Blockchain-based Global Travel Review Framework

Tanakorn Karode[1], Warodom Werapun[2]
College of Computing
Prince of Songkla University
Phuket, Thailand

Tanwa Arpornthip[3]
Faculty of Technology and Environment
Prince of Songkla University
Phuket, Thailand

Abstract—**An online review system is an important part of almost every e-commerce platform, especially a tourism e-commerce. However, various problems exist in the current online review systems. The review content is stored in a centralized database of each individual platform. Each platform differs in review management methods. In some cases, the review score of the same product disagrees across different platforms. Moreover, a centralized system has low transparency because it is difficult to trace individual actions within the system. As a result, some users are skeptical of the reliability of online reviews in centralized systems. This work proposes a global travel review framework based-on the blockchain technology. The incorporation of blockchain helps improve an online review system. The best practices for online review management from popular platforms, and the guidelines from trusted sources are used to develop the new system. The use of blockchain improves an online review system through its unique features of high transparency, security, and reliability. Additionally, the proposed framework relies on a community-driven environment. The accessibility level of users is controlled by using the smart contract. There is no single authoritative owner of the system. All participants in the system can exert controls on the system equally. This work illustrates the details of a blockchain-based global travel review framework. The advantages and disadvantages of such a system are discussed. The proposed framework can be easily integrated with any existing platforms since it can be accessed publicly.**

Keywords—Consumer online review; traveling; blockchain; smart contract

I. INTRODUCTION

From the Mintel report, 60% of travelers use online reviews to make a holiday trip plan [1]. People consider online reviews to reduce the risks of wasting money and time. It means that an online review much influences the travel-related products [2]. An online review impacts to the customer's trust and also the business's revenue. When people realized the effects of online review, they tried to manipulate it. As a result, fraudulent activities in online review systems are widespread over the internet [3]. It causes information that people perceive is misleading. The review readers need to take a longer time for online product assessment. And also, the business's credibility is undermined. Many platforms are struggling with those problems. Some methods they are using work very well. However, some strict procedures are not suited to the user's needs. For example, the automatic filtration scopes down the reviewer's opinion. Low-score reviews are frequently filtered out. The similar cases happen to the very high-score reviews. A blog author argues that his genuine review was filtered out from a platform, and the reason that he got was not making

sense [4]. Moreover, other customers do not know when a review is filtered out, updated, or removed since those actions are not exposed publicly. The online review Today's online review is controlled by the platform providers who can manage their platforms as they prefer. Each platform has its database and might have different practices in its system. According to the news, the score of a product is contrastive in two platforms [5]. This kind of circumstance critically affects the customer's trustworthiness toward the business. The score might partially reflect the quality of the product. However, the platform practice is one factor that impacts the overall score of a product. It occurs when a platform tries to maintain the attractive view of a partner business. The separated sources of reviews undermine user credibility. The businesses are also inconvenient to maintain the same score in every platform they use.

In this work, the blockchain-based global travel review framework is proposed. The main objective of this framework is to improve the credibility of the online review. The transparency of the system is much raised by utilizing the blockchain technology. Exposing actions in the system increases the user's credibility since it can be traced publicly. Blockchain helps in communication among the different systems that have its database much easier. All individuals have the same level of accessibility. The accessibility rule is constructed once by using a smart contract. The rule is displayed publicly and cannot be updated. Users can decide to participate in the system if they agree on the rules. Traveling reviews are stored in a single global database, which can be accessed publicly. There are many potential applications that can extend from this characteristic. For example, a business ranking application, a travel suggestion system, a fake review detection system, and many others.

The main contributions are not only the idea of the framework but also the implementation guidelines for the smart contract and decentralized applications (DAPPs). Additionally, the framework's performance in terms of cost and speed are analyzed to consider the potential of the real environment usage of the framework.

Although the proposed framework is implemented with blockchain technology, the centralized online review system's guidelines or practices are still needed. That information will be described in Section II. Then, we propose a framework in Section III. Section IV is the discussion about the advantages and some issues in the framework. Eventually, we conclude the work in Section V.

II. LITERATURE REVIEW

A. Online Review Components and its Impact

A consumer review contains the essential components that every platform presents, including review content, author's profile information, and review scores. That information describes the consumer's opinion of a product or service. There are the additional components that some platforms include them while some platforms do not use them, such as graphical information (i.e., pictures and videos), review timestamps, review helpfulness score, response to a review, and reviewer contribution history. The additional components provide further information, which makes the reader understand better and more accurate. Furthermore, the reader gets more information to decide whether to trust the review they are reading.

Prior researches investigated the effects of the review component as followings:

1) Review content: The descriptive text for the feedback explanation is the most important part of the review. There are many attributes inside the review content that the researchers use to analyze their characteristics. For example, readability represents how easily the reader can perceive the information from the review. The review content with low readability (i.e., difficult to read, using vague and improper words) can be treated as a low-quality review. Chen et al. proposed the manipulation review detection model by using a decision tree [6], where the critical attribute for review manipulation classifying was sentimental (both positive and negative sentimental). The informative direction is an important attribute for the quality review. As shown in [7], the review content that describes in one direction (either positive or negative) is likely to get more helpful score than the review that does not clearly present the aspect.

2) Rating: The numeric data that the reviewers provide to the products or services. This numeric data can be aggregated to create the summary data, which can minimize a huge load of information the readers comprehend. Also, the rating can be used to be the comparator among the businesses that participate in a platform. As reported in [8], a business with the higher review score and a greater number of reviews likely is to obtain more revenue.

3) Reviewer: The reviewer information is an essential source of data that the reader can use to consider the review credibility. The authors in [9] stated that the reviewers who disclose their identity more get more helpfulness scores. Trip Advisor is a platform that pays much attention to the reviewer's information by presenting the reviewer contribution system. Every user has the contribution score and history, which is very useful information for deciding the trustworthiness of a review posted by that user.

4) Graphical data: Photo or video is the attractive information that provides more details in the review content and raises the review credibility. The graphical data shows the real place, product, or situation is likely to get more trust. Especially, the one that appears the author identity. Thus, it can support the purchasing decision more than the only textual review [10].

5) Review helpfulness score: It is presented as the two-ways review. The scores that people give to a review reflect the level of trust among the readers. It supports reader consideration in trusting a review and its author. Many researchers use this component to analyze the perceived usefulness of the review readers [11]. Moreover, the review quality assessment is constructed by using helpfulness score. A high helpfulness score review is often used as a baseline for the quality review.

6) Review response: It expresses the opinion of other consumers or the business towards that review. It is a fair practice for the platform to provide a public replying channel. As a result, a reviewed business can dispute some misleading reviews.

7) Review timestamp: The time of writing review which can be used to identify some strange behaviors in the online review system. For example, the reviews posted to a business by the same user in a short period can be considered a spam.

B. The Guidelines for Online Consumer Review Platforms

Even though the consumer online review platforms contain similar components, the presenting information practice is quite different. Both consumers and businesses suffer from fraudulent activities in the online review. They need some guidelines for the best practice to address the credibility problem in the online review system. The Australian Competition and Consumer Commission (ACCC) published the online consumer review guidelines for consumers, businesses, and system providers [12]. We pick the guideline for the system provider to discuss the on-going platforms today. To create a consumer review system that plays the fairest to both consumer and business, ACCC provides the guideline for platform providers as followings:

1) Disclosure the commercial relationships: The platform and the business could have a commercial relationship that does not affect the review results, such as advertising or promoting searching results. The prominent disclosure about the commercial relationship should be presented to convey key information to any user. A guideline example is a prominent disclosure should be placed near the aggregated review results [13].

2) Do not publish misleading reviews: The misleading reviews cause perceived information about the reviewed business to mismatch the fact. The misleading reviews can be written by the reviewed business itself or the consumer who gets a benefit for posting an inflated review. On the other hand, the negative misleading reviews can also be generated by a competitor business or a third party that has a relationship with it.

3) The platform should not edit or delete the posted reviews: The information of review may be misleading if it does not actually come from the review authors. Removing or updating the review by the platform, particularly negative reviews cause decreasing the platform credibility.

4) Detecting and removing fake reviews: The platform should detect and manage the fake review properly to keep the platform's integrity and make it useful for the consumers. The ACCC recommends that online consumer review platforms remove the reviews that they know to be fake. There is no precise way to detect fake reviews. Here is the guideline from the ACCC. The fakes review may include those:

a) which are part of a significant frequent in reviews about a particular business in a period of time.

b) written from the same IP address or email of the reviewed business or the friendly business.

c) written about a particular business where each of those has abnormal similarities (e.g., username, IP address, email).

d) which use overly positive marketing-style language.

e) which do not make sense.

f) which use the same language style as the other reviews of the same business or product.

A practical way to detect fake reviews is to include a flag button, which provides users with an opportunity to point out fake reviews to the attention of platforms.

5) Incentivized user review: The ACCC recognizes that the potential of incentivized reviews may lead to biased reviews, inflating review results, and misleading consumers in some circumstances. When an online review platform offers an incentive, it should do following these recommendations:

a) The platform should disclose any incentive prominently on the review page of the businesses whose reviews are affected by that incentive.

b) The platform should be alert to the customer incentivizes provided by the businesses in order to manage it properly. If there is some review clearly and dramatically inflated by an incentive, the platform should remove that review to prevent misleading.

c) The additional best practice is to ask the reviewer whether they have received any incentives from the business when writing the review.

The incentive offers should not affect the review result. Namely, the incentives are offered regardless of the review score given by the reviewer.

6) The overall score of review is important: The overall review score (e.g. star ratings) of businesses should be presented in the platform. In many cases, users do not read many reviews before relying on the overall review score. It is the responsibility of the review platform to keep the review results be genuine. Deleting or hiding reviews suspected of being fake is not misleading as the consumers prefer improving the quality of reviews. When the platform provides

the aggregated rating. It is recommended to show the number of reviews next to the average scores (e.g., 5 stars, 20 reviews). Content moderation policy ensures users and businesses have a clear understanding of the reason for removing reviews. It is recommended that the providers inform the policy to the businesses and consumers.

7) Dealing with the businesses who have got unfavorable reviews: Businesses may receive negative reviews, which is understandable to be concerned. It is recommended that the platform should provide the public reply channel for the business to substantiate publicly that the review is fake. The review platform should follow the investigation. When there is enough evidence that suggests that the review does not come from the truth, the platform should remove that review as soon as possible.

8) A review should be written by a person who has already consumed a product: Businesses should not post a review to competitor businesses and their own business too. If there is some friendly business review, the platform should disclose the relationship between them. Importantly, businesses must avoid paying for posting reviews. This practice could induce misleading reviews.

C. The Current Online Review Systems

Nowadays, there are many tourism related platforms that provide the channel for the consumers to give some feedback and suggestion to the businesses publicly. In this work, we investigate the top six tourism related platforms on their consumer review systems by comparing with the ACCC guidelines. The studied platforms are Trip Advisor, Yelp, Booking.com, Expedia, AirBnB, and Agoda. The comparisons are presented in Table I.

When we compare the service practice in the popular platforms, we can clearly notice that the third-party platforms like Trip Advisor and Yelp (i.e., the platforms that do not provide the booking or payment process) are likely to contain more information than the booking or purchasing platforms. Also, the conquering fake reviews procedures are stricter in the third-party platforms. For example, Trip Advisor and Yelp contain the automatic filtration system to remove the reviews pointed out to be fake reviews. Additionally, the flag system that allows users to point out fake reviews is available on those platforms. More importantly, readers can consider trusting a review by considering its author's contributing history. In contrast, the booking platforms do not make much earnest about the online review system. While posting images and videos is the common practice for the user-generated content application, these platforms do not provide this feature. However, a huge advantage of the booking platforms is the review posting privilege. Only users who have consumed a service can post a review. This rule causes constructing fake reviews more difficult and costly.

TABLE I.   ONLINE REVIEW PLATFORM COMPARISON

Guidelines / Components	Platforms					
	Trip Advisor	*Yelp*	*Booking.com*	*Expedia*	*AirBnB*	*Agoda*
Review verification	The posted review is verified by automatic and manual system	The reviews are posted immediately	The reviews are verified before listed in the platform	The reviews are posted immediately	The reviews are posted immediately	The reviews are posted immediately
Removing or updating reviews by plaform	In many cases, the user reviews are filtered out	Many reviews are filtered out by the automatic system	Reviews could be removed if they do not follow the rules	The reviews are removed by platform if they contain the violent content	Reviews could be removed if they do not follow the rules	Reviews could be removed if they do not follow the rules
Fake or violent reviews report channel	Flag system	Flag system	None	None	None	None
Review response	None	The business can reply a review, but it does not show publicly.	None	None	None	None
Review posting allowance	Any user can post review	Any user can post review	Only user who has already purchased	Only user who has already purchased	Only user who has already purchased	Only user who has already purchased
Images or videos	Available	Available	Available	None	None	None
Reviewer contribution history	Available	Available	None	None	None	None

In summary, today's service practice in popular platforms is acceptable in some aspect, whereas some practices are questionable. If an online review platform is created with the best practice, it can eliminate a large amount of fake and violent reviews. However, detecting an actual fake review is not a simple task. In the current platforms, many genuine reviews are filtered out by automatic systems. Such a situation hurts the reviewers who spend some time to provide true information, but their reviews still get filtered out. As a result, the reviews are scoped in the narrow space. In addition, some platforms do not provide acceptable rules for review filtration. Thus, the very strict automatic filtration might not be suited for online reviews in some situations. A key for the quality review platform obtained from a research published by Wu, Ruhai, et al. is transparency [14]. It can be achieved by exposing the actions taking place in the platform as much as possible. The rest processes are just to let users find the evidence and consider trusting the information by themselves.

D. Online Review with Blockchain

As mentioned in the previous section, transparency is key to achieve a high credibility online review system. Sometimes, the reviewers might prefer to change or delete their reviews after posted. Allowing users to manage their reviews is a good practice because there might be mistakes in writing a review. However, the readers should be able to see all previous versions of the manipulated reviews. This practice offers more information to consider reviews. Some current platforms allow users to manipulate their reviews, but they do not provide all previous versions of reviews. Even though some platforms reveal all versions of the reviews, the platform owner can still manipulate them without the awareness of users since the data is stored in the centralized database. It is a trust issue that users need to rely on the terms and conditions provided by the platform owner. A centralized database cannot serve the full transparency, a feature that is supported natively in a blockchain-based database.

The first emergence of blockchain technology was the time where Satoshi Nakamoto proposed an electronic cash system that can be done without intermediary [15]. Instead of storing all ledger data in the central authority, the blockchain ecosystem distributes all transaction history to every participated node. By doing so, individuals can validate their data with each other. Thus, tempering data is more difficult for more nodes in the system and cannot be done eventually. In the technical term, there are several steps to make it work. When a transaction is sent, it needs to be verified by the special nodes called "miner" before getting recorded. The miners check whether a transaction is valid by considering its correctness, such as whether the sender balance enough for the transferred amount plus the transaction fee, the receiver address, and the other aspects. Then miners gather the validated transactions into a set of data called "block". While miners simultaneously verify the transactions and put them to block, only a block from a miner gets recorded for each round. With that procedure, the blockchain data is sorted in the same way among all participated nodes. The blockchain network uses a consensus algorithm to select a miner. Once the consensus is succeeded, a miner who completes the consensus broadcasts its block to all other nodes and gets a reward from the blockchain network (coin base) plus a transaction fee. The name "blockchain" comes from the data structure using in its ecosystem. Every block of data is chained with its previous block using the cryptographic hash. With mathematical power, the hash function gives the same value for the same input every time. If a small piece of data in blockchain is changed, an individual can simply check by comparing its hash value.

The first version of blockchain uses Proof-of-work (POW) as a consensus algorithm to select a miner who has the right to use his/her block append to the latest block. Miners need to

find the hash value that has a lower value than the target value. The problem can be illustrated as the following equation:

$$SHA256(v, h_{prev}, h_{merkle}, t, b, n) = hash_{cur} \qquad (1)$$

POW uses the SHA256 algorithm to calculate the block hash ($hash_{cur}$), as shown in (1). It gets the blockchain version (v), the hash value of the previous block (h_{prev}), the hash value of the Merkle root tree (h_{merkle}), timestamp (t), the target bytes (b), and a nonce (n) as the function parameters. The only way to solve the problem is to attempt changing n value until the $hash_{cur}$ value is lower than b value. A miner who seizes more computational power has faster attempting and more chance to win. Once a miner solves the problem, it broadcasts the n value throughout the network to proof. Other miners can simply use that value to check the answer and record the block data. This procedure provides very strong security when there are a large number of miners in the network. This is how Bitcoin was presented its security.

However, POW consumes much energy and spend a long time to complete a transaction. Moreover, most miners gather and create mining pools to get a higher possibility of winning. Thus, the computational power is not distributed and can be attacked with the 51% attack much easier. As a result, other consensus algorithms are proposed by many groups of developers. An interesting one is Proof-of-Stake (POS), that does not require a lot of computation power but using the amount of token miners staking instead. At the time of writing, the Ethereum blockchain uses POW as a consensus algorithm, and will be upgraded to POS in Ethereum 2.0 soon. Thus, the cost and transaction duration illustrated in this paper might be much cheaper and faster in Ethereum 2.0.

A smart contract is a small computer program that is running on the blockchain environment. It can be treated as the agreement that is created once and used in the long term without updating. The only way to update the agreement is to create a new one and use it instead of the deprecated ones. It plays fair to every participant since the agreement is exposed publicly. Anyone who wants to join the contract can estimate risk before participating in the contract. The Ethereum team firstly proposed the utilizing of the smart contract with blockchain. It improves the capability of blockchain to be able to work in general applications. According to its capability to connect the separated parties, it is utilized in the provenance application for product tracking [16]. It is also used in reward and loyalty programs since it can securely protect the data and cannot easily be hacked [17]. Moreover, the applications that need high transparency and the integrity of data history, such as voting, and ballot are the first usage of the smart contract [18].

Ethereum virtual machine (EVM) is a place that miners execute the transactions. A transaction sender needs to pay a cost if it contains state updating operations. The transaction cost is needed to keep the miners in the network and for the terminating mechanism. Since the smart contract can be developed similar to the general program, it might contain any mistakes such as infinity loop. According to Ethereum Yellow Paper [19], the transaction cost is positively correlated to the amount of data and the operation in that transaction. Such that, reducing those things in a transaction is a practical way to

reduce the cost. In our previous work [20], we proposed ways to reduce the amount of data and the operations by using the Interplanetary File System (IPFS) and the smart contract event. IPFS is the distributed file system that can keep the permanently non-tempering data. It can store the huge amount of data and return the IPFS hash, which is the 48-character string refers to the actual data in the IPFS network. The proposed approach keeps IPFS hash in the blockchain history by emitting the event instead of using the smart contract state. The result showed that it could reduce approximately 20 times of cost compared to the smart contract that does not use IPFS and keeps the review content inside the smart contract state. That is a guideline for storing content data in the blockchain system. This approach will be used in this work for the smart contract implementation.

Currently, there are some groups of developers who are working on the blockchain-based online review system. We investigate some of the top of them listed below:

1) Revain [21]: The crypto community online review platform utilizes blockchain technology. This project is currently on the production state. It contains many businesses and users who generate a lot of reviews everyday. This project introduces the advantages of using blockchain with the online review system such as transparency, reward token, and the system cooperation. The businesses can easily integrate this review system in their platform by using the completed user interface provided by Revain or directly accessing review data in the blockchain storage. Moreover, this platform provides the user contribution history feature in the name of "karma". Every action of the reviewers reflects the karma point, which can increase their credibility. This platform is a pioneer project for the blockchain-based online review system that introduces various practical ways to improve online review credibility. There is something different from our work. Revain platform targets the crypto businesses review, but this work aims to the travel businesses. There is no purchasing verification before posting a review in the Revain platform, where anyone can still generate review without the real consuming experience. Even though the platform contains automatic filtration, it mainly focuses on the sentimental analysis where the extremely negative or positive reviews are filtered out. As a result, the overall reviews in the platform are scoped to be moderate tone.

2) Lina.Review [22]: Lina is a platform that utilizes blockchain technology in various fields, including review, supply chain, individual identity, healthcare, and education. Lina.Review is a module in the Lina platform. It stores the submitted reviews from users in a secure manner and rewards quality reviews. The individuals or businesses can build their systems on Lina.review platform. A special feature of Lina.Review is reviews from experts. A reviewer who proves the domain knowledge by providing CV to the platform becomes an expert. An alternative is getting promoted from other users by posting many accepted reviews. The experts and helpers write reviews to the businesses regarding their knowledge domain. They are entitled to receive the reward

from advertisement revenue and registration fee. Lina.review stores the review content in their private blockchain to reduce the transaction cost. As a result, the platform is under controlled by the Lina team. This point is the main difference between Lina and our work.

3) Dentacoin [23]: Dentacoin (DCN) claimed to be the first blockchain-based online review system for dental services. The dentists can register their dental offices to get patient feedbacks and display in public. Additionally, the patient can also register the dental clinics they have serviced. It uses the concept of "trusted reviews", where only the patients who have received service from the corresponding dentists can post the review. These patients are verified by the dentists sent a link for posting reviews via email. The reviews posted via those links are marked as trusted reviews. The reviewer gets the reward in DCN token after posting a review. DCN token can be used to get discounts or promotions for further treatment. Moreover, DCN token will be distributed through the industries which means that the users who are holding DCN token can use it as a cryptocurrency. The trusted reviews procedure presented in the DCN platform is an interesting way to reduce fake reviews. However, this approach still lacks of transparency. The dentist or even platform can send email to any reviewers, who might not have taken a service. While those actions cannot be traced publicly. Unlike in our work, the validating step relies on the transactions that take place in the blockchain. Thus, every action can be perceived in public.

III. PROPOSED FRAMEWORK

In this work, we create a global travel review system by using the Ethereum smart contract. The main goal of the system is to improve the review credibility. The travel review contents are stored in the distributed database among the participants. Every user sees the same version of reviews regardless of the platform or business they are using. The system does not need the central authority. It manages the accessibility by using the smart contract. The review authors have the most privilege in their reviews. Updating and deleting the posted reviews are possible but with a traceable history. This system is a community-driven environment. The incentive and fake review omission features are done by the user community. A review author is incentivized by the helpful score they get. This approach, customers are encouraged to write a quality review to get much helpful score from other users. Fake reviews can be pointed out by a user who has some clues. A user can get help from the community to judge a fake review by opening an issue. Other users can vote to agree or disagree with the argument provided by the issuer. Once the voting time is up, the winners get the reward, and the review is stamped to be fake if the "Yes" score is higher than the "No" score. All of the actions are recorded in blockchain. Thus, people can know all movements in the system and can consider trusting information presented in the platform. The framework details are described in the following sections:

A. System Architecture

The core component of the system is the smart contract. It enforces a rule that every participant needs to follow up. All participants can see the rules in the smart contract code and decide whether to join the system. The deployed smart contract cannot be updated. As a result, the rules do not change after the system starts operation. Every user in the Ethereum blockchain is a customer at the beginning state. When a user records his/her product in the smart contract, that user becomes a seller. While both customer and seller can retrieve data in the same way, there are the differences in actions they can take to the smart contract as followings:

1) Seller: Sellers can record their travel-related products (e.g., hotel room, food, tour guide, accommodation, and other travel products.) in the smart contract. Once a product is recorded in the smart contract, customers can use Ether to purchase it through the smart contract. The sellers are not allowed to purchase a product and do other actions requiring purchasing status, including posting a review, giving a helpful score, opening issue, and voting to remove a fake review. However, sellers can reply to a review that might be misleading review to clarify some misleading statements. The replying message is exposed publicly.

2) Customer: The customer can purchase products that are listed in the smart contract. After that, some actions are unlocked by using the purchasing state of the particular product. For example, a customer needs to refer to a purchased order to post a review. Every action the customer interacts with the system is recorded permanently in blockchain. All actions can be treated as user contribution history. It improves user's credibility and provides many opportunities for being an influencer in the traveling community.

The possible structure of the system can be presented as Fig. 1. Every participant can directly interact with the smart contract. A technical user who has some experience about the smart contract interaction might implement a channel to retrieve data or take some actions directly. However, creating a product order needs to be done by the product seller. Thus, businesses need to provide a channel for the user to request a product order for purchasing. It could be a business own website or a third-party platform. Presenting reviews with the correct content is the responsibility of the platform provider. If a platform does not play fair by changing some content in the presentation layer, the customers can be aware of that action by comparing it with other platforms or the smart contract. With the proposed structure, there can be many possibilities to support the travel industry. For example, a third-party can directly retrieve all customer feedbacks from the smart contract to create a travel suggestion website. The mentioned application is very useful if the review content is factual information. Thus, the community-driven approach presented in this work is a way to make it possible.
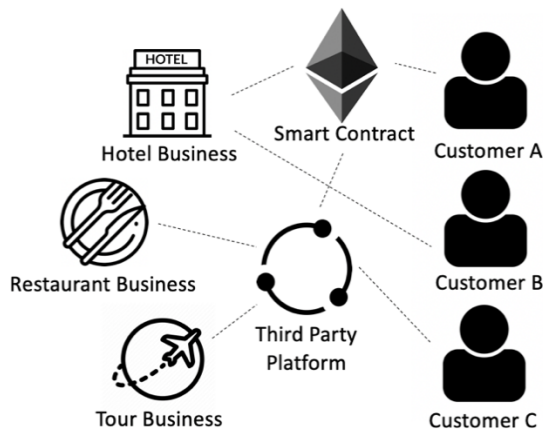
Fig. 1.   System Architecture.

B. System Functions

The smart contract contains several functions that let users interact with the system. The overall system workflow is described below:

1) Recording a product: Sellers need to record product information and its review value in the smart contract. The product information needs to be stored in IPFS and get its hash to stamp in the smart contract. The schema of product information might be varied, but every user needs to follow up on the same format. The simplest schema contains the product name and a URL link for more information. Since updating data in the smart contract requires cost, the frequently changed data should be avoided storing in the smart contract. The review value is the amount of Ether that the business willing to pay for the user community to incentivize quality reviews and handle fake reviews. The review value can be changed afterward, but not too frequently, because it might not motivate users to post reviews.

2) Recording user profile: Like the product information, the user profile needs to be stored in IPFS, and its schema should be the same for all users. Otherwise, it might cause problems in the presentation layer. The users have alternatives to put their information into the system or not. According to prior research, the helpful score of a review is directly affected by the user identity disclosure. As a result, users are allowed to record their information to improve their credibility. The recorded information is permanently bound with the user address. Users can update their profile data, but all of its versions are available in blockchain.

3) Purchasing a product: After a product is recorded, it appears to every user. The product purchasing steps are illustrated in Fig. 2. A customer can buy a product by requesting the seller to create a product order. A seller creates an order by determining product price in Ether and the buyer's address. Since the product price can be varied by factors such as the number of products, promotion, etc., the system is designed to handle the dynamic pricing. When an order is already created, it got an identification number (order id). The order id is returned to the customer, and he/she can use it to

purchase a product with the defined price in the order. The net amount of Ether that the business gets is the total amount deducted by the review value (i.e., net amount = price – review value). The review value is kept in the smart contract. A customer can refer to a purchased order to get the right to do these actions including posting a review, give a helpful score to another's review, open issues, and vote for issues.
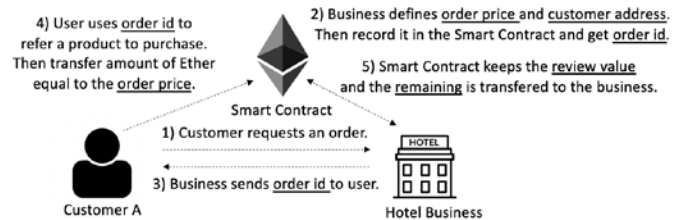

Fig. 2.   Purchasing Procedure.

4) Managing a review: A review posted to the system needs to be stored in the IPFS to reduce the transaction cost. When a review is recorded in the blockchain, it can be updated or deleted by its author. In practice, the smart contract events for deleting and updating a review are emitted to update the review version, while the old versions of the review are still accessible. In the presentation layer, a platform that utilizes this system should only present the latest version of the reviews. And also, other versions should be available for users because they can be proofs of fake reviews.

5) Review Replying: The system allows businesses or other consumers to reply to a review if there is some misleading information. The replying content needs to be stored in IPFS too. The smart contract emits an event to record the replying message. It is the responsibility of a platform to display all the replied messages appending to the particular reviews.

6) Helpful score: After finish purchasing, a customer has two choices about the review value. Firstly, giving a helpful score to another's review within a time. This way, the review value is transferred from the smart contract to the author of a review that gets a helpful score. Lastly, omitting a helpful score giving. If a customer does not take any action to the helpful score until the end of the time, the customer cannot use that order to give a helpful score anymore. The review value of that order can be picked by anyone who opens an issue. The review value is used to be the additional reward for the issue winners.

7) Openning an issue: Once a customer notices that a review in the product he/she has ever purchased might be misleading, the customer can open an issue for that review. For opening an issue, the customer needs to define voting timeout, the maximum value to vote, and the argument text to point out the mistakes of that review. If there is an order that is not spent on giving a helpful score, it can be picked up as the additional reward for the issue winners. The customer can define the amount of Ether in voting that review at the time of opening an issue.

8) Voting an issue: Customers who purchased a product that contains an issue can participate in the issue by voting. A voter can decide to vote "yes" to agree or "no" to disagree with the issuer's argument. The level of confidence depends on the amount of Ether the voter spends. While everyone can see the realtime voting result, there might occur the last-minute voting problem. In order to prevent it, the voting timeout is extended in a period of time if there still exists voting near the ending time. When the extended time is up without additional votes, the voting result is summarized. If "yes" score wins, the review is marked as a fake review. Otherwise, it is still in the same place. The reward calculation can be illustrated as (2), (3), and (4). Firstly, the reward portion (P) is calculated by dividing the user's voting amount (V_{own}) with the total voting amount in the same side ($V_{total\ same}$). If there exist the additional reward ($R_{addition\ total}$) from an unused order, it is shared among the winners by ($R_{addition}$) value. Finally, the voting reward (R) is the partition of total votes in the opposite side ($V_{total\ opposite}$) plus the voter's vote amount (V_{own}) and the portion of additional reward ($R_{addition}$). The reward is distributed amog the winners. Investing more Ether increases the portion of the earned reward. However, losing an issue means wasting all invested Ethers too. With this condition, voters need to be confident in their votes.

$$P = \frac{V_{own}}{V_{total\ same}} \tag{2}$$

$$R_{addition} = P \times R_{addition\ total} \tag{3}$$

$$R = (P \times V_{total\ opposite}) + V_{own} + R_{addition} \tag{4}$$

C. Performance

We tested the system on the Ethereum Ropsten test network because it uses POW as a consensus algorithm. Thus, the result is nearest the main network. Objectives of the experiment is to evaluate cost and response time for a transaction. The Gas price used in the experiment is 3 GWEI since it is the average speed of the transaction suggested by the Metamask wallet. We tried submitting 20 transactions for each method. The experiment results are presented as followings:

1) Response time: We focus on two types of response time; hash time and block time. Hash time is the duration starting from a transaction is submitted until it gets the transaction hash. Block time is when a transaction is submitted until the time that it is recorded in the blockchain. From the experiment, the average hash time ranges from 1 to 2 seconds. At the same time, the block time is in the range of 20 to 30 seconds.

2) Transaction cost: Each method consumes a different amount of cost as shown in Table II.

The result presented in Table II is the number of gas used for each transaction. The actual cost can be calculated by defining gas price value and multiply with the gas used value. For example, the gas price is 3 GWEI. The transaction cost of the "Add product" method is 78,379 x 3 GWEI, which is 235,137 GWEI (1 GWEI = 10^{-9} Ether). The transaction cost in fiat can be calculated by considering the Ether value comparing to fiat. For instance, the Ether value at the time of writing is 244.55 USD. As a result, the transaction cost for the "Add product" method in fiat is 235,137 x 10^{-9} x 244.55 USD, which is 0.0575 USD.

TABLE II. Gas used for each Method

Method Name	Gas Used
Add product	78,379 ($\pm$ 7,246)
Update product	26,024 ($\pm$ 0)
Update profile	25,442 ($\pm$ 0)
Create order	117,374 ($\pm$ 16,807)
Purchase	81,233 ($\pm$ 2,589)
Post review	50,216 ($\pm$ 4,085)
Delete review	27,148 ($\pm$ 0)
Update review	30,080 ($\pm$ 0)
Reply review	27,725 ($\pm$ 0)
Give helpful	50,203 ($\pm$ 3,338)
Open issue	133,041 ($\pm$ 16,432)
Vote	75,277 ($\pm$ 7,131)
Get reward	71,743 ($\pm$ 11,475)

IV. Discussion

As mentioned in Section II, today's popular online review platforms have their strengths, but they lack some important components. The proposed work tries to gather all advantages to raise the highest credibility to the world of online review as much as possible. With the blockchain, there are many advantages compared to the existing solutions. However, some weaknesses still exist. Both advantages and disadvantages are described below:

A. Advantages

1) Global database: Today online reviews are separated in each platform. A business that participates in more than one platforms might have many versions of its reviews. It much improves their credibility, if all of those are the same trend. In contrast, if those versions have big differences, the business loses its credibility from the consumers. The platform might be one main factor of the difference score because of the platform providers' different practices. Keeping the review in one place handles this problem and helps consumers to focus on one point of trust. The business gets the benefit from this practice too. By using the blockchain as a global database, every platform can use the same version of the reviews. The businesses do not need to begin with zero reviews when they move to a new platform. The global database is an ability that cannot easily be achieved with the centralized system since it needs trust among the database providers.

2) The value of review: Before posting a review, the customer needs to purchase a product. Moreover, posting a review to the smart contract needs transaction costs. Thus, a review presented in the system is more valuable because of the effort needed to generate it. A review can also be treated as a

property of the review author and the business that gets reviewed. While the review is recorded permanently in the blockchain, it is bound to the author and the business addresses. This framework does not rely on any authority. As a result, the reviews are still valuable if at least one platform uses the system. In contrast, the reviews are unworthy if a platform that is maintained by an authority stops the service.

3) Communinty-driven ecosystem: As described in the previous sections, the community promotes quality reviews and tackles fake reviews. In reality, defining good or fake reviews is not a simple task. It cannot be handled by just using text analysis or some automatic filtration because it depends on the real experience that a customer met. The people who can give the best answer are those who get the same experience, not the automatic filtration system or any specialist. The extremely positive reviews can be fake or honest, and in the same case for the extremely negative reviews. The majority controls the direction of the system. Thus, the proposed work lets the full control of the ecosystem to the users. This feature cannot be accomplished without trust in the centralized system since a system needs the maintainer who has the highest privilege to control everything in the platform.

4) Real purchasing validation: Some current platforms do not allow customers to post a review without purchasing a product. The validation procedure uses the data in the centralized database to check the user's purchasing status. Obviously, the status can be changed by the platform owner. There might exist the case that a business pays to the platform to boost its review score. Additionally, the purchasing status might get fake by the platform provider itself. These practices cannot be done in the proposed framework. All purchasing states are the real transactions generated by the actual purchasing between the customer and the seller. Thus, generating fake negative reviews needs much effort to do. On the other hand, fake positive reviews might be generated by friendly businesses or third customers. However, these actions can still be detected by users. Since the transaction history in the blockchain is exposed publicly, anyone can find the relationship between those accounts. Consequently, it provides useful clues to judge the fraudulent activities in the system.

5) Two levels promotion: In the popular Trip Advisor platform where the incentive does not exist, plenty of reviews are still generated every day. One of the factors is that Trip Advisor is a popular platform with a large traveling community. The user's contribution history impacts the review credibility, and it is an opportunity for the reviewer to make their profile. In the proposed framework, the user contribution creates more impact since every action needs cost to do. Moreover, the incentive is available in the proposed system. This incentive directly promotes the reviewer to create a review that gives benefit to the readers. Unlike the general platforms that give reward to every reviewer who follows up some conditions such as the minimum word count, the graphical information. The result from that practice is low-

quality reviews from the users who only need a reward from posting a review. In the proposed framework, the customers are promoted in two levels to keep the best practice in their reviews and avoid the punishment. The first is the reward from the helpful score and the last is the contribution history which directly impacts the reviewer's credibility.

6) On-demand review: The businesses can express their requirement for reviews by adjusting the review value. Increasing the review value motivates the reviewer to post review more. The business can also minimize the review value if it does not need more reviews in a period of time.

7) High-level data protection: As mentioned in the basic knowledge about the blockchain, the possible attack that can manipulate the newly recorded data in the blockchain is 51% attack. It needs extremely high effort and cost. Hackers receive little gain compared to the effort they need use to attack the system. In addition, hacking the blockchain network is almost impossible because the difficulty increase along with the number of transactions in the network.

B. Other Issues

1) Changing of Ether value: In the proposed framework, the main currency that is used to drive every action in the system is Ether. Since the Ether is a volatile currency, its value change over time. As a result, the transaction cost can be very cheap and expensive sometimes. To deal with the high transaction cost, the sender might reduce the gas price value when the Ether value is very high. Another case is in the purchasing procedure, where a business defines the product price for each order. The volatility of Ether might affect the business that mainly uses fiat to define the product price. The created order needs to be purchased immediately before the Ether value gets much different. Otherwise, the business needs to create a new order where the additional transaction cost is needed. This issue can be solved by using a stable coin for purchasing procedures. However, the transaction cost might be higher than those which appear in this work. The best solution is to use the cryptocurrency as the main currency in the system. It might be possible for a blockchain network with enough speed and cheap transaction cost, where people prefer to use it as the main currency.

2) Uncommon user interface: Like every new technology in the early phase, general users are not familiar with its processes. In the proposed framework that utilizes the blockchain as the core system, users must keep their private key secretly. Besides, they might also need to know about the gas price and gas limit they define every transaction. Moreover, the submitted transaction is not complete until a bunch of time for Block confirmation. This experience needs some time for people to get familiar. Fortunately, many DAPPs are being developed and coming closer to general users every day. The day that people use DAPPs as the primary applications is not so far from now.

V. CONCLUSION AND FUTURE WORK

The main contribution of this work is to discover the potential features of a blockchain-based online review system. We proposed a global-scale online review for tourism system. The same version of consumer reviews can be displayed seamlessly in any platform. The proposed framework supports consumers and businesses better than the centralized approach. Consumers can be confident that the review score is not affected by the platform providers. Beside the businesses can maintain the same rating score regardless the platform they take part. Low-quality review handling is a challenge for the global-scale review system. The automatic filtration is a popular solution that the existing platforms use to address the problem. However, such complex solution cannot easily operate on-chain. Thus, we enforce a set of rules for maintaining the review trustworthiness. A customer needs to purchase a product before posting a review to that product. The posted reviews can be marked as "fake" or "low-quality" when the majority users agree. Every action in the system is recorded permanently and exposed publicly. Violent actions undermine the reviewer credibility. In contrast, well actions increase the author faithfulness. The review authors get incentivized from those actions. As a result, the system environment motivates users to take actions properly. Eventually, this framework can be easily integrated into the existing platforms and acts as an alternative way for the users who need more credible information. This way, people can get familiar with the uncommon interface of the framework.

The proposed work still has some features that can be improved more, such as the ability to check purchasing status for fiat, consuming validation without payment. These abilities provide the wider potential of usage since people still use fiat as the main currency today. Moreover, the reviews that does not need to be purchased are the general use cases in the online review system, such as attraction reviews. It needs off-chain verification to validate those events. A possible way to do is to use an Oracle. These issues will be investigated in future work to improve the capability of this work.

REFERENCES

[1] J. Worthington, "Executive Summary: Holiday Planning and Booking Process- UK-May 2018," 2018.

[2] U. Gretzel and K. H. Yoo, "Use and Impact of Online Travel Reviews," Inf. Commun. Technol. Tour. 2008, pp. 35–46, 2008, doi: 10.1007/978-3-211-77280-5_4.

[3] S. Gossling, C. M. Hall, and A.-C. Andersson, "The Manager's Dilemma: A conceptualization of online review manipulation strategies," Curr. Issues Tour., vol. 21, no. 5, pp. 484–503, 2018.

[4] CliveNicol, "Review censorship!!!??," 2015. [Online]. Available: https://www.tripadvisor.com/ShowTopic-g1-i12105-k8465871-o60-Review_censorship-Tripadvisor_Support.html. [Accessed: 13-Jul-2020].

[5] M. McGrath, "Why Consumer Reports Says You Can't Trust Angie's List," 2013. [Online]. Available: https://www.forbes.com/sites/maggiemcgrath/2013/09/18/why-consumer-reports-says-you-cant-trust-angies-list/#647bc5531bfa. [Accessed: 10-Jan-2020].

[6] L. S. Chen and J. Y. Lin, "A study on review manipulation classification using decision tree," in 2013 10th International Conference on Service Systems and Service Management - Proceedings of ICSSSM 2013, 2013, pp. 680–685, doi: 10.1109/ICSSSM.2013.6602538.

[7] I. E. Vermeulen and D. Seegers, "Tried and tested: The impact of online hotel reviews on consumer consideration," Tour. Manag., vol. 30, no. 1, pp. 123–127, 2009, doi: 10.1016/j.tourman.2008.04.008.

[8] S. Park and J. L. Nicolau, "Asymmetric effects of online consumer reviews," Ann. Tour. Res., vol. 50, pp. 67–83, 2015, doi: 10.1016/j.annals.2014.10.007.

[9] Z. Liu and S. Park, "What makes a useful online review? Implication for travel product websites," Tour. Manag., 2015, doi: 10.1016/j.tourman.2014.09.020.

[10] E. J. Lee and S. Y. Shin, "When do consumers buy online product reviews? Effects of review quality, product type, and reviewer's photo," Comput. Human Behav., vol. 31, pp. 356–366, 2014, doi: 10.1016/j.chb.2013.10.050.

[11] B. Fang, Q. Ye, D. Kucukusta, and R. Law, "Analysis of the perceived value of online tourism reviews: Influence of readability and reviewer characteristics," Tour. Manag., vol. 52, pp. 498–506, 2016, doi: 10.1016/j.tourman.2015.07.018.

[12] C. Commision, "WHAT YOU NEED TO KNOW ABOUT: Online reviews—a guide for business and review platforms," Canberra, Australien Captial Territory, 2013.

[13] Y. Shen, W. Shan, and J. Luan, "Influence of aggregated ratings on purchase decisions: an event-related potential study," Eur. J. Mark., 2018, doi: 10.1108/EJM-12-2016-0871.

[14] R. Wu and C. Qiu, "Seller manipulation of consumer reviews under competition," Proc. Annu. Hawaii Int. Conf. Syst. Sci., vol. 2016-March, pp. 3575–3583, 2016, doi: 10.1109/HICSS.2016.447.

[15] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," Consulted. 2008, doi: 10.1007/s10838-008-9062-0.

[16] Q. Lu and X. Xu, "Adaptable Blockchain-Based Systems: A Case Study for Product Traceability," IEEE Softw., vol. 34, no. 6, pp. 21–27, 2017, doi: 10.1109/MS.2017.4121227.

[17] L. Wang, X. Luo, Y. Hua, and J. Wang, "Exploring How Blockchain Impacts Loyalty Program Participation Behaviors: An Exploratory Case Study," in Proceedings of the 52nd Hawaii International Conference on System Sciences, 2019, doi: 10.24251/hicss.2019.553.

[18] F. P. Hjalmarsson, G. K. Hreioarsson, M. Hamdaqa, and G. Hjalmtysson, "Blockchain-Based E-Voting System," in IEEE International Conference on Cloud Computing, CLOUD, 2018, pp. 983–986, doi: 10.1109/CLOUD.2018.00151.

[19] G. Wood, "Ethereum: a secure decentralised generalised transaction ledger," Ethereum Proj. Yellow Pap., vol. 151, pp. 1–32, 2014, doi: 10.1017/CBO9781107415324.004.

[20] T. Karode and W. Werapun, "Performance Analysis of Trustworthy Online Review System using Blockchain," in The 17th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON 2020), 2020, pp. 510–513.

[21] Revain LLP., "Revain Full Whitepaper," 2018.

[22] L. Network, "(LINA) Blockchain Based Application for Innovation LINA Network," pp. 1–34, 2019.

[23] T. M. Switch, "Dentacoin: The Blockchain Solution for the Global Dental Industry," p. 37, 2017, doi: 10.1108/09604521111113465.