International Journal for Housing Science and Its Applications
Publish August 10, 2025. Volume 46, Issue 4 Pages 2063-2075

https://doi.org/10.70517/ijhsa464177

A Study on Blockchain-Based Sustainable Packaging and Brand Credibility Enhancement Based on Consumer Perception

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Abstract The great advantage of blockchain technology in the trust mechanism makes it quite popular in the production field in recent years. With the research purpose of enhancing the trustworthiness of blockchain technology in the consumer market, this paper constructs a blockchain-based product traceability model by integrating core elements such as ledger-splitting technology, smart contract, and cross-ledger event notification mechanism. Meanwhile, for the problem of heavy data communication burden in the product production process, we introduce the sharding technology in the PBFT consensus algorithm and propose the SHT-PBFT algorithm. In the design work of traceability and production information protection scheme, Hyper ledger Fabric is selected as the underlying technology platform, and the smart contract based on BLAKE2 algorithm is used to process the data. Combined with the transaction process of the product supply chain, the blockchain-based information protection scheme is established. Under the proposed information traceability model and information protection scheme, consumer recognition and adoption are set as independent variables and relevant independent variables are selected to construct a model for regression analysis. Among them, Blockchain technology's own advantages (Technicaladvantages) (6.169*) and high cost (Highcost) (8.901*) positively influence consumers' perception of sustainable packaging and brand credibility of Blockchain technology.

Index Terms sht-pbft algorithm, blockchain platform, blake2 algorithm, consumer perception, brand credibility, product traceability

I. Introduction

In today's highly competitive market environment, packaging and brand credibility are critical to a company's success, and consumer perception plays a significant role in purchasing decisions, sustainable packaging, and enhancing brand credibility [1]-[3]. Consumer perception refers to the level of understanding and awareness consumers have of a product or service [4], [5]. It encompasses not only consumers' understanding of product quality, functionality, features, and related information but also their perceptions of the company's brand image, market competition landscape, price levels, and after-sales service [6]-[9]. Understanding consumer perception helps businesses develop products and marketing strategies tailored to consumer needs, thereby better meeting consumer demands and enhancing product competitiveness and credibility [10]-[12].

Packaging is an important means of enhancing consumer cognition. Elegant packaging can elevate a product's quality and appeal, prompting consumers to desire purchase [13]-[15]. Packaging carries various product-related information and serves as the visual interface between the product and consumers [16], [17]. It stimulates consumers' sensory organs through different patterns, colors, text, materials, and shapes, thereby influencing consumer psychology [18], [19]. As designers, packaging design should focus on consumer perception, accurately identifying and applying the patterns of consumers' psychological activities and needs to packaging design, which can help enhance consumer perception [20]-[22]. However, the two are mutually reinforcing: consumers' perception of a brand also requires the brand to continuously improve in areas such as packaging, quality, cost, and price, thereby enhancing consumers' trust in the brand [23]-[25].

Literature [26] highlights the increasing demand for in vitro diagnostic (IVD) reagents and the impact of consumer distrust on the purchase and use of IVD products. It also examines how visual packaging elements influence changes in consumer trust, revealing that factors such as font, color, and patterns all affect consumers' perceived trustworthiness. Literature [27] aims to assess the impact of packaging on consumer purchasing behavior, identifying the factors behind successful product packaging. Through questionnaire analysis, it identifies key variables and emphasizes their benefits for all types of organizations. Literature [28] analyzes the relationship between green packaging and consumer purchasing intent, examining the impact of green packaging on consumer perception and loyalty. The results emphasize the significant role of green packaging in shaping purchasing intent and consumer loyalty. Literature [29] analyzed the impact of packaging on brand quality and loyalty based on the intervention effects of brand associations in the over-the-counter health market. Using systematic sampling, a questionnaire survey was conducted among consumers. The analysis results established that the interaction between packaging and brand associations is a key factor in enhancing brand quality and customer loyalty in the over-the-counter health market. Literature [30] analyzed the impact of consumers' perceptions of corporate social responsibility on their purchasing intentions, aiming to determine the role of integrating corporate social responsibility into business development. It validated that consumers' perceptions of corporate social responsibility influence their willingness to purchase a brand. Literature [31] explored the impact of packaging on consumers' perceptions of product quality, using variables such as protecting products and consumers and promoting products. The study found that all variables significantly influence consumers' perceptions of product quality during the purchasing process. Literature [32] explores the impact of brand reputation on brand performance, the impact of brand credibility on brand reputation, and the impact of brand performance on brand credibility, describing the complex dynamics in brand management and emphasizing that brand reputation, performance, and credibility play a key role in shaping brand success. Literature [33] discusses the importance of packaging design in influencing purchasing behavior, demonstrating through experiments that packaging design has a positive impact on purchasing behavior and brand trust, while brand trust also has a positive impact on purchasing behavior. Literature [34] argues that the success of environmentally friendly packaging depends on consumers' understanding and acceptance, indicating that packaging style elements and environmental claims influence assessments of packaging eco-friendliness and brand social responsibility. Literature [35] emphasizes that consumers' perceptions of food packaging encompass multiple aspects, including visual appeal, convenience, and safety. Consumer perceptions are significant for manufacturers and marketers in developing packaging strategies and building brand loyalty. The above studies highlight the influence of product packaging on consumer purchasing decisions, revealing that factors such as packaging materials, safety, and convenience all impact consumer purchasing behavior. Companies can enhance brand credibility and competitiveness by designing assurances relevant to consumers.

This paper firstly briefly describes the design idea and operation process of product traceability model, focuses on analyzing the mechanism optimization of PBFT algorithm in the traceability model, and constructs the product traceability model. Subsequently, based on the Hyper ledger Fabric technology platform, the computing process of BLAKE algorithm is elaborated, and the smart contract based on BLAKE2 algorithm is designed, which lays the foundation for the construction of the blockchain platform. At the same time, based on the transaction steps of product and raw material procurement, we determine the transaction information to be protected in the process of product transaction, and form the protection program of product information and transaction information under blockchain technology. Then, the performance and stability of SHT-PBFT algorithm in the transaction are examined by controlling the state change of nodes. For the performance evaluation of the information traceability model, a comparison test with similar algorithms is conducted in terms of traceability time. Noise attacks and rotation attacks are used to verify the effectiveness of the designed smart contract in information security maintenance. Finally, taking the text data of a social network platform as the research object, variables are set, models are built and regression analysis is conducted to explore the mechanism of improving the credibility of blockchain technology under consumer perception.

II. Blockchain-based information traceability models

II. A. Model Design Ideas

Aiming at the problems of low data reliability, easy data tampering and high storage pressure of single ledger in traditional traceability model, a blockchain-based traceability model is constructed. By integrating blockchain technology, smart contract, distributed ledger and cross-ledger event notification mechanism, the model provides an efficient, transparent and tamper-proof structure for the traceability system. Traceability data is categorized into “uploaded data”, which is recorded and verified using blockchain technology to ensure authenticity and tamperability, and “non-uploaded data”, which is stored in traditional databases to improve access and update speed. The model combines the dual-track storage architecture of blockchain and traditional databases to ensure data security while also taking into account the efficiency of transaction processing.

Smart contracts are also being researched in the proposed split ledger technology, which adopts the idea of “one link, one ledger” and combines with the cross ledger event notification mechanism to achieve automatic transmission of information and real-time synchronization between different ledgers, ensuring the dynamics and real-time nature of the traceability chain. It plays a key role in the traceability process by automatically assessing the grade of the product and automatically determining the quality of the product to ensure that it meets the quality standards. Based on the evaluation results, the contract decides whether the product enters the qualified quality book or the unqualified product book, so as to allow real-time inquiry and traceability by consumers, enterprises and regulatory authorities.

The model also realizes fine management of products through quality grading of collected traceability information, and generates traceability codes for multi-party verification and use. Consumers can access the whole process information with the help of the traceability code, while enterprises and regulators can conduct accurate quality management and feedback through the dynamically updated traceability data. The overall design not only improves the degree of automation and data transparency of the traceability system, but also ensures the quality traceability of the whole process with the participation of multiple parties, which effectively promotes the efficient operation of the industry and the traceability of product quality.

II. B. Optimization of the PBFT algorithm

II. B. 1) Problem analysis of PBFT consensus mechanism

PBFT (Practical Byzantine Fault Tolerance) is used as a consensus algorithm for distributed systems, where the presence of malicious nodes in the system ensures the consistency and reliability of the system. In distributed systems, some nodes may fail or be maliciously attacked, and these nodes may pass inconsistent information, causing the system to fail to reach consistency. Figure 1 shows the PBFT algorithm operation flow.

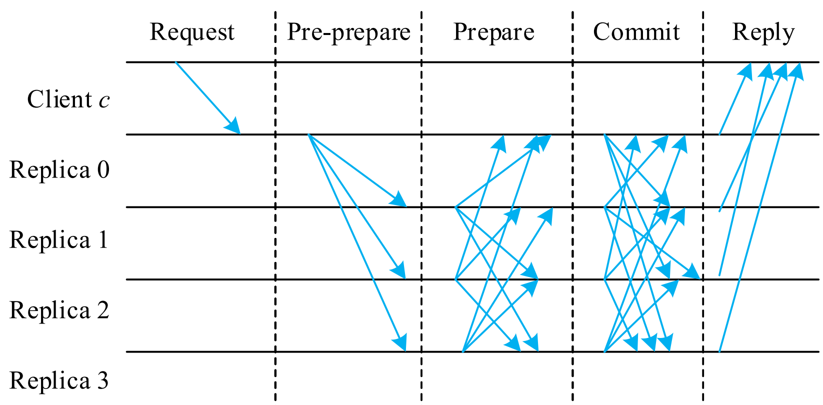


Figure 1: PBFT operation process

The PBFT algorithm is divided into three main phases: the Pre-Prepare phase (Pre-Prepare), the Prepare phase (Prepare) and the Commit phase (Commit).

(1) Pre-Prepare stage

The master node P initiates the proposal m and broadcasts it to the $N-1$ replica nodes. The replica node receives the proposal and enters the preparation phase with equation (1):

$$P \rightarrow all\ replicas : \Pr e\text{-}\Pr epare(m) \tag{1}$$

(2) Prepare phase

Each replica node enters the Prepare phase after receiving the proposal from the master node and broadcasts Prepare messages to other replica nodes. If the replica node receives the same $Prepare(m)$ message from at least $2f+1$ different node, it enters the next phase with equation (2):

$$\forall i \in \{1,2,...,N-1\}, i \rightarrow all\ replicas : \Pr epare(m) \tag{2}$$

(3) Commit phase

The replica node enters the commit phase, each node i broadcasts a message, if the node receives $Commit(m)$ messages from at least $2f+1$ different nodes, the proposal m is finalized and executed with equation (3):

$$\forall i \in \{1,2,...,N-1\}, i \rightarrow all\ replicas : Commit(m) \tag{3}$$

(4) When a node receives at least $2f+1$ $Commit(m)$ message, the node executes proposal m.

In the PBFT algorithm, each node needs to perform a lot of network communication during the consensus process. In particular, during the prepare and commit phases, each node needs to broadcast and receive messages from other nodes to ensure that a sufficient number of confirmations (usually one, where f is the maximum possible number of failed or malicious nodes) is reached, and this large number of network interactions increases the communication overhead of the system.

II. B. 2) SHT-PBFT algorithm construction

Aiming at the lower consensus efficiency of PBFT algorithm, which is difficult to meet the needs of traceability model, the research uses the slicing technology to optimize the PBFT algorithm, marking and packing the data of the same production link, and at the same time combining the batch processing mechanism to reduce the communication overhead, improve the throughput and the performance of the system to reduce the complexity of the communication, and to improve the efficiency of the communication.

(1) Data labeling and node allocation

The data written to the system is identified according to the production chain, with the planting data labeled D_{plant}, the harvesting data labeled D_{pick}, the processing data labeled $D_{process}$, the warehousing data labeled $D_{warehouse}$, the transportation data labeled $D_{transportation}$, and the sales data labeled D_{sales}.

All nodes need to be registered in the system and assigned a unique identifier and a security certificate or key pair associated with it. In PBFT, each proposal m is processed independently. By introducing a batch mechanism, instead of processing individual proposals, multiple proposals are formed into batches, which are processed and broadcast simultaneously. Suppose a batch B contains k proposals, i.e., $B=\{m_1,\ m_2,\cdots,m_k\}$. The PBFT algorithm will process this batch at once, and all phases of the operation will be applied to the entire batch.

(2) SHT slicing algorithm

In order to ensure the security of slicing, the study adopts the principle of consistent hashing, which first generates a corresponding hash value for each node by uniquely identifying the hash-consistent node. Let the node public key is $PK(Ni)$ and the assigned node is equation (4):

$$Si=\frac{H\left(PK\left(Ni\right)\right)}{6} \tag{4}$$

Where Si is the slice number to which node Ni belongs and H is the hash function.

(3) Consensus process: when the transaction side initiates a request, the batch is sent to the corresponding consensus group according to the data marking in the batch, and then the following operations are performed:

In the Pre-Prepare phase, the

The master node broadcasts batch $B=\{m_1,m_2,\cdots,m_k\}$ and each batch contains k proposals. The master node generates batch B and broadcasts it to all replica nodes as in equations (5)-(6):

$$P\rightarrow all\ \ replicas:\Pr e\text{-}\Pr epare(B) \tag{5}$$

$$P\rightarrow all\ \ replicas:\Pr e\text{-}\Pr epare(B) \tag{6}$$

Each replica node after receiving batch B from the master node broadcasts $Prepare(B)$ message for each proposal in the batch. Each node i broadcasts $Prepare(B)$ message as in equation (7) after receiving batch B:

$$\forall i\in\{1,2,...,N-1\},\ i\rightarrow all\ \ replicas:\Pr epare(B) \tag{7}$$

If a replica node receives the same $\Pr epare(B)$ message from at least $2f+1$ different node, it proceeds to the next phase.

In the Commit phase, each replica node broadcasts $Commit(B)$ messages to all proposals in batch B. As in equation (8):

$$\forall i\in\{1,2,...,N-1\},\ i\rightarrow all\ \ replicas:Commit(B) \tag{8}$$

If a node receives a $Commit(B)$ message from at least one different node, it finalizes and executes batch B.

When a node receives at least $Commit(B)$ messages, the node executes batch B.

(4) In this phase, each transaction consensus group sends the batch that passes the execution to the consensus integration group, which adds the block to the local ledger after successful validation.

III. Blockchain-based information protection scheme

III. A. Smart Contracts Based on BLAKE2 Algorithm

III. A. 1) BLAKE algorithm flow

BLAKE algorithm is similar to other summarization algorithms, generally consists of preprocessing of data, cyclic compression calculation of data and calculation of the final output. In the use of compression function for cyclic compression calculation of data in addition to the input information also need to be added to the function of the compression calculation of the calculator value, salt value and constant crop input parameters, the hash value obtained from the calculation of the crop next round of the initial hash value will be brought into the next round of calculations. Next h will denote the initial hash value, m will denote the input information block, s will denote the salt value, t will denote the counter value and c will denote the constants.

(1) Preprocessing process

The preprocessing process of BLAKE algorithm is similar to SHA2 algorithm but the variables are not initialized in the same way. The message is first padded to make its length an integer multiple of 512 bits. If the input message does not meet the multiplier requirements, first in the back to add the beginning of the end of 1 in the middle of the 0 bits to make the message after padding modulo 512 is equal to 448, and then in the next 64 bits to record the length of the message, so that the message can be divided by 512. Then divide it into message blocks and finally initialize the variables. The variables are initialized as in equation (9), $\oplus$ denotes the different-or operation.

$$\begin{bmatrix} v_0 & v_1 & v_2 & v_3 \\ v_4 & v_5 & v_6 & v_7 \\ v_8 & v_9 & v_{10} & v_{11} \\ v_{12} & v_{13} & v_{14} & v_{15} \end{bmatrix} = \begin{bmatrix} h_0 & h_1 & h_2 & h_3 \\ h_4 & h_5 & h_6 & h_7 \\ s_0 \oplus c_0 & s_1 \oplus c_1 & s_2 \oplus c_2 & s_3 \oplus c_3 \\ t_0 \oplus c_4 & t_0 \oplus c_5 & t_1 \oplus c_6 & t_1 \oplus c_7 \end{bmatrix} \tag{9}$$

During the variable initialization process, 16 intermediate variable parameters need to be calculated according to the given formula V. The value of counter t is determined based on the accumulation of message blocks. However, a problem can be faced: two messages with originally different lengths may become the same length after the complement. To avoid this, the counter accumulates the length of the original message block, not the complemented length. For example, if an 800-bit message is padded to 1024 bits and split into two 512-bit blocks, the counter takes values of 512 for t0 and 800 for t2. Salt s and Constant c are user-defined, and usually use fixed values set by the user.

(2) Cyclic compression calculation

The 16 intermediate variables V obtained from the calculation will be brought as parameters into the cyclic compression calculation of the compression function G. The traditional algorithmic compression cycle will generally carry out 14 rounds, and the specific cyclic compression process is shown in Equation (10).

$$\begin{gathered} G_0(v_0, v_4, v_8, v_{12}) G_1(v_1, v_5, v_9, v_{13}) G_2(v_2, v_6, v_9, v_{14}) \\ G_3(v_3, v_7, v_{10}, v_{15}) G_4(v_0, v_5, v_{10}, v_{15}) G_5(v_1, v_6, v_{11}, v_{12}) \\ G_6(v_2, v_7, v_8, v_{13}) G_7(v_3, v_4, v_9, v_{14}) \end{gathered} \tag{10}$$

The $G_i(a,b,c,d)$ compression function for each round is computed as follows, where i represents the i rd G function, with equation (11).

$$\begin{aligned} & a \leftarrow a + b + \left(m_{\sigma(2i)} \oplus c_{\sigma(2i+1)}\right) \\ & d \leftarrow (d \oplus a) >>> 16 \\ & c \leftarrow c + d \\ & b \leftarrow (b \oplus c) >>> 12 \\ & a \leftarrow a + b + \left(m_{\sigma(2i)} \oplus c_{\sigma(2i+1)}\right) \\ & d \leftarrow (d \oplus a) >>> 8 \\ & c \leftarrow c + db \leftarrow (b \oplus c) >>> 7 \end{aligned} \tag{11}$$

In the above formula, "+" represents the modulo addition operation, ">>>" represents the right circular shift, and m_l and c_j represent the corresponding message blocks and constants of the input.

(3) Final Output

The 16 variables V are obtained by the loop compression calculation in the previous section, and the final hash value is calculated according to equation (12).

$$h_i^r = h_i^0 \oplus v_i \oplus s_j \oplus v_{i+8} \tag{12}$$

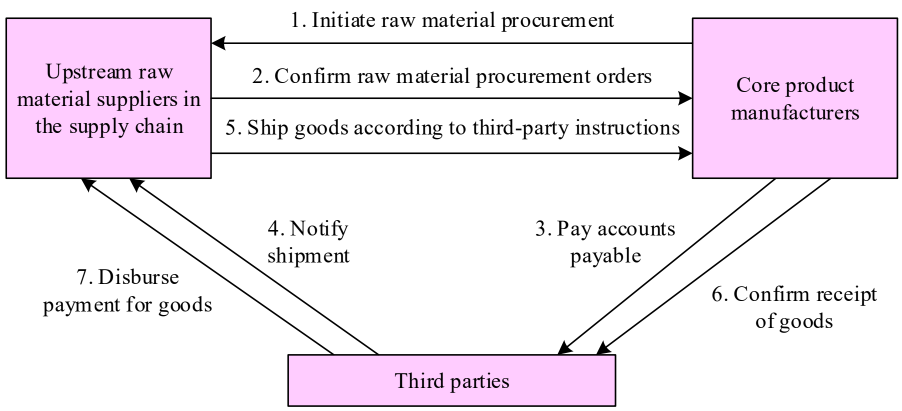
In the above formula, the value range of i is $0 \le i \le 7$, the value of j is the result of $I \bmod 4$, and r represents the r th round of computation. The calculated hash value h will be used as the initial hash value of the next message block, the new hash value calculated by the next message block after the same steps by will be used as the initial hash value of the next next message block. After all the message blocks have been computed the final hash value computed is the hash value of the entire message requested.

III. A. 2) Smart contracts in Hyper ledger Fabric

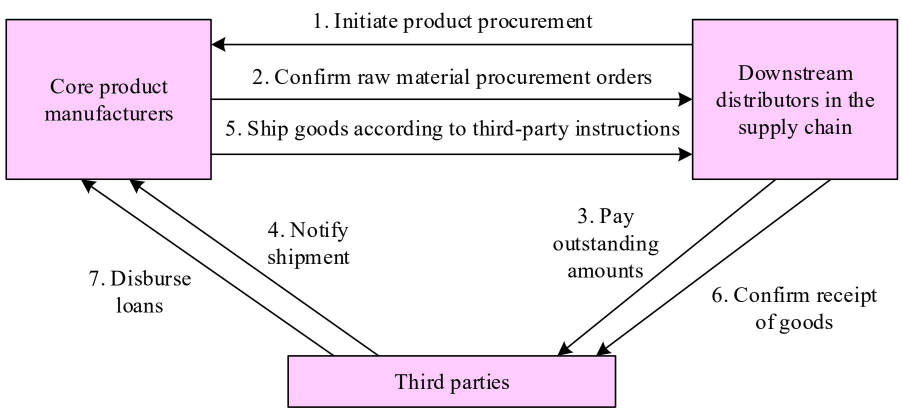
In Hyperledger Fabric, smart contracts are often referred to as "chaincode". It is responsible for managing the business logic of the data in the network. Chaincode runs in the Peer nodes of the blockchain network and enforces predefined business rules to facilitate consensus among the parties in the network. Hyperledger Fabric's chaincode supports multiple programming languages, including Golang, JavaScript (Node.js), Java, etc. This multi-language support allows developers to write chaincode in a language they are familiar with. This multi-language support allows developers to write chaincode in a language they are familiar with. Here we choose to use Golang language for smart contract writing. One reason is that the Fabric framework itself is developed by the Golang language, and writing in Golang has better compatibility and stability. Secondly, one of the major features of smart contracts is that they need to run in a distributed network and at the same time need to ensure that each node executes the same result when executing transactions. This makes the security requirements of smart contracts much higher than that of ordinary programs, and Golang language has a better exception error handling mechanism, which can meet the above requirements.

III. B. Product supply chain transaction process analysis

The transaction process of product supply chain generates a lot of transaction process data. These data can be used as an important basis for tracing funds in case of disputes over transaction funds in the later stage. Analyzing the transaction process of product supply chain can sort out the transaction information involved and determine which information cannot be tampered with or deleted as important information. In order to illustrate this more clearly, the steps of the product transaction are shown in Figure 2, and the following steps in the process involving the generation of important transaction process information will be analyzed in order to obtain the order transaction information that needs to be protected.



(a) Steps in raw material procurement transactions



(b) Product procurement transaction steps

Figure 2: Transaction steps

(1) Initiate a transaction with the seller to confirm the transaction order, the transaction information contained at this time are order details and commodity information, which order details include order number, order date, order type, consignee's cell phone, delivery address, creation time and buyer's company name. Commodity information includes commodity name, commodity unit price, specifications, harvest time, purchase quantity and batch number.

(2) After notification of shipment, the seller's enterprise carries out shipment, and at this time, there is new logistics information in the transaction information, including shipment time, shipment address, logistics company and logistics single number.

(3) Throughout the transaction process, the transaction information contains payment-related information, including the total amount, the amount of goods, freight and paid amount.

(4) After the end of the transaction needs to have the transaction process of the order of each key node of the operation information records, including the initiation of the order, the seller to confirm, prepayment confirmation, the merchant shipment and confirmation of receipt, each key node of the operation information contains the operator and the operation time.

Comprehensive analysis of the above can get the information that needs to be protected using blockchain technology is shown in Figure 3.

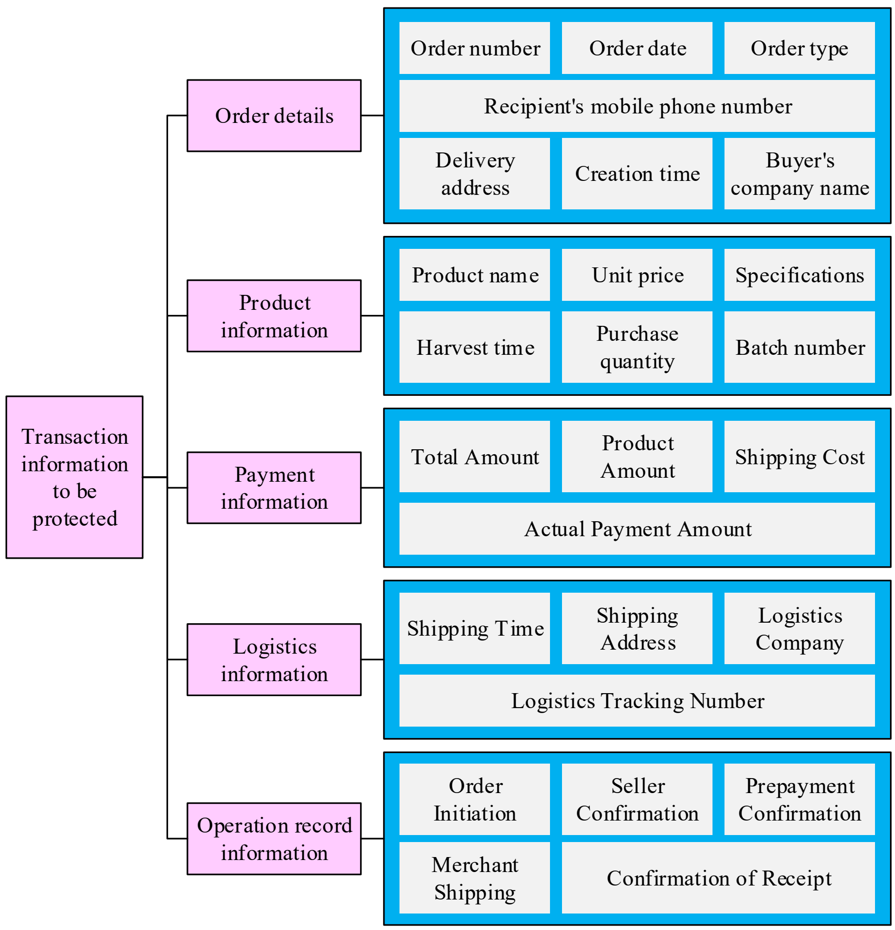


Figure 3: Transaction information that needs protection

IV. Evaluation of Blockchain Technology and Trustworthiness Regression Analysis

IV. A. Test of the SHT-PBFT algorithm

IV. A. 1) Stable trend of node state change

Fig. 4 shows the experimental comparison results between the improved (B1) algorithm of this paper and (B2) original clique algorithm when sending a transaction every 1s. It can be seen that the number of transactions packaged by (B2) original clique algorithm, i.e., throughput, is obviously affected by offline authoritative nodes, and the throughput decreases more. While (B1) the algorithm in this paper is affected very little, the decline in throughput is very small and basically stabilized.

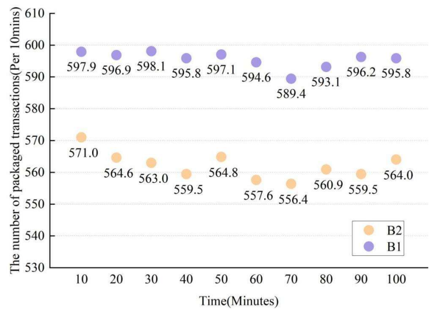


Figure 4: Algorithm throughput when a transaction is sent once per second

Fig. 5 shows the experimental comparison results of (B1) this paper's algorithm and (B2) the original clique algorithm when sending a transaction every 500ms. It can be seen that (B2) the throughput of the original clique algorithm by the influence of the offline authority node becomes greater, and compared to Figure 4 performance of the throughput decline is more, while (B1) this paper's algorithm throughput decline is more pronounced compared to the algorithm, but the decline is not large between 20 and throughput is more stable.

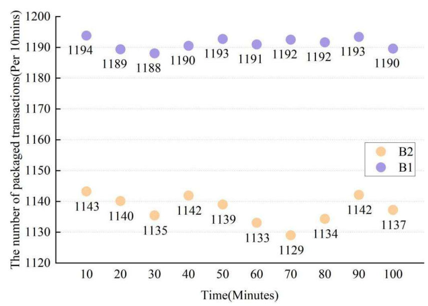


Figure 5: Algorithm throughput when a transaction is sent once per 5 second

IV. A. 2) Dramatic changes in node state

When the node state changes drastically, the experimental comparison results of (B1) this paper's algorithm and (B2) the original clique algorithm are shown in Fig. 6. It can be seen that compared with the node state change tends to be stable, when the node state changes drastically, both algorithms' throughput decreases are more obvious and drastic, especially the throughput (<335) of (B2) the original clique algorithm decreases to more than half of the original clique algorithm. reaches more than half. The throughput of (B1) algorithm also decreases, but the decrease is not large compared to (B2) original clique algorithm, and the throughput remains stable (524.8~547.2).

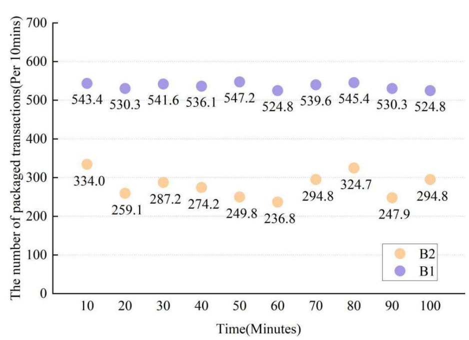


Figure 6: Algorithm throughput under drastic state changes

IV. B. Performance testing of information traceability models

For the time test of the designed information traceability model, this paper compares vertically and horizontally the time used to query the information by comparing the traceability time used for different transaction quantities under the same order of magnitude.

In this experiment, the time consumed to query 100, 150, 200, 250, 300 and 350 pieces of traceability information of the system is counted respectively. The difference in traceability time for the same order of magnitude of information is compared vertically from (B1) this paper's algorithmic model, (B2) the original clique algorithmic model and (B3) the SM9 algorithmic model is shown in Fig. 7.

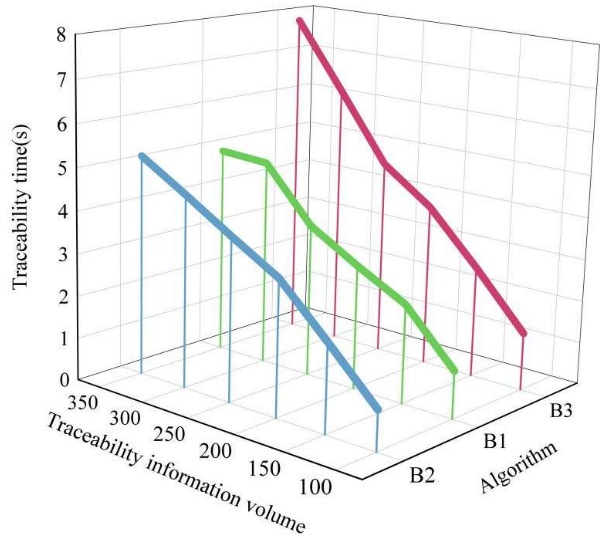


Figure 7: Comparison chart of longitudinal information traceability time

As the amount of traceability information increases, the traceability time of all three algorithmic models increases. The overall (B3) SM9 algorithm model traceability time is longer, the highest time required is as high as 7.81s when the amount of information is 350. (B1) The algorithm model of this paper and (B2) the original clique algorithm model are more similar in the performance of time for different amounts of information, but the traceability time required for (B1) the algorithm model of this paper is in the range of 1.12-4.92s for different amounts of information, and the traceability time required for (B2) the original clique algorithm model is in the range of 0.94-5.19s, in terms of stability and large-scale information amount. The required traceability time interval of the original clique algorithm model is 0.94~5.19s, and the running time of (B1) this paper's algorithm model is slightly better in terms of stability and large-scale information quantity.

IV. C. Security Verification of Smart Contracts

In this paper, the encrypted QR code embedded with watermark is subjected to noise attack and rotation attack to verify the robustness of (C1) BLAKE2 algorithm in this paper, and the comparison algorithms chosen for the experiments in this section are (C2) SHA2 algorithm, (C3) traditional digest algorithm.

IV. C. 1) Noise attacks

A Gaussian noise attack introduces random noise disturbances that make the image blurry, distorted, or visibly noisy, resulting in degradation of the image quality. Pepper noise attack introduces obvious black and white spots in the image, making some pixel values become maximum or minimum. The encrypted QR code image after embedding the watermark is subjected to the Gaussian noise attack with a mean of 0 and variance of 0.01 and 0.05 and the pretzel noise attack with a density of 0.01 and 0.05, respectively. The results of the performance of the three algorithms in terms of NC and DR values under the Gaussian noise attack with variance of 0.01, 0.05 and pretzel noise attack with density of 0.01, 0.05 are shown in Table 1.

Table 1: NC values and DR Values under noise attacks

Noise attack		Index	C1	C2	C3
Gaussian noise	0.01	NC	0.9708	0.9338	0.9501
		DR	0.9681	0.9378	0.9471
	0.05	NC	0.9673	0.799	0.8495
		DR	0.9629	0.7337	0.7984
Salt and pepper noise	0.01	NC	0.9691	0.9226	0.9634

		DR	0.9656	0.8987	0.9573
	0.05	NC	0.9659	0.7879	0.8789
		DR	0.961	0.7173	0.8379

As the noise variance or density increases, the NC and DR values of the extracted watermark gradually decrease, indicating that the watermarked image of the extracted vocabulary gradually becomes blurred. Among the three algorithms, (C2) SHA2 algorithm has a weaker performance, not only the NC and DR values have the lowest performance, the highest is only 0.9338, and the lowest is 0.7173, the performance fluctuation is larger. In contrast, (C1) BLAKE2 algorithm in this paper has stable NC and DR values above 0.9600 and the highest NC value of 0.01 variance reaches 0.9708, which indicates that the smart contract algorithm designed in this paper is able to effectively resist noise attacks to a certain extent.

IV. C. 2) Rotational attacks

Rotation attacks may lead to distortion, distortion, and positional changes of the image content, thus affecting the process of image recognition, analysis, and processing. The encrypted QR code images after embedding the watermark were rotated by 5°, 15°, 30°, and 60°, respectively, to simulate various rotational transformations that may be encountered in practical applications. The comparison of the performance of the three algorithms in terms of NC and DR values under the attack of different rotation angles is shown in Table 2.

Table 2: Rotate attack the NC value and DR Value

Angle(°)	Index	C1	C2	C3
5	NC	0.9574	0.8813	0.933
	DR	0.9485	0.8454	0.9394
15	NC	0.952	0.7932	0.927
	DR	0.9407	0.7277	0.9343
30	NC	0.9559	0.8496	0.9365
	DR	0.9463	0.8019	0.9323
60	NC	0.9537	0.8492	0.9336
	DR	0.9432	0.8017	0.9399

Overall as the rotation angle increases, the three algorithms have different degrees of change in both metrics. Among them, (C2)SHA2 algorithm is most affected by the rotation angle, and the variation of NC and DR values under different angles is as high as 0.1536. (C1)BLAKE2 algorithm of this paper and (C3)traditional summarization algorithm have smaller variation under the attack of different rotation angles, and have the same stability. However, (C1) the BLAKE2 algorithm in this paper performs 0.9400 and above in both NC and DR values, which is better than the overall performance of the (C3) traditional summarization algorithm (>0.9300). Therefore, this paper's algorithm is less affected by the rotation angle and can effectively resist rotation attacks.

IV. D. Regression Analysis of Consumer Perception of Blockchain Applications

This section takes the text data of "blockchain" and "credibility" on W social network platform as the research object, and puts forward the argument about the application of blockchain in sustainable packaging and brand credibility enhancement on the basis of the designed information traceability model and information protection scheme. The variables are selected and modeled for regression analysis to explore the mechanism of sustainable packaging and brand credibility enhancement by blockchain under consumer perception.

The variables are set as follows:

(1) Dependent variable: consumer recognition and adoption (LikeNum), reflected as the number of likes in the text data.

(2) Independent variables: Blockchain technology's own advantages (Technicaladvantages), the promotion of national policy opinions (Nationalpolicy), high cost (Highcost), immature technology (Immaturetechnology), users do not understand or not enough demand (Lackofdemand). Blockchain needs regulation (Regulatoryneed).

The descriptive statistics of the variables obtained after performing Tobit regression on the model are shown in Table 3, where it can be seen that the number of likes embodying the dependent variable is distributed in the range of 0-487 out of 250 textual data, while the respective variables take the values of 0 and 1.

Table 3: Descriptive Statistics of Variables

Variable	Obs	Mean	Std.Dev.	Min	Max
LikeNum	250	5.484	34.183	0	487
Technicaladvantages	250	0.945	385	0	1
Nationalpolicy	250	0.212	291	0	1
Highcost	250	0.192	252.41	0	1
Immaturetechnology	250	0.356	423.977	0	1
Lackofdemand	250	0.161	0.173	0	1
Regulatoryneed	250	0.152	0.147	0	1

The results of the Tobit regression analysis of the model are shown in Table 4, and the p-values of the four views of blockchain technology's own advantages (Technicaladvantages), the promotion of nationalpolicy opinions (Nationalpolicy), the high cost (Highcost), and the need for blockchain to be regulated (Regulatoryneed) are all less than 0.1, indicating that they significantly influence consumer recognition and adoption at a confidence level of 0.1, and the two views of Blockchain technology's own advantages (Technicaladvantages) (6.169*) and high cost (Highcost) (8.901*) positively influence consumer recognition and adoption, while the promotion of national policy opinions (Nationalpolicy) (-9.486*) and Blockchainneededregulation (-15.78*) are two views that negatively influence consumer recognition and adoption.

Table 4: Tobit Regression Analysis Result

LikeNum	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Technicaladvantages	6.169	3.469	1.93	-0.53	12.668	6.169	*
Nationalpolicy	-9.486	5.272	-1.75	-19.741	0.568	-9.486	*
Highcost	8.901	5.06	1.9	-0.935	18.537	8.901	*
Immaturetechnology	2.031	3.216	0.74	-4.169	8.032	2.031	
Lackofdemand	-1.956	6.9	-0.19	-15.42	11.309	-1.956	*
Regulatoryneed	-15.78	9.582	-1.56	-34.534	2.774	-15.78	**
Constant	-8.377	3.455	-2.43	-15.048	-1.907	-8.377	
var(e.LikeNum)	216.21	33.36	.b	.b	292.687	216.21	
Mean dependent var		5.484		SD dependent var		34.329	
Pseudo r-squared		0.1247		Number of obs		250.00	
Chi-square		16.355		Prob > chi2		0.136	
Akaike crit. (AIC)		928.798		Bayesian crit. (BIC)		955.264	

Note:***p<0.01,**p<0.05,*p<0.1

In summary, it can be seen that the unique decentralization and other characteristics of blockchain technology, as well as the advantages of smart contracts, consensus mechanisms and other core technologies applied to product traceability, are more recognized by consumers in their perception. However, due to the high operating cost of the blockchain system and fewer opinions on the current relevant national policies, consumers are skeptical about the extensive and reliable application of blockchain technology.

V. Conclusion

In information traceability, this paper builds an information traceability model based on blockchain technology by designing SHT-PBFT algorithm to improve the data reading and writing efficiency of the model, so as to ensure the real-time and accuracy of traceability data. The designed SHT-PBFT algorithm can better adapt to different node states, and the throughput is still maintained at 524.8~547.2 under the environment of drastic changes in node states.In addition, the model shows superior stability and performance compared with the same type of algorithms in the traceability scenarios with different scales of information volume (0.94~5.19s).

For the information security needs in the production and transaction process, this paper proposes a smart contract based on BLAKE2 algorithm and applies it to the transaction process of product supply chain to establish an information protection program based on blockchain technology. Under different degrees of noise attacks, the NC and DR indexes of information security maintenance behavior of the proposed smart contract are stable above

0.9600. The NC and DR indicators of the proposed smart contract for information security maintenance behavior are stabilized above 0.9400 under different degrees of rotational attacks.

In the regression analysis of consumer cognition based on the traceability model and information protection scheme proposed in this article, two viewpoints, namely "the inherent advantages of blockchain technology (6.169*)" and "high cost (8.901*)", positively influence consumer recognition and adoption. There are two viewpoints, namely "the promotion of national policy opinions (-9.486*)" and "blockchain needs regulation (-15.78*)", which have a negative impact on consumer recognition and adoption. In this regard, this article suggests that reducing the operating costs of the system should be the key focus of the development strategy for the application of blockchain technology. At the same time, efforts should be made to strengthen calls for and assist in the improvement of relevant policies and laws, thereby enhancing the brand trust and sustainable development of blockchain technology.

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