Journal of Computer and Communications, 2023, 11, 118-139
https://www.scirp.org/journal/jcc
ISSN Online: 2327-5227
ISSN Print: 2327-5219

A Blockchain-Based Framework for Smart Tourism

Chun He, Caijian Hua

School of Computer Science and Engineering, Sichuan University of Science & Engineering, Zigong, China
Email: hwacj@qq.com

How to cite this paper: He, C. and Hua, C.J. (2023) A Blockchain-Based Framework for Smart Tourism. *Journal of Computer and Communications*, **11**, 118-139.
https://doi.org/10.4236/jcc.2023.117008

Received: June 27, 2023
Accepted: July 25, 2023
Published: July 28, 2023

Copyright © 2023 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

The rapid development and globalization of modern tourism have brought more and more tourists and tourist attractions, bringing opportunities to the tourism industry. However, challenges also come with it, including the cost of travelers' trust, the satisfaction of personalized tourism needs, and the supervision and management of tourist attractions. In order to solve these problems and improve the tourism experience, this paper designs a blockchain-based smart tourism platform. First, by adopting blockchain technology, a decentralized database is established to reduce the cost of trust for travelers. Secondly, through the blockchain-based smart tourism platform, travelers can customize personalized travel routes and itineraries according to their preferences and needs. The platform uses the data interaction function of blockchain to visually display various resources and services of tourist attractions, and travelers can choose according to their own preferences to enhance the personalized experience of tourism. Third, the smart tourism platform based on the blockchain can provide the reliability and transparency of data information, and through the decentralized nature of blockchain, the relevant data of tourist attractions can be recorded and stored, and cannot be tampered with, ensuring the authenticity and credibility of the data. Regulatory authorities can easily access and review these data, and more effectively control and supervise scenic spots. Finally, this paper combines DPOS (Delegated Proof of Stake) and PBFT (Practical Byzantine Fault Tolerance) consensus algorithms to improve the on-chain consensus efficiency of blockchain-based smart tourism platforms. The consensus algorithm is the core mechanism to ensure the normal operation and consistency of the blockchain system, and improve the throughput and performance of the system by introducing DPOS and PBFT algorithms.

Keywords

Trust, Smart Tourism, Scenic Data Information, Regulation, Decentralization

1. Introduction

Smart tourism is an important tool for comprehensively improving the level of tourism development, promoting the transformation and upgrading of the tourism industry, and enhancing tourist satisfaction. It is of great significance to build the tourism industry into a modern service industry that is more satisfactory to the people [1]. Scenic area units should be responsible for the authenticity and accuracy of scenic area data in collaboration with relevant regulatory authorities, and should not tamper with or forge data, to ensure the effective guarantee of the development of the tourism industry in the new era.

However, scenic area units are unable to guarantee the authenticity and accuracy of the data they supervise, which has created a trust gap between tourists and scenic areas [2]. At the same time, problems have also arisen for tourists preparing for "scenic spot check-ins" and regulatory authorities overseeing scenic areas. For example, when people travel, they usually need to consult third-party software platforms for advanced understanding and reservations. However, high intermediary commissions and handling fees have caused high travel costs, false advertising, difficulties in consumer rights protection, lack of protection for personal interests, privacy issues caused by illegal use of personal information, being told there are no rooms available after booking, and temporary malicious price increases and other issues abound in Online Travel Agencies (OTAs), which make it difficult for tourists to judge the authenticity of information and plan their travels accordingly [3].

The diverse and scattered data types in the supervision process of scenic areas and regulatory authorities result in low efficiency in evidence recognition during law enforcement, leading to shortages of law enforcement and judicial resources. In addition, the inability to share data among different businesses creates information silos, and the contradiction between data sharing and data security is difficult to reconcile. The low efficiency of data integration and unified supervision also exist [4]. The data generated by scenic area departments have shortcomings, such as easy loss, forgery, and tampering without a trace, which results in low credibility when used as evidence for law enforcement by tourism management departments, and lack of authority when used as analytical samples for travel and tourism.

Blockchain is seen as the key to unlocking the future of the tourism industry. It is a culmination of various computer technologies, such as P2P networks, distributed databases, Merkle trees, hash functions, asymmetric encryption algorithms, consensus mechanisms, and smart contracts [5]. Transaction information and digital signatures are stored in blocks, which were proposed by Satoshi Nakamoto in 2008. Encryption algorithms, such as hash functions, ensure the security of data on the chain, while decentralized storage ensures the authenticity of information on the chain [6]. Transparency, equality, and decentralization are the hallmarks of blockchain. Due to these features, blockchain can become the "guarantor" of data authenticity in the tourism industry.

In summary, this article aims to improve the quality of monitoring and surveillance data in tourism scenic areas, reduce user trust costs, and facilitate big data analysis by using blockchain technology to develop a trusted ecosystem among regulatory agencies, scenic areas, and tourists. The article proposes the establishment of a blockchain-based smart tourism platform, which ensures the real-time blockchain-based certification of critical information in scenic areas, guaranteeing the authenticity and accuracy of data sources. The platform also builds a multi-level collaborative management ledger, turning regulatory data such as scenic area information and commodity details into reliable legal evidence, effectively enhancing the credibility of tourism scenic areas. Furthermore, the platform enables both horizontal and vertical data communication and sharing, ensuring the safety and immutability of data at the storage level and promoting the improvement of a trusted evidence chain throughout the entire lifecycle of tourist travel. The contributions of this article are as follows:

The design of a blockchain platform architecture to ensure the secure and authentic storage of tourism data on the chain, addressing issues of data security and authenticity.

The design of a consensus algorithm that combines Practical Byzantine Fault Tolerance (PBFT) and Delegated Proof of Stake (DPOS) to improve consensus efficiency and reduce communication costs, enabling consensus among nodes on the chain.

The implementation of a blockchain-based smart tourism platform that presents accurate and authentic information about tourist attractions to travelers.

A forward-looking vision and prediction for the future of smart tourism to drive the development of the tourism industry.

The rest of this paper is structured as follows. Section 2 discusses related work. Section 3 proposes the conceptual framework design of the platform and the consensus algorithm of PBFT combined with DPOS. Section 4 presents the development, implementation, and algorithm evaluation of the prototype system. Section 5 Section gives the conclusion.

2. Related Work

In this section, we discuss related work on smart tourism and blockchain.

2.1. Information Technology for Smart Tourism

There are two main perspectives for applying information technology to smart tourism, namely the Internet of Things and big data analysis [7].

Wang *et al.* provided an overview of IoT systems empowered by 5G and AI for intelligent tourism from the perspective of the IoT. They applied the advantages of 5G technology in efficient data transmission and AI-based intelligent data processing to optimize the data processing capability of smart tourism [8]. Peng *et al.* integrated the IoT into tourism projects to maximize information communication and proposed a human-guided machine-learning classification method based on tourist selection behavior to effectively help tourists make decisions when choosing a tourism destination [9].

Zubiaga *et al*. conducted research in the field of big data analysis for smart tourism and proposed a method for managing tourist flow based on the analysis of data collected from monitoring devices, which generates information for analyzing passenger flow. This ensures that city managers can make management decisions when tourism capacity is exceeded and overtourism occurs in the current context of big data [10]. Xia pointed out the obvious deficiencies in internet information loading and user experience, and improved collaborative filtering algorithms based on tourist data to develop a stable intelligent travel recommendation system that aims to recommend travel-related information to users in a targeted manner, improving the user experience [11].

In summary, most of the previous research has focused on the use of information technology to guide tourists (such as AI communication and tourism recommendations). However, there has been a lack of consideration on how to ensure the authenticity of tourism-related information. Typically, the obtained data is stored in a centralized database (such as the scenic spot organization), and from the perspective of interests, a centralized database may have the disadvantage of being tampered with and containing false information. If tourists are guided by false information, they may incur unnecessary financial, physical, and human losses. Therefore, research on how to use information technology to ensure the authenticity of tourism information is necessary.

2.2. Blockchain and Its Application in the Field of Smart Tourism

The blockchain is essentially a blockchain-style data structure that processes transactions through transparent and credible rules, builds unforgeable, tamper-proof, and traceable blockchain data structures [12]. Among them, the blocks on the blockchain are generated according to their respective. The time sequence is linked, and the security of data transmission and access is guaranteed through cryptography. The smart contract code and the data on the chain form an automated script code, and the blockchain is stored in all servers. Using the distributed characteristics, as long as there is one server in the system that can run normally, and its entire blockchain can be guaranteed to be safe [13]. The distributed network nodes of the blockchain maintain their own blockchain ledgers, and the transaction information in the block is verified by the respective blockchain nodes to reach a consensus through a consensus algorithm. The saved data cannot be tampered with, and the changes to the data on the chain are traceable to ensure that the data on the chain cannot be tampered with.

In terms of the application of blockchain in smart tourism, Elnaz Irannezhad and Renuka Mahadevan proposed that blockchain is a disruptive technology that enables P2P transactions to be decentralized, encrypted, intelligent, and secure, making it suitable for application in smart tourism. The dispersed nature of the tourism industry, with frequent contracts and transactions among various groups, creates security risks, disputes, and delays, all of which can be addressed by using blockchain technology [14]. Tyan *et al.* developed a blockchain-based medical tourism review system that requires multi-party authentication for data processing, consensus, and publication, preventing environmental data forgery, and ensuring secure data sharing and privacy through cryptocurrency payments [15]. Luo *et al.* pointed out that the traditional tourism industry can be reformed and innovated through blockchain technology, connecting travel companies and tourists through a reliable platform to lower travel costs and improve efficiency [16]. Zhou *et al.* suggested that tourism platforms can use blockchain technology to disclose product information, enhancing their core competitiveness [17].

To sum up, blockchain applications mainly rely on the following three functions: 1) Decentralized recording of relevant information to ensure information security, transparency and traceability; 2) Chained storage structure of blockchain Making the on-chain information non-tamperable ensures its authenticity; 3) Automatic execution of business transactions; these functions make the blockchain a trustworthy platform, while reducing interest disputes among platform users. When key tourism information is stored on the chain, the blockchain will record it, and all participants on the chain can see it. Once an interest dispute is discovered, the information recorded on the chain can be used as judicial evidence for accountability.

3. Design of Smart Tourism Platform Based on Block Chain

In this section, we propose a conceptual framework for a blockchain-based smart tourism platform. Specifically, we introduce the architecture of the blockchain system, the on-chain information flow, and study its main framework, on-chain information flow, and the design and technical advantages of the platform.

3.1. Overall Conceptual Framework

Ensuring the authenticity of data in tourist attractions is an effective way to reduce the cost of user trust. The conceptual framework proposed in this paper is shown in **Figure 1**, which includes the scenic spot, blockchain network, and end users. Through the integration of sensors and wireless processing protocols at each site (ticket gate, merchant scanning window, parking station entrance), and manual management of scenic spots, the collected data is uploaded to the decentralized blockchain network storage. In a blockchain network, data can be accessed by every node and cannot be tampered with. In the following chapters, this article mainly focuses on the blockchain network, and discusses in detail the technical advantages of the blockchain to ensure the authenticity of information in tourist attractions.

3.2. Information Flow on the Chain

In this study, the open-source system HLF (Hyperledger Fabric) was used as the

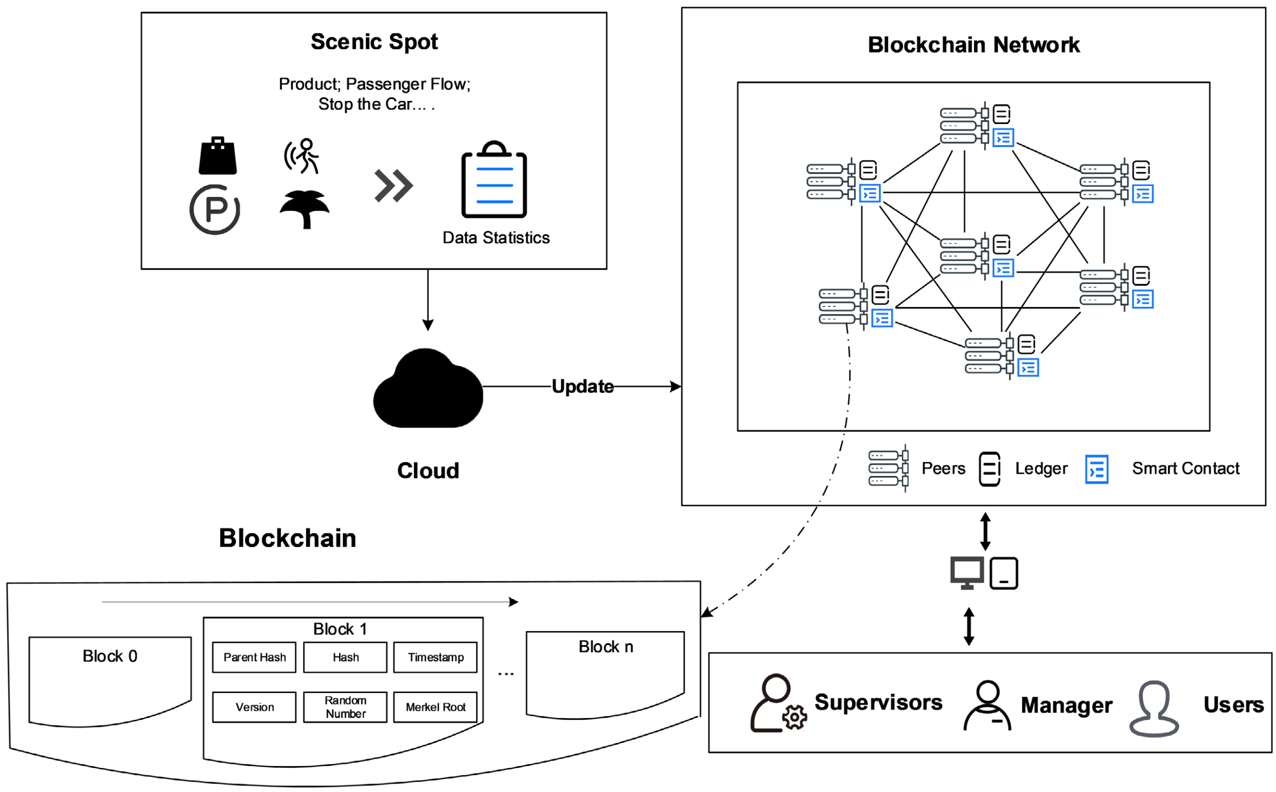

Figure 1. Conceptual framework of smart tourism platform based on blockchain.

platform architecture for deploying and operating permissioned blockchains. Compared to permissionless blockchain architectures, it can guarantee the privacy requirements and data authenticity in tourism industry, and is more energy-efficient and easy to implement.

Fabric is a permissioned blockchain that implements the concept of Membership Service Provider (MSP) and Fabric Certificate Authority (Fabric-CA) for authorization. MSP is a modular part of HLF that provides identity for all nodes participating in the blockchain network [18]. Fabric-CA manages membership by registering, adding, and revoking member certificates. In a blockchain-based smart tourism platform, all participants need to send a registration request through the client to join the blockchain network. Once registered, participants can access and process information on the blockchain within the allowed scope.

Tourist organizations and merchants submit tourism and merchandise data to the client, which converts the information into transactions. The client then submits the signed transaction to the endorsing peers. The endorsing nodes operate a simulation to check the validity of the proposed transaction. If the following are verified, the endorsing node produces a transaction result, including a response value, read set, and write set: 1) correct information format, 2) not previously submitted (replay attack protection), 3) validity of the signature using MSP, and 4) appropriate authorization for the submitter (client) to execute the proposed operation on that channel. Channels can be used to partition the state of the blockchain network [19].

When the client collects enough responses from the endorsing nodes, the ordering node will distribute the transaction blocks to all nodes in chronological order. Each peer in the channel will verify each transaction in the block to ensure that signatures, endorsements, and endorsement policies are compliant.

Inside the blockchain, there are mainly the following four transactions:

Business information (Type = 1, idT, S, T, P). When the status of a merchant in a scenic spot is updated, the merchant itself will issue a transaction to change the information. Each merchant transaction has the following four fields:

- Merchant ID (idT): A unique identifier for the merchant.
- Status (S): The latest status of the merchant, which can be "Open" or "Closed".
- Time (T): The time of the merchant's latest status.
- Signature (P): The signature of the merchant in the scenic spot that can be publicly verified.

Such a transaction means that at time T, the status of merchant idT is updated to S.

Commodity information (Type = 2, idT, idV, V, T, P1, P2). When a merchant in a scenic spot enters new products, the merchant will release a transaction with changed product information. Transactions for each listing have the following four fields:

- Item ID (idT): A unique identifier for the item.
- Merchant ID (idV): A unique identifier for the merchant.
- Price (V): The price of the item.
- Time (T): The time when the product information is on the shelf.
- Signature (P1): The signature of the merchant in the scenic spot that can be publicly verified.
- Signature (P2): The signature of the scenic institution that can be publicly verified.

Such a transaction means that at time T, the merchant idV prices the product idT at V and puts it on the shelves for sale after being verified by the scenic spot organization.

Access records (Type = 3, idT, idV, idY, T, PV, PT). When a traveler consumes in a merchant store, there will be a visit record transaction published by the traveler. Each access record transaction has the following five fields:

- Merchant ID (idT): Unique identifier of the merchant being visited.
- Passenger ID (idV): Unique identifier for the traveler.
- Item ID (idY): Unique identifier for the item
- Time (T): Access time.
- Passenger Signature (PV): The signature of the traveler that can be publicly verifiable.
- Travel Signature (PT): The signature of the scenic spot merchant that can be publicly verified.

Such a transaction means that at time T, tourist idV consumes commodity idY at merchant idT.

Token transfer (Type = 4, id1, id2, v, T, P1). Tourists and merchants may transfer tokens to each other, resulting in token transfer transactions. Each transaction of token transfer has the following four fields:

- Sender ID (id1): The unique identifier of the sender, which can be a traveler or a merchant in a scenic spot.
- Recipient ID (id2): The unique identifier of the recipient, which can be a tourist or a merchant in a scenic spot.
- Amount (v): The amount of tokens to transfer.
- Time (T): The time when the transfer behavior occurred.
- Sender's Signature (P1): The publicly verifiable signature of the sender.

Such a transaction means that at time T, the amount of v tokens is transferred from id1 to id2.

3.3. Related Technical Advantages

3.3.1. Distributed Storage of Tourism Data Based on P2P Network

The decentralized database can effectively guarantee the data security of the tourism platform. The platform uses the distributed storage technology of the peer-to-peer (Peer-to-Peer, P2P) network structure through the blockchain to organize all network nodes. Each node stores a copy of the complete data. In the field of tourism, a centralized attraction management agency is indispensable, so a hybrid P2P network is used to ensure the controllability of the platform, as shown in **Figure 2**. Regulatory departments, scenic spots agencies and scenic

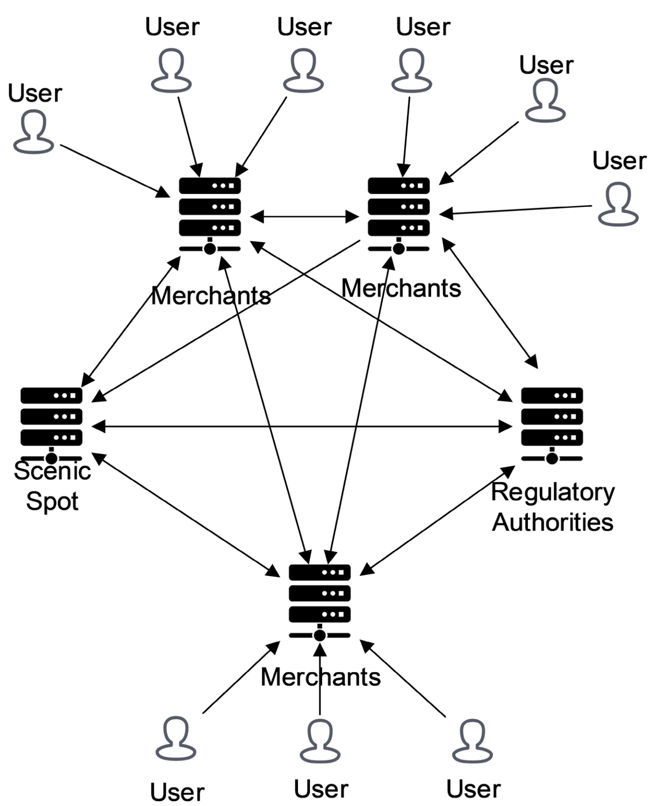

Figure 2. P2P-based network architecture.

spot merchants form a distributed network as super nodes. Each super node and several common nodes form a local centralized network. Data is shared globally except for user privacy data, and only supernodes have the authority to read and write overall user data.

The P2P structure can effectively utilize the vast and decentralized storage resources in the network to achieve distributed storage of credit data. Each node maintains a complete database, which means that all scenic area data is public, transparent, and completely consistent, reducing the cost of trust between nodes [20]. Data is transmitted directly between nodes without going through a third party, reducing the risk of data leakage. This ensures a relatively good reliability of the system, and the damage to a single node database will not affect the normal operation of the entire blockchain [21].

3.3.2. Consensus Algorithm

The consensus mechanism establishes trust between decentralized nodes through mathematical algorithms, ensuring the consistency of data on the blockchain without centralized control [22]. This platform uses a combination of PBFT and DPOS to achieve consensus between nodes, optimizing node selection and reducing the number of consensus nodes to reduce communication consumption.

The PBFT (Practical Byzantine Fault Tolerance) consensus mechanism was proposed by Miguel Castro and Barbara Liskov in 1999, which reduces the exponential complexity to polynomial level based on BFT algorithm [23]. It establishes trust among decentralized nodes through mathematical algorithms to ensure the consistency of data on the blockchain. In this platform, PBFT is combined with DPOS to optimize node selection and reduce the number of consensus nodes for lower communication costs. When a node sends a request to the broadcast network, the main node decides the processing order, and the other nodes execute the request in this order. After more than two-thirds of the nodes in the network reach a consensus on the received information data, the information data is stored on the chain to ensure the consistency of the information data [24].

The consensus process of DPOS (Delegated Proof of Stake) is achieved by electing nodes to allow users in the network to delegate their stake to other users to represent them in the consensus process [25]. In the DPOS algorithm, users can choose nodes they trust as representatives to generate new blocks. They are granted the right to generate new blocks and prove their stake by performing proof of work. Producers generate new blocks and broadcast them to the network, and other nodes verify whether the new blocks comply with the network's rules. When they comply with the network rules, other nodes add the blocks to their respective databases to ensure the consistency of information data [26].

DPOS is used in combination with PBFT to select validators in the consensus network, with a limited number of validators to ensure fast consensus. PBFT is used to handle the actual consensus process. During the consensus process, validators use the PBFT algorithm to go through multi-stage protocols to determine consensus. DPOS provides PBFT with an efficient consensus selection mechanism, while PBFT provides DPOS with stronger fault tolerance. The combination of DPOS and PBFT enables the algorithm to have a mechanism for upgrading and downgrading, simplifying the consensus status, reducing network overhead, and improving consensus efficiency. The process includes initialization, voting, block generation, and consensus.

Initialization: DPOS committee member list and voting weight

When the network starts, all nodes need to initialize the DPOS validator member list and the voting weight of each node. The list of validator members is voted by the network consensus rules, and the voting weight is calculated based on the number of tokens they hold. In DPOS, all nodes have the right to vote, but with different weights. The voting weight calculation formula is as follows:

$$d = s \times p/\text{sum} \tag{1}$$

where d represents the voting weight, s represents the number of tokens held by the node, p is the adjustment coefficient, and sum is the sum of the tokens held by all nodes.

Voting: Each node distributes votes to candidate validator members

At the beginning of each block cycle, all nodes can participate in voting and election. A node can assign all of its voting weight to one candidate node, or assign it to multiple candidate nodes. After the voting is completed, DPOS calculates the validator member list based on the voting weight of each node. The number of validators is set to n, and n is currently set to one-third of the total nodes.

Uplink: The node sends a data uplink request

The node sends a data uplink request to the master node and sends the original message m, and the master node sends a message m1 to each verifier node for verification (m1 can only be received by the verifier node).

Consensus: All validator members confirm new blocks through the PBFT consensus algorithm

All validator members confirm messages through a three-phase consensus protocol. When the validator members reach a consensus, the master node broadcasts the message m2 to the network (m2 can only be received by non-validating nodes), and the rest of the nodes add new blocks through the broadcast information and become part of the blockchain. The algorithm flowchart is shown in **Figure 3**.

The flow chart of the three-stage consensus protocol in the PBFT consensus process is shown in **Figure 4**, which includes three broadcast communication processes and five state stages [27].

Among them, the Request stage: data uplink request, the node sends an uplink request to the master node.

Pre-prepare stage: The master node receives the chain request and sends the original message m, so that each verification node can obtain the original message.

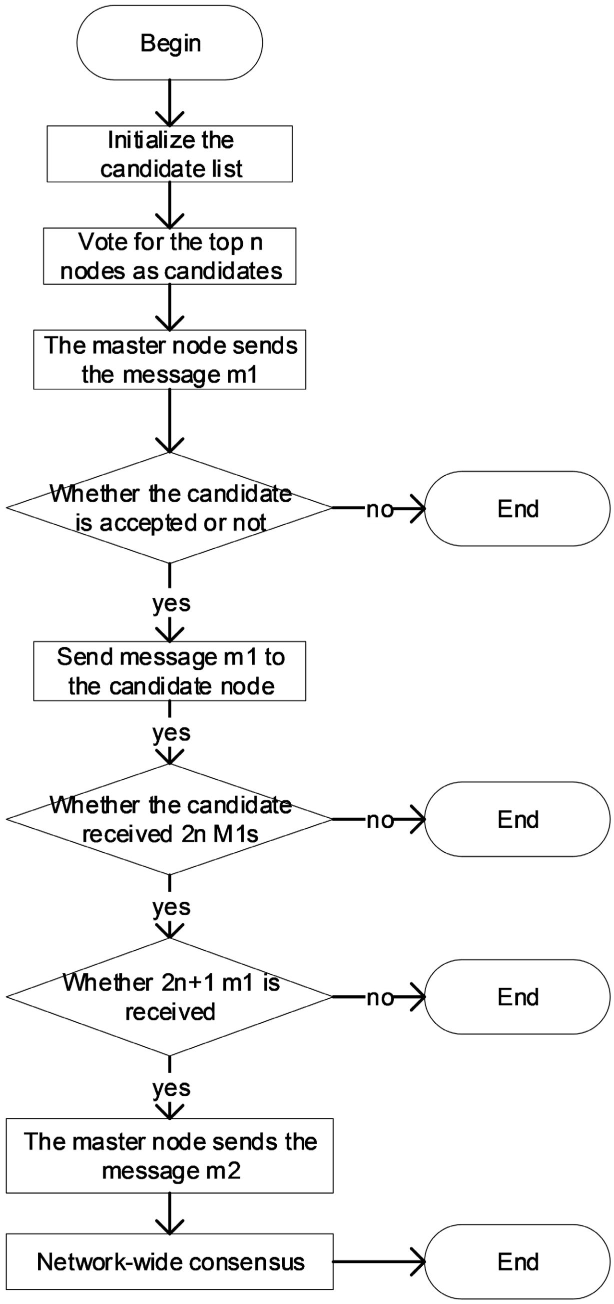

Figure 3. PBFT combined with DPOS algorithm flowchart.

Prepare phase: Use m to send, if a node receives 2f + 1 prepare messages, it is considered "prepared", indicating that most nodes have already agreed with this m. f is the number of faulty nodes, and the value of f needs to satisfy $n \geq 3f + 1$.

Commit: Use m to send. If a node receives 2f + 1 commits, it can be considered that most nodes have "executed" this m.

Reply: All verification nodes enter the Reply stage after receiving the Commit message. Each node performs identity verification of the message sending node, then performs view verification, and then performs hash digest calculation to verify the message m, and finally counts whether the received message exceeds

2f + 1, if it exceeds 2f + 1, it proves that a consensus has been reached, if it is less than 2f + 1, it will be resent.

PBFT combined with DPOS to vote out the candidate node algorithm pseudo-code is shown in **Table 1**.

PBFT combined with DPOS consensus process candidate master node R0 pseudocode is shown in **Table 2**.

3.3.3. Smart Contracts

With the smart contract as the core, the scenic spot specialty commodity trading module and the information sharing module are built for data query. Smart contracts are automated contracts based on blockchain technology, which can automatically execute transactions negotiated by both parties, reduce intermediary links

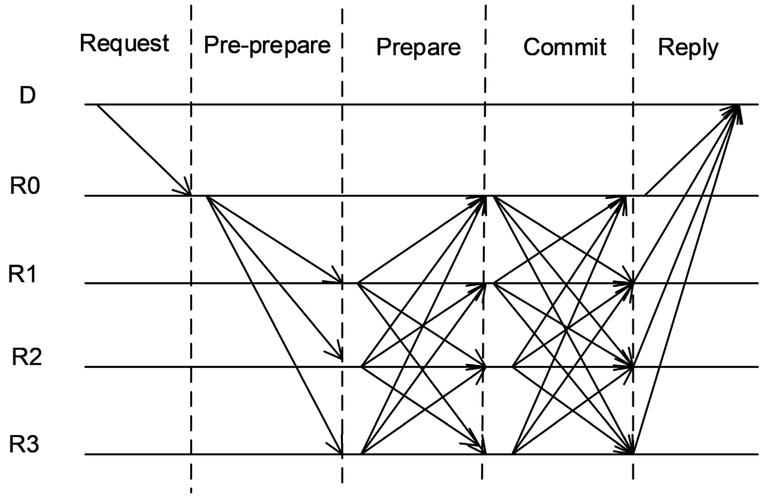

Figure 4. PBFT consensus schematic.

Table 1. PBFT combined with DPOS voting to select candidate nodes.

Require: Nodes participating in the campaign exist
Ensure: Select the candidate node
1: Initialize the number of participating node votes
2: For delegation in delegations do
3: If delegate a representative online then
4: If the delegation is valid for the duration of the authorization then
5: The total number of votes received by the delegate plus the number of votes authorized by that delegate;
6: End if
7: End if
8: End for
9: Sorts nodes in descending order of total votes
10: Return n nodes with the most votes

and transaction costs, and improve transaction efficiency and credibility [28]. At the same time, the transaction status and historical records of specialty products in scenic spots executed by smart contracts will be open and transparent on the chain. The transaction records of specialty products in scenic spots that users inquire on the travel platform can be used as judicial evidence for offline rights protection, ensuring the user's personal rights and interests. Moreover, when the flow of people, vehicles and other information in the scenic spot reaches a certain threshold, the smart contract will automatically execute the early warning procedure to ensure that the scenic spot generates additional risks. The smart contract of the blockchain-based smart tourism platform is shown in Figure 5.

3.3.4. Product Traceability

Detailed commodity information can make consumers in scenic spots more assured to buy favorite specialty products. With the blockchain as the core, a commodity traceability module is established, and each specialty commodity in

Table 2. PBFT combined with DPOS operates at candidate node R0.

```
Require: Data is sent from candidate node R1
Ensure: PRE-PREPARE message
Generate the sequence number M of REQUEST
Generate the PRE-PREPARE message from REQUEST
For i = 1 to 3n do
    Send PRE-PREPARE message to Ri
End for
```

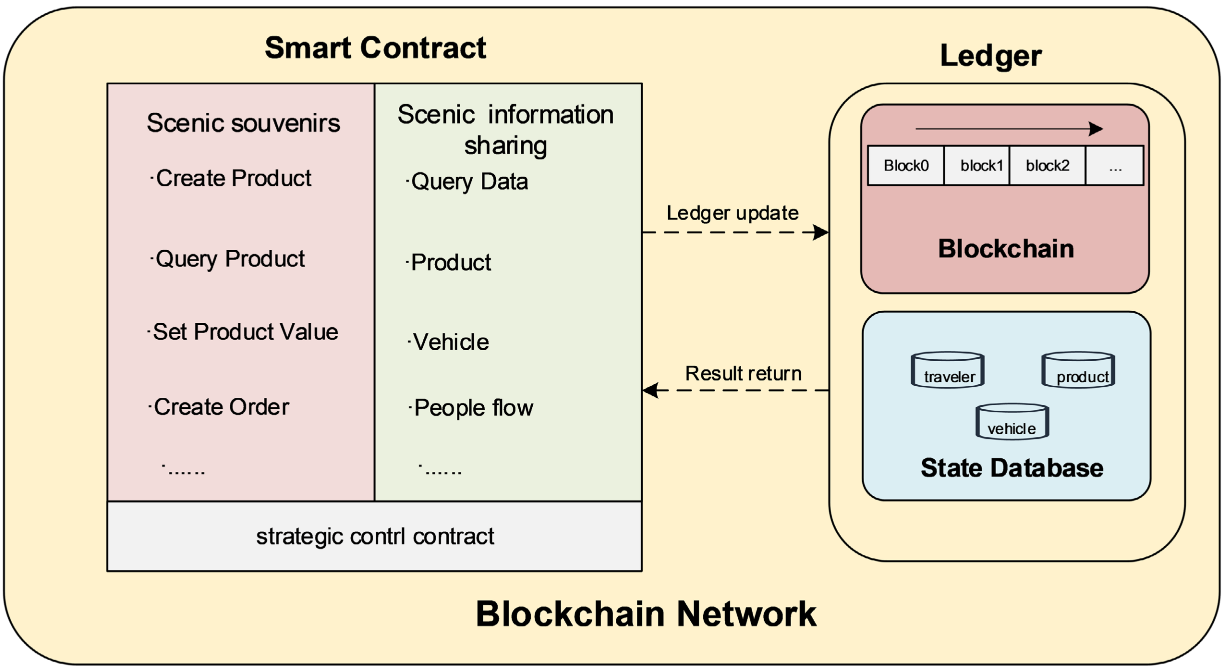

Figure 5. Smart contracts for smart tourism platforms based on blockchain.

the scenic spot will generate a corresponding traceability code, from production, processing, transportation, sales The entire information is recorded on the blockchain, and at the same time, the time stamp of the product information on the chain is saved to provide proof of existence for the data, ensuring that the data can be checked, cannot be tampered with, and is authentic [29]. The traceability code of the blockchain is in one-to-one correspondence with the physical commodity, which can be used as a circulation or as an exchange voucher [30]. Its traceability model diagram is shown in **Figure 6**.

3.4. Prototype Development

The functions and connections of the prototype system are shown in **Figure 7**. The developed prototype is divided into application layer, interface layer, service layer and blockchain layer. Among them, build the blockchain layer in the Linux server, complete the construction of the blockchain platform, create the configure ration files required by the client and other multi-nodes during use, start the alliance chain, and allow other nodes such as regulators to join, complete the construction of tourism blockchain.

The main function of the application layer is to call smart contracts through the interface layer, use smart contracts to realize authorization management and data access control, and provide users with various services and applications. Provide users with login, registration, product traceability and other operations, and grant data certificates to registered users, complete identity confirmation, and perform data interaction with the server through RESTful API. In addition, this layer includes system management, which mainly manages blockchain nodes, organizations, channels, etc.

The interface layer mainly connects the web server and the Fabric blockchain through Fabric SDK and RESTful API. Build smart contracts and application layer interfaces, and call smart contracts. Provide users with login, registration,

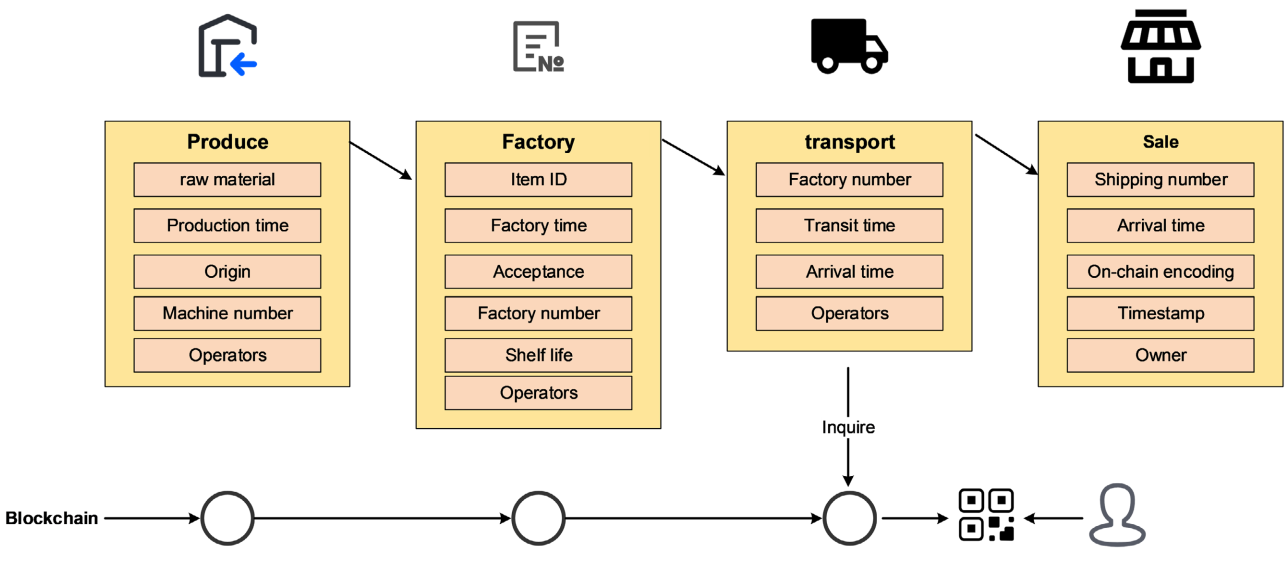

Figure 6. Product traceability data model.

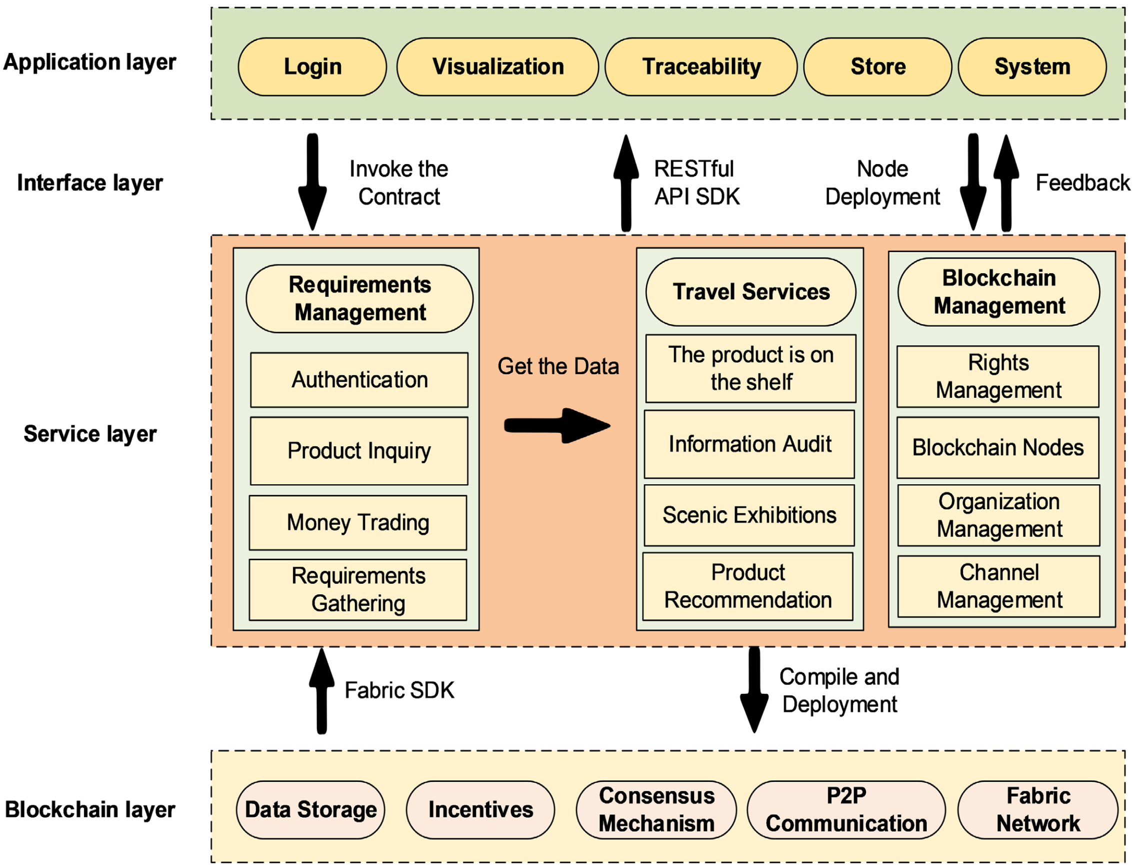

Figure 7. Functions and connections of each layer of the prototype system.

product traceability and other services through the application layer interface.

The service layer mainly provides business services of the smart tourism platform, and specifically implements user management, tourism services and background management functions. Among them, user management uses the trust mechanism of the blockchain to provide functions such as identity verification, product query, and capital transactions. Passengers can query the details of the product through product information to ensure the credibility of the product. Travel service merchants use the non-tamperable feature of the chain information on the blockchain to upload product information, including the holder, place of production, production information, logistics transactions, etc., and the background will review it so that all product information and transaction information on the platform can be verified trace back.

The blockchain layer includes data storage, incentive mechanism, consensus mechanism, P2P communication, etc. Store the key information and smart contracts of the tourism platform to achieve information transparency and ensure its security.

4. Implementation and Evaluation of Smart Tourism Platform Based on Blockchain

This section discusses the platform development environment, the performance evaluation of the platform, verifies the feasibility of the proposed blockchain-based conceptual framework through case studies, and develops a blockchain prototype system in a laboratory environment.

4.1. Development Environment

The blockchain platform studied in this paper uses VMware virtual machines to build local linux servers and build networks through Shell scripts. Smart contracts are implemented in Go language. Develop and implement the Restful interface for resource calls. The front end uses the Vue framework, and the back end uses the Spring Boot framework. This system includes four types of participants: government departments acting as inspectors, scenic spots agencies participating in the review, tourists, and merchants. The prototype system components are shown in Table 3.

4.2. Prototype Implementation

In this case study, we use the example of vehicle information, crowd density, local specialties, and general information about the scenic spot to validate the proposed conceptual framework. The study takes the Shunan Bamboo Sea Scenic Area in Yibin, Sichuan Province, as a reference model and collects part of the scenic area data through field investigations as the experimental basis. The focus is on exploring the potential of blockchain in data recording and monitoring on smart tourism platforms to ensure data authenticity. Therefore, several assumptions were made in this case study: 1) the production process of goods for merchants is roughly the same; 2) the number of vehicles currently passing through the scenic area roads is calculated by the difference between vehicles entering the scenic area and occupying parking spaces; 3) vehicle information is uploaded to display the remaining parking spaces in the scenic area parking lot through parking lot sensors.

The information display on the big screen is shown in Figure 8. The parking lot sensors collect vehicle information data, while the ticket-checking sensors in various areas collect people flow data information. The collected data, including sensor IDs, checkpoint IDs, and specific vehicle and people flow data information, is integrated with the cloud platform, uploaded to the blockchain system,

Table 3. The prototype system components.

System Components	Description
Hyperledger Fabric	Hyperledger Fabric v2.2
Operating System	Ubuntu 20.04
Memory	2 GB
Hard Disk	100 GB
Storage	Mysql
Browser	Google Chrome

Figure 8. Large-screen information display.

and displayed on the smart tourism big screen. Travelers can use the web client to get real-time information on the status of the scenic spot and make reasonable travel arrangements to avoid congestion and insufficient parking spaces. After entering the scenic spot, travelers can observe the scenic spot details based on the big screen route guidance and choose their favorite areas for a fun-filled experience.

In addition to the sharing of scenic spot information, the platform also enables the purchase of specialty products in the scenic spots, and recommends specific products based on users' personal attributes. Tourists can purchase products through the merchants' shelves and trace the source of the products through the product traceability code to obtain information such as place of origin, production date, and on-shelf date. In case of product defects, chain records can be used as legal evidence to protect the rights and interests of consumers. The functional implementation of the traceability system is shown in Figure 9. To reduce repetition, the translation emphasizes the functionalities of the platform, which include purchasing of products, product traceability, and using chain records as legal evidence.

The research case proves that the blockchain-based smart tourism platform has front-end and back-end programs, which can ensure the authenticity of scenic spot information and provide convenience for scenic spot data supervision.

4.3. Performance Evaluation

The throughput and latency of the blockchain will be affected by the number of nodes, and this paper will take the number of blockchain nodes as a parameter, when the researchers specify the same amount of access data but different number of nodes, the platform's delay and data throughput changes.

TPS (Transaction per Second) in blockchain refers to the total number of transactions that are initiated and confirmed by the blockchain within a unit of time. TPS measures the blockchain's ability to process consensus transaction requests, and the higher the TPS, the faster the system runs. Its formula is expressed as:

$$\text{TPS} = \text{Transtions}_{\Delta t} / \Delta t \tag{2}$$

The experiments in this article fixed the number of requests for PBFT consensus algorithm and the improved PBFT combined with DPOS consensus algorithm to 500. Different numbers of nodes were set in the same time for 10 tests, and the average value was taken as the experimental result. The number of nodes was set to 5, 10, 15, 20, 25, and 30 in the experiments. The throughput test results are shown in Figure 10.

From the above experiments, it can be seen that with the increase in the

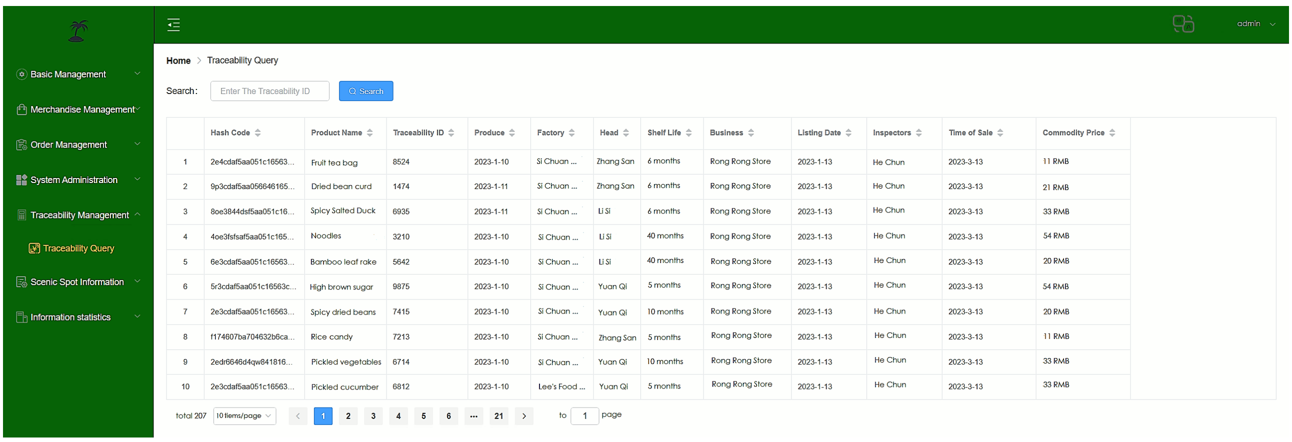

Figure 9. Traceability interface.

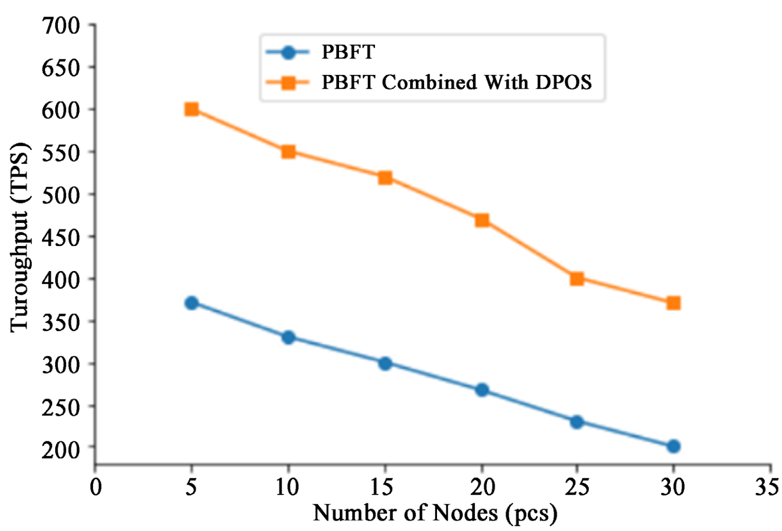

Figure 10. Comparison of PBFT and improved PBFT throughput.

number of nodes, the consumption of system communication resources increases, and the throughput shows a downward trend. However, by sacrificing part of the decentralization feature in the improved algorithm, the number of nodes participating in consensus verification is reduced, thereby reducing system communication consumption.

The consensus delay index in the blockchain refers to the time required from initiating a data on-chain request to the data being confirmed on-chain by the entire network. It is a standard for testing the consensus efficiency of the blockchain network. The lower the delay, the lower the consensus algorithm. Better performance. Its formula expression is:

$$T_{delay} = T_{ensure} - T_{request} \tag{3}$$

Among them, T_{delay} represents the consensus delay of the blockchain, T_{ensure} represents the confirmation time of the quantity on the chain, and $T_{request}$ represents the request time of the data on the chain.

In this paper, the number of requests is fixed to 500 by combining the PBFT consensus algorithm with the improved PBFT consensus algorithm and the DPOS consensus algorithm. Set different numbers of nodes at the same time for 10 tests, and take the average value as the experimental result of this experiment. The number of nodes set in this experiment is 5, 10, 15, 20, 25, and 30 respectively. The delay test results are shown in Figure 11.

According to the experimental results mentioned above, it can be observed that when the number of nodes is small, there is not much difference in latency between the traditional PBFT algorithm and the improved algorithm. Reducing the number of consensus nodes can reduce a certain amount of latency, but the DPOS election of validators requires additional time delay, resulting in a similar latency. However, as the total number of nodes increases, the improved consensus algorithm has lower latency due to the reduced number of validation nodes, and

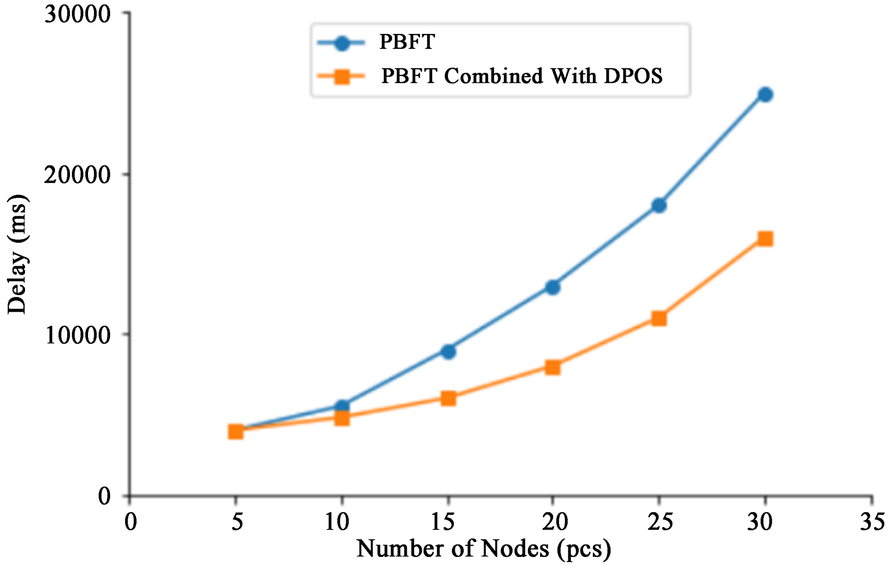

Figure 11. Comparison of PBFT and improved PBFT delay test.

the time taken for the main node to send broadcast verification messages is shorter. Therefore, it can be concluded that when there are many nodes, the improved consensus algorithm outperforms the traditional PBFT consensus algorithm.

5. Conclusion

In this paper, we first proposed a blockchain-based smart tourism platform that brings together tourists, scenic institutions, and merchants to make the data of scenic spots transparent, reduce the trust cost of tourists, and improve the quality of monitoring data for tourism spots. Secondly, a consensus algorithm combining PBFT and DPOS was proposed in the smart tourism platform, which broadcasts among a small number of delegated nodes to achieve consensus on the entire blockchain data and improve the efficiency of consensus. At the same time, a conceptual framework was developed for the application of blockchain in smart tourism. Finally, the smart tourism platform was implemented and extensively tested. The experimental results show that the blockchain-based smart tourism platform can effectively ensure the authenticity and accuracy of data recording. In the future, there are more possibilities for information technology applied to smart tourism platforms, such as introducing VR to smart tourism for users to experience scenic spots in real-time. Additionally, the platform's functionality can be enriched by utilizing the features of smart contracts for automated execution.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Lee, P., Hunter, W.C. and Chung, N. (2020) Smart Tourism City: Developments and Transformations. *Sustainability*, **12**, Article 3958. https://doi.org/10.3390/su12103958

[2] Shen, S., Sotiriadis, M. and Zhang, Y. (2020) The Influence of Smart Technologies on Customer Journey in Tourist Attractions within the Smart Tourism Management Framework. *Sustainability*, **12**, Article 4157. https://doi.org/10.3390/su12104157

[3] Benner, M. (2020) The Decline of Tourist Destinations: An Evolutionary Perspective on Overtourism. *Sustainability*, **12**, Article 3653. https://doi.org/10.3390/su12093653

[4] Atun, R.A., Nafa, H. and Türker, Ö.O. (2019) Envisaging Sustainable Rural Development through "Context-Dependent Tourism": Case of Northern Cyprus. *Environment, Development and Sustainability*, **21**, 1715-1744. https://doi.org/10.1007/s10668-018-0100-8

[5] Lu, Y. (2019) The Blockchain: State-of-the-Art and Research Challenges. *Journal of Industrial Information Integration*, **15**, 80-90. https://doi.org/10.1016/j.jii.2019.04.002

[6] Li, X., Jiang, P., Chen, T., *et al.* (2020) A Survey on the Security of Blockchain Systems. *Future Generation Computer Systems*, **107**, 841-853.

https://doi.org/10.1016/j.future.2017.08.020

[7] Zhang, C. (2020) Design and Application of Fog Computing and Internet of Things Service Platform for Smart City. *Future Generation Computer Systems*, **112**, 630-640. https://doi.org/10.1016/j.future.2020.06.016

[8] Wang, W., Kumar, N., Chen, J., *et al.* (2020) Realizing the Potential of the Internet of Things for Smart Tourism with 5G and AI. *IEEE Network*, **34**, 295-301. https://doi.org/10.1109/MNET.011.2000250

[9] Peng, R., Lou, Y., Kadoch, M., *et al.* (2020) A Human-Guided Machine Learning Approach for 5G Smart Tourism IoT. *Electronics*, **9**, Article No. 947. https://doi.org/10.3390/electronics9060947

[10] Zubiaga, M., Izkara, J.L., Gandini, A., *et al.* (2019) Towards Smarter Management of Overtourism in Historic Centres through Visitor-Flow Monitoring. *Sustainability*, **11**, Article 7254. https://doi.org/10.3390/su11247254

[11] Xia, W. (2022) Digital Transformation of Tourism Industry and Smart Tourism Recommendation Algorithm Based on 5G Background. *Mobile Information Systems*, **2022**, Article ID: 4021706. https://doi.org/10.1155/2022/4021706

[12] Syed, T.A., Alzahrani, A., Jan, S., *et al.* (2019) A Comparative Analysis of Blockchain Architecture and Its Applications: Problems and Recommendations. *IEEE Access*, **7**, 176838-176869. https://doi.org/10.1109/ACCESS.2019.2957660

[13] Ferretti, S. and D'Angelo, G. (2020) On the Ethereum Blockchain Structure: A Complex Networks Theory Perspective. *Concurrency and Computation*: *Practice and Experience*, **32**, e5493. https://doi.org/10.1002/cpe.5493

[14] Irannezhad, E. and Mahadevan, R. (2020) Is Blockchain Tourism's New Hope? *Journal of Hospitality and Tourism Technology*, **12**, 85-96. https://doi.org/10.1108/JHTT-02-2019-0039

[15] Tyan, I., Guevara-Plaza, A. and Yagüe, M.I. (2021) The Benefits of Blockchain Technology for Medical Tourism. *Sustainability*, **13**, Article 12448. https://doi.org/10.3390/su132212448

[16] Luo, L. and Zhou, J. (2021) BlockTour: A Blockchain-Based Smart Tourism Platform. *Computer Communications*, **175**, 186-192. https://doi.org/10.1016/j.comcom.2021.05.011

[17] Zhou, L., Tan, C. and Zhao, H. (2022) Information Disclosure Decision for Tourism O2O Supply Chain Based on Blockchain Technology. *Mathematics*, **10**, Article 2119. https://doi.org/10.3390/math10122119

[18] Zhong, B., Guo, J., Zhang, L., *et al.* (2022) A Blockchain-Based Framework for On-Site Construction Environmental Monitoring: Proof of Concept. *Building and Environment*, **217**, Article ID: 109064. https://doi.org/10.1016/j.buildenv.2022.109064

[19] Pal, O., Alam, B., Thakur, V., *et al.* (2021) Key Management for Blockchain Technology. *ICT Express*, **7**, 76-80. https://doi.org/10.1016/j.icte.2019.08.002

[20] Zhang, J., Tan, R., Su, C., *et al.* (2020) Design and Application of a Personal Credit Information Sharing Platform Based on Consortium Blockchain. *Journal of Information Security and Applications*, **55**, Article ID: 102659. https://doi.org/10.1016/j.jisa.2020.102659

[21] Wang, T., Zhao, C., Yang, Q., *et al.* (2021) Ethna: Analyzing the Underlying Peer-to-Peer Network of Ethereum Blockchain. *IEEE Transactions on Network Science and Engineering*, **8**, 2131-2146. https://doi.org/10.1109/TNSE.2021.3078181

[22] Hu, W., Hu, Y., Yao, W., *et al.* (2019) A Blockchain-Based Byzantine Consensus Al-

gorithm for Information Authentication of the Internet of Vehicles. *IEEE Access*, **7**, 139703-139711. https://doi.org/10.1109/ACCESS.2019.2941507

[23] Kim, H., Lee, S., Kwon, H., *et al.* (2021) Design and Implementation of a Personal Health Record Platform Based on Patient-Consent Blockchain Technology. *KSII Transactions on Internet and Information Systems* (*TIIS*), **15**, 4400-4419. https://doi.org/10.3837/tiis.2021.12.008

[24] Wang, Q., Li, R. and Zhan, L. (2021) Blockchain Technology in the Energy Sector: From Basic Research to Real World Applications. *Computer Science Review*, **39**, Article ID: 100362. https://doi.org/10.1016/j.cosrev.2021.100362

[25] Liu, W., Li, Y., Wang, X., *et al.* (2021) A Donation Tracing Blockchain Model Using Improved DPoS Consensus Algorithm. *Peer-to-Peer Networking and Applications*, **14**, 2789-2800. https://doi.org/10.1007/s12083-021-01102-9

[26] Gao, Y.L., Chen, X.B., Xu, G., *et al.* (2020) A Novel Quantum Blockchain Scheme Base on Quantum Entanglement and DPoS. *Quantum Information Processing*, **19**, Article No. 420. https://doi.org/10.1007/s11128-020-02915-y

[27] Li, W., Feng, C., Zhang, L., *et al.* (2020) A Scalable Multi-Layer PBFT Consensus for Blockchain. *IEEE Transactions on Parallel and Distributed Systems*, **32**, 1146-1160. https://doi.org/10.1109/TPDS.2020.3042392

[28] Tyan, I., Yagüe, M.I. and Guevara-Plaza, A. (2020) Blockchain Technology for Smart Tourism Destinations. *Sustainability*, **12**, Article 9715. https://doi.org/10.3390/su12229715

[29] Varavallo, G., Caragnano, G., Bertone, F., *et al.* (2022) Traceability Platform Based on Green Blockchain: An Application Case Study in Dairy Supply Chain. *Sustainability*, **14**, Article 3321. https://doi.org/10.3390/su14063321

[30] Demestichas, K., Peppes, N., Alexakis, T., *et al.* (2020) Blockchain in Agriculture Traceability Systems: A Review. *Applied Sciences*, **10**, Article 4113. https://doi.org/10.3390/app10124113