***Abstract—***
***Index Terms—***

# Analyzing the Ethereum Blockchain

Christin Sauerbier
*Humboldt University Berlin*
Berlin, Germany
christin.sauerbier@outlook.com

Roman Proskalovich
*Humboldt University Berlin*
Berlin, Germany
romanarion@gmail.com

Thomas Siskos
*Humboldt University Berlin*
Berlin, Germany
thomas.siskos@hu-berlin.de

## I. Introduction

With the Introduction of Bitcoin in 2008, a signifikant new currency was brought into life. It is based on a peer to peer network which gives the opportunity to cancel out intermediaries within money transfers, through a decentralized verification process. With that knowledge the ideas was born to use such a technology to run decentralized application on such a Platform. Ethereum can provide that and is now the second largest cryptocurrency after Bitcoin in terms of market capitalization. []

This paper is supposed to do an explorative study on the Ethereum blockchain. The idea is to replicate what Lischke and Fabian did and transfer it to another crypto technology the Ethereum Blockchain. They used the address spaces and transaction history of the Bitcoin and added off-set network data to get more insights about the bitcoin economy. The period analysed included the first four years of the bitcoin existence. They were able to combine off-set network data and transaction data to get good statements about the business categories the currency is used for.

This paper is structured as follows. The first part is dedicated to the basics of Ethereum and how it got evolved from the bitcoin currency, or moreover the technology behind it. As we replicate a paper about the bitcoin blockchain [Fabian, 2016] we also compare the Ethereum blockchain with the bitcoin blockchain.

After that the reader got a proper foundation that we can dive into the underling methodology in section 3. (Here the focus is mainly on graph analysis with a discrete part of descriptive statistics.) So that we can continue to describe the process of getting access to the data, structure them and the main part to analyze them with descriptive statistics and graph analysis. This we discus in section 4 and the last part. Section 5 concludes the article and discusses the outlook we received during our analysis. We also want to use this part to discuss what are the main differences to the former paper about the bitcoin blockchain and give an idea about future work.

## II. Literature Review

## III. Ethereum Theory

Before diving into Ethereum one has to give a short introduction about the main invention of cryptocurrencies, Bitcoin and the blockchain technology behind it. This ideas drove Vitalik Buthin when he tried to design another cryptocurrency to take the bitcoin technology to the next level with giving developers to opportunity to write their own programs on the blockchain technology. This created the opportunity to use the blockchain technology and combine it with several business cases, not just as a currency.
The Bitcoin is a decentralized cryptocurrency which was invented by Satoshi Nakamoto, it combines three technologies with each other, Cryptography, Proof of Work and decentralized Networks. The idea was to create a currency which is independent from other institutions, who does control the network as an intermediary. When using cryptocurrency, the network is decentralized, and an intermediary gets obsolete. The network takes over the function of an intermediary, as everyone keeps a transaction history, and this gets verified against each other, every time someone makes a new entry. Resulting a technology that is hard to manipulate, or that someone would take over control or shut the entire network down. (?, ?)

They could realize such a network with three already existing technologies which got combined the first time by Satoshi Nakamoto, for the Bitcoin. It describes the whole process how the Bitcoin blockchain gets assembled, validated and agreed for a transaction. The blockchain can be assumed as a database that is stored on several computers, in the same version. (?, ?)
The blockchain component can be described as a series of blocks that are combined ordered or chained with each other. Everyone stores a variety of information with a hash function. Were the information in every hash is related to the former one, plus the verification that the transaction is proofed. So far, most crypto technology's work with the so-called proof-of-work. (?, ?)
Main idea is to find a consent in the network witch transactions or blocks are getting approved trough the network. The work part in proof of work relates to the puzzle the community has to solve to verify a transaction and if enough transactions get combined, they can get collected to a block.

(maybe more information about the nonce and the regarding puzzle) Resulting every transaction can only be verified, if they are part of a newly created block. The person in the network who is creating the new block is called miner and gets compensated with a value for mining. The exact compensation depends on the crypto technology. In Bitcoin if they verify for the Bitcoin network and in gas if one if mining for the

Fig. 1: Blockchaintechnology is the basis for Ethereum

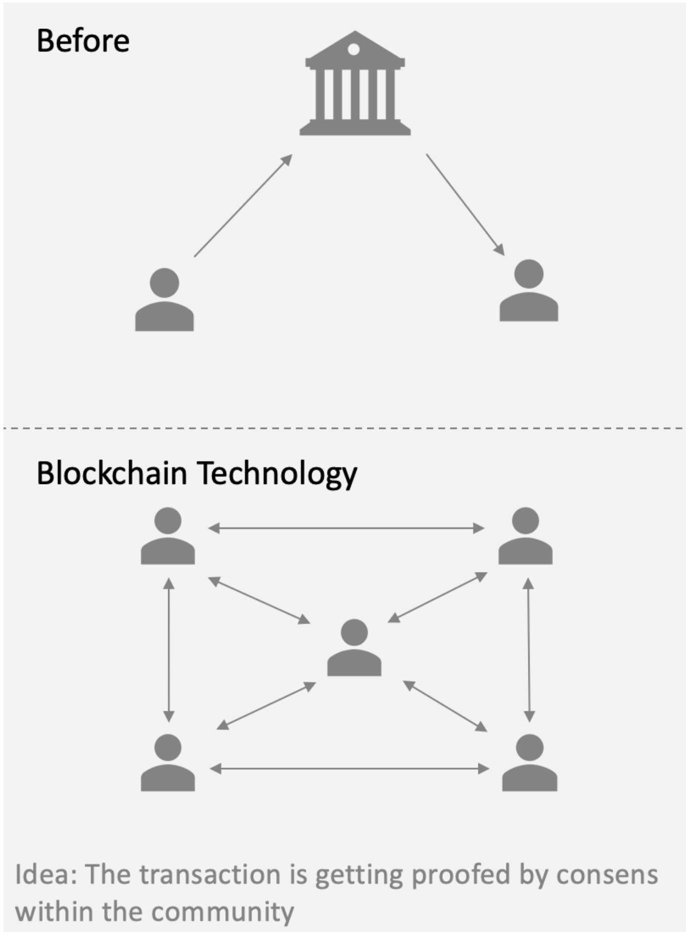
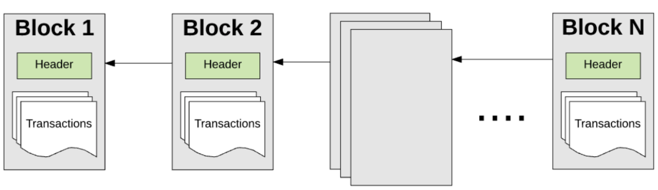



Fig. 2: How Blocks get chained




Ethereum Blockchain. Throughout the hash every transaction gets collected and approved in a block and lines up to a chain, so that it gets really hard to manipulate a transaction in a simple manner. Here one can lead over to the next important component of the bitcoin technology, the peer to peer networks.

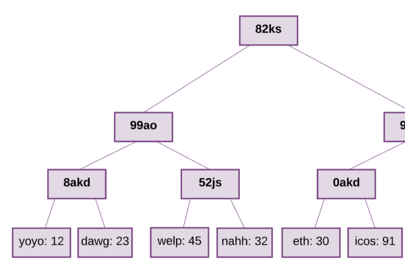
Transferred it means, that there is a network which is connected to each other without any other intermediary in between. There is a direct connection between the participants within the network. It also is decentralized, such that nobody can manipulate anything.

When the creator of Ethereum thought about this idea and technology, the main question was, what else can be decentralized to cancel trusted intermediaries out and go beyond currencies. This let Vitalik Buterin in his white paper in late 2013, to describe a platform which can run decentralized applications and therefore run economic systems in pure software. The Vision of Ethereum “is to create an unstoppable censorship-resistant self-sustaining decentralized world computer.” [Ray, 2018] The Ethereum can be explained best, if the dimensions get differentiated into the currency and the platform. The platform includes the Ethereum Virtual Machine, the smart contracts and the decentralized applications.

To add on to the former Bitcoin explanations, the Ethereum is also providing a virtual machine to realize smart contract code. Bevor diving into that topic it should be noted that the Ethereum platform is able to access and alter data to compute anything a turing complete machine could, it is also able to use conditional branches. The last requirement to fulfill the turing completeness is to have an arbitrary amount of memory. As not all requirements are met the Ethereum virtual machine (EVM) is only quasi-turin complete, because every transaction or computation is requiring a defined amount of gas, that is used to pay the system for mining the blocks. The programming language to write applications for the EVM is solidity, which gets compiled to the ‘EVM bytecode’. What is the EVM programming language. The advantage to work on the Ethereum virtual machine allows to make transitions from one state to the other. For example, transactions get executed and gathered into a new block, the new state gets stored and this new block describes the next state. Here Merkle Patricia trees are used to optimize the verification process of transactions on the EVM. [Bisade, 2018]

The mapping between account addresses and the equivalent state of the account has to get stored within the Ethereum platform. That the data don’t have to get sored in a giant block header the Merkle Tree structure is used to make the hole system scalable. In general, a Merkle is following the idea to have a big amount of data which are hashed together. They get split into smaller chunk buckets, this gets repeated until there is just a root hash left. (?, ?)

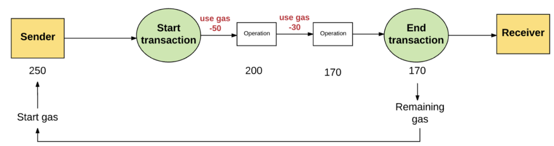
Fig. 3: Merkle Tree Struc




As answered before, this whole process is done to make it possible to perform Merkle proofs. They are much quicker and therefore better scalable. The proof consists of all the hashes going from the last one up to the root hash, if this get verified by other persons, at least for the verified branch. The idea is, that within the database the data are stored in a Merkle

tree and the main root is publicly known and proofed. If so, a person who wants to get the knowledge about data at a specific position this can be done within less time. Because just small amounts of data have to get searched. [Buterin, 2015] This capability to store information in Merkle trees is very useful to improve the scalability and it is called ‘light nodes’. So, in the blockchain system exists to types of nodes, full and light ones. Whereas the complete one does synchronize the hole chain and is also executing everyone. Even though a node does keep every transaction, it’s not necessary to store all the data. One would just get the header of every transaction done since the first block was mined. This system works, because the data are stored in merle trees and can get verified top down. In conclusion, the advantages of using such a tree is that the hashes in one tree are always dependent on the other hash buckets in the rest of the tree. Therefore, if someone wants to manipulate something, it’s hard to perform. As the root hash always keeps information about actual state, receipts and transactions done, nodes can validate little parts of the chain. [Kasireddz 2017]
After giving insights into the processing and storing process in the Ethereum World, the applications on the platform are another important topic. The Smart contract can be used to run code on the Ethereum Virtual machine in a decentralized way. It is comparable to real world contracts. A collection of conditions and actions, if a condition occurs, the associated actions are getting executed. In a result many real-world applications can be applied to smart contracts. The execution happens on the blockchain and is immutable ever after. One example often used, is a rent contracts in the real work. In the real work one would pay rent on defined date and get entrance to a place for the paid time. A contract represented on Ethereum would look the same, the contracts gets written in Solidity. Then the network executes the contract on the defined date and if the renter does pay as expected, means fulfill the condition he gets entrance to his place. If not, the contracts would simply not open the door anymore.
So, every component of a contract gets represented the enforcement, management and the payment component. [] Back to the example, the person who is renting the property would not get access to his door anymore, if the rent was paid a day later. Here the first problem with smart contracts occurs, the rules are really strict, without any room for exceptional circumstances. Ones, code is executed on the network it cannot get edited or corrected anymore. Everything gets executed as written in the code. If one does think about complex contracts this can be a problem. If something gets wrong or if there are paragraphs in it which are not covered by law, with a real contract the law in backing these contracts and one could take out paragraphs after a legal process. This is not the case in Ethereum, because to edit such a contract the entire network would have to get convicted, that something hast to get changed. What is almost not possible. []
Ethereum also provides a currency to run and incentivize the former described system. In Ethereum the currency is called Ether. To execute and deploy contracts on in the platform and

Fig. 4: Transactions




[h]

to fulfill the contracts a fee has to get payed. This will be done in Gas. The concept can be subdivided into gas price and gas. The gas-price represents the amount of Ether that one is willing to pay for every unit of gas. The subunit of Ether is Wei and is representing the smallest unit. The Gas serves as a fee that is required to execute something in the network. As shown in the figure, every operation spends the defined amount of gas. In case the gas is not enough to fulfill the transactions, the sender ‘runs out of gas’ and the End transaction does not get reached.

If someone wants to execute something in the network, one has to decide about the gas limit and gas price. This has an influence on the amount of computations that one transaction can do. It works as followed, the miner can collect transactions from the transaction Pool, after they took them the regarding code gets executed on the Virtual Machine and the Merkle proof gets created. The last step is to confirm the transaction with the proof of work algorithm. The reward depends on the selected amount of gas for the transaction. That also means, that some transaction might not get mined in case the fee is chosen to low. Another part the gas is used for, is the storing fee, the amount depends on the size of the storage used. [] On the one hand this was done, that people will write optimized and efficient code and won‘t waste the Ethereum network computing power on unnecessary tasks. [] On the other hand, to incentivize the mining process of transaction. This helps to verify the transaction and should be described a little more into detail. This process verifies the transaction and is carried out to secure against counterfeiting. It is also applying the proof-of-work and uses the Ethereum network, respectively the nodes and creates new blocks with validated transactions.
The technology also has downsides, one is definitively the scalability. Every node in the system is storing the full data and executing every transaction. To store the stat is a matter of security, also the high degree of decentralization. As more traffic get on the system and more applications get written the data that have to be stored and verified for in the chain, get more and more. Specially on the Ethereum platform were there are more then just currency transaction other than the bitcoin. To be comparable to common systems, the Ethereum blockchain has to be able to keep on to the security and decentralization but also work on the scalability. So far, the community is working on different alternatives, [Gadaleta 2018]

- sharding

- plasma chains

Vitalik Buterin describes Sharding, combined with Plasma as the most promising solution to make the platform more scalable. [Giese 2018] Here Sharding describes a partition of the main net in smaller shards. So far, the blockchain can support 15 transactions per second, with the new solution this could work for 100 transactions afterwards. Combined with the plasma solution this could scale up to a million transactions per second. The plasma solution represents a second-layer solution could bundle transactions and handle therefore more at ones. [Giese 2018] The main issue always is, that if one wants to higher the scalability, the verifications has to be reduced or less difficult. In this triangle one always reducing something, what means the points which have to be manipulated in the network are getting reduced. Next problem is the high computational power that is needed to verify or mine the transactions, here a lot of energy is needed that the system can work. So far, there is no solution for that. But with the change to the proof-of-stake this should change. Besides the scalability and the energy consumption Ethereum has to deal with the high volatility in the crypto market. One can imagine, that in case of Ethereum the volatility has an influence on the usage of the platform. As described before the currency, called Ether is meant to be the Gas (fee) to pay the system for executing applications. If the price went up and down and is opposed by speculation, the original purpose might not get used anymore. [Chandersekhar 2018] Chandersekhar looked into the data of Smart Contracts and found out, that 94

## IV. Ethereum and the Bitcoin

Bitcoin which was 2008 introduced, is the more mature platform, compared to Ethereum. We want to give a short overview about both technologies and compare them. As the original paper is analyzing and describing the Bitcoin world. On the one hand we want to give some insights in the most important technologies on the blockchain market and also might gather some information about possible problems with the outcome.

Let's start with the data, by now the Bitcoin blockchain has the size of 197 gigabytes in the beginning of January its growing constantly, since it was introduced. [https://www.statista.com/statistics/647523/worldwide-bitcoin-blockchain-size/] It takes on average 9,6 minutes to confirm a transaction at the end of February 2019. [https://www.statista.com/statistics/793539/bitcoin-transaction-confirmation-time/] The Bitcoin index value for the same period was 3.799,68 US Dollar. [https://www.statista.com/statistics/326707/bitcoin-price-index/], were the number of wallets grew over the last years constantly and reached 32 million wallet users at the end of 2018. [https://www.statista.com/statistics/647374/worldwide-blockchain-wallet-users/] The market capitalization had a peak in Quarter four 2017 and it has since decreased, to a value of 66,18 million US Dollar in the end of 2018. [https://www.statista.com/statistics/377382/bitcoin-market-capitalization/] Compared the Ethereum already grew to the size of 181.65 GB, this represents the full blockchain size of all blocks. The average mining time is less that the Bitcoin, with 13.5 s per block. [https://bitinfocharts.com/ethereum/] The number of wallets exceeded 50 million in the end of 2018. [https://cointelegraph.com/news/ethereum-unique-addresses-break-50-million-active-wallet-number-keeps-dropping]

Even if the wallets are increasing, the number of active addresses, referencing to BitInfoCharts, there are less active Ethereum addresses in 2018. The price of Ethereum is in the End of February 2019 amounted to 134,82 UD Dollar. [https://www.statista.com/statistics/806453/price-of-ethereum/] Comparable to the Bitcoin, the peak was in 2017 and has been decreasing since then. Similar to the peak in price to most active period was in the end of 2017, here more than 1.13 million addresses were registered. [https://cointelegraph.com/news/ethereum-unique-addresses-break-50-million-active-wallet-number-keeps-dropping] In the End of 2018 there were only 328.400 active addresses recorded.

The data can give some insights, but just in relation to the idea of both technologies they get more relevance. The most important difference is, that the idea behind the bitcoin was to create an independent currency. That is not easy to manipulate and does not need an intermediary to be trusted. The community should be the verification, that no one would manipulate the blockchain. The technology was described in the former chapter. In contrast the Ethereum was developed afterwards. The person who wrote the white paper, Vitalik Butin, wanted to create more than a currency. He got inspired by the technology behind the bitcoin and wanted to go beyond. That why he created a platform usable to write applications on, backed with the same technology. As described in the 'Ethereum Theory' chapter, along the way he also was able to improve some downsides about the bitcoin, introducing the merkle Patricia tree. Another advantage is that he made the platform able to work with a turin-complete language. In the End all that was necessary, as the Ethereum Blockchain has to deal with way more complexity when it wants to serve as a platform for applications.

## V. Methodology

### A. *Data Preparation*

### B. *Graph Analysis*

### C. *Descriptive Analytics*

## VI. Findings

### A. *Data Preparation*

### B. *Graph Analysis*

### C. *Descriptive Analytics*

## VII. Conclusion