A Blockchain-Based Multiplayer Transaction For Tourism Serious Game

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***Abstract*— A tourism serious game requires a transaction system to handle the transaction process's visualization between players. In this paper, we propose a serious game with a blockchain-based multiplayer transaction system. To integrate the transaction system with the game engine, we use the ethereum platform. In this serious game, ethereum handles the simulation of transaction activities between several characters' choices, including tourists, ticket sellers, jeep drivers, traders, and horse rental. The experimental results show that the gas price variable affects the speed of the transaction process. Meanwhile, setting the gas limit value in this serious game affects the transaction process's success rate between players.**

Keywords—tourism, serious game, multiplayer, transaction system, blockchain

I. INTRODUCTION

There are three phases in traveling activities: before the trip, during the trip, and after the trip [1]. Between the three stages, before the trip becomes an essential phase, a tourist prepares and plans the tourism activities they will do in this phase. In the before trip phase, tourists explore data and information before determining the choice of tourism destinations. Today's development makes it easy for tourists to explore tourist destinations from the internet through websites and social media [2]. However, tourists' not all required information is well visualized, especially concerning interactions and transactions between parties at tourist attractions, such as tourists and ticket providers, tour guides, or other parties at tourist attractions. This visualization is important because tourists need an understanding of the activities to be carried out at tourist attractions as a consideration for determining destination choices. To answer this problem, it is necessary to develop alternative media with visualization that makes tourists interested and easier to absorb the information illustrated.

Several studies have developed various forms of media as information providers for tourists, among others, the web [3], mobile application [4], augmented reality [5], and game [6]. Among these media, games are an interesting one to be developed as a medium of learning, simulation, and information visualization. The serious game is one of the game genres appropriate to be used as a medium of learning and visualization. It has elements of teaching, learning, training, adaptation to the environment, and entertainment. [7] [8]. Therefore, this study uses a serious game to simulate and visualize transactions between tourists so that users as potential tourists are interested and easily understand the transaction activities.

We propose an architecture using blockchain technology to support a transaction system's development in a serious game. In some research, blockchain has been used successfully in the cryptocurrency transaction system on Bitcoin [9], tourism rating data sharing [10], medical data sharing [11], and also autonomous transaction for IoT-based e-commerce [12]. Blockchain is a technology platform that uses a decentralized network architecture [13]. This architecture has advantages over other architectures, namely centralized. Using a decentralized architecture, each node in the network has characteristics connected, so that data transmission between nodes does not need to go through the middle node. [14]. Apart from having a decentralized architecture, blockchain also has distributed data sharing characteristics and has better security [15]. This research takes advantage of blockchain's benefits to improve the transaction system's performance in the serious game of tourism.

To integrate blockchain technology, we use Etherium as a platform that supports game design through the Unity 3D game engine. The platform has a Smart Contract feature that allows transaction scenarios to set the game's economic value [16]. We built a serious game with Bromo Mountain tourism's theme to implement the proposed blockchain-based multiplayer transaction system architecture. This game has several characters that can be used by each user to simulate transactions between them. Furthermore, this study's trial phase has a role in determining and analyzing the speed of the process and the success of transactions between users based on several variables on the ethereum platform.

We divide this paper into several sections to explain the steps for designing a serious game and the trials' analysis results. These sections include Introduction, Related Work, Design and Method, Result and Discussion, and finally, Conclusion.

II. RELATED WORK

Several studies discuss the implementation and integration of games in the tourism sector. In a paper, Feifei Xu shows his research results that identify tourists' motivation to play tourist games [17]. In another article, he stated that building a tourism serious game was useful for increasing brand awareness and loyalty to the destination [18]. This paper describes several conceptual examples of the application of games in the tourism sector. Paper [19] proposed gamification techniques on three phases of the trip to support the tourism destination's visiting process. Gamification in the before trip stage has a function to increase the interest of tourists to visit. One way is to design game content that contains visualizations of internal activities at tourist attractions. Paper [20] proposed a tourism game architecture with a multiplayer concept. This research still discusses communication between players to find virtual and real objects in the game and has not yet addressed the transaction system's visualization.

Paper [21] discusses the concept of transactions in the massively multiplayer online games genre. The author of the paper proposes a transaction concept to determine the consistency model in the game environment. Jouni Smed presents four aspects that affect multiplayer computer games, including the communication architecture and control architecture used, for example, centralized, decentralized, distributed, and replicated. At his point, Leo Besancon proposes blockchain as a decentralized and distributed architecture to handle data exchange transactions in video games. He also presented the original data representation of game assets using blockchain to improve the data exchange process [22]. Paper [23] introduced a multiplayer online game using blockchain as realtime cheat prevention to increase security in the game.

III. DESIGN AND METHOD

In this study, we built a transaction system between players for a blockchain-based tourism serious game. Figure 1 shows a proposed system architecture consisting of several parts: player, player device, game visualization, ethereum blockchain transaction system, ethereum blockchain network, and other player devices.

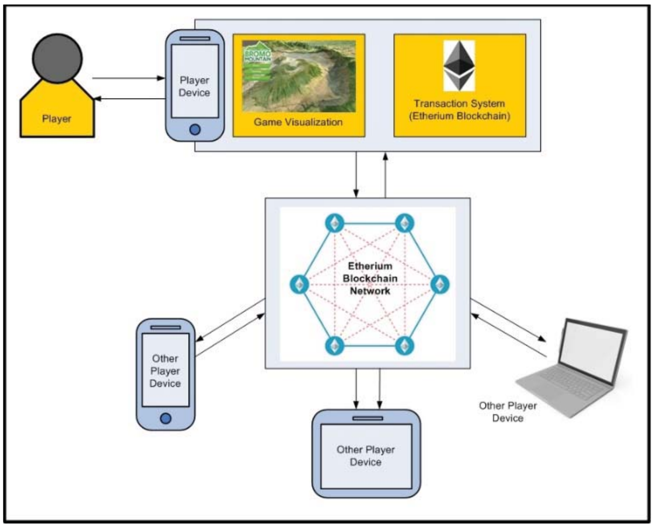

Figure 1: Proposed system architecture

In this study, prospective tourists play games using their own devices, such as smartphones, iPads, or computers. In the user's device, we designed the game visualization using the Unity3D game engine. To build 3D assets, we use Blender3D software. To construct an ethereum blockchain-based transaction system, we use Visual Studio as the Script Editor and Metamask as the blockchain wallet dashboard. The software is open-source with an easy to understand user interface. This research uses the ethereum blockchain network to connect each player device to interact with each other.

Furthermore, this paper describes the research steps in two stages. First, designing and building visualization and scenario of the Mount Bromo tourism game, and the second is building an ethereum blockchain-based transaction system. The details of the two stages are as follows.

A. Mount Bromo Tourism Game

Mount Bromo tourism game is a serious game genre that simulates transaction activities between parties in Mount Bromo tourist attractions. When playing this game, players must follow the game flow, as shown in Figure 2. In the early stages of the game, the player as the host faces the start menu, which can be accessed after acquiring clients in their room. Three menus can be selected on the main menu, starting to enter the gameplay location selection, finding out information about the Mount Bromo tourist park, and exiting to exit the game.

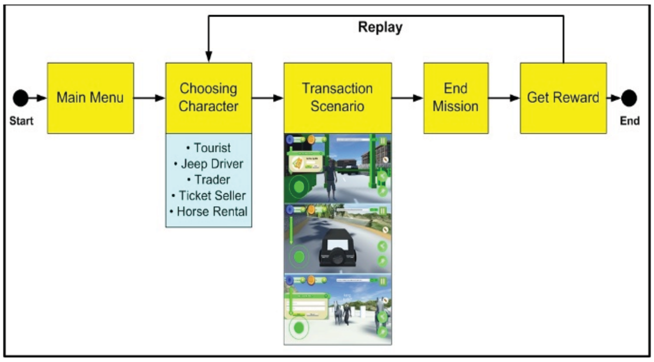

Figure 2: Mount Bromo tourism game flow

After the main menu display, the game's scenario rules start from choosing the character player want to play, where each character has a different role. These characters' choices include tourists, jeep drivers, shop traders, ticket sellers, and horse rental services. After character selection, players will immediately enter the game and carry out tasks according to their respective roles. The tasks of each character are as follows.

- Tourists explore all locations in the tourist park of Mount Bromo.
- Jeep driver driving a jeep rented by tourists.
- Traders are selling goods to tourists.
- Ticket seller sells tickets to tourists who will enter tourist attractions.
- Horse rental services provide horse riding services for tourists.

If the players complete the mission, they will get reward points. Then they can choose to play again or finish playing.

B. Blockchain Transaction

To implement blockchain technology in game design, we use the Ethereum framework. This framework handles the transaction system between players in the Unity 3D game engine. By using blockchain as a decentralized method, allowing players and developers to control transactions jointly. So that players can fully own and manage their items and assets. Players can sell their assets to get the currency they can use both inside and outside the game. Item ownership cannot be changed or deleted even by the developer because the decentralized system is complicated to penetrate. Therefore, using this decentralized system is expected to increase credibility and security in playing this game. Figure 3 shows an illustration of the transaction flow in this proposed game.

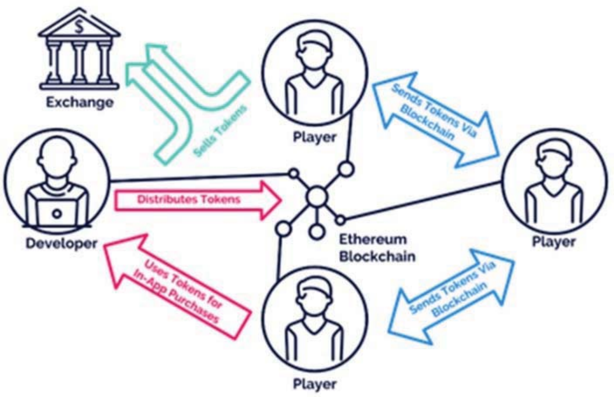

Figure 3: Transaction flow

When the player performs the transaction process in the game, some data is ready to be sent. The data includes the player's identity, type of transaction, and the number of tokens used. The system uses this data as input to be processed by ethereum for verification purposes. After the data is verified, the photon network then processes it to produce a photon output process. Figure 4 illustrates each of these processes.

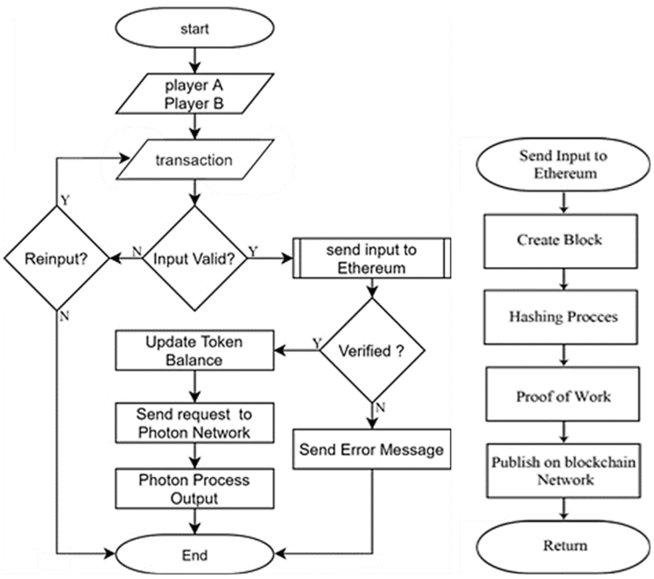

Figure 4: Transaction process

After ethereum gets input data from player transactions, there are several processes this framework carries out, including creating block structures, hashing, validating Proof-of-Work, and publishing to the blockchain network. Figure 5 shows the block structure published on the ethereum blockchain network, including the block header, block index, previous block hash, transaction root hash, receipt root hash, timestamp, difficulty, nonce, gas limit, and the gas used.

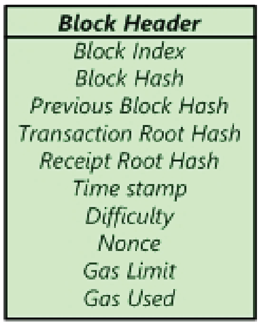

Figure 5: Block structure

A detailed explanation of the parts of the block structure is as follows.

- Block index hash is the index number of the block
- Block hash is the hash value of the block
- The previous block hash is the hash value of the previous block
- Transaction root hash is the hash value that generated for each transaction execution
- Receipt root hash is the hash value of the transaction details
- The timestamp is the time of block creation
- Difficultly is the level of difficulty to mine.
- The nonce is an integer value determined by the miner to select a valid hash value.
- The gas limit is the gas variable limit set for the block
- The gas used is the amount of gas used by all transactions

In an ethereum blockchain-based transaction system, each data input will go through several processes, including creating blocks, hashing, Proof-of-Work validation to broadcast blocks to the blockchain network. Figure 6 shows in detail each step in the process. The first process in sending input data to ethereum is entering data into blocks, including the type of transaction, the value sent, the destination of transaction, gas limit, private critical account. After the data entry to the block, the system performs the hashing process using the Keccak-256 algorithm.

Keccak-256 is a hashing algorithm used on the Ethereum network. This algorithm is similar to the SHA-3 hashing standard, but the two algorithms produce different outputs. This algorithm also produces an output of 32 bytes with an input of an arbitrary length. As with other hashing algorithms, this algorithm also has a characteristic where the initial input generated cannot be easily calculated even with known output.

One of the main functions for Keccak-256 in the Ethereum framework is to handle the creation of account addresses. The address has a hexadecimal value, where each ethereum address is 40 hexadecimal digits long [24]. This algorithm is used automatically in the hashing process by the ethereum and is the framework's default.

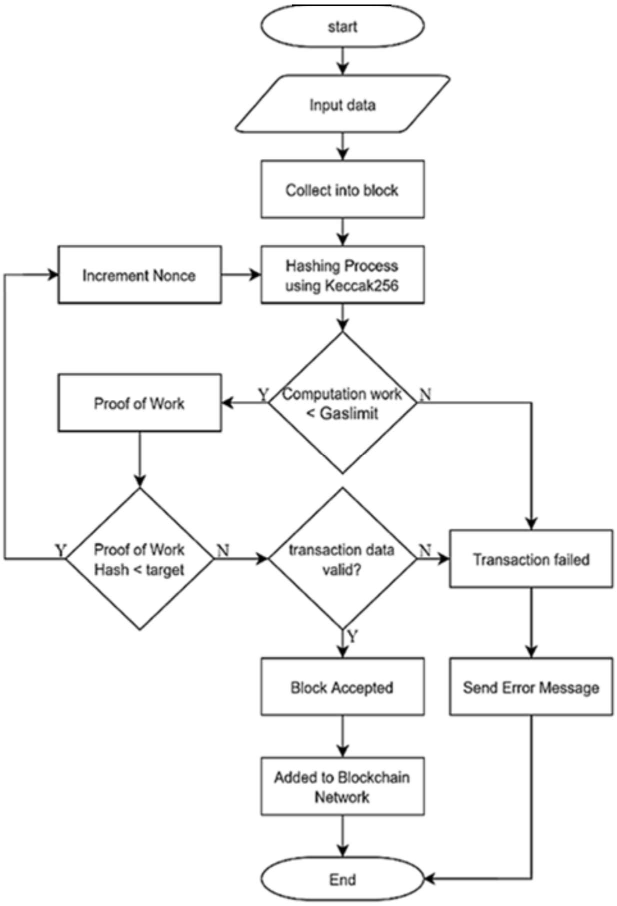

Figure 6: Validation using Proof of Work

The hashing process will check whether the computation amount exceeds the previously entered gas limit value in the unity3D code line. If the computation value exceeds the specified gas limit, the system stops the process. If the computation has not exceeded the gas limit value, it continues to the Proof of Work process. In the Proof of Work process, the system validates the hash value. If the hash value still hasn't reached the target, the system will perform a pseudorandom increment process and repeat the hashing process until the hash value reaches the target. After the target is achieved, the Proof-of-Work process continues to validate the input data. If the data entered is invalid, then the process is stopped, and the program sends a message to the system, in the form of error details. Otherwise, the system continues the block publication process to the blockchain network.

After publishing a new block to the network, each block forms a block's chain to be connected. Each block is associated with a block hash and a previous block hash. For example, the previous block hash of block 2 has the same value as the block hash of block 1, while the previous block hash value is block 3, same as the block hash of block 2. The data contained by the new block is broadcast throughout the network so that every connected node in the network can store the data.

C. Ethereum Blockchain Setup

In the ethereum blockchain setup, this study's first process is to make a wallet that will accommodate smart contract tokens to become the main currency in this tourism serious game. A smart contract is one of the advantages of the Ethereum framework, where everyone can program the transactions they want. In this research, we use smart contracts to create an in-game currency used for transactions between players and developers. Figure 7 shows the flow of smart contract token creation to support the transaction system in this study.

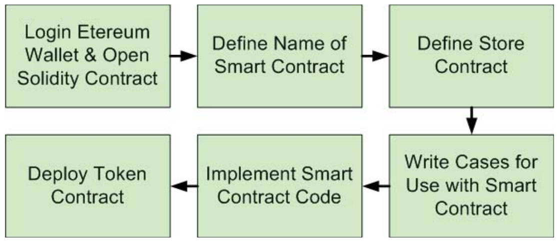

Figure 7: Smart contract creation flow

IV. Result And Discussion

This section describes the results of testing the transaction system carried out between characters. Some examples of transaction activity between characters are as follows.

- When tourists transact with the ticket seller, tourists make payment transactions for Bromo tourism entrance tickets. After tourists have completed payment transactions, the gate bar for tourist attractions opens.
- When tourists have made payments for jeep driver services, the jeep driver takes the tourists to Bromo crater's location.
- When players meet with rental horses, they can choose a horse and make transactions for the rental. The player interacts with horse rental services to simulate a tour by riding a horse.

The transaction testing in this study includes testing the transaction speed, transaction success, and transaction accuracy. Several variables influence testing, including gas price, gas limit, gas used, and data size. Gas price is the cost incurred for each gas used, and the gas limit is the limit for using gas in the transaction process, gas used is the amount of gas used in the transaction process, while data size is the weight of the data that processed in the transaction.

A. Transaction Speed

Several things that affect the speed of transactions include the number of blocks in the network, gas price, and data weight. The more blocks in the blockchain network, the longer the Proof of Work validation process will take. Gas price also affects the speed of the hash value prediction because the more significant the price offered, the faster the transaction process will be. The data weight affects the transaction process's speed because the more influential the processed data's weight, the longer the processing time is needed. It is impossible to change the number of blocks and data weights to adjust the transaction speed. These two variables are variables related to the amount and quality of data. So that among the three variables, gas price is the most likely to be adjusted to get changes in transaction speed. Equation 1 is a reference for calculating the average for processing a transaction.

$$\bar{T} = \frac{1}{n}\sum_{i=1}^{n} Ti \tag{1}$$

$\bar{T}$ is the average time needed to process a transaction. Ti is the time it takes i to process a transaction. n represents the number of experiments. This experiment uses a variable cost of 0.001 Gwei, 0.01 Gwei, 0.1 Gwei, 1 Gwei, 3 Gwei, and 30 Gwei to see the cost effect on time. The value of 0.001 Gwei is the minimum value for this experiment. This value is the lower limit of the miner's fee, so if you use a price below that, the ethereum system will automatically reject it. Figure 8 shows a graph of the difference in transaction time to the gas price value for ten experiments. Based on calculations through equation 1 of the chart, the gas price value of 0.001 gwei has an average transaction time of 60.6 seconds, 0.01 gwei has an average transaction time of 43.1 seconds, 0.1 gwei has an average transaction time of 29.2 seconds, 1 gwei has an average. Average transaction time of 9.7 seconds, 3 gwei has an average transaction time of 6.3 seconds, and 30 gwei has an average transaction time of 3.8 seconds. The graph also shows that when the gas price bid increases, it makes the mining transaction process faster.

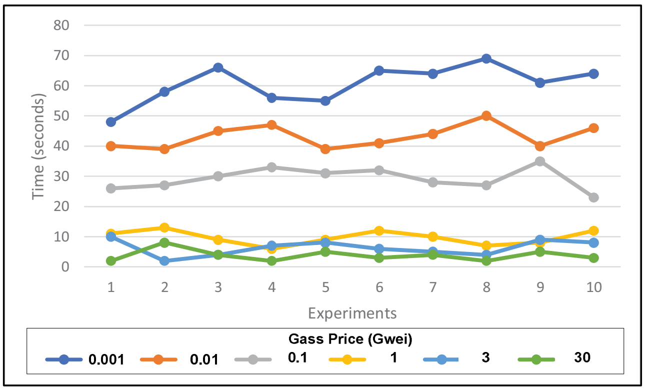

Figure 8: Comparison of gas price value and transaction time

B. Transaction Success

The second test in this chapter aims to get a better transaction success rate for the gas limit value. The serious game's transaction fee is controlled by adjusting the gas Limit value and will not be out of the estimated development cost. Table 1 shows the difference in the success of the transaction on the gas limit value. Based on the table, the gas Limit value of 60000 is the most optimal because it is the smallest value that produces maximum success. Success is an indicator that the data transmission can be processed where the gas used does not exceed the gas limit. Unsuccess indicates that data cannot be processed because the gas used for the transaction exceeds the gas limit value.

TABLE I. GAS LIMIT VALUE FOR TRANSACTION SUCCESS

Experiment	Gas Limit			
	40000	*50000*	*60000*	*70000*
1	Success	Success	Success	Success
2	Success	Success	Success	Success
3	Success	Success	Success	Success
4	Unsuccess	Success	Success	Success
5	Unsuccess	Success	Success	Success
6	Unsuccess	Success	Success	Success
7	Unsuccess	Unsuccess	Success	Success
8	Unsuccess	Unsuccess	Success	Success
9	Success	Success	Success	Success
10	Unsuccess	Success	Success	Success

C. Transaction Accuracy

Measurement of transaction accuracy at this stage aims to determine the accuracy of transaction cost predictions. The way to get this accuracy value is to compare the estimated cost with a transaction cost. If the transaction cost has a value less than or equal to the estimated cost, the transaction is accurate. Meanwhile, if the transaction cost value is greater, transaction costs will not be accurate. Figure 9 shows the comparison between the estimated cost and transaction cost in 30 experiments. The result is that the experiment occurs six times the transaction cost value that exceeds the estimated cost value. Based on these data, it means that the accuracy value of transaction cost predictions is 80%.

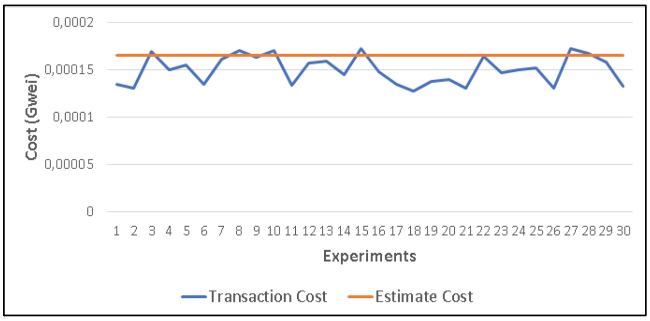

Figure 9: Comparison of transaction cost and estimate cost

V. CONCLUSIONS

This paper proposes a serious game with a transaction system architecture to increase tourists' knowledge of transaction activities between parties in a tourist destination. This serious game has several characters, including tourists, ticket sellers, jeep drivers, traders, and horse rental. The system uses the ethereum framework to handle blockchain implementation in unity3D game engines. Based on the test results, setting the gas price value affects the speed of a transaction process. This effect is that the greater the gas price, the faster the transaction processing time. The experiment results also show that the gas limit with a value of 60,000 is more optimal for use in serious transaction processes for tourism. Besides, the prediction of transaction costs in this study has an accuracy of 80%.

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