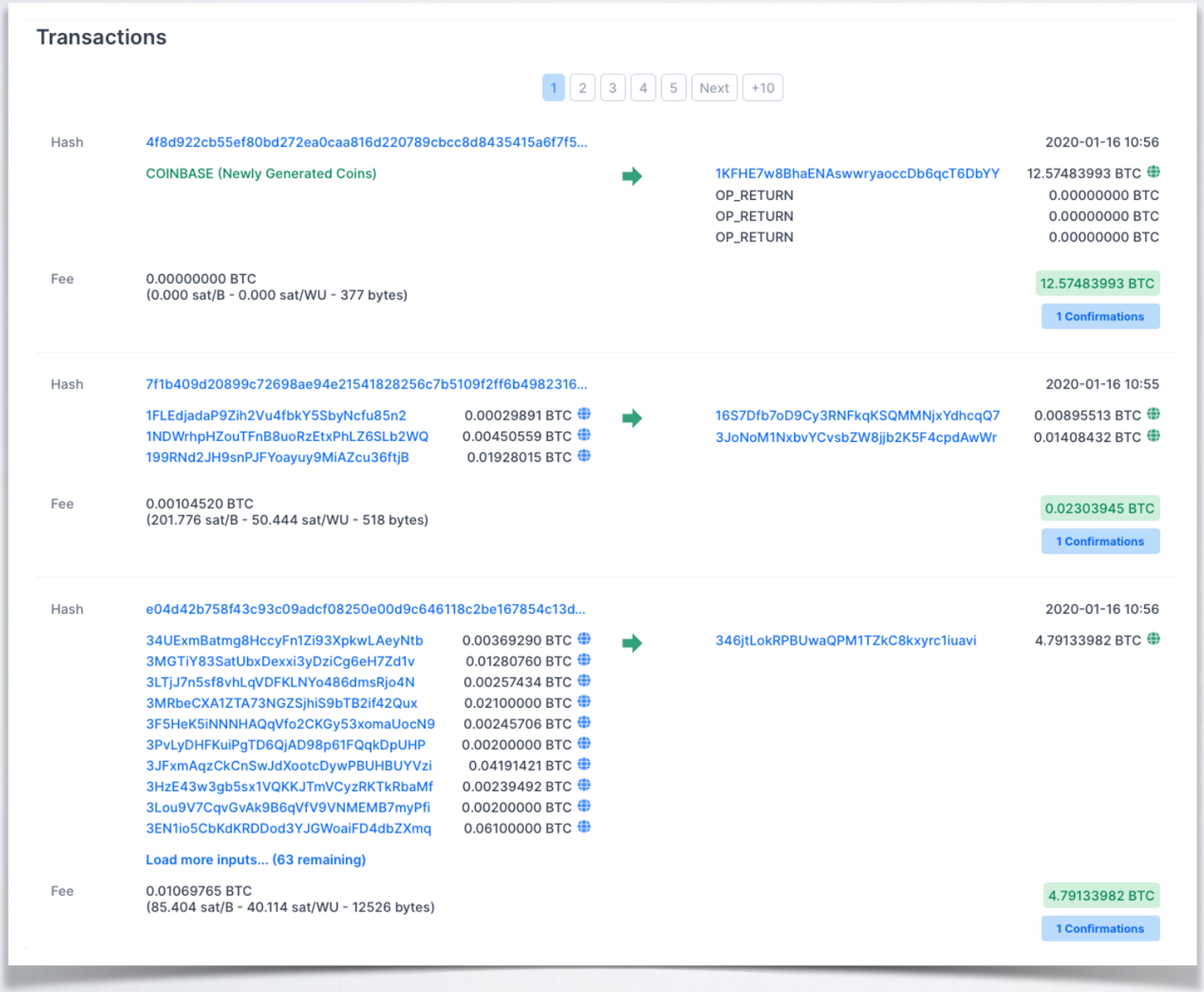
- The data we use: Content of the bitcoin blockchain
  - Seen as a simple list of transactions

Transaction	From	To	Value
t0	@1	@2	5
t1	@1	@3	2
…	…	…	…

- Bitcoin transactions are a little bit more complicated than that

BITCOIN - DATA

- You can explore it using tools such as a blockchain explorer
  - E.g.: https://www.blockchain.com/explorer



Transactions

1 2 3 4 5 Next +10

Hash	4f8d922cb55ef80bd272ea0caa816d220789cbcc8d8435415a6f7f5...			2020-01-16 10:56
	COINBASE (Newly Generated Coins)	→	1KFHE7w8BhaENAswwryaoccDb6qcT6DbYY	12.57483993 BTC
			OP_RETURN	0.00000000 BTC
			OP_RETURN	0.00000000 BTC
			OP_RETURN	0.00000000 BTC
Fee	0.00000000 BTC (0.000 sat/B - 0.000 sat/WU - 377 bytes)			12.57483993 BTC
				1 Confirmations
Hash	7f1b409d20899c72698ae94e21541828256c7b5109f2ff6b4982316...			2020-01-16 10:55
	1FLEdjadaP9Zih2Vu4fbkY5SbyNcfu85n2 0.00029891 BTC	→	16S7Dfb7oD9Cy3RNFkqKSQMMNjxYdhcqQ7	0.00895513 BTC
	1NDWrhpHZouTFnB8uoRzEtxPhLZ6SLb2WQ 0.00450559 BTC		3JoNoM1NxbvYCvsbZW8jjb2K5F4cpdAwWr	0.01408432 BTC
	199RNd2JH9snPJFYoayuy9MiAZcu36ftjB 0.01928015 BTC			
Fee	0.00104520 BTC (201.776 sat/B - 50.444 sat/WU - 518 bytes)			0.02303945 BTC
				1 Confirmations
Hash	e04d42b758f43c93c09adcf08250e00d9c646118c2be167854c13d...			2020-01-16 10:56
	34UExmBatmg8HccyFn1Zi93XpkwLAeyNtb 0.00369290 BTC	→	346jtLokRPBUwaQPM1TZkC8kxyrc1iuavi	4.79133982 BTC
	3MGTiY83SatUbxDexxi3yDziCg6eH7Zd1v 0.01280760 BTC			
	3LTjJ7n5sf8vhLqVDFKLNYo486dmsRjo4N 0.00257434 BTC			
	3MRbeCXA1ZTA73NGZSjhiS9bTB2if42Qux 0.02100000 BTC			
	3F5HeK5iNNNHAQqVfo2CKGy53xomaUocN9 0.00245706 BTC			
	3PvLyDHFKuiPgTD6QjAD98p61FQqkDpUHP 0.00200000 BTC			
	3JFxmAqzCkCnSwJdXootcDywPBUHBUYVzi 0.04191421 BTC			
	3HzE43w3gb5sx1VQKKJTmVCyzRKTkRbaMf 0.00239492 BTC			
	3Lou9V7CqvGvAk9B6qVfV9VNMEMB7myPfi 0.00200000 BTC			
	3EN1io5CbKdKRDDod3YJGWoaiFD4dbZXmq 0.06100000 BTC			
	Load more inputs... (63 remaining)			
Fee	0.01069765 BTC (85.404 sat/B - 40.114 sat/WU - 12526 bytes)			4.79133982 BTC
				1 Confirmations

Hash	7f1b409d20899c72698ae94e21541828256c7b5109f2ff6b4982316...			2020-01-16 10:55
	1FLEdjadaP9Zih2Vu4fbkY5SbyNcfu85n2	0.00029891 BTC	16S7Dfb7oD9Cy3RNFkqKSQMMNjxYdhcqQ7	0.00895513 BTC
	1NDWrhpHZouTFnB8uoRzEtxPhLZ6SLb2WQ	0.00450559 BTC	3JoNoM1NxbvYCvsbZW8jjb2K5F4cpdAwWr	0.01408432 BTC
	199RNd2JH9snPJFYoayuy9MiAZcu36ftjB	0.01928015 BTC		
Fee	0.00104520 BTC (201.776 sat/B - 50.444 sat/WU - 518 bytes)			0.02303945 BTC 1 Confirmations

Hash	e04d42b758f43c93c09adcf08250e00d9c646118c2be167854c13d...			2020-01-16 10:56
	34UExmBatmg8HccyFn1Zi93XpkwLAeyNtb	0.00369290 BTC	346jtLokRPBUwaQPM1TZkC8kxyrc1iuavi	4.79133982 BTC
	3MGTiY83SatUbxDexxi3yDziCg6eH7Zd1v	0.01280760 BTC		
	3LTjJ7n5sf8vhLqVDFKLNYo486dmsRjo4N	0.00257434 BTC		
	3MRbeCXA1ZTA73NGZSjhiS9bTB2if42Qux	0.02100000 BTC		
	3F5HeK5iNNNHAQqVfo2CKGy53xomaUocN9	0.00245706 BTC		
	3PvLyDHFKuiPgTD6QjAD98p61FQqkDpUHP	0.00200000 BTC		
	3JFxmAqzCkCnSwJdXootcDywPBUHBUYVzi	0.04191421 BTC		
	3HzE43w3gb5sx1VQKKJTmVCyzRKTkRbaMf	0.00239492 BTC		
	3Lou9V7CqvGvAk9B6qVfV9VNMEMB7myPfi	0.00200000 BTC		
	3EN1io5CbKdKRDDod3YJGWoaiFD4dbZXmq	0.06100000 BTC		
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Fee	0.01069765 BTC (85.404 sat/B - 40.114 sat/WU - 12526 bytes)			4.79133982 BTC 1 Confirmations

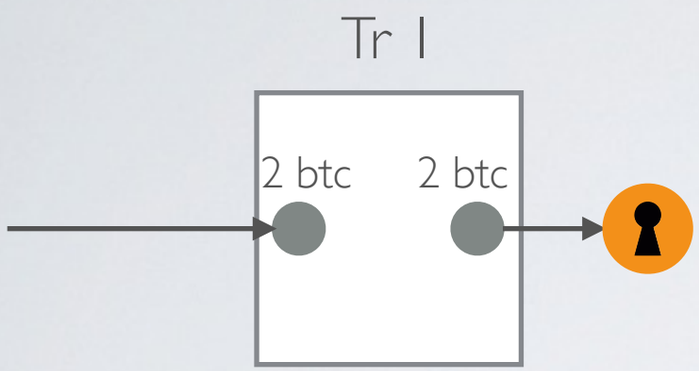
UNDERSTANDING BITCOIN TRANSACTIONS

- Transactions are between *m* "inputs" and *n* "outputs"
- Each *input* (resp. *output*) is a pair (value,bitcoin address)
- *inputs* are necessarily *outputs* of previous transactions
  - Unlocked by the private key of the payer

UNDERSTANDING BITCOIN TRANSACTIONS

- A user possess one (or several) **private keys**
- A user can generate **public keys** (bitcoin adresses) corresponding to these private keys
  - Instantaneously
  - At no cost
  - As often as wanted
- Public key ≈ lock that can be opened only by an associated private key

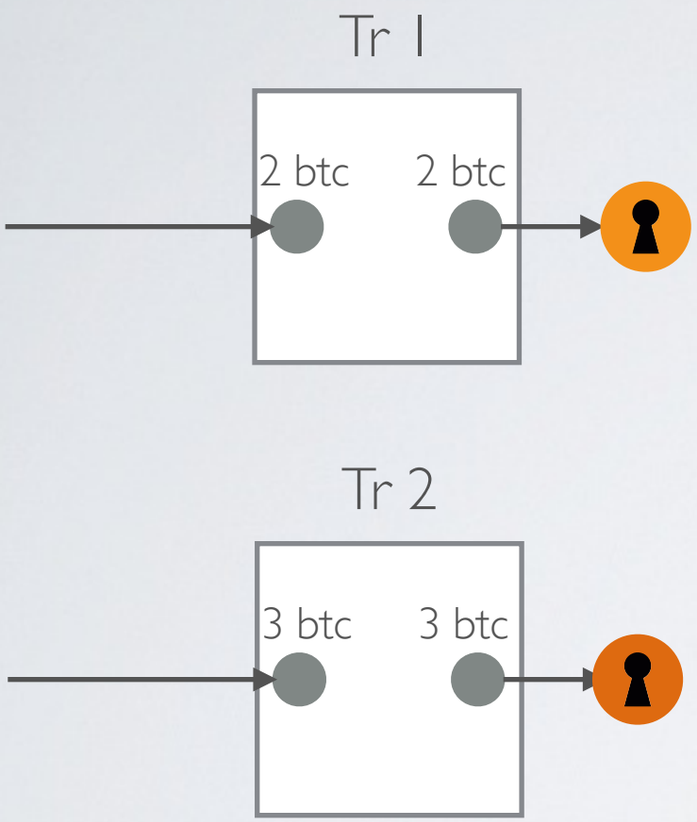
ILLUSTRATION



Public keys of user U1 :

1BusVkYQvbbGbSDZNo5DfhrFeQdgK1Y1VY

ILLUSTRATION



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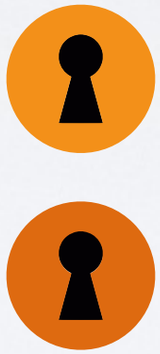

1BusVkYQvbbGbSDZNo5DfhrFeQdgK1Y1VY

1QFdbGkhiCDFF45mBHgzWUdiqv55NJbd4u

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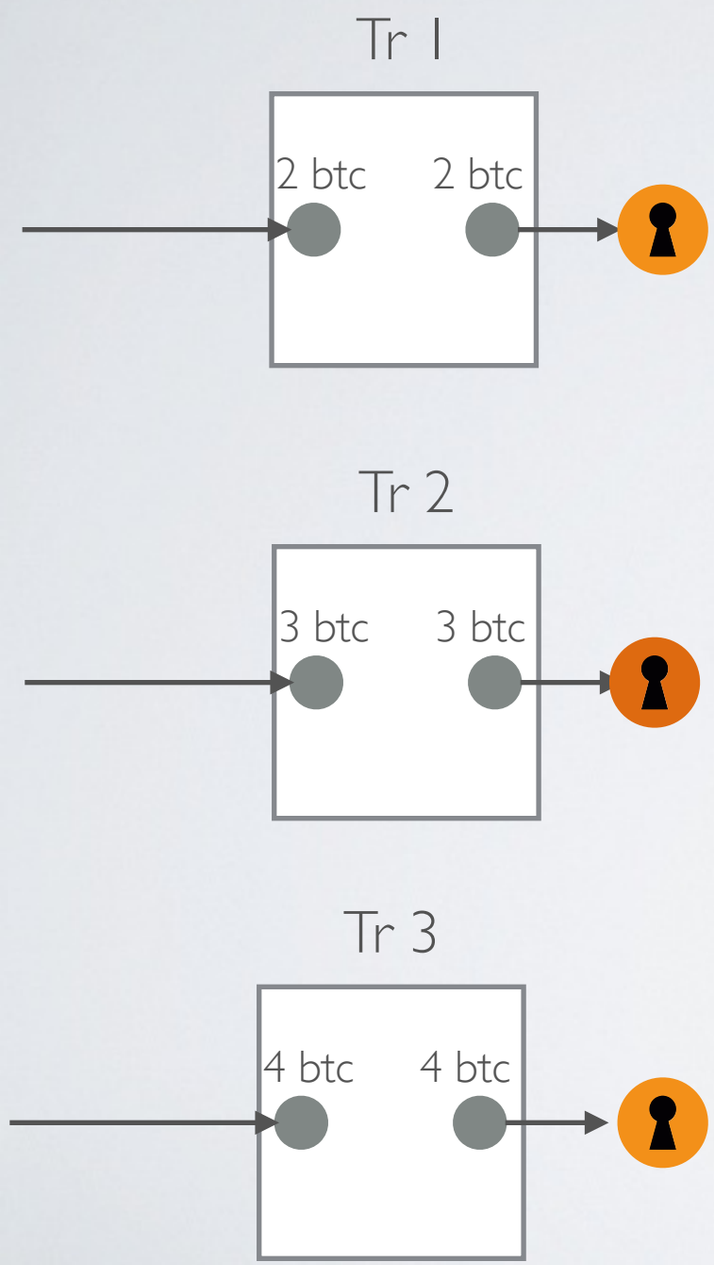


Public keys of user U1 :

1BusVkYQvbbGbSDZNo5DfhrFeQdgK1Y1VY

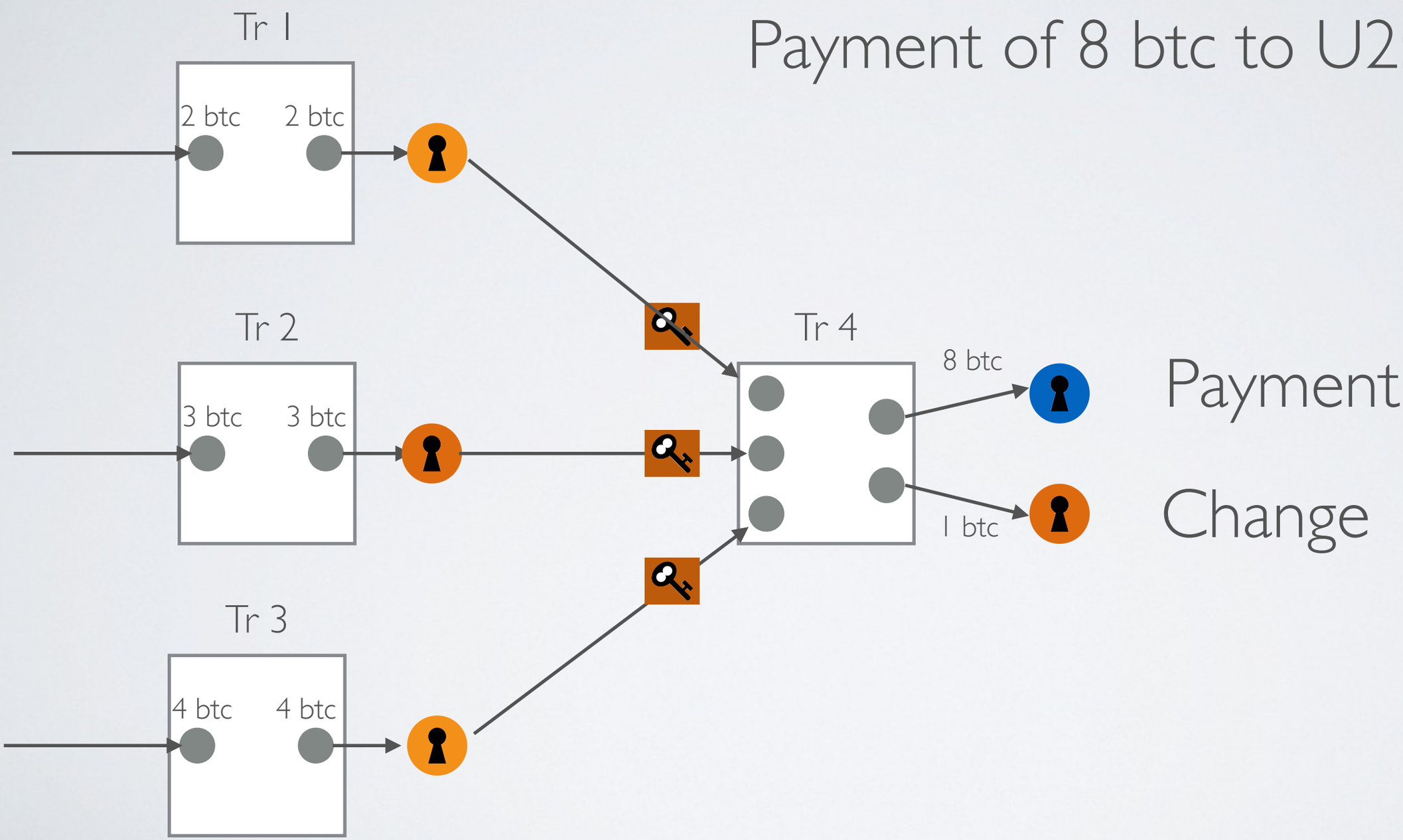
1QFdbGkhiCDFF45mBHgzWUdiqv55NJbd4u

“Wallet” of U1:

- 9 btc
- Divided in 3 “output”
- Locked by 2 different public keys

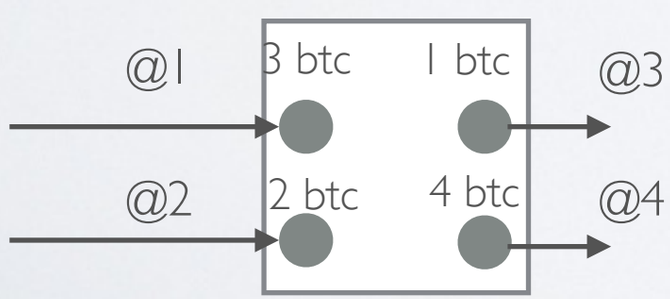
ILLUSTRATION

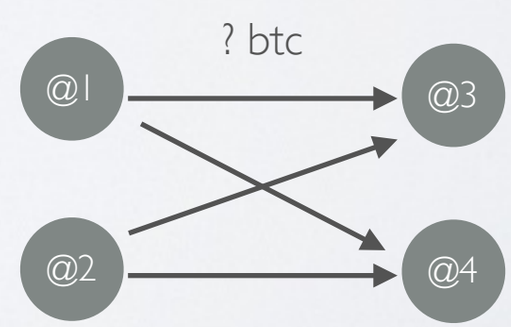
Payment of 8 btc to U2:



ADDRESS NETWORK

- First network, node=Address
  - Naive approach
  - One address ≠ one user!
- Node: bitcoin address (public key)
- Edge: input addresses to output addresses.
- Problem: most transactions have several inputs, several outputs
  - Values ?





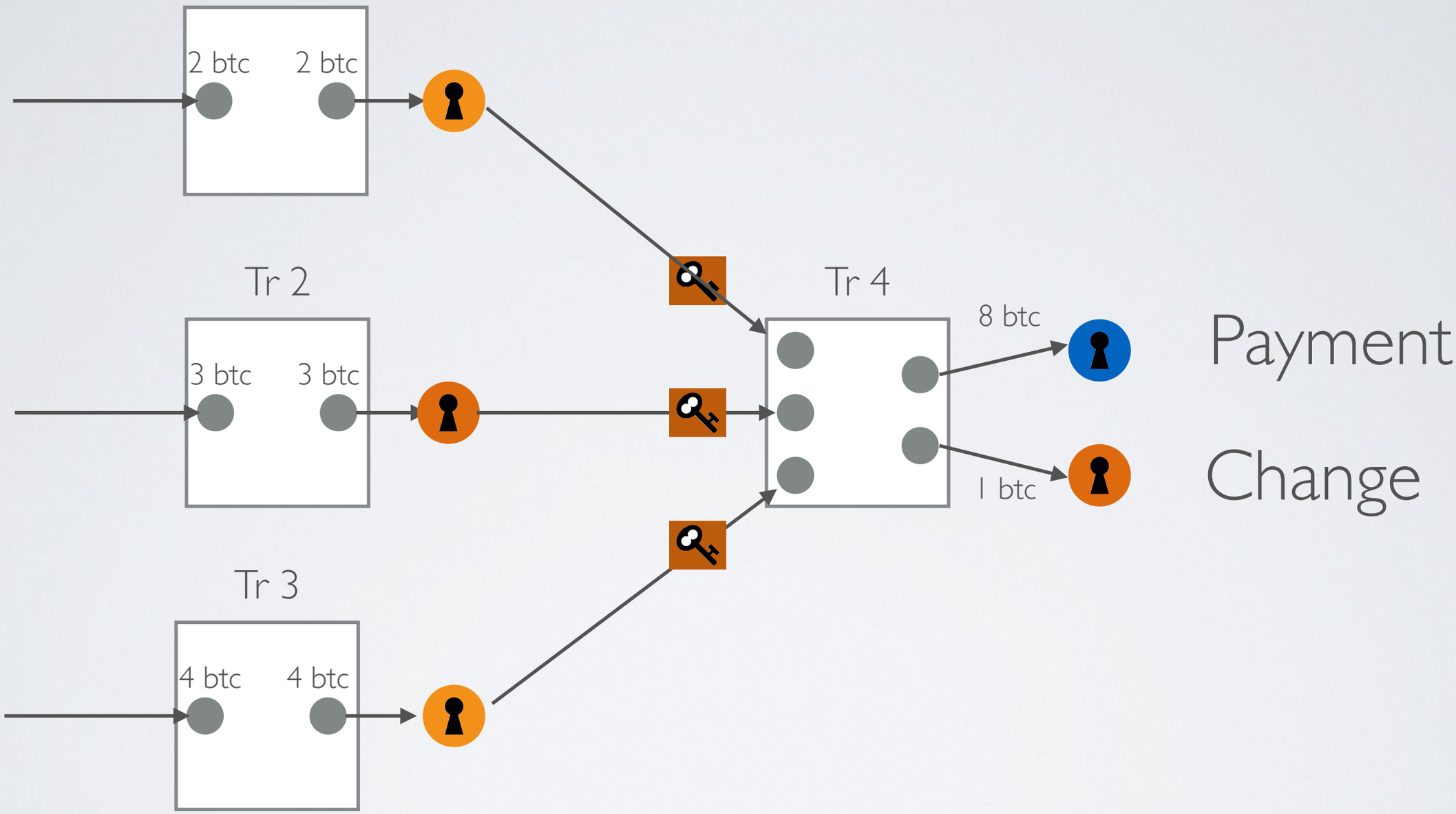
ADDRESS NETWORK

- Example: 2 days (August 2&3 2016)
  - # Transactions: 490 441
  - # Transaction outputs: 1 210 004 (avg. 2,46)
  - # Transaction inputs 1 211 790 (avg. 2.47)
  - # Addresses: 933 645
  - # @->@ Edges: 3 014 350
- Very large, hard to interpret

ACTOR NETWORK

- Transactions between "actors" of the bitcoin ecosystem
  - Individuals with their own private key(s) (e.g., using BRD, Atomic Wallet, etc.)
  - Companies/organisations with their own private key(s)
  - Exchanges (e.g., Binance, CoinBase, etc.)
  - Mining Pool
  - etc.
- An actor can have **many** public keys/addresses
- How to retrieve addresses belonging to the same actor?

ACTOR NETWORK

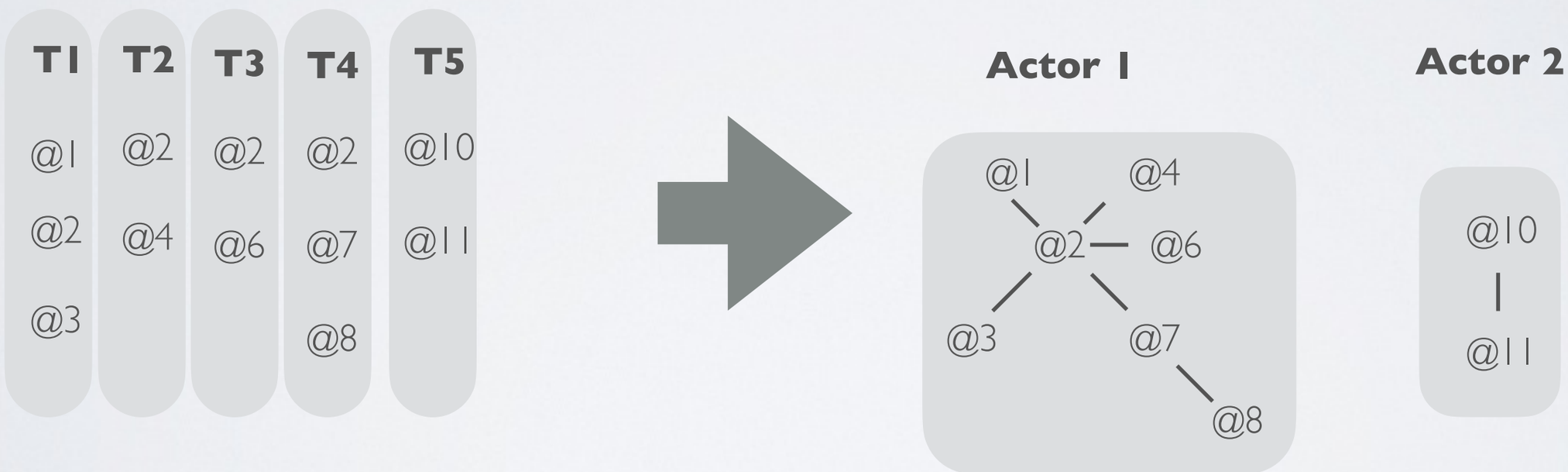


and are inputs of the same transaction
=> same actor

ACTOR NETWORK

- Actor identification: find all addresses of a same user
  - Currently a research question…
- Heuristics (input):
  - All addresses in input of a same transaction belongs to the same person

ACTOR NETWORK



ACTOR NETWORK

- Actor identification: find all addresses of a same user
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- Heuristics (input):
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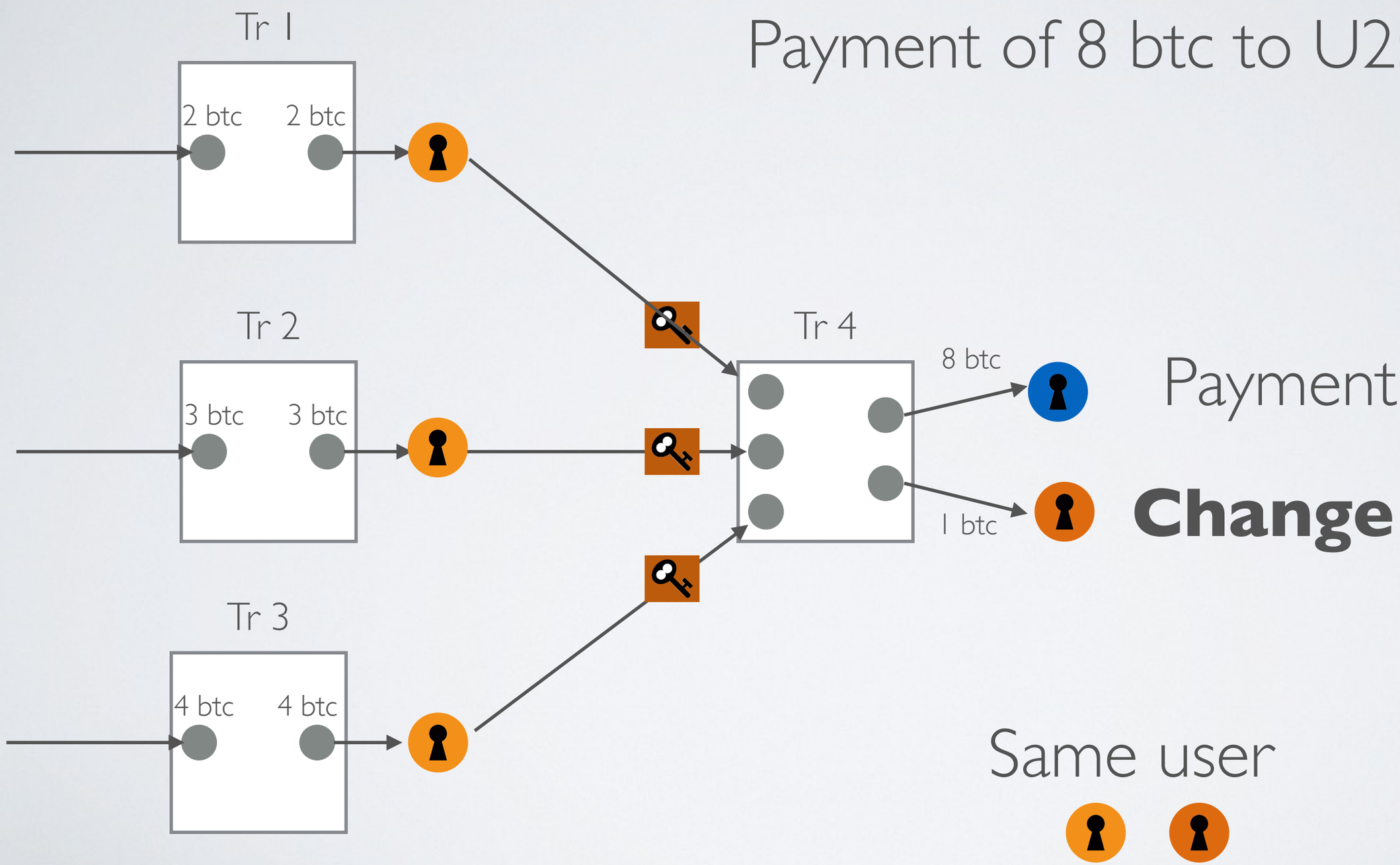
- Heuristics (output):
  - One of the addresses in output is probably a **change address**, thus an address of the same user as the one in input
  - But which one ?

ACTOR NETWORK

Payment of 8 btc to U2:



ACTOR NETWORK

- Heuristics (output):
  - One of the addresses in output is probably a **change address**, thus an address of the same user as the one in input
  - But which one ?
    - Lower value ?
    - Value with the same decimal as input?
    - Learn which one using machine learning and examples ?
    - …

ACTOR NETWORK

- Examples of methods:
  - Cazabet, R., Baccour, R., & Latapy, M. (2017, November). Tracking bitcoin users activity using community detection on a network of weak signals. In The 6th International Conference on Complex Networks and Their Applications.
  - Towards a better identification of Bitcoin users by Supervised Machine Learning
  - Möser, M., & Narayanan, A. (2021). Resurrecting Address Clustering in Bitcoin

ACTOR NETWORK

- Describe each output using features:
  - Value in satoshi
  - Value in $
  - Value of input
  - Number of decimals in Bitcoin
  - Date
  - Fees
  - Number of inputs/outputs
  - Number of reuse
  - …
- Train a machine learning algorithm to recognise change transactions

ACTOR NETWORK

- Group of addresses => Anonymous actor
  - Can we know who is this actor?
  - It is sufficient to identify *one* address
  - One transaction with a person/company => we know one of its addresses
  - On the internet, many company/individuals provide their addresses.
  - For some actors, we might infer their category
    - => Miners
    - => Large transactions profiles VS low transaction profiles
    - Has made transactions to identified money laundering services => suspicious
    - Machine learning => Automatically recognize profiles, identify similar actors, …
    - etc.

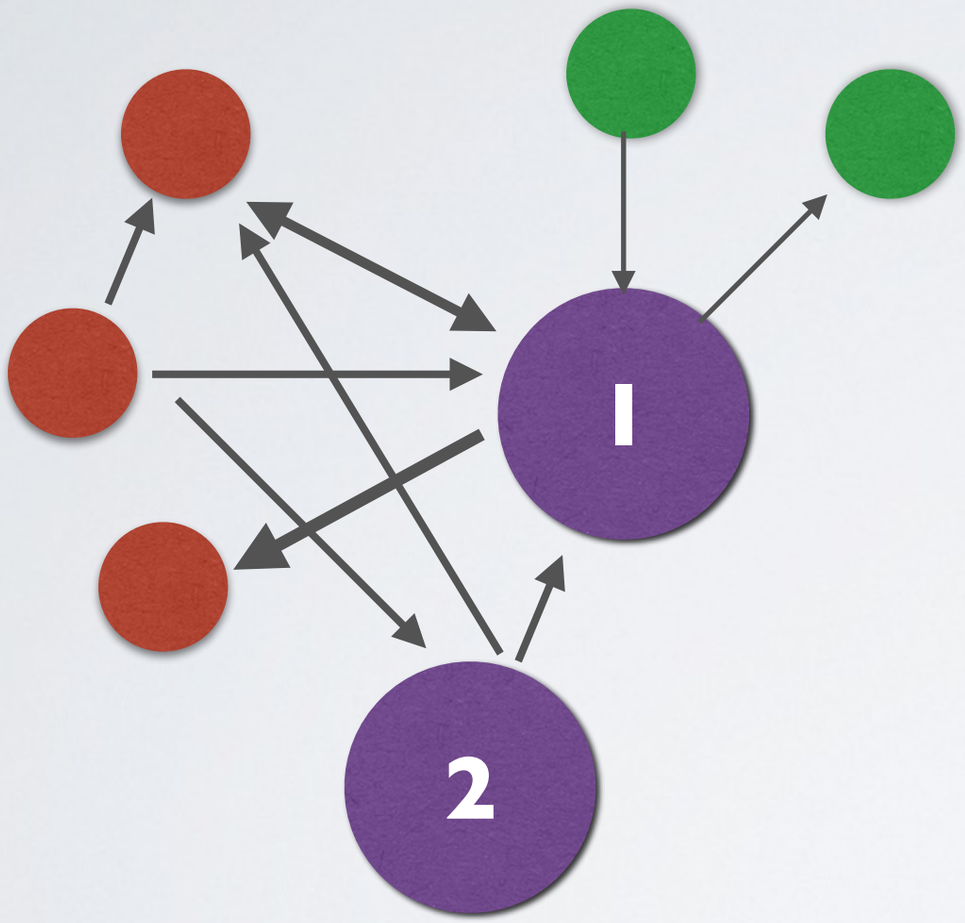
ACTOR NETWORK

List of actors addresses, for instance: https://www.walletexplorer.com

Top wallets

Exchanges:	Pools:	Services/others:	Gambling:	Old/historic:
Huobi.com (2)	BTCCPool	CoinPayments.net	SatoshiDice.com (original)	AgoraMarket
Bittrex.com	SlushPool.com (old) (old2)	Xapo.com	LuckyB.it (chatbot)	BetcoinDice.tm
Poloniex.com	GHash.io	Cubits.com	BitZillions.com	SilkRoadMarketplace
Luno.com	AntPool.com (old) (old2)	Cryptonator.com (old)	999Dice.com	DeepBit.net
BTC-e.com (output) (old)	BitMinter.com	BitPay.com (old) (old2) (old3)	CoinGaming.io	SilkRoad2Market
Kraken.com (old)	EclipseMC.com (old) (old2) (old3)	BitoEX.com	PrimeDice.com (old) (old2) (old3) (old4)	EvolutionMarket
LocalBitcoins.com (old)	KnCMiner.com	HaoBTC.com	CloudBet.com	Instawallet.org
Bitstamp.net (old)	Bitfury.org	Cryptopay.me (old)	SatoshiMines.com	UpDown.BT
MercadoBitcoin.com.br	BW.com	AlphaBayMarket (old)	NitrogenSports.eu	AbraxasMarket
BitZlato.com	Eligius.st	NucleusMarket	SecondsTrade.com	MintPal.com
Cryptsy.com (old)	Kano.is (old)	BitcoinFog	PocketDice.io	SealsWithClubs.eu
Bitcoin.de (old)	Telco214	CoinJar.com	FortuneJack.com	PandoraOpenMarket
Cex.io		BitcoinWallet.com	Rollin.io	MiddleEarthMarketplace
Binance.com (old)		HolyTransaction.com	BitZino.com	BtcDice.com
BtcTrade.com		HelixMixer (old) (old2) (old3) (old4) (old5) (old6) (old7) (old8) (old9) (old10) (old11) (old12) (old13) (old14) (old15) (old16) (old17) (old18) (old19) (old20) (old21) (old22) (old23) (old24) (old25) (old26) (old27) (old28) (old29) (old30) (old31) (old32) (old33) (old34)	BitcoinVideoCasino.com (old) (old2)	McxNOW.com
YoBit.net		BTCJam.com	Betcoin.ag (old)	SheepMarketplace
OKCoin.com (2)		VIP72.com	YABTCL.com	DiceOnCrack.com
BTCC.com (old) (old2)		MoonBit.co.in	SatoshiBet.com	BlackBankMarket
BX.in.th		CoinKite.com	SafeDice.com	BTCGuild.com
HitBtc.com (old)		FaucetBOX.com	Coinroll.com	Coin-Swap.net
MaiCoin.com		OkLink.com	Crypto-Games.net	BlueSkyMarketplace
Bter.com (old) (old2) (old3) (cold)		Purse.io	Betcoin.tm	Justcoin.com
CoinSpot.com.au		ePay.info	SwCPoker.eu	PinballCoin.com
Hashnest.com		Loanbase.com	SatoshiRoulette.com	Inputs.io
AnxPro.com		GermanPlazaMarket	BTCOracle.com	BitAces.me (old)
BitBay.net		Paymium.com	Peerbet.org	AllCoin.com
Bleutrade.com		Bitbond.com	AnoniBet.com	Bitcoin-24.com (old) (old-hotwallet)
Bitfinex.com (old) (old2)		CrimeNetwork.co (old)	Satoshi-Karoshi.com (old)	Betcoins.net
Matbea.com			777Coin.com	CrimeNetwork.biz
Bit-x.com			BitStarz.com	Bitcoin-Roulette.com
VirWoX.com			SatoshiCircle.com	Bitmit.net
Paxful.com			Coinichiwa.com	Cryptorush.in
BitBargain.co.uk				

OBTAINED NETWORK

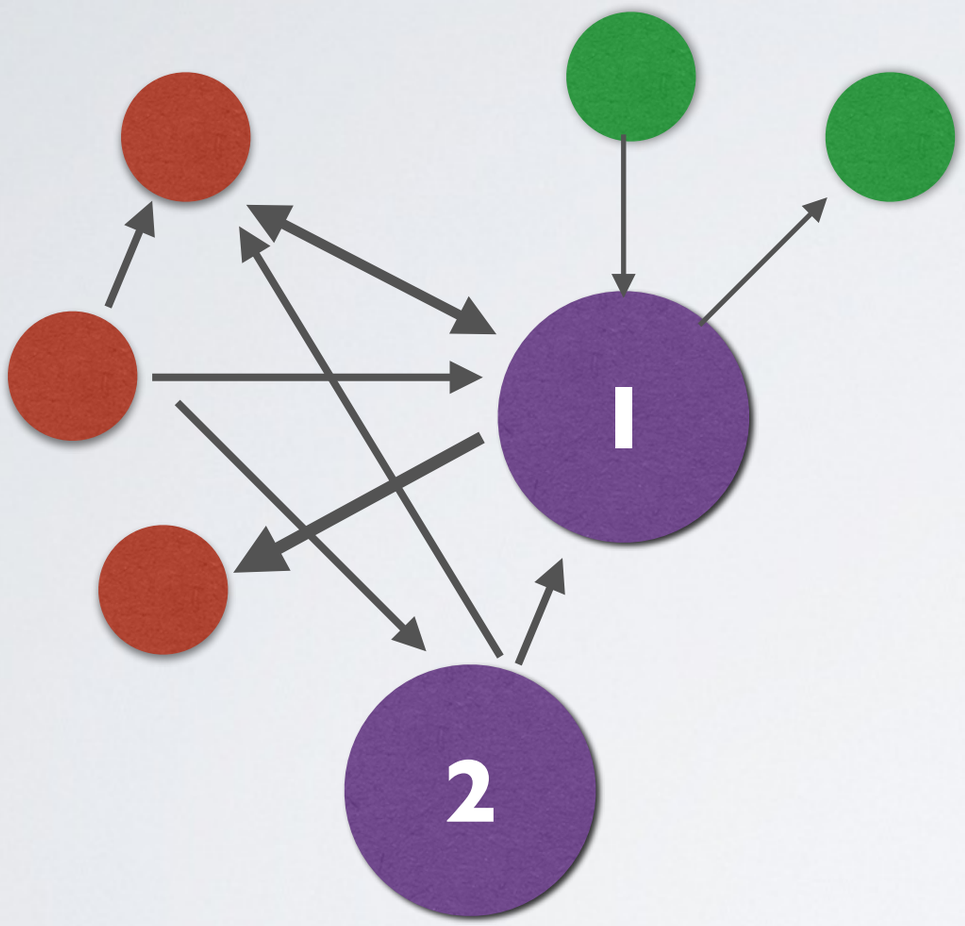


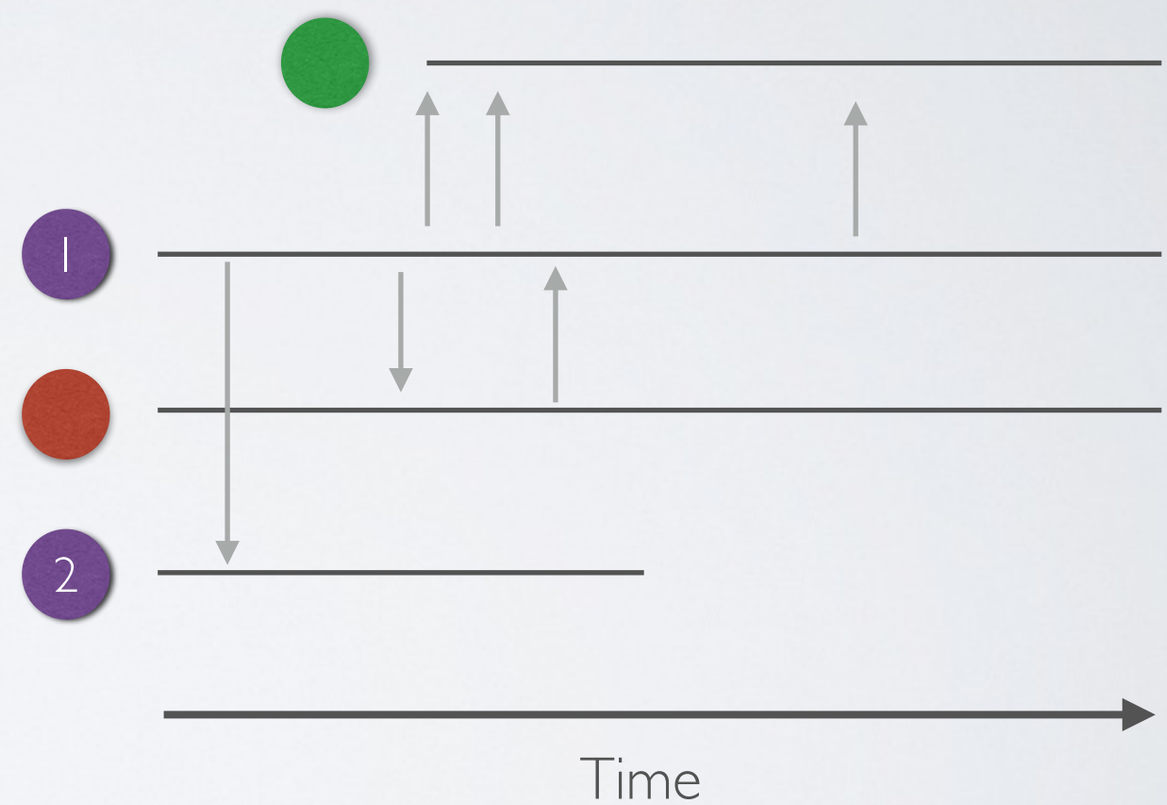
Identified nodes

Category 1

Category 2

OBTAINED NETWORK





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ACTOR NETWORK

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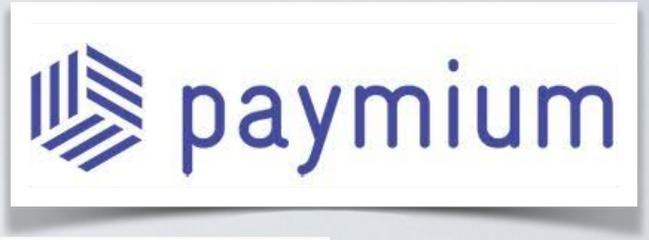
  - # Addresses: 933 645
  - # @->@ Edges: 3 014 350
- Actor network
  - # Clusters: 456 012
  - Largest clusters sizes: 20 023, 19 381, 17 244
  - # Edges (Actor -> Actor) : 956 347

BITCOIN BLOCKCHAIN ACTIVITY TRACKING EXAMPLE

Transfer (€)

1 Traditional Bank



deposited 75.00 € processed 2/10/2017

Operations

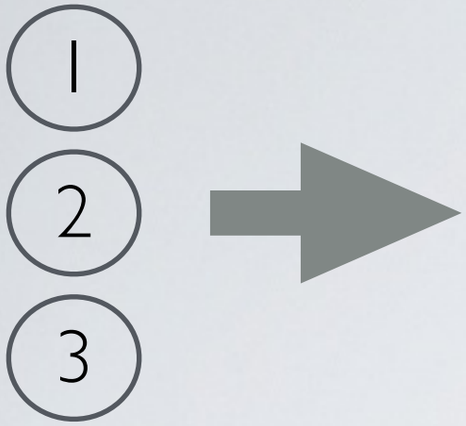
Account	Name	Amount	Date
available	operation	+75.00 €	2/10/2017 - 3:28 PM

2 Initial Bitcoin purchase (trading)

bought	0.05423052 btc	for	921.99 €	average	filled	2/10/2017

3 "Trading"

sold	0.07130000 btc	for	1,059.00 €	average	filled	2/22/2017
bought	0.07136414 btc	for	1,008.91 €	average	filled	2/18/2017
sold	0.07400000 btc	for	980.17 €	average	filled	2/18/2017
bought	0.05076142 btc	for	985.00 €	average	filled	2/17/2017
sold	0.02600000 btc	for	975.01 €	average	filled	2/16/2017



Offchain

- How it works (probably)
  - The exchange company owns a stock of Bitcoin
  - It maintains a list of customer accounts, and how much each customer owns at time t
  - When customer c1 buys BTC to a customer c2, change in the internal database of the company (scripture)
    - Goal: no transaction fees, easier to manage
  - The company itself certainly buys and sell on the market to ensure liquidity
    - Success=more customers who want to buy=>need to provide fresh coins
    - Need of buying/selling on the blockchain
  - The company needs enough reserve since customers can order bitcoin transactions from their (*virtual*) account to a *real bitcoin wallet*

bought 0.05417748 btc for 1,974.99 € average filled 5/28/2017

9:23GMT+1

	timestamp	sender	receiver	value	date	value_btc
619503540	1495929670	-192947146	Paymium.com	4276511	2017-05-28 00:01:10	0.042765
619622208	1495940615	35172026	Paymium.com	21408870	2017-05-28 03:03:35	0.214089
619627952	1495940615	36676998	Paymium.com	1278580	2017-05-28 03:03:35	0.012786
619641058	1495941084	320110	Paymium.com	2889754	2017-05-28 03:11:24	0.028898
619678470	1495946218	234	Paymium.com	50000000	2017-05-28 04:36:58	0.500000
619720731	1495953357	21	Paymium.com	500000000	2017-05-28 06:35:57	5.000000
619724954	1495954071	Poloniex.com	Paymium.com	90000000	2017-05-28 06:47:51	0.900000
619734802	1495953492	15195288	Paymium.com	563100	2017-05-28 06:38:12	0.005631
619742071	1495956403	32328334	Paymium.com	300000000	2017-05-28 07:26:43	3.000000
619769598	1495956760	Bitstamp.net	Paymium.com	500000000	2017-05-28 07:32:40	5.000000
619773769	1495962103	Poloniex.com	Paymium.com	5990000	2017-05-28 09:01:43	0.059900
619823537	1495968880	Poloniex.com	Paymium.com	299990000	2017-05-28 10:54:40	2.999900
619834805	1495969178	-193097249	Paymium.com	5000000	2017-05-28 10:59:38	0.050000
619836324	1495969665	-193098289	Paymium.com	501097	2017-05-28 11:07:45	0.005011
619859643	1495972870	Bittrex.com	Paymium.com	99900000	2017-05-28 12:01:10	0.999000
619870536	1495971407	-193116479	Paymium.com	4113900	2017-05-28 11:36:47	0.041139
619874781	1495972455	5224442	Paymium.com	1373550	2017-05-28 11:54:15	0.013735
619877924	1495973819	-193121122	Paymium.com	365283	2017-05-28 12:16:50	0.003653
619880471	1495972455	-193122823	Paymium.com	59539	2017-05-28 11:54:15	0.000595
619880482	1495972455	-193122827	Paymium.com	58606	2017-05-28 11:54:15	0.000586
619882043	1495973387	Paymium.com	16096	620000	2017-05-28 12:09:47	0.006200
619882044	1495973387	Paymium.com	222	6800000	2017-05-28 12:09:47	0.068000

… (153 total)

Paymium on-chain activity on 2017-05-28

Hard to say what it corresponds too… But my exact transaction is not there

4 Sending 0.005 btc from Paymium exchange to my personal wallet

paymium

transferred	0.00500000 btc	processed	2/10/2017

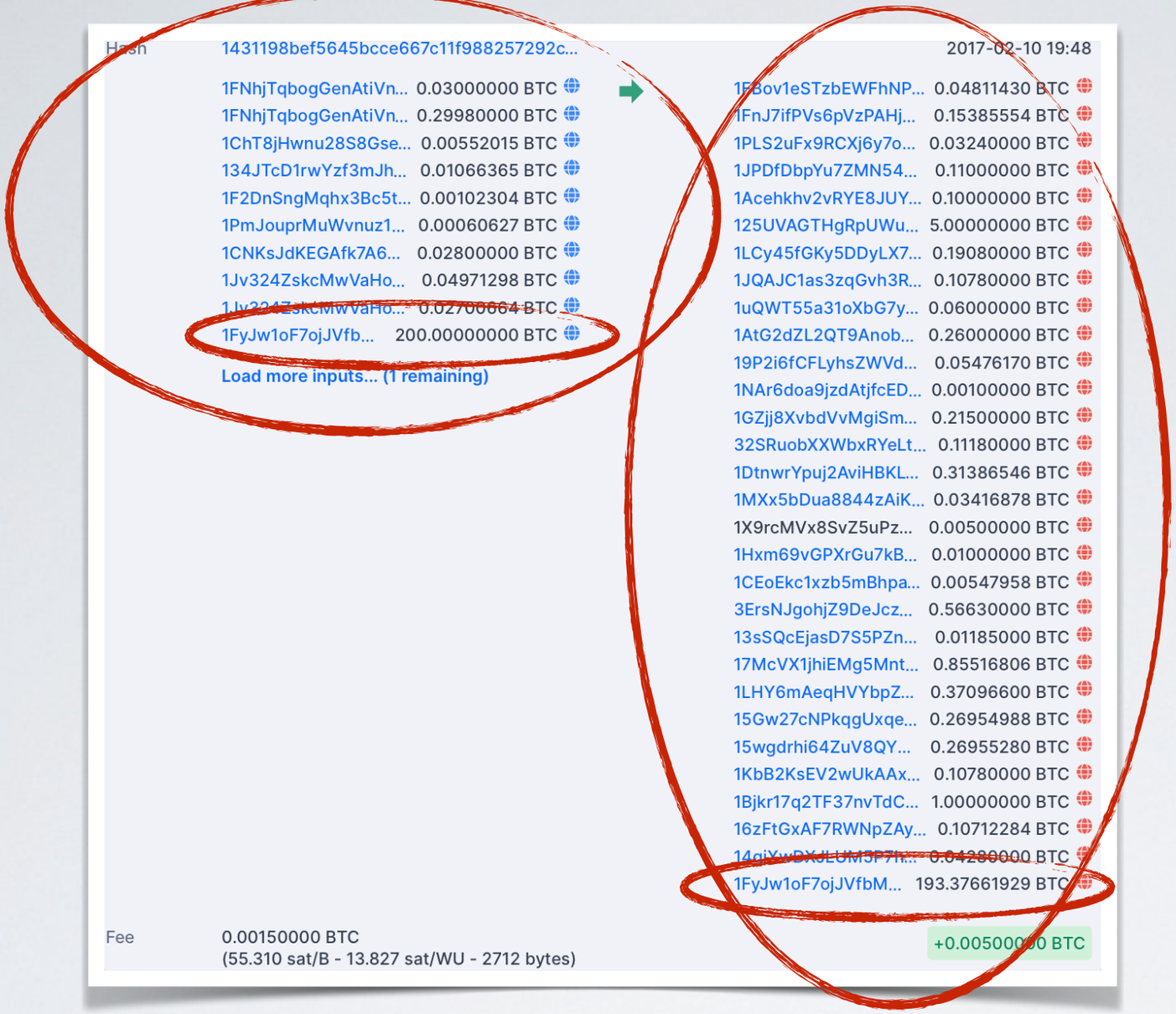
Hash 1431198bef5645bcce667c11f988257292c... 2017-02-10 19:48

Inputs		Outputs	
1FNhjTqbogGenAtiVn...	0.03000000 BTC	1FBov1eSTzbEWFhNP...	0.04811430 BTC
1FNhjTqbogGenAtiVn...	0.29980000 BTC	1FnJ7ifPVs6pVzPAHj...	0.15385554 BTC
1ChT8jHwnu28S8Gse...	0.00552015 BTC	1PLS2uFx9RCXj6y7o...	0.03240000 BTC
134JTcD1rwYzf3mJh...	0.01066365 BTC	1JPDfDbpYu7ZMN54...	0.11000000 BTC
1F2DnSngMqhx3Bc5t...	0.00102304 BTC	1Acehkhv2vRYE8JUY...	0.10000000 BTC
1PmJouprMuWvnuz1...	0.00060627 BTC	125UVAGTHgRpUWu...	5.00000000 BTC
1CNKsJdKEGAfk7A6...	0.02800000 BTC	1LCy45fGKy5DDyLX7...	0.19080000 BTC
1Jv324ZskcMwVaHo...	0.04971298 BTC	1JQAJC1as3zqGvh3R...	0.10780000 BTC
1Jv324ZskcMwVaHo...	0.02700664 BTC	1uQWT55a31oXbG7y...	0.06000000 BTC
1FyJw1oF7ojJVfb...	200.00000000 BTC	1AtG2dZL2QT9Anob...	0.26000000 BTC
Load more inputs... (1 remaining)		19P2i6fCFLyhsZWVd...	0.05476170 BTC
		1NAr6doa9jzdAtjfcED...	0.00100000 BTC
		1GZjj8XvbdVvMgiSm...	0.21500000 BTC
		32SRuobXXWbxRYeLt...	0.11180000 BTC
		1DtnwrYpuj2AviHBKL...	0.31386546 BTC
		1MXx5bDua8844zAiK...	0.03416878 BTC
		1X9rcMVx8SvZ5uPz...	0.00500000 BTC
		1Hxm69vGPXrGu7kB...	0.01000000 BTC
		1CEoEkc1xzb5mBhpa...	0.00547958 BTC
		3ErsNJgohjZ9DeJcz...	0.56630000 BTC
		13sSQcEjasD7S5PZn...	0.01185000 BTC
		17McVX1jhiEMg5Mnt...	0.85516806 BTC
		1LHY6mAeqHVYbpZ...	0.37096600 BTC
		15Gw27cNPkqgUxqe...	0.26954988 BTC
		15wgdrhi64ZuV8QY...	0.26955280 BTC
		1KbB2KsEV2wUkAAx...	0.10780000 BTC
		1Bjkr17q2TF37nvTdC...	1.00000000 BTC
		16zFtGxAF7RWNpZAy...	0.10712284 BTC
		14qiXwDXJLUM5P7h...	0.04280000 BTC
		1FyJw1oF7ojJVfbM...	193.37661929 BTC

Fee 0.00150000 BTC
(55.310 sat/B - 13.827 sat/WU - 2712 bytes)

+0.00500000 BTC

4



The exchange do not write on-chain transaction for each custom activity, but instead factorize them.
It reduces individual transaction fees.
Same for inputs.
Note the <u>change address</u> with a large amount

5

Sending back **0.001** from Wallet to Paymium Exchange

Address I received payment to

Address provided by Paymium

Hash	40a08e1ff76d8133c151705f816bec87c75a8d7dd0957b4bd1ecd...				2017-02-11 07:56
	1X9rcMVx8SvZ5uPzpjaaPn6psXkw5LZhB	0.00500000 BTC	→	1NdhZ1TBi1dE8uk1qzUqYR2x7dRi52j5wr	0.00100000 BTC
				1ArvJf54cVwJ2Y6gH6nic63ofQeiN32jbf	0.00380700 BTC
Fee	0.00019300 BTC (85.778 sat/B - 21.444 sat/WU - 225 bytes)				0.00480700 BTC

High fees:
20% of the amount sent

Change
(My address in my wallet)

What happens with coins sent at this address?

Hash	40a08e1ff56d8133c151705f816bec87c75a8d7dd0957b4bd1ecd...			2017-02-11 07:56
	1X9rcMVx8SvZ5uPzpjaaPn6psXkw5LZhB	0.00500000 BTC	1NdhZ1TBi1dE8uk1qzUqYR2x7dRi52j5wr	0.00100000 BTC
			1ArvJf54cVwJ2Y6gH6nic63ofQeiN32jbf	0.00380700 BTC
Fee	0.00019300 BTC (85.778 sat/B - 21.444 sat/WU - 225 bytes)			0.00480700 BTC

Hash	59c821350e1291c55ae8e0286b05e3627...			2017-02-11 14:09
	1HsSSUvaMuL3VUw...	0.72080588 BTC	1544JSQRTLCkfhJ1E...	0.05040000 BTC
	1NdhZ1TBi1dE8uk1qz...	0.00100000 BTC	1HzGDkZN7fe4rAmW...	0.04910000 BTC
	1KM3b551HzSQ4MQ...	0.00951400 BTC	128DsHfMjaeCDunze...	0.44900000 BTC
	1HUxJ5kTqLNhuMZy...	0.45732080 BTC	1NCe8eAhHzyZPneYh...	0.11000000 BTC
	1BoBVfPfk3BxaN1M1...	0.03900991 BTC	1CjcXagRZviJwWSH...	0.06900000 BTC
	1MgQhKRk4QqMTgeY...	0.01447889 BTC	1A4wdSpiToSc3rw1G...	2.30000000 BTC
	1FyJw1oF7ojJVfbM...	193.18850960 BTC	19DBZUM62sYv66up...	0.05344623 BTC
			1PKmMMR7S26Usjrkj...	0.34257068 BTC
			17puCgUUALRV222V...	2.09300000 BTC
			1HoEKSQfmCebgcKo...	0.04000000 BTC
			Load more outputs... (19 remaining)	
Fee	0.00150000 BTC (72.886 sat/B - 18.222 sat/WU - 2058 bytes)			-0.00100000 BTC

"My" coins have been spent the same day, and not by me!
=>1Ndh… Is not "my" address, it's paymium's address.
It's just that when coins are sent to this address, Paymium *credit* my customer account of the same amount.

6

Using my wallet coins to buy some real things (Amazon gift card)

Hash	40a08e1ff56d8133c151705f816bec87c75a8d7dd0957b4bd1ecd...			2017-02-11 07:56
	1X9rcMVx8SvZ5uPzpjaaPn6psXkw5LZhB	0.00500000 BTC	1NdhZ1TBi1dE8uk1qzUqYR2x7dRi52j5wr	0.00100000 BTC
			1ArvJf54cVwJ2Y6gH6nic63ofQeiN32jbf	0.00380700 BTC
Fee	0.00019300 BTC (85.778 sat/B - 21.444 sat/WU - 225 bytes)			0.00480700 BTC

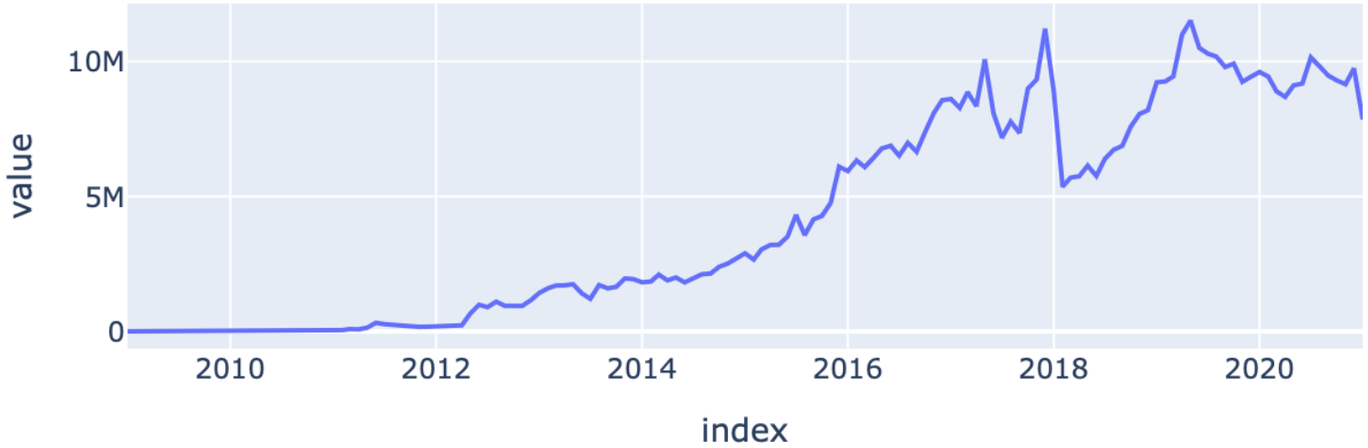
Hash	1650dd5cd9233705193aa83e42d8460d...			2021-01-27 23:16
	1ArvJf54cVwJ2Y6gH...	0.00380700 BTC	bc1qcp8uuxkx48ylrg...	0.00060200 BTC
			3JnJU19y21FgySKoX...	0.00300300 BTC
Fee	0.00020200 BTC (91.403 sat/B - 22.851 sat/WU - 221 bytes)			-0.00380700 BTC

Company selling gift card

Hash	7578596ecc510bb93d662d97d8bf6c8b7...			2021-01-28 05:08
	3PXW8ghgJuC4J5y1...	0.00438600 BTC	bc1qj4zp28m9r3elw5...	7.00529441 BTC
	3Q2xe5JyvuL5mvxn...	0.01404900 BTC		
	38LwzsRkxqXe3jfSD...	0.00806700 BTC		
	3C8i2YX1EWurpK9qt...	0.00318400 BTC		
	34Z85bRMu4jE5mRm...	0.00212500 BTC		
	35zcYgpERQo9SUUo...	0.01549100 BTC		
	3GZ2PMcvphAiYdA2...	0.00325000 BTC		
	349AFe7DdK4bfJZ7R...	0.00212600 BTC		
	3N3W124kvbjPQ89u...	0.02365300 BTC		
	32dkoFUb5bh9ECPG...	0.00314300 BTC		
	Load more inputs... (776 remaining)			
Fee	0.00163316 BTC (1.211 sat/B - 0.571 sat/WU - 134825 bytes)			-0.00300300 BTC

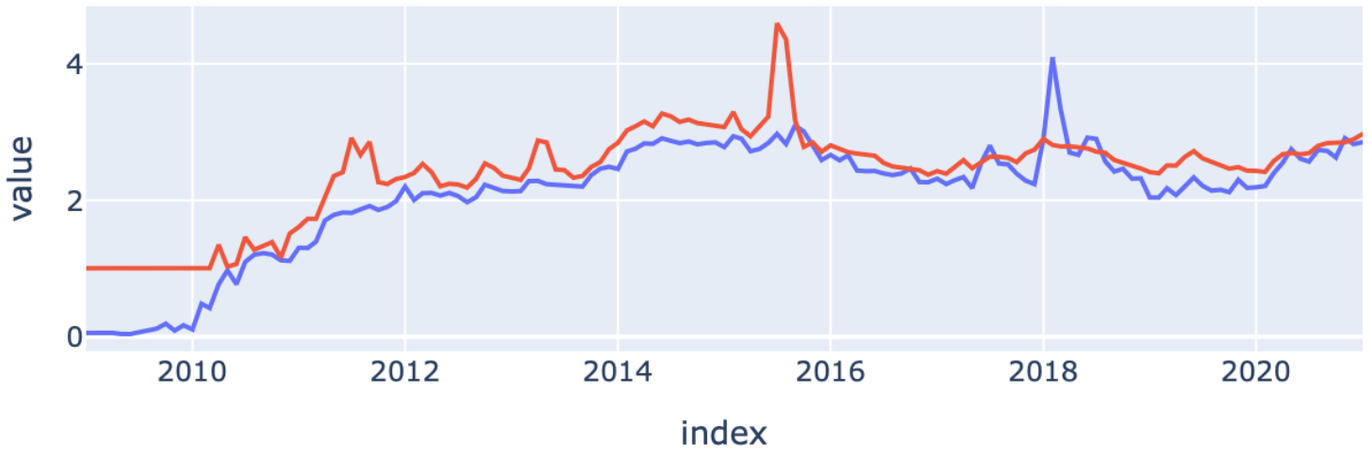
ACTIVITY DESCRIPTION

http://bitunam.sci-web.net



Number of transactions

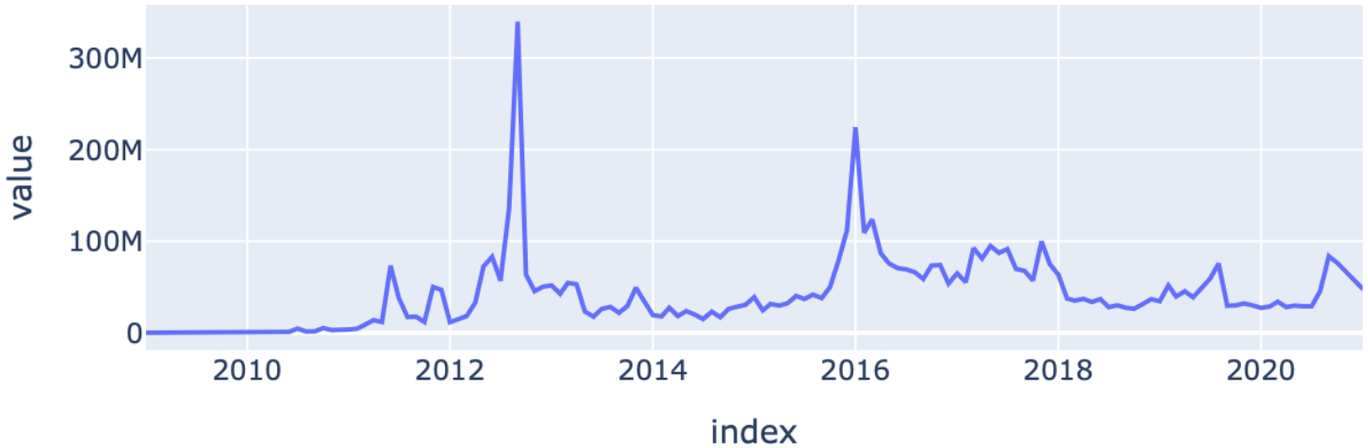
A first property we can look at is the evolution of the number of Bitcoin transactions present in the Blockchain by month. The total number of transactions at the end of the dataset is 609,437,067.



Inputs/Outputs

Bitcoin transactions have between zero (mining) to several inputs and 1 or several outputs (more on that later). This is the evolution of th average number of inputs and outputs by transaction.

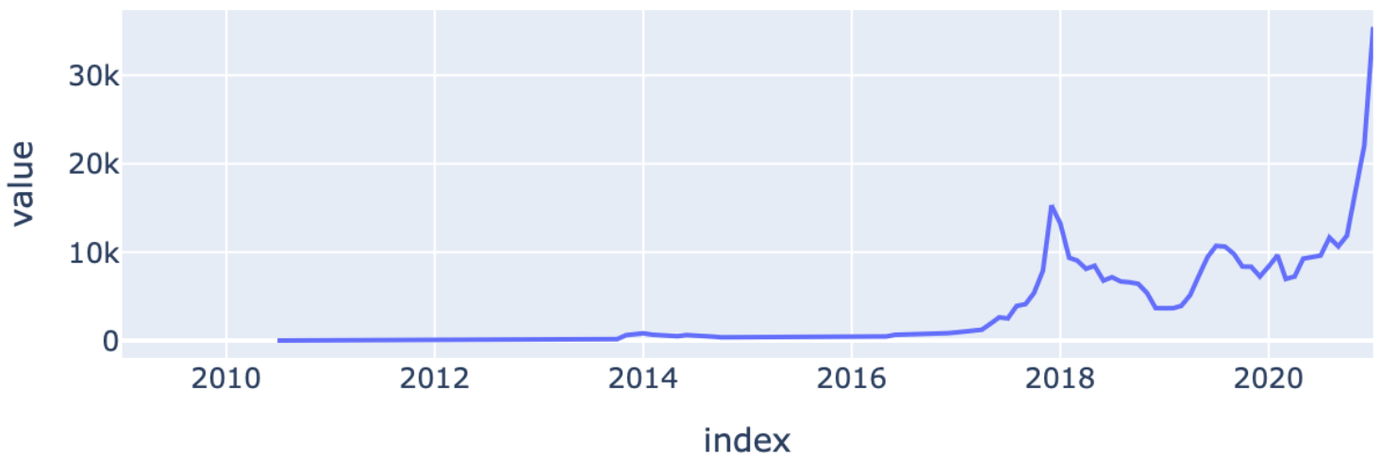
Red=output



BTC sent by month

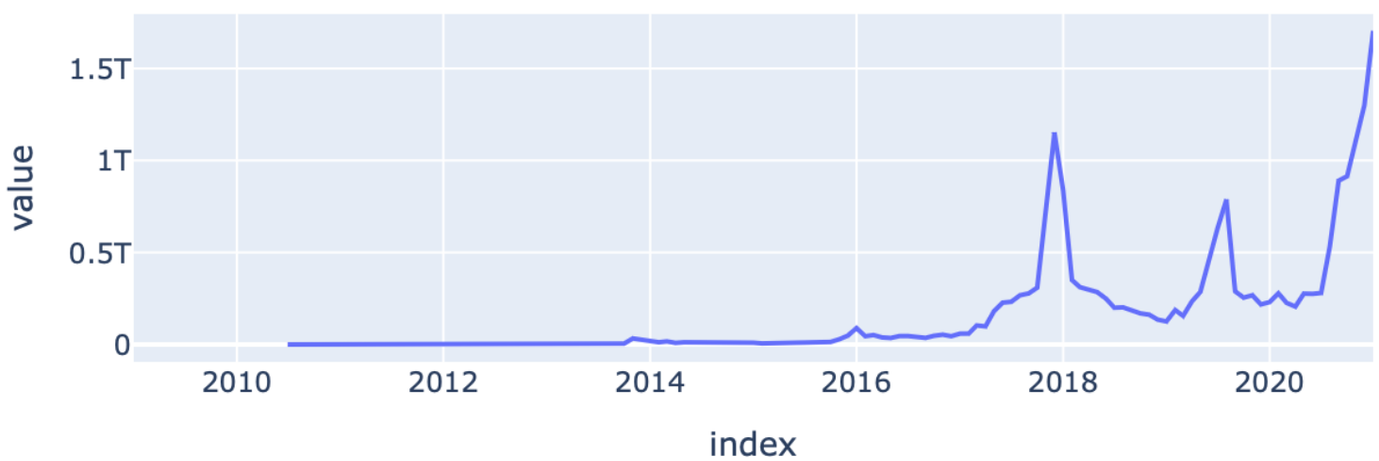
Let's now observe the evolution of the total of bitcoin sent by month (sum of the values in output).

Bitcoin Exchange rate



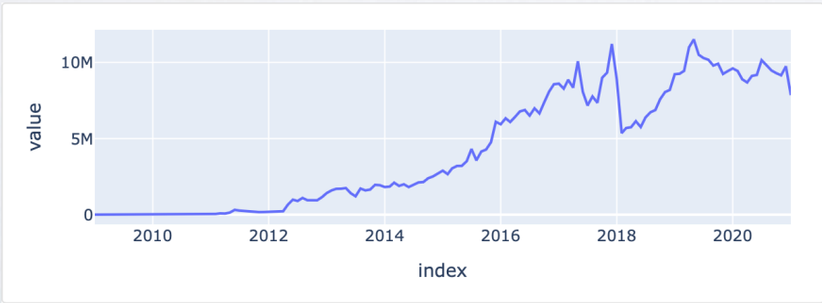
Bitcoin Price

The value in Dollars of the Bitcoin varies greatly along time. Here is the average Bitcoin value for each month. We can clearly observe some bubbles. It is often interesting to observe correlations between those prices and other properties.



USD sent by month

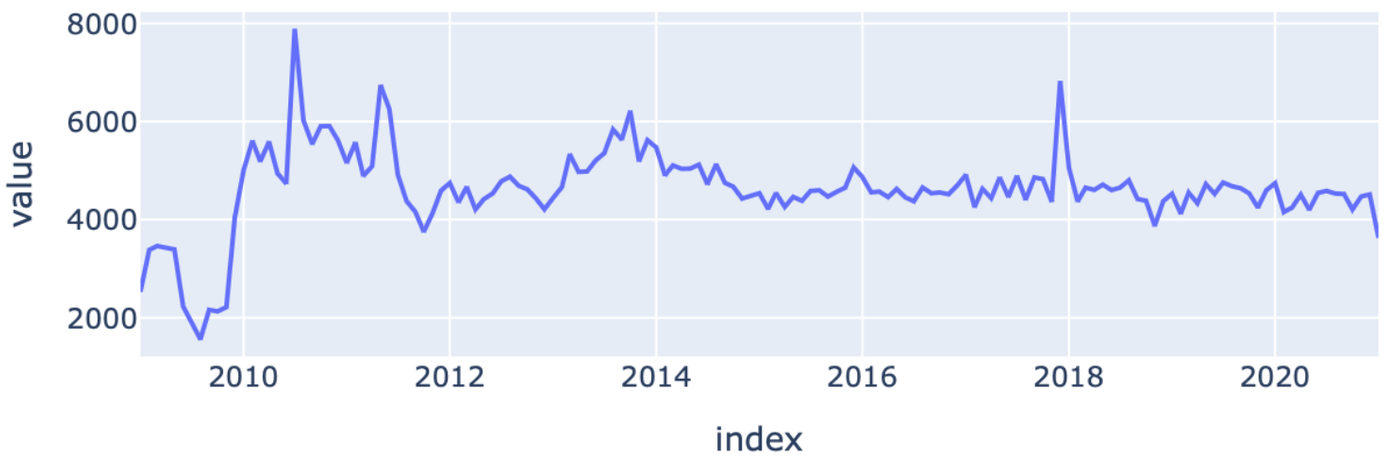
The price of Bitcoin varies greatly along time. To get a better sense of how much value is exchanged, we can plot the total value exchanged in USD, at the time of the transaction. We can observe that it is much more correlated to the change in bitcoin prices rather than change in bitcoin exchanged.



Number of transactions

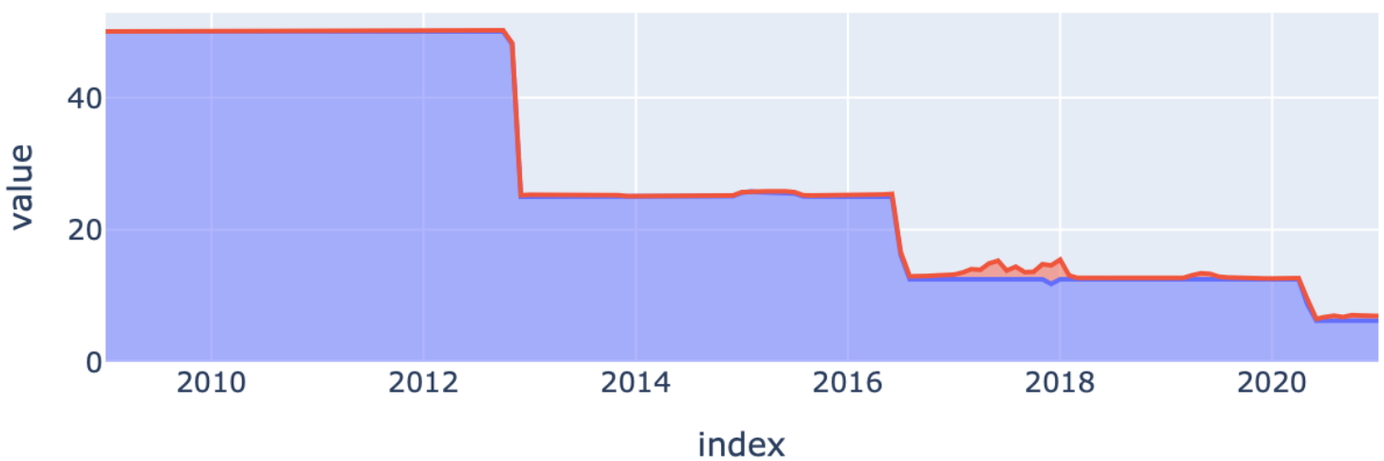
A first property we can look at is the evolution of the number of Bitcoin transactions present in the Blockchain by month. The total number of transactions at the end of the dataset is 609,437,067.

Mining



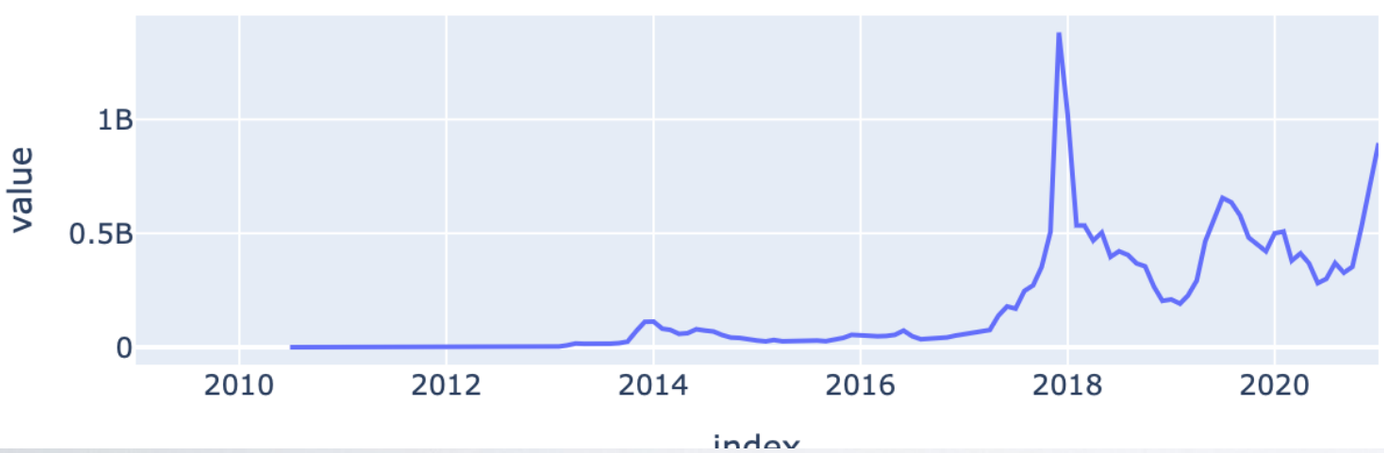
Number of Mining

The number of mining transactions. It stays mostly constant along time because the mining task is controled automatically by the Bitcoin protocol. Since each successful *mining* operation appends a *block* to the block-chain, i.e., validates a set of transaction request, the objective is to have such validations every about 10 minutes.



Individual mining reward: BTC

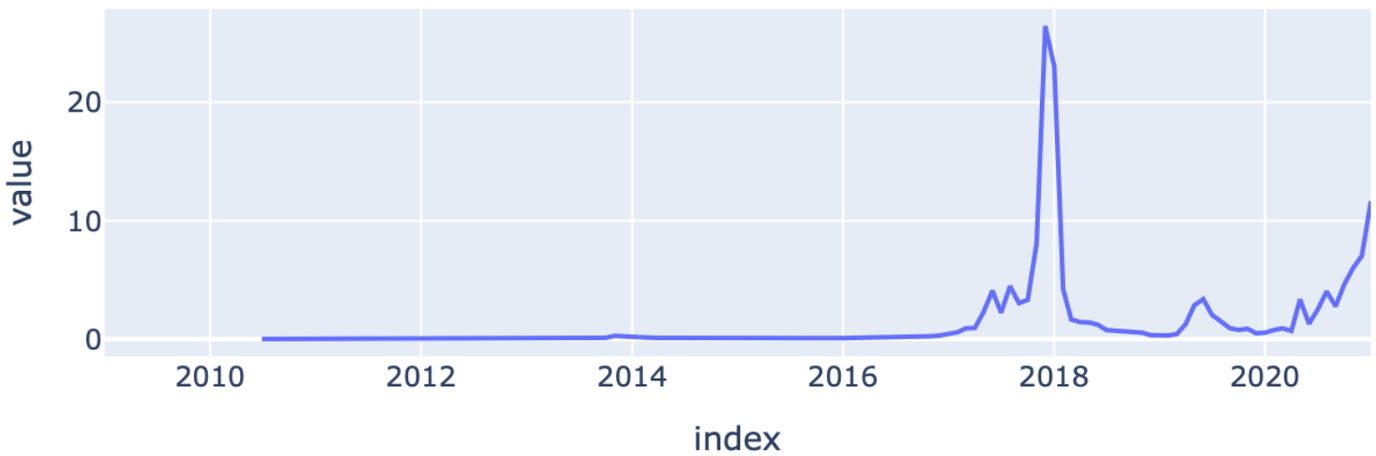
When a miner *mines* a block, it receives a reward, which is composed of 1) Newly minted coins (blue), and 2) Fees paid by customer who send bitcoins(red). The reward is controled by the Bitcoin protocol and we can clearly see effect of successive halvings, programed to progressively reduce the amount of newly created bitcoins. Fees are regulated as a **market**, not by the Bitcoin Protocol: if more customers want to make transactions, fees tend to increase, since each block can only contains a fixed amount of transactions. In 2021, the reward is fixed at 6.25btc, but we observe an average mining gain of 7btc, i.e., fees become increasingly important in the mining economy.



Total mining reward: USD

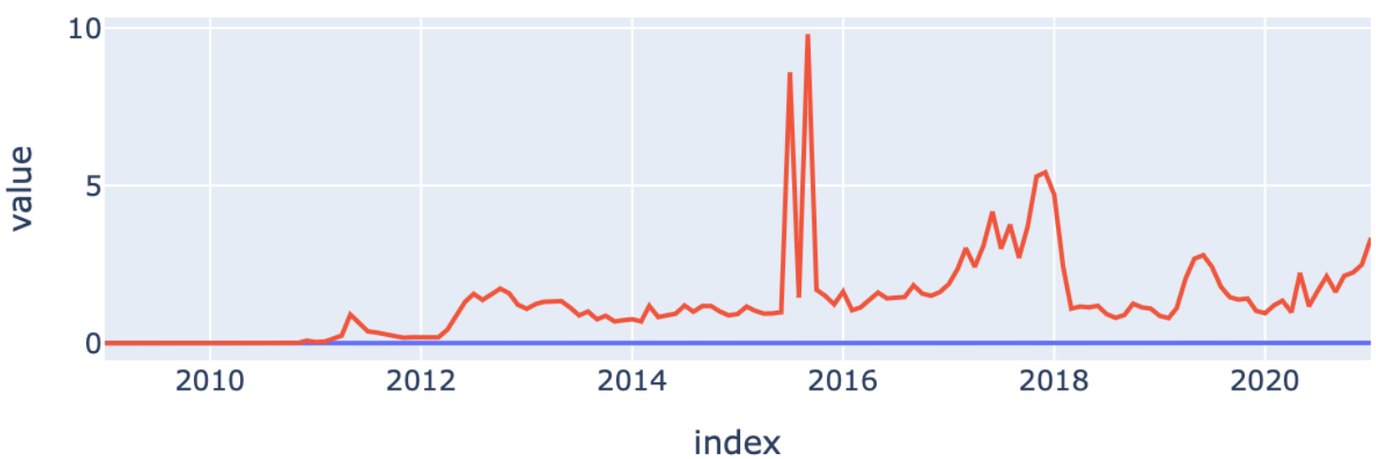
A well-know problem of Bitcoin is its huge waste of electric power, often compared with medium-sized country. This electic power is the consequence of miners competing with ever-more powerful hardware to have chances to win mining rewards. Again, this is a market: If all miners combined receive 1 Billion USD over this month, then the sum of what they collectively spend in electricity+hardware investment has to be around 50%/90% of this value, to remain profitable. If Bitcoin price were to remain stable, Bitcoin energy waste would naturally decrease until the

Fees



Fees by transaction - USD

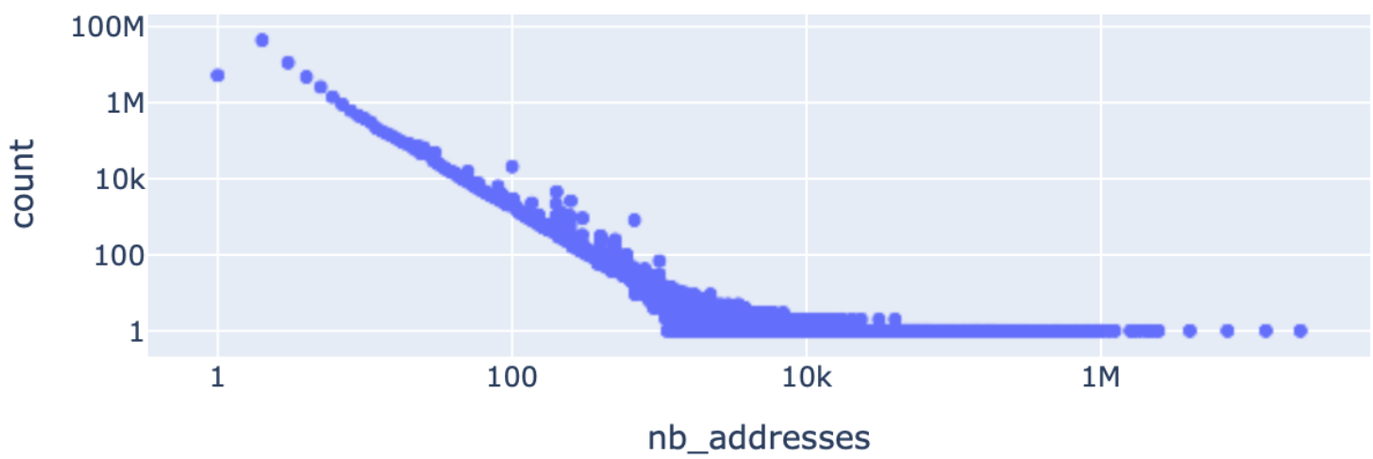
Each transaction must pay transaction fees to miners. The everage transaction fee en dollars varies greatly over time. Beware, this value might be misleading, since fees vary according to some transaction properties (its weight in bits, which depends on various factors).



% of transactions paid as fee

Another way to understand fee is to compute the average % of transactions paid as fee. For comparison, the average credit card fee is 2% of each transaction (hidden to you). We compute two variants of the percentage of each transaction value that is paid as fee: 1) Red: the average of the fee fraction per transaction, 2)Blue: The fraction of all amounts spent sent as fees for each month. Fees are mostly independent from values sent, so low amount transactions pay expensive fees (about 2%), while large transactions pay negligeable fees (less tahn 0.01%).

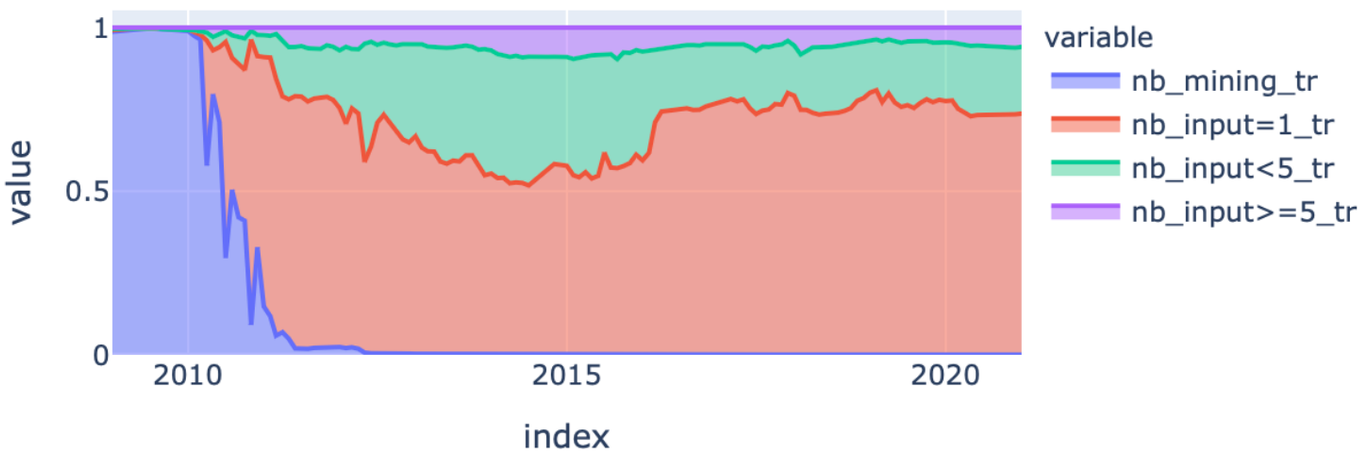
Actors

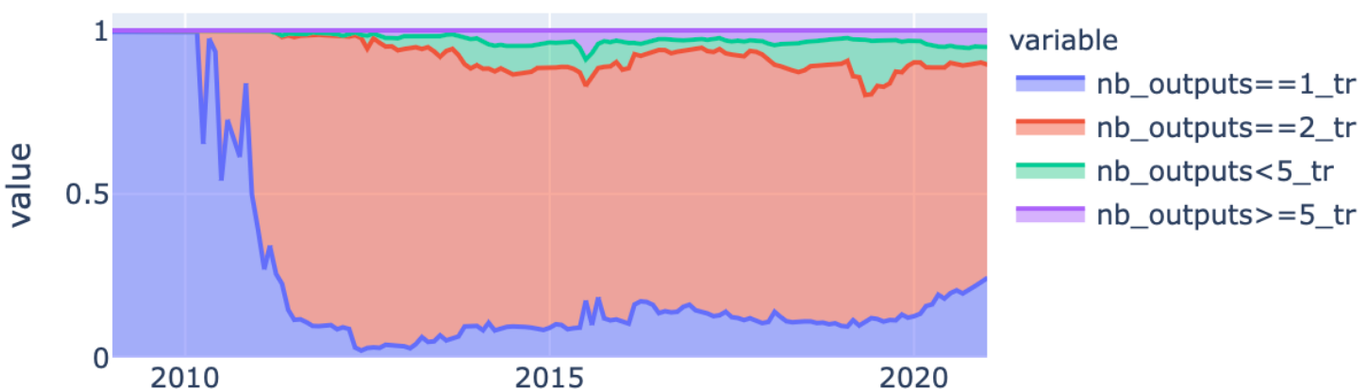


Addresses by actors

The distribution of the number of adresses by actors follows a line on a log-log plot, which is typical of a *power law* distribution: There is no "typical scale": Most actors (tens of millions) have less than 3 adresses, while a few actors have tens of millions of adresses. Note that the number of adresses by must be understood as a bottom-line: we know that an identify actors has at least those adresses, but they could have much more thatn we could not identify.

Transactions inputs/ouputs





Distribution of input addresses

We observe that most transactions have a single address in input. It means that these transactions do not allow to create clusters of Addresses Note however that those singleton addresses might be reused, and thus might be re-identified somewhere. It is for instance common for companies to use a "peeling" strategy, i.e., make many successive paiments from one address, sending the change to the same address.

Distribution of output addresses

As expected, most transactions have 2 output addresses, probably corresponding to the payment and the "change address". This information confirms the importance of change address identification for tracking bitcoin users.