Performance Analysis of Trustworthy Online Review System using Blockchain

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***Abstract*—Today, the online review system cannot fully support the business since there are fraudulent activities inside. The companies that get low score reviews are induced to raise their score for the market competition capability by paying to the platform for deleting or editing the posted reviews. Moreover, the automatic filtration system of a platform removes some reviews without the awareness of the users. The low transparency platform causes low credibility toward the reviews. Blockchain technology provides exceptionally high transparency since every action can be traced publicly. However, there are some tradeoffs that need to be considered, such as cost and response time. This work tends to find the potential of using Blockchain technology in the online review system by testing four implementation approaches of the Ethereum Smart Contract. The result illustrates that using IPFS to store the data is a practical way of reducing transaction costs. Besides, preventing using Smart Contract states can significantly reduce costs too. The response time for using the Blockchain and IPFS system is slower than the centralized system. However, posting a review does not need a fast response. Thus, it is worthy of trading response time with transparency and cost. In the business view, the review posting with cost causes more difficulty to generate fake reviews. Moreover, there are other advantages over the centralized system, such as the reward system, bogus review voting, and global database. Thus, credibility improvement for a consumer online review system is a potential application of Blockchain technology.**

Keywords—Online Review, Blockchain, Ethereum, Smart Contract, IPFS

I. Introduction

Online review systems bring many benefits to both consumers and businesses. Searching for a good quality product is easier for consumers. The business trustworthiness is improved more. Many businesses realize the importance of consumer reviews and try to maintain the overall reviews to be attractive. Recently, there was reported that a popular TripAdvisor was fined $600,000 for allowing fake reviews on its site [1]. There are many claims that positive and negative reviews are made invisible or promoted in Yelp, Uber, AirBnB, and many others are in similar cases [2]. Therefore, the traditional online review system is full of dubiousness.

Ethereum provides various implementations for Blockchain application. Instead of using a centralized database, review information can be stored in Ethereum Blockchain where the data manipulation is prevented. Additionally, every action in the system is traceable publicly. Therefore, the online review system transparency can be much improved by using Blockchain.

According to the complexity and the novelty of Blockchain technology, the implementation guideline for Blockchain application is still restricted. This work proposes a Blockchain-based online review system approach and identifies the pros and cons of this approach compared to the traditional approaches in the aspects of cost and response time. Also, a guideline for the system implementation is presented in this work.

The rest of this paper is organized as follows: Section II gives some background knowledge about Online Review System, Blockchain, Smart Contract, and IPFS. We proposed the Blockchain-based Online Review system in Section III. The testing methodology and the results are described in Section IV. Finally, Section V is the conclusion and future work.

II. Background Knowledge

A. Online Review System

Online consumer review becomes an essential part of businesses since it can support consumers' consumption decision as well as sellers' credibility. 60% of consumers consider ratings and reviews when searching for products [3]. Many people conduct consumer reviews to make a holiday plan since the only review is a useful information source in decision making [4], [5]. As an online reputation system reflects in economic success, the business providers may be tempted to manipulate the review content. The results in [6] confirm that there exists a wide range of review manipulation methods. This unfair business practice undermined consumer trust toward the online review. The companies need to focus on maintaining transparency and trustfulness rather than improving the ratings and scores [7]. Moreover, the number of reviews for a business can be inferred to the popularity of the service. The authors of [8] mentioned that the number of reviews per room for a hotel corresponds to sales per room. The business revenue is not affected by only review scores but also other factors such as the number of reviews, rating trends, consumers' identity disclosure, and level of expertise. Therefore, transparency improvement in online review system benefits to both consumers and businesses.

B. Ethereum and Smart Contract

A Smart Contract composes of an address, states, and functions. A Smart Contract address is used for referring to a Smart Contract that is deployed into Ethereum Blockchain Network. Once the Smart Contract is deployed, it will be running on Ethereum Virtual Machine (EVM) [9], which manages Smart Contract execution. A user has to create a transaction and specify a Smart Contract address as well as its function in order to run a Smart Contract function. A transaction that is sent to the Ethereum network will be waiting in the queue before selected by EVM to execute. The selection of transactions depends on the Gas mechanism, which is described in the next part. During the execution of the Smart Contract function, the state might be changed according to the definition of that function. The Smart Contract states can be any data that is similar to the common programming languages. Thus, a Smart Contract can be utilized in many working fields because it provides a variety of usages by assigning in its states and functions not only

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financial but also logistics, energy, environment, business, and so on.

C. Gas Mechanism

Since the Smart Contract is Turing Completeness, the developers can write a Smart Contract in different ways. Sometimes, there are some mistakes in the implemented programs such as an infinite loop. These mistakes directly affect the runtime environment, which needs the terminating mechanism to solve it. In the case of EVM, it is no way to terminate the contract execution directly. Therefore, the Gas mechanism is proposed to address this problem. Gas is used in terms of the transaction cost in Ethereum Blockchain. A miner who executes the transaction gets the reward in Ether with respect to the Gas mechanism. There are steps as follows: (1) Users define *gasLimit* and *gasPrice* in the step of creating transactions. The *gasPrice* is the cost for each step of the execution and *gasLimit* is the maximum gas in the transaction. (2) When a transaction is sent, Ethereum deducts the *feeMax* (*gasPrice* x *gasLimit*) from a sender and broadcast an execution request to all nodes. At this moment, the transaction will be waiting in the transaction pool. (3) The special node called miner picks a transaction from the transaction pool for performing the execution. The node prioritizes the requests by *feeMax* to earn the highest reward. (4) Once the execution begins, its fee (*gasUsed*) is calculated and accumulated for every step. (5) Concurrently, the EVM checks whether *gasUsed* is less than *feeMax*. If that is the case, the execution continues until complete and return the remaining gas (*feeMax* – *gasUsed*) to the sender. (6) Otherwise, the execution is terminated and thrown gas limit exceeded exception.

D. IPFS

Interplanetary File System (IPFS) is a distributed file system that utilizes the idea of previous peer-to-peer systems, including Distributed Hash Table (DHT), BitTorrent, Git, and Self-certifying File System (SFS). It enhanced and combined all proven techniques into a single system. IPFS is a peer-to-peer system that includes many nodes of computers. Nodes store IPFS objects in local storage and connect each other for transferring data among them. With the peer-to-peer characteristic, IPFS can save immense bandwidth especially for the video file up to 60% [10]. IPFS keeps every version of files permanently. Preserving humanity's history is possible with the emerging of IPFS. Data is stored in a decentralized way which provides accessibility in public with IPFS. Thus, this can be used to reduce duplication and make it simple to transfer data between different systems. Moreover, decentralization makes more reliability. It does not need any backup system. IPFS provides many approaches to store data. One of them is immutable data which is suitable for using Blockchain. Since having a large amount of data in Smart Contract might costly, using IPFS is an interesting way to manage this issue. After data is placed in IPFS, it can be accessed via a link. Storing a short string link instead of massive data can significantly reduce a large amount of cost.

III. Proposed System

The core component of the proposed systems is the Smart Contract which keeps all transaction history permanently and publicly. IPFS is used to minimize the amount of data stored in the Smart Contract. At the time of writing, there is no service fee to record the amount of data in IPFS. However, there is no guarantee that IPFS always continues with no fee charged. As a result, we propose both IPFS and without IPFS Smart Contract and show the difference of cost used in an empirical way. The Smart Contract was implemented by using Solidity. For the application, Web3js library is used to interact with the deployed Smart Contract. The proposed approaches have the description as follows:

A. Smart Contract Without IPFS

The images and videos data can be converted into byte data and directly sent to the Smart Contract. However, by doing so, the extremely high transaction fee is produced due to the massive amount of data transferred. To avoid it, we store the images and videos in the centralized database with their hash values. The changing of those files can be traced by comparing hash values in the Smart Contract and the centralized server. However, this approach cannot prevent file manipulation.

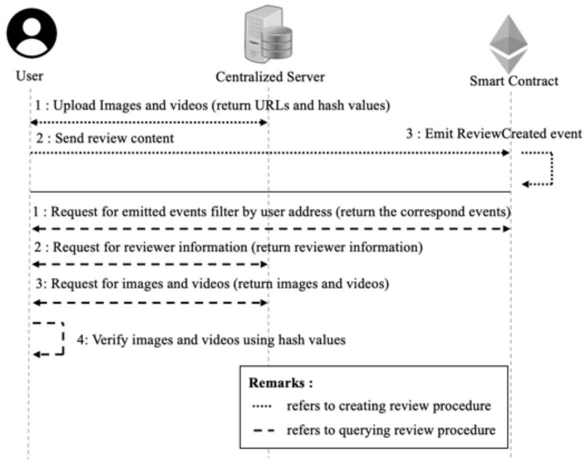

Fig. 1. Smart Contract without IPFS Sequence Diagram

As shown in Fig. 1, The review content is sent directly from the reviewer to the Smart Contract. Then it keeps the reviewer and reviewee addresses along with review content. User information is kept in the centralized database due to the reason of transaction cost as well. In this approach, it can be divided into two types: state and stateless Smart Contracts. The stateless Smart Contract does not have the state variables. It is suitable for the simple review that only keeps data permanently. In contrast, the state Smart Contract stores the review data in the mapping array data type. More complex review systems such as reputation, reward, and verification can be further implemented by using the state. However, it consumes more computation power and cost.

B. Smart Contract With IPFS

Since IPFS is a distributed file system, storing images, files, and data structures are its relevant application. The data stored in IPFS obtain a hash value which is the content address. It can be used to query the data from the IPFS network. This approach not only reduces the cost of storing data but also prevents a large amount of data from manipulation with meager transaction costs. Currently, IPFS limits up to 100 MB data per request. However, a large file can be separated into small pieces and stored by using many requests.

The sequence diagram in Fig. 2 illustrates that the images and videos are sent to IPFS and its hash is kept in review content. After that, the review content will be sent to IPFS, and its hash will be stored in the Smart Contract. The data sent to the Smart Contract are fixed-length 32 bytes string, reviewer, and reviewee addresses. This approach contains 2 different types (i.e., state and stateless) same as the first approach to illustrate the difference of cost used and the potential of a more complex system.

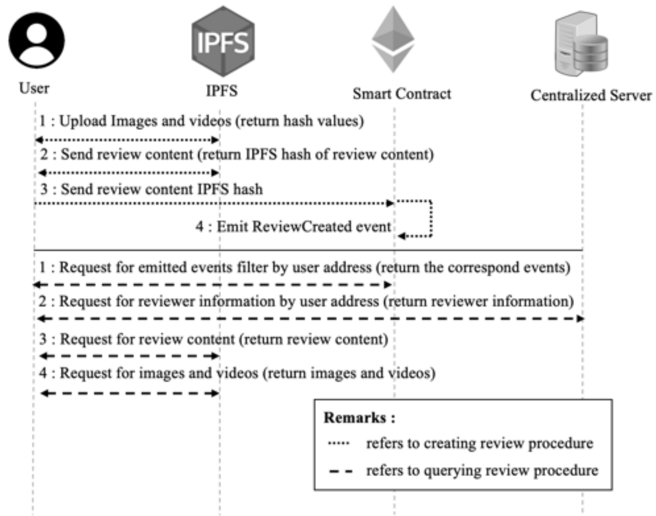

Fig. 2. Smart Contract with IPFS Sequence Diagram

IV. Experiment Result and Analysis

This section illustrates the results of using the Blockchain-based online review system in terms of cost and response time. All of the proposed approaches were tested and compared to each other as well as the centralized approach. The experimental details are described below:

A. *Controlled Factors*

1) Image and Video file sizes are at most 100 MB.
2) Review Content size is in range of 200 bytes to 2 KB.
3) Ropsten test network is used in the experiment. Its consensus algorithm is Proof-of-Work (POW).
4) Ethereum node is used through the Infura service.
5) The Gas Price value is 3 GWEI (1 Ether = 10^{-9} GWEI) which provides the average speed of the transaction. ETH Gas Station Service is used to monitor the transaction cost for the average transaction speed in this experiment.
6) The centralized server is the cheapest 1 GB RAM and 1 CPU of Digital Ocean droplet.

B. *Testing Methodology*

There are 2 experiments in this work. The first experiment aims to find the relation between content size (input) with the transaction cost and the response time (outputs) for every proposed approach and the centralized system. The second experiment focuses on testing the performance of the storage system (i.e., a centralized database and IPFS). File size and uploading time are the input and output, respectively. The experiment procedures are described as follows:

1) Input size, transaction cost and response time experiment
   a) Create the review content by assigning the data size to be 200 + (100 x *i*) bytes, where *i* denotes the round number that is range from 0 to 18
   b) Post a review to the system. Record the input size, the transaction cost, and the response time
   c) Repeat the above steps for 10 times
   d) Increase the round number and repeat the above steps until the final round
2) File size and uploading time experiment
   a) Upload a file to the storage server (i.e., centralized server or IPFS)
   b) Record a file size and uploading time
   c) Repeat the above steps for 20 times
   d) Increase a file size and repeat the above steps until a file size is closed to 100 MB

C. *Experiment Results*

The experiment results are shown in the following charts and tables:

1) *Input Size and Transaction Cost*

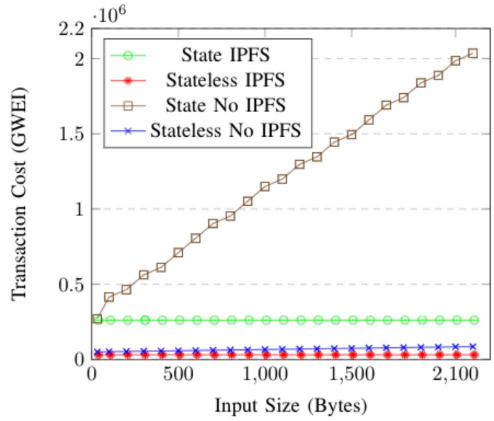

Fig. 3. Input size and Transaction cost Chart

The input size is directly relative to the amount of transaction cost for No IPFS approaches as shown in Fig. 3. In contrast, the transaction cost is constant in the systems that use IPFS. Besides, keeping state (i.e., array of mapping) in Smart Contract also produces higher transaction cost than the stateless approach.

TABLE I. TRANSACTION COST FOR A REVIEW CREATION

Approaches	Cost in GWEI[a]	Cost In USD[b]	Number of Reviews for 1 USD[b]
State IPFS	261,402	0.03776	26
Stateless IPFS	31,342	0.00453	220
State No IPFS	710,204	0.1026	9
Stateless No IPFS	58,348	0.00843	118

[a] Cost at 500 bytes input size which is the typical length of review content in Trip Advisor, Lazada, Alibaba, Amazon, and Yelp.
[b]1 Ether = 144.47$ at the time of writing. Cost in USD may vary with respect to Ether value.

2) *Input Size and Response Time*

Since the experiment result indicates that the input size is not directly relative to response time, all of the response time records are presented in the form of the average value for each approach. In order to illustrate clearly, the response time is divided into 3 sections: centralized, Smart Contract, and IPFS response times as the sequence diagrams in section 3. The results in TABLE II demonstrate the average value (first number) and the standard deviation (in the parenthesis) of response time.

TABLE II. RESPONSE TIME FOR A REVIEW CREATION

Approaches	Response Time (seconds)			
	Centralized	Smart Contract	IPFS	Total
Centralized	0.13 (0.04)	0	0	0.13 (0.04)
State No IPFS	0.12 (0.03)	1.01 (0.11)	0	1.17 (0.11)
Stateless No IPFS	0.12 (0.04)	1.06 (0.1)	0	1.17 (0.11)
State IPFS	0.17 (0.08)	1.12 (0.2)	5.17 (7.25)	6.51 (7.29)
Stateless IPFS	0.25 (0.17)	1.42 (0.36)	4.53 (5.04)	6.21 (5.28)

3) *File Size and Uploading Time*

TABLE III demonstrates average and standard deviation values of the uploading time in centralized and IPFS approaches.

TABLE III. UPLOADING TIME

File Size	Uploading Time (seconds)	
	Centralized	IPFS
1MB	0.4 (0.4)	1.2 (0.4)
5 MB	1.3 (0.5)	4.3 (0.4)
10 MB	1.9 (0.5)	10.3 (1.8)
50 MB	10.5 (0.4)	70.2 (30)

D. Result Analysis

Assume that the review system is working on a small size business that has 50 posting reviews per day approximately. The average size of the review content is 500 bytes. The cheapest Digital Ocean cluster is used for the backup of the centralized system. The monthly cost of the systems is compared in TABLE IV.

TABLE IV. MONTHLY COST COMPARISON

Approaches	Cost (USD/month)	
	Backup Cost	Transaction Cost*
Centralized	15	0
State IPFS	0	56.64
Stateless IPFS	0	6.795
State No IPFS	0	153.9
Stateless No IPFS	0	12.645

* The transaction cost is linearly varied by the Ether value and the number of reviews per day.

The Smart Contracts that keep state (i.e., mapping of array) consume considerably higher cost than the centralized system. Thus, other techniques are needed for a more complex logical review system. In contrast, the stateless systems cost less than the centralized approach in case of the small systems that need backup only review data. The monthly transaction cost is presented in the aggregated value, but it does not mean that a business needs to pay all transaction fee for the customer. Review cost might be included in the product price. It depends on the business model which can be adapted in various ways. By the way, the transaction cost in the experiment results are acceptable for a review posted especially the stateless with IPFS approach.

Although the response time and the uploading time of the IPFS system is longer than the centralized storage, there are some methods to address this issue, such as background uploading. In addition, the spent time is the small trade-off compared to a large amount of saved cost.

V. CONCLUSION AND FUTURE WORK

This work analyzed the performance of the Blockchain-based online review system with two different approaches: Smart Contract with IPFS and without IPFS. The experiment results illustrated that using IPFS to store the review content and avoiding keeping data in the Smart Contract state reduce transaction cost significantly. Thus, for the online review Smart Contract implementation, any long content should be put on the IPFS, and the Smart Contract state should be used as little as possible. However, there are some circumstances that the Smart Contract needs to use its state variables, for example, a Smart Contract that allows only customers who purchased a product to post a review. The well business model is a solution for the more cost in the more complex system. In conclusion, it has the potential to use the Blockchain technology to raise transparency in an online review system by a proper system implementation and business management.

Although the high cost and slow response time are the drawbacks of using Blockchain, there are various advantages that the centralized system cannot simply achieve, such as global storage, which any platform can store their reviews in one place. With the result of this work, the further implementation of the Blockchain-based online review system will be proposed in the future work in order to indicate all the advantages over the centralized system that Blockchain can achieve. The security issues must be investigated to have a more reliable system in the production environment.

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