Benefit analysis of blockchain technology on Hyperledger and Ethereum platform

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***Abstract*— : In this paper, we will analyze benefits of two popular private blockchain platforms, Ethereum and Hyperledger Fabric. Blockchain is decentralized transaction and data management technology and is said that its impact will be similar to the impact Internet had. Blockchain can be implemented in many industries, but the question is: is it needed, regarding scalability, business value and performance? The goal of this paper is to present analysis results regarding business value of both blockchain platform.**

I. Introduction

One of the current hot research topics, both in industry and academia, is blockchain. Blockchain is often identified with bitcoin, a public blockchain used for transferring money, although it represents a lot of broader image. The idea behind bitcoin was to send money quickly from one end of the world to another without commission and without the control of a central organization. This idea has resemblance to *digicash*, which was created by David Chaum in 1989 [1]. Digicash was based upon transactions where participants were anonymous and used cryptographic protocols, such as public and private keys to preserve anonymity. Unlike *digicash*, which broke down in 1998, bitcoin has a decentralized system, which excludes the need for a confirmation of a certain tranche and allows everyone to have a copy of the entire blockchain. Defined as a shared, distributed ledger, blockchain uses a set of nodes to maintain data structure, organized in blocks. Blockchain is not a new technology *per se*, it is a combination of three technologies which are being used for quite some time. Using peer-to-peer networking, asymmetric cryptography and cryptographic hashing, blockchain mimics a simple database that is decentralized and stored in the nodes of the network [2]. Motivation in this paper stands in perceiving main benefits and flaws of Ethereum and Hyperledger platform, as currently leading private blockchain platforms, as well as their applicability in various industry and academia fields. Benefits and flaws will be represented in terms of scalability, performances and security.

A. Keywords

In order to compare these private blockchain platforms, certain concepts and keywords must be comprehended:

1) Block

Blockchain represents a history of all transactions which have occurred. This history is organized in blocks, units of time that encompasses a certain number of transactions. When the unit of time elapses, the next block begins. This period of time is characteristic for every blockchain.

2) Smart contract

Smart contract are agreements between accounts, to render a transfer of ether when certain conditions are met. They are used in both Ethereum and Hyperledger network.

3) Proof-of-work

Proof-of-work (POW) is a consensus algorithm, which rewards participants who solve cryptographic puzzles to validate transactions and create new blocks. This algorithm is used in Ethereum and Blockchain network.

4) Partial Byzantine Fault Tolerance

Partial Byzantine Fault Tolerance (PBFT) is a consensus algorithm used in Hypeledger Fabric network. Using PBFT, transactions reach the validating peers at different times, so they don’t have the same order of transactions. The peers then “vote” for a validating leader, which choose the sequence. The other peers communicate with one another until they have the same sequence and a consensus [3].

5) Public blockchains

First one is differentiation of private and public blockchains. Public blockchains are open and anyone can participate in it. These blockchains, such as Bitcoin, allow any node to enter the system, or to leave it, making the system fully decentralized, resembling a peer-to-peer network. Ethereum blockchain can be public or private network. One of the drawbacks of a public blockchain is the substantial amount of computational power that is necessary to maintain a distributed ledger at a large scale. More specifically, to achieve consensus, each node in a network must solve a complex, resource-intensive cryptographic problem called a proof of work to ensure all are in sync. [4]

6) Private blockchains

Unlike public, private blockchains require an invitation to be able to participate in it. In private blockchains, such as Hyperledger, one can only enter the system if permitted, i.e. every node is authenticated by an access control system, making every node known to others. Ethereum as mentioned, can be public and private network. If someone, or some organization chooses to use Ethereum as private network, they need to fork Ethereum project, thus making their own Ethereum [2]. In this paper, we will use Ethereum as private network, to test its performance.

7) Permissioned blockchains

Another type of blockchain is permissioned blockchain, where in an enterprise software context, company sets up permissioned blockchain, where corporate stakeholders are given certain rights to read and write to this chain [2].

The remainder of this paper is organized as follows: Section II reviews related works regarding Ethereum and Hyperledger platform. Section III describes methods used in this analysis. Section IV presents results obtained in this analysis. Section V summarizes our testing and gives a scope for future work.

II. Related works

Vast number of industries have shown interest in blockchain technologies, including health departments, economics and even gambling [5] which are finding usage of blockchain technologies. Also, there is an ongoing process in Dubai for introducing blockchain into government thus reducing paperwork [6]. In paper [7], authors discuss architectural styles of blockchain that can be implemented in Internet-Of-Things (IOT) services. Another example of using blockchain in IOT industry is presented in [8] where authors use smart contracts, which are part of Ethereum network, to create Turing-complete code. Another example of blockchain technologies used in industry is presented in [9], where authors describe how this technology can be used in blockchain-based electricity trading system. An extensive research was conducted by authors [10], using their BLOCKBENCH, an open source tool for quantitative analysis for blockchain, which compares Ethereum, Parity and Hyperledger. As Ethereum and Hyperledger represent a novelty in industry and science, it remains a question whether its performance, in terms of scalability, speed and reliability, can justify expectations. Authors in [11] have come to conclusion that, in terms of the average execution time, average latency and average throughput, Hyperledger Fabric outperforms Ethereum across all scenarios.

III. Methods

In this section methodology that is used to evaluate the blockchain platforms is going to be described.

A. Infrastructure Setup

As mentioned, two blockchain platforms that are being analyzed and tested in this evaluation are Hyperledger Fabric and Ethereum. The infrastructure for testing is Azure Virtual Machine (F8 v2 instance) with the 2.7 GHz Intel Xeon® Platinum 8168 8 core CPU, 16GB RAM, 64GB SSD hard drive and running Ubuntu 16.04 [12]. One blockchain node is deployed for each platform with appropriate software, for Ethereum, Ethereum's geth 1.5.8 is used, and for Hyperledger, Hyperledger Fabric 0.6 is used. Consensus mechanism is turned off because only one node is deployed. There are four modules in the architecture for testing:

- blockchain platform,
- configuration module,
- workload dispatcher,
- performance counters.

Architecture is shown on Figure 1. The first and second module are set up before evaluation, and the last two modules run during tests. Workload dispatcher is used to send transactions to the blockchain and performance counters are used to collect results.

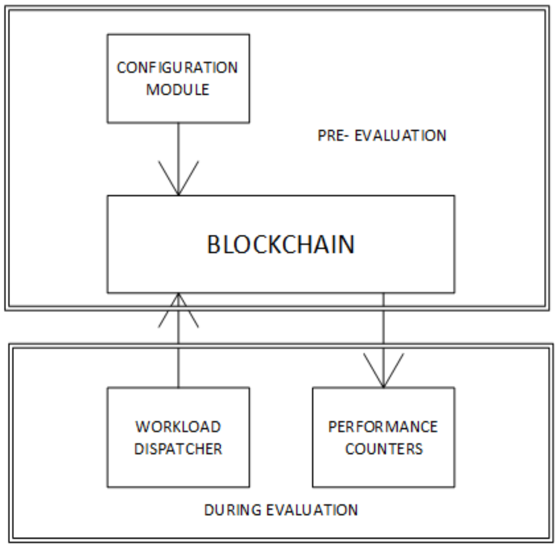

Figure 1. Architecture for testing

B. Test Application

For testing two blockchain platforms application was constructed to execute experiments as item transfer application. Application has 3 functions: user account can be created (function *CreateAccount*), item can be loaded to an account (*LoadItem* function), and item can be transferred from one account to another (function *TransferItem*). For each platform, implementations are done separately. To create account in Ethereum, passphrase is used, which is required to decrypt the private key. For Hyperledger Fabric, key-value pair is used. For loading items function, we add the item into an account by specifying account name as the key. Items are transferred between accounts by subtracting number of items from the source account and adding the same number of items to the target account. During configuration, all smart contracts are written and deployed separately for each platform to be ready for testing and evaluation.

C. Evaluation

Experiments are performed where a client sends N requests of transaction s to target platform in an asynchronous manner. The number of requests are 1, 100 and 1000 requests. The transaction s can be *CreateAccount*, *LoadItem* and *TransferItem*. The data used for functions (e.g. number of items to be transferred between accounts) is randomized and does not effect the final result. Final results are calculated as average of ten independent runs. The interactions between the client and the blockchain are done with HTTP requests. For Ethereum, all requests are implemented with Web3.js [12]. For Hyperledger Fabric, all requests are implemented with the RESTful API.

D. *Performance counters*

Within this subsection, data that is collected for the analysis and the evaluation metrics are explained.

1. *Transaction Time*: for evaluating performance, data is collected for each transaction:
   a. T1 - time when transaction is deployed on blockchain
   b. T2 - time when transaction was confirmed by the blockchain
2. *Evaluation*: The parameters that are measured for the evaluation are execution time and throughput.
   a. Execution time – For each set of transactions, execution time is the total amount of time (in seconds) blockchain took to execute and confirm all transactions in the set.
   b. Throughput – is measured as a number of successful transactions per second, starting from the first transaction. Average throughput is the average of the throughput for the execution time.

IV. Results

A. *Performance*

This section assesses the performance of blockchain platforms for average execution time and average throughput. It is observed that Hyperledger Fabric outperforms Ethereum on all scenarios.

Execution time grows as the number of transactions increases. In Figure 1 we compare the differences in execution time for two platforms for different number of transactions. Hyperledger Fabric has the execution time consistently lower than Ethereum for all scenarios. The gap in the execution time between two platforms also grows as the number of transactions grow. For large number of transactions, Ethereum has the execution time for *CreateAccount* (12.86) considerably lower than *LoadItem* (28.27) and *TransferItem* (28.26). *LoadItem* loads item to one account, while *TransferItem* subtracts number of items from one account and adds that same number of items to another account, which gives the amount of workload for *LoadItem* approximately half of the amount of workload for *TransferItem*. For 1000 transactions, *LoadItem* and *TransferItem* takes 2.65 and 3.88 seconds respectively for Hyperledger, and for Ethereum takes 28.27 and 28.26 seconds respectively. From the results, we can see large differences in data access and management for the two platforms. Tables I, II and II show execution time in seconds for Ethereum and Hyperledger Fabric with different number of transactions for *CreateAccount*, *LoadItem* and *TransferItem*.

Average throughput comparison is shown on Figure 2 where *TransferItem* function is analyzed for each platform in ten sets of experiments. Hyperledger Fabric has higher throughput than Ethereum in all scenarios. The highest throughput for both platforms is when number of transactions is 100. Also, it can be observed that when changing the number of transactions, the change of average throughout of Hyperledger is larger than that of Ethereum.

TABLE I.
Execution time where number of requests is N=1

N=1	Create Account [s]	Load Item [s]	Transfer Item [s]
Ethereum	0.61	0.18	0.19
HyperLedger	0.1	0.09	0.08

TABLE II.
Execution time where number of requests is N=100

N=100	Create Account [s]	Load Item [s]	Transfer Item [s]
Ethereum	2.51	2.54	2.51
HyperLedger	0.31	0.28	0.28

TABLE III.
Execution time where number of requests is N=1000

N=1000	Create Account [s]	Load Item [s]	Transfer Item [s]
Ethereum	12.86	28.27	28.26
HyperLedger	2.4	2.65	3.88

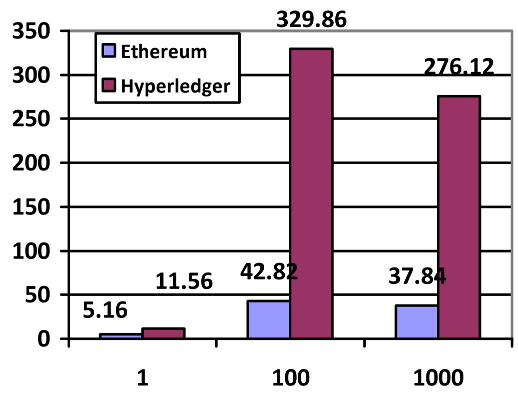

Figure 2. Average throughput comparison between Ethereum and Hyperledger Fabric

B. *Implication*

This analysis shows that Hyperledger Fabric performs better in every scenario than Ethereum in term of throughput and execution time. The analysis shows that the difference between Ethereum and Hyperledger Fabric becomes even more significant for larger number of transactions. Implication is that for a specific blockchain application, estimating expected number of transactions will be important for selection of suitable platform.

C. *Limitations*

In this paper, execution layer is analyzed of both blockchain platforms with consensus layer excluded from the analysis. Reason for excluding consensus layer is that two platforms utilize different consensus protocols which can impact performance. In theory Proof-of-Work mechanism of Ethereum is slower than PBFT. The presence of consensus mechanism provides security but reduces the performance, therefore for testing performance of the execution layer consensus mechanism is not needed.

V. Discussion

In this paper we present analysis of Ethereum and Hyperledger Fabric as private blockchain platforms with different set of transactions. Results shows that Hyperledger Fabric performs better with higher throughput and lower execution time compared to Ethereum when the workloads are varied up to 1000 transactions. Differences between these two platforms for execution time become more significant as the number of transactions grow. Because of the higher throughput, Hyperledger performs better in scalability then Ethereum. For future work, we plan to analyze two platforms with consensus mechanism included. Furthermore, we plan to analyze what is the maximum number of concurrent transactions for both platforms and explore differences between private and public blockchain platforms.

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