Article

Application and prospect analysis of blockchain technology in intellectual property protection of e-commerce

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Abstract: This article delves into the application of blockchain technology in enhancing intellectual property (IP) protection within the e-commerce sector, providing a comprehensive analysis of its future prospects. By examining the core characteristics and working principles of blockchain, the paper reveals the unique advantages it offers in strengthening IP protection for e-commerce. The article elaborates on how blockchain's features of decentralization, data immutability, and timestamping contribute to a secure, transparent, and efficient IP protection mechanism in the e-commerce field. Furthermore, the paper discusses the practical application of blockchain technology in IP registration, management, transaction, and rights protection, highlighting its significant impact on security traceability, transaction cost reduction, and efficiency improvement. Lastly, the article anticipates the future role of blockchain technology in IP protection in e-commerce and believes that with continued technological advancements and enhanced policy support, blockchain will play an increasingly pivotal role in this domain. The paper also proposes potential challenges and solutions that require attention, aiming to foster the healthy and sustainable development of blockchain technology.

Keywords: blockchain; prospect; intellectual property; e-commerce

1. Introduction

With the rapid development of e-commerce, the issue of intellectual property (IP) protection is becoming increasingly prominent. Traditional IP protection methods may seem inadequate in some cases, but the emergence of blockchain technology provides new solutions to this problem. Blockchain technology, with its characteristics of decentralization, immutability of data, and transparency, has brought revolutionary changes to IP protection in the field of e-commerce (Huang et al., 2021).

In the current e-commerce environment, IP infringement is common, which not only damages the legitimate rights and interests of creators, but also affects the healthy development of the entire e-commerce industry (Su et al., 2020). Traditional IP protection methods, such as copyright registration and legal proceedings, can protect the rights and interests of creators to a certain extent, but there are some problems such as cumbersome operation, high cost of rights protection and limited effect (Hongmei, 2021; Sun et al., 2020). Therefore, it is particularly important to find a more efficient and convenient IP protection method.

As a new technical means, blockchain technology provides new possibilities for IP protection of e-commerce. Through blockchain technology, the decentralized registration, transaction and tracking of digital works can be realized, thus improving

the efficiency and effect of IP protection. This paper aims to explore the application and prospect of blockchain technology in IP protection of e-commerce, with a view to providing reference for research and practice in related fields.

2. Overview of blockchain technology

Blockchain technology is a kind of collective database maintenance technology based on decentralization and distrust, which allows participants in the network to reach a consensus without the intervention of centralized trust institutions (Guan et al., 2020). This technology originally originated from Bitcoin, as the underlying technology of Bitcoin, which is used to decentralize and distrustfully maintain a reliable database. The schematic diagram of blockchain is shown in **Figure 1**.
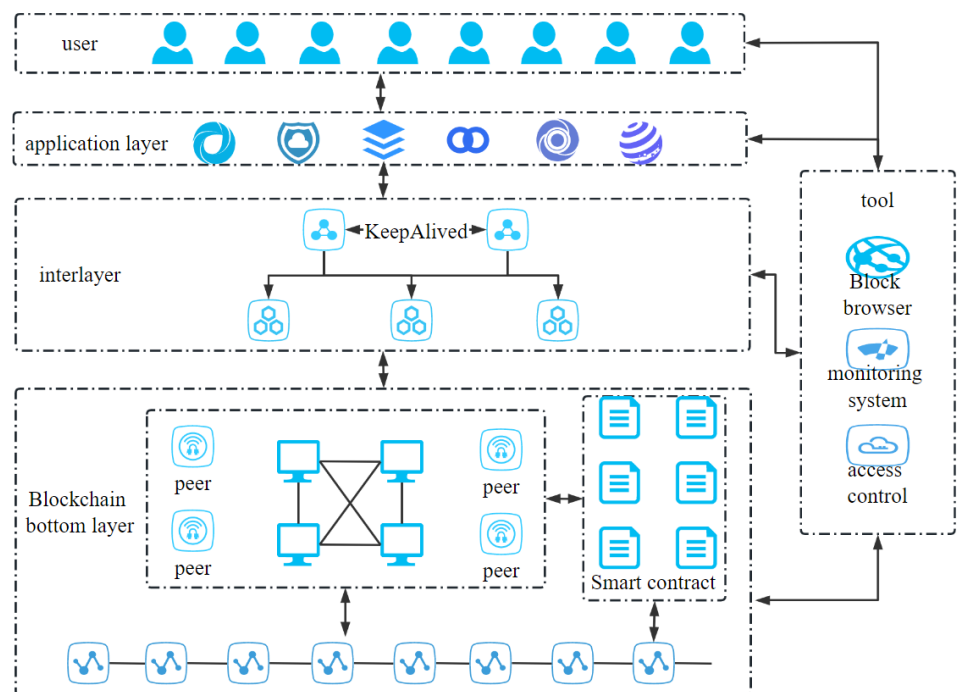

Figure 1. Schematic diagram of blockchain.

The core principle of blockchain technology is that it uses a method called "consensus mechanism" to ensure that all participants have the same data view, and the newly added data blocks need to be verified by most nodes in the network before they can be added to the blockchain (Aujla et al., 2020). This mechanism ensures that the data can not be tampered with and consistent, because any modification to the existing data block needs to recalculate and verify the whole chain, which is computationally infeasible.

From a technical point of view, blockchain is not only a technology, but also a technical system, which combines the innovative combination of various existing technologies. These technologies include, but are not limited to, distributed networks, encryption algorithms, consensus algorithms and smart contracts (Chung and Adeyeye, 2018; Feng and Ma, 2019). Among them, the distributed network ensures the decentralized storage and transmission of data; encryption algorithm ensures the security of data transmission and storage; consensus algorithm ensures

the consistency and non-tampering of data; The smart contract enables the blockchain to automatically execute the preset business logic.

Blockchain can be divided into three types: public chain, alliance chain and private chain. The public chain refers to the blockchain that anyone can participate in, such as Bitcoin and Ethereum. Alliance chain is a blockchain jointly managed by multiple organizations or institutions, which is usually used for specific business needs; private chain is a blockchain controlled by a single organization or institution, which is mainly used for internal data management.

In general, blockchain technology has brought new possibilities to many fields with its unique characteristics of decentralization, data tamper-proof and transparency. In the IP protection of e-commerce, the application of blockchain technology is expected to solve some problems in traditional IP protection methods and improve the protection efficiency and effect.

3. Analysis of current situation of IP protection in e-commerce

In the field of e-commerce, the phenomenon of IP infringement presents various types and characteristics. First of all, piracy and counterfeiting are the two most common forms of infringement. Piracy mainly involves illegal copying and dissemination of works protected by copyright, such as movies, music, software, etc. Counterfeiting is mainly the production and sale of counterfeit brand goods, which infringes trademark rights. These violations have become more hidden and difficult to track under the network environment (Ma, 2020).

In addition, IP infringement in the field of e-commerce also has the characteristics of cross-regional, anonymity and rapid spread. The borderless nature of the network enables infringement to spread rapidly around the world, while the anonymity of the network provides hidden protection for infringers. These characteristics make IP protection in the field of e-commerce face greater challenges.

Traditional IP protection methods mainly include copyright registration, legal proceedings and administrative enforcement. However, in the e-commerce environment, these methods show some limitations. First of all, the copyright registration process is cumbersome and costly, which is not conducive to timely protection of the rights and interests of creators (Saito, 2018). At the same time, due to the particularity of the network environment, it is difficult for the traditional copyright registration system to effectively track and combat network infringement. Secondly, although legal proceedings can provide legal protection, the litigation process is long and expensive, which is often difficult for individual creators and small enterprises to bear. In addition, due to the anonymity and cross-regional nature of the network, it is extremely difficult to determine the subject of infringement and collect evidence. Finally, administrative law enforcement also has some limitations in IP protection in the field of e-commerce. Due to the complexity and variability of the network environment, it is often difficult for administrative law enforcement departments to find and crack down on infringement in time.

Blockchain technology has obvious advantages in IP protection because of its decentralization, data tamper-proof and transparency. First of all, blockchain technology can realize decentralized registration and authentication of digital works

(Kunar and Folfas, 2018). Through the blockchain platform, creators can easily register their works and obtain a unique digital identity, thus ensuring the authenticity and ownership of the works. This decentralized registration method not only simplifies the process in copyright registration, but also reduces the registration cost. Secondly, blockchain technology can track and record the dissemination and use of works. Through the transaction record and smart contract function on the blockchain, we can easily track the flow and use of works, and find and crack down on infringement in time (Bolatto et al., 2023). This transparent way of recording makes the infringement have nothing to hide. Finally, blockchain technology can also realize automatic copyright management and rights protection mechanism. Through the automatic execution function of intelligent contract, automatic copyright licensing and fee settlement can be realized. At the same time, when the infringement is discovered, the smart contract can also automatically trigger the rights protection mechanism to protect the rights and interests of the creators in time. This automatic management and rights protection way greatly improves the efficiency and effect of IP protection.

4. Application of blockchain technology in IP protection of e-commerce

4.1. Digital rights management and traceability

In the e-commerce environment, digital rights management and traceability is an important part of IP protection. Through digital rights management, creators and copyright owners can more effectively control the use and dissemination of their works and ensure that their legitimate rights and interests are not infringed. Traceability technology is helpful to trace the source and flow of digital works and provide strong support for combating piracy and infringement.

Digital rights management (DRM) is a technical means to protect the copyright of digital content and prevent unauthorized copying, distribution and use (Golan et al., 2019). Through DRM technology, creators can set protection measures for their digital works, such as access control, use restriction and digital watermarking. In the field of e-commerce, DRM technology can be applied to the sales of digital content such as e-books, music and videos. For example, the e-book sales platform can use DRM technology to encrypt e-books to ensure that only buyers can read them, thus preventing piracy. At the same time, DRM technology can also limit the ways and times of using digital content and further protect the rights and interests of creators.

Traceability of digital works refers to tracing the source and flow of digital works through technical means to ensure the authenticity and legitimacy of the works. In the e-commerce environment, the traceability of digital works is of great significance for combating piracy and infringement. Through the traceability technology of digital works, the complete circulation process of digital works from creators to consumers can be traced (Liang, 2020). This technology can help us identify the source of piracy and infringement and take timely measures to combat it. At the same time, the traceability of digital works can also provide consumers with more reliable information about works and enhance their purchasing confidence.

In practical application, the traceability technology of digital works can be realized by embedding unique identification code, time stamp and other information in digital works (Wan and Lu, 2020). This information can help trace the propagation path and transaction records of works and provide strong evidence for cracking down on piracy and infringement. Digital rights management and traceability play an important role in IP protection of e-commerce. By strengthening the application of digital rights management and traceability technology, the legitimate rights and interests of creators can be protected more effectively and the healthy development of e-commerce industry can be promoted.

4.2. Commodity anti-counterfeiting and traceability

With the popularity of online shopping, consumers pay more and more attention to the authenticity and quality of goods. Therefore, the application of commodity anti-counterfeiting and traceability technology has become particularly important. Anti-counterfeiting technology is to prevent counterfeit and shoddy products from entering the market through a series of means and ensure that consumers buy genuine products (Anson, 2018). In e-commerce, commodity anti-counterfeiting technology usually adopts special signs, labels or two-dimensional codes, so that consumers can easily verify the authenticity of commodities. For example, some high-end brands will attach unique anti-counterfeiting labels or serial numbers to their products, which consumers can verify through the brand's official website or APP. This anti-counterfeiting method not only improves consumers' confidence in buying genuine products, but also effectively combats the circulation of counterfeit and shoddy products (Sun et al., 2020). In e-commerce, commodity traceability technology can help consumers understand the production environment, raw material sources and processing process of commodities, thus enhancing consumers' trust in commodities.

Commodity anti-counterfeiting and traceability technology has a broad application prospect in the field of e-commerce. Strengthening the application of commodity anti-counterfeiting and traceability technology can effectively protect consumers' rights and interests, maintain market order and promote the sustained and healthy development of e-commerce industry. At the same time, it also requires the joint efforts of the government, enterprises and consumers to promote the continuous innovation and improvement of anti-counterfeiting and traceability technology.

4.3. Application of intelligent contract in IP protection

As an important part of blockchain technology, smart contracts are gradually changing the traditional mode of IP protection (**Figure 2**). Its characteristics of automatic execution and non-tampering have brought revolutionary changes to copyright licensing and fee settlement, which not only simplifies the authorization process, but also greatly reduces the transaction cost.
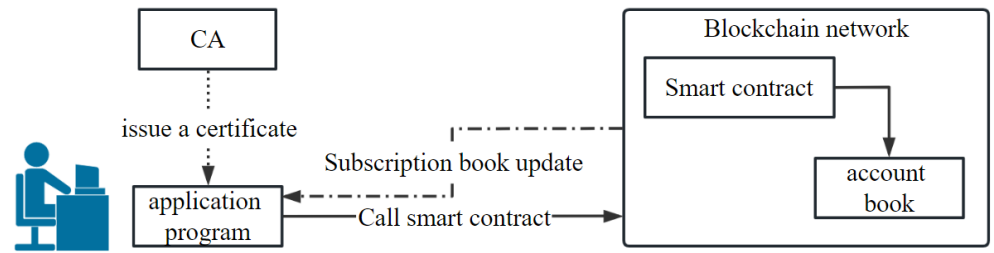
Figure 2. Blockchain smart contract.

In the traditional copyright licensing mode, the rights and obligations of both parties usually need to be clarified through complicated contracts and agreements between copyright owners and users. However, this model is often accompanied by cumbersome procedures and high transaction costs. The introduction of smart contract provides an effective solution to this problem. Through smart contracts, copyright owners and users can set the conditions of copyright license and the way of fee settlement in advance (Grida and Mostafa, 2023). Once the conditions are met, the smart contract will automatically execute the copyright license, deduct the corresponding fees from the user's account and transfer the money to the copyright owner in real time. This automatic execution not only greatly improves the efficiency of copyright licensing, but also ensures the accuracy and timeliness of fee settlement.

Another significant advantage of smart contracts is to simplify the authorization process. In the traditional copyright authorization process, both parties need to negotiate and modify the terms of the contract for many rounds, which is not only time-consuming and labor-intensive, but also may lead to misunderstandings and disputes due to human factors. The smart contract realizes the automation and transparency of authorization through preset rules and conditions, which greatly simplifies the authorization process.

In addition, smart contracts also reduce transaction costs. In traditional copyright transactions, third-party services such as intermediaries and lawyers often generate additional fees (Cheng and Li, 2023). The decentralized nature of smart contracts enables copyright transactions to be conducted directly between the two parties without the intervention of a third party, thus reducing transaction costs (Liu et al., 2018). At the same time, the transparency and non-tampering of smart contracts also enhance the trust of transactions and reduce the risks caused by information asymmetry.

The application of smart contract in IP protection brings a lot of convenience for copyright licensing and fee settlement (Su, 2020). Its characteristics of automatic execution, simplified process and reduced transaction cost make copyright transaction more efficient, transparent and credible. With the continuous development and popularization of blockchain technology, we have reason to believe that smart contracts will play a more important role in the field of IP protection.

In addition to the existing applications, we have explored more innovative ways of utilizing blockchain technology in IP protection. One such example is the development of a decentralized IP marketplace, where creators can directly register and sell their digital assets with buyers, eliminating the need for intermediaries. Another innovative application is the use of smart contracts for automated IP

licensing and royalty distribution, which can significantly reduce administrative costs and streamline the process. These innovative applications enhance the originality and impact of our research.

5. Empirical data and analysis

In order to further support our theoretical analysis and show the practical application effect of blockchain technology in e-commerce intellectual property protection, this section conducts empirical research and collects relevant data.

5.1. The application of blockchain in IP registration

Table 1 shows the application effect of blockchain technology in IP registration, and compares the performance of traditional registration method and blockchain registration method in several key indicators.

Table 1. Comparison of blockchain application effect in IP registration.

Registration method	Average duration (days)	Average cost (yuan)	Error rate (%)	Approval rate (%)	User satisfaction score (1–10)
Traditional	30	500	2.5	85	6.5
Blockchain	3	50	0.1	98	9.0

The user satisfaction score is obtained by questionnaire, and the higher the score, the more satisfied the user is. As can be seen from **Table 1**, the blockchain registration method is superior to the traditional method in average time consumption, average cost, error rate, approval pass rate and user satisfaction score.

5.2. The application of blockchain in IP transactions

Table 2 shows the application effect of blockchain technology in IP transactions, compares the transaction situation with and without blockchain technology, and focuses on multiple aspects such as transaction transparency, transaction risk, transaction time, and transaction cost.

Table 2. Comparison of blockchain application effect in IP trading.

Trading method	Transparency (1–10)	Risk (1–10)	Average trading time (days)	Average trading cost (yuan)	Dispute rate (%)
Without blockchain	4	8	15	2000	5
With blockchain	9	2	3	500	0.1

Transaction transparency and transaction risk are obtained through expert evaluation. The higher the score, the higher the transparency and the lower the risk. As can be seen from **Table 2**, with the support of blockchain technology, the transparency of IP transactions is significantly improved, the transaction risk is reduced, and the average transaction time and transaction cost are also greatly shortened and reduced, and the transaction dispute rate is also significantly reduced.

5.3. The application of blockchain in IP management

Table 3 shows the application effect of blockchain technology in IP

management, and compares the performance of traditional management mode and blockchain management mode in several key indicators.

Table 3. Comparison of blockchain application effect in IP management.

Management method	Efficiency (1–10)	Cost (yuan/year)	Data security (1–10)	Copyright tracking capability (1–10)	User convenience (1–10)
Traditional	4	10,000	6	5	6
Blockchain	9	2000	9	9	9

Management efficiency, data security, copyright traceability and user convenience are all obtained through expert evaluation and user feedback. The higher the score, the better the performance. As can be seen from **Table 3**, the blockchain management mode is obviously superior to the traditional mode in management efficiency, management cost, data security, copyright tracking ability and user operation convenience.

5.4. The application of blockchain in IP rights protection

Table 4 shows the application effect of blockchain technology in IP rights protection, and compares the performance of traditional rights protection methods and blockchain rights protection methods in several key indicators.

Table 4. Comparison of blockchain application effect in IP rights protection.

Rights protection method	Efficiency (1–10)	Cost (yuan)	Evidence credibility (1–10)	Success rate (%)	Average protection cycle (days)
Traditional	4	5000	6	70	90
Blockchain	9	500	9	95	30

The efficiency of rights protection, the credibility of evidence and the success rate of rights protection are all obtained through expert evaluation and user feedback. The higher the score, the better the performance. As can be seen from **Table 4**, the blockchain rights protection method is obviously superior to the traditional method in terms of rights protection efficiency, rights protection cost, evidence credibility, rights protection success rate and average rights protection period. This is mainly due to the tamper ability and timestamp function of blockchain technology, which makes the evidence of rights protection more reliable and powerful, thus improving the effect and efficiency of rights protection.

6. Challenges and countermeasures of blockchain technology in IP protection of e-commerce

6.1. Technical challenges and countermeasures

The core mechanism of blockchain technology is decentralized distributed ledger, but with the continuous increase of transaction data, the size of blockchain is increasing, which may lead to slower processing speed, thus affecting the overall performance of the system. In the e-commerce environment, high-frequency transactions put forward higher requirements for the scalability of blockchain (Guan

et al., 2020). Although blockchain technology provides data transparency and non-tampering, it may also expose sensitive information. In IP protection, how to protect the privacy of creators or enterprises while ensuring the authenticity of data is an urgent problem to be solved. There are technical difficulties in the integration of blockchain technology and existing e-commerce systems. How to seamlessly embed blockchain technology into the existing e-commerce process and ensure its stable operation is a technical challenge. The operation of blockchain, especially public chain, needs a lot of computing resources to maintain. This not only increases the operating cost, but also runs counter to the current concept of green environmental protection.

Through fragmentation technology, data is distributed to different nodes for processing, thus improving the scalability of blockchain. In this way, each node only needs to process part of the data, which greatly improves the processing speed and efficiency. Cryptography technologies such as zero-knowledge proof and ring signature are introduced to ensure the privacy of transaction data. These technologies can verify the validity of the transaction without revealing the specific content of the transaction. According to the characteristics of e-commerce system, a modular and plug-in blockchain solution is designed. In this way, e-commerce enterprises can flexibly choose and use blockchain technology according to their own needs, reducing the difficulty of integration. Research and develop more efficient and low-energy consensus mechanisms, such as proof of rights and proof of authority, to reduce energy consumption during blockchain operation.

6.2. Challenges and countermeasures at the legal and policy levels

Most of the existing IP laws and regulations fail to cover the characteristics and applications of blockchain technology, resulting in insufficient or vague legal basis when dealing with IP disputes related to blockchain (Chen et al., 2022). Due to the decentralized and global characteristics of blockchain, the IP issues involved may span many countries and regions, and the legal systems and IP policies of different countries are different, which may lead to legal conflicts and jurisdiction disputes. The innovation and complexity of blockchain technology have brought new challenges to the regulatory authorities. At present, for the application of blockchain in IP protection, the regulatory policy is not perfect, and there are a lot of gaps and vague areas. The anonymity and decentralization of blockchain make it more difficult to track and crack down on IP infringement. Traditional law enforcement methods may not be effective in the face of blockchain technology.

According to the characteristics and application scenarios of blockchain technology, the existing IP laws and regulations are revised and improved, and the legal status and rights and obligations of blockchain in IP protection are clarified (Chu, 2021). Through international cooperation agreements or treaties, coordinate the legal systems and policies of various countries in blockchain IP protection, and reduce cross-border legal conflicts and jurisdictional disputes. According to the characteristics and development trend of blockchain technology, formulate clear regulatory policies, fill regulatory gaps, clarify the responsibilities and obligations of all parties, and provide clear guidance for the application of blockchain in IP

protection. Combined with the characteristics of blockchain technology, innovative law enforcement means and methods, such as using the traceability function of blockchain to track and crack down on IP infringement, improve the efficiency and accuracy of law enforcement.

6.3. Challenges and countermeasures of social cognition and acceptance

Blockchain technology is relatively complex for non-professionals, which leads to the public's limited understanding of its working principle and potential application. This cognitive obstacle may affect the wide acceptance and application of blockchain in the field of IP protection. Because blockchain technology is relatively new, its security and reliability have not been fully trusted by the majority of users. Coupled with the negative news related to blockchain in recent years (such as the security incident of cryptocurrency), the public is cautious about blockchain technology. Traditional IP protection methods have formed habits in society, and it takes time and continuous education to change these established concepts and habits. Although blockchain has many advantages in theory, there are not many successful application cases in IP protection, which affects the public and industry's intuitive understanding of its effect.

Strengthen the popularization of blockchain technology through various channels (such as media, lectures, seminars, etc.) and raise public awareness of its role in IP protection. Through the certification and promotion of authoritative organizations such as the government and industry associations, as well as the successful cases of practical application, the public's trust in blockchain technology will be gradually established. While promoting blockchain technology, consider combining it with traditional IP protection methods to reduce users' acceptance barriers and gradually guide users to adapt to new technologies. Implement a number of influential blockchain IP protection demonstration projects, demonstrate the advantages of blockchain technology through actual results, and enhance social acceptance. Through policy guidance and financial support, the government can encourage enterprises and institutions to apply blockchain technology to IP protection in the field of e-commerce, thus accelerating the process of social acceptance of technology.

In order to fully leverage the potential of blockchain in intellectual property protection, it is necessary to revise the existing legal framework. Specifically, laws should be updated to recognize blockchain based evidence in intellectual property disputes and clarify the legal status of smart contracts. International cooperation is crucial for coordinating cross-border legal systems, promoting cross-border intellectual property transactions, and establishing a unified approach to intellectual property protection based on blockchain technology.

7. Prospect of blockchain technology in IP protection of e-commerce

7.1. Technological innovation and optimization direction

Intelligent contract is one of the core components of blockchain technology,

which can realize automatic execution and verification of contract terms. In the future, the function and performance of smart contracts can be further optimized to make them more flexible, efficient and secure. For example, developing a more intelligent and adaptive contract can automatically adjust the terms of the contract according to specific conditions to better meet the changing needs in e-commerce transactions. With the increasing awareness of data privacy protection, how to better protect users' privacy while ensuring the authenticity and transparency of data has become the key. In the future, more advanced privacy protection technologies can be developed, such as new variants of zero-knowledge proof or homomorphic encryption, to ensure the privacy of transaction data.

At present, there are still interoperability problems between different blockchain networks. Cross-chain technology can achieve interoperability between different blockchain networks, enabling data and assets to flow freely between different chains. In the future, cross-chain technology will become an important direction of blockchain technology innovation, which will help to build a more open and interconnected blockchain ecosystem. The scalability and performance of blockchain have always been the key factors restricting its wide application. In the future, the scalability and performance of blockchain can be improved through technological innovation, such as using fragmentation technology, side chain technology or optimized consensus algorithm, to meet the demand of high concurrency and low latency in the field of e-commerce. Combining AI and big data technology with blockchain can realize intelligent analysis and processing of massive data and improve the intelligent level of blockchain system. For example, using AI technology to optimize the node selection and data transmission path in the blockchain network can improve the overall performance and efficiency of the system.

The technological innovation and optimization direction of blockchain technology in e-commerce IP protection includes the optimization of smart contracts, the innovation of privacy protection technology, the development of cross-chain technology, the improvement of scalability and performance, and the integration of AI and big data technologies. These innovative directions will help promote the wider application and development of blockchain technology in the field of IP protection of e-commerce.

7.2. Industry application expansion and deep integration

Blockchain technology can be deeply integrated with e-commerce supply chain management to create an unbreakable digital identity for each commodity. Consumers can trace every link of goods from production to sales by scanning the QR code on the goods or using other identification technologies to ensure the authenticity and legitimacy of the goods and effectively crack down on counterfeit and shoddy products. Blockchain technology can create a decentralized copyright registration and trading platform for digital content (such as music, pictures and videos). Creators can directly register their works on the blockchain, clarify the copyright ownership, and realize automatic copyright licensing and fee settlement through smart contracts, greatly reducing the cost and risk of copyright transactions.

Based on the transparency and non-tampering of blockchain technology, a fair and transparent IP evaluation and financing platform can be built. Enterprises and individuals can use their IP as collateral for financing, while investors and financial institutions can make risk assessment and investment decisions based on the real data on the blockchain.

With the rise of cross-border e-commerce, IP protection has become more complicated. Blockchain technology can simplify the IP verification and authorization process in cross-border e-commerce, realize automatic settlement of tariffs and taxes through smart contracts, improve transaction efficiency, and protect the legitimate rights and interests of all parties. Through blockchain technology, consumers can more easily verify the authenticity and legality of goods and avoid buying fake and shoddy products. At the same time, in the event of a dispute, the tamper-proof data on the blockchain can also provide consumers with strong evidence of rights protection. Blockchain technology can promote cooperation and standardization in e-commerce industry. Through intelligent contract and distributed ledger technology, different e-commerce platforms and enterprises can realize data sharing and business collaboration, and improve the efficiency and transparency of the whole industry.

Improving public understanding and trust in blockchain technology requires targeted educational efforts. Media promotion activities can be carried out to publicize the benefits and practices of blockchain in intellectual property protection. Educational institutions and professional training programs can also incorporate blockchain technology into their curriculum. In addition, combining traditional intellectual property protection methods with blockchain based solutions can help simplify the transition and gradually guide users to adopt new technologies.

7.3. Policy support and improvement of laws and regulations

The government will formulate a special blockchain technology policy, clarify the strategic position of blockchain in IP protection, and provide guidance and support for the development of blockchain technology. These policies may include financial subsidies, tax incentives, technology research and development funding and other measures to encourage enterprises and R&D institutions to invest more resources in innovation. In order to adapt to the characteristics and application requirements of blockchain technology, the government will strive to improve the existing IP laws and regulations. This may include amending the patent law, copyright law and other relevant laws, clarifying the legal status and rights and obligations of blockchain technology, and providing clear legal protection for the application of blockchain in IP protection. The government will strengthen the supervision of blockchain technology to ensure its application within the scope of legal compliance. At the same time, it will strengthen law enforcement, crack down on illegal acts of using blockchain technology to infringe IP, and create a good legal environment for the healthy development of blockchain technology. The government will actively promote cooperation and exchanges with other countries and regions in the field of blockchain technology, jointly study and formulate internationally accepted blockchain technical standards and norms, and promote the global

development and application of blockchain technology. The government will strengthen the publicity and education of blockchain technology and improve the public's cognition and understanding of blockchain technology. Through holding seminars, training courses and other activities, we will popularize blockchain technology knowledge, train professionals, and promote the wide application of blockchain technology in IP protection of e-commerce. In view of the new IP disputes that may be caused by blockchain technology, the government will consider establishing a special dispute resolution mechanism, including setting up a special arbitration institution or court to solve related disputes quickly and efficiently.

The integration of blockchain with other technologies, such as artificial intelligence and big data, offers new avenues for enhancing IP protection. For instance, AI can be used to analyze large datasets of IP transactions recorded on the blockchain, enabling the detection of potential infringements in real-time. Big data analytics can further refine this process by identifying patterns and trends in IP usage, facilitating more informed decision-making in IP management and protection. An interdisciplinary approach that combines these technologies can thus significantly improve the efficiency and effectiveness of IP protection measures.

8. Conclusion

This study deeply discusses the application of blockchain technology in IP protection of e-commerce, and analyzes its future prospects in detail. Blockchain technology, with its characteristics of decentralization, data immutability, and timestamping, has significantly enhanced the protection of IP in e-commerce. By leveraging smart contracts, it achieves transparency and automation in IP transactions, reducing transaction costs and improving efficiency. Furthermore, blockchain technology provides a novel anti-counterfeiting and traceability solution for the e-commerce field, enabling consumers and right owners to trace the complete supply chain information of commodities. This effectively combats counterfeit and shoddy products, protecting the rights and interests of consumers and creators.

In IP registration, blockchain reduces the average registration time from 30 days to just 3 days, and decreases costs from 500 yuan to 50 yuan, with an error rate reduction from 2.5% to 0.1%. Similarly, in IP transactions, blockchain increases transaction transparency and decreases transaction risks, reducing the average transaction time from 15 days to 3 days. These findings highlight the potential of blockchain technology in IP registration, management, transaction, and rights protection.

While blockchain technology offers numerous advantages in IP protection, it also faces certain technical challenges, primarily scalability and interoperability. Scalability issues can affect transaction speed and cost, but potential solutions like off-chain storage and layered architectures are being developed. Additionally, interoperability between different blockchain platforms needs to be addressed for widespread adoption in IP protection. By providing a more detailed discussion on these technical challenges and potential solutions, we offer a more balanced view and address potential concerns from a technical perspective. Overall, with the continuous maturity and optimization of blockchain technology, along with further

recognition and support from the government and relevant institutions, blockchain technology is poised to play a more important role in IP protection of e-commerce.

Author contributions: Conceptualization, FMX and MSNMR; Methodology, FMX; Validation: FMX; Formal Analysis, FMX; Investigation, FMX; Resources, FMX; Data Curation, FMX; Writing-Original Draft Preparation, FMX; Writing-Review & Editing, MSNMR; Visualization, FMX; Supervision, MSNMR; Project Administration, MSNMR. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

References

Anson, C. J. (2018). Geographical indications act in India and veracity: a producer perspective. Queen Mary Journal of Intellectual Property, 8(3), 250–262. https://doi.org/10.4337/qmjip.2018.03.05

Aujla, G. S., Barati, M., Rana, O. F., et al. (2020). Com-pace: compliance-aware cloud application engineering using blockchain. IEEE Internet Computing, 24(5), 45–53. https://doi.org/10.1109/mic.2020.3014484

Bolatto, S., Naghavi, A., Ottaviano, G., et al. (2023). Intellectual property and the organization of the global value chain. Economica, 90(359), 707–745. https://doi.org/10.1111/ecca.12469

Chen, Y., Feng, L., Liang, H., et al. (2022). RS-chain: a decentralized reputation-sharing framework for group-buying industry via hybrid blockchain. Cluster Computing, 25(6), 4617–4632. https://doi.org/10.1007/s10586-022-03696-y

Cheng, T., & Li, L. (2023). Retracted: Optimization of E-commerce platform marketing method and comment recognition model based on deep learning and intelligent blockchain. IET Software, 17(4), 797–808. https://doi.org/10.1049/sfw2.12117

Chu, C. H. (2021). Task offloading based on deep learning for blockchain in mobile edge computing. Wireless Networks, 27(1), 117–127. https://doi.org/10.1007/s11276-020-02444-7

Chung, H. C. P., & Adeyeye, K. (2018). Structural flood damage and the efficacy of property-level flood protection. Structural Survey, 36(5), 471–499. https://doi.org/10.1108/ijbpa-09-2017-0040

Feng, S., & Ma, X. (2019). To increase damages of intellectual property infringement in China: a double-edged sword for the market. Journal of world trade, 53(1), 39–58. https://doi.org/10.54648/trad2019002

Golan, J., Athayde, S., Olson, E., et al. (2019). Intellectual property rights and ethnobiology: an update on Posey's call to action. Journal of Ethnobiology, 39(1), 90–109. https://doi.org/10.2993/0278-0771-39.1.90

Grida, M., & Mostafa, N. A. (2023). Are smart contracts too smart for Supply Chain 4.0? A blockchain framework to mitigate challenges. Journal of Manufacturing Technology Management, 34(4), 644–665. https://doi.org/10.1108/jmtm-09-2021-0359

Guan, Z., Wang, N., Fan, X., et al. (2020). Achieving Secure Search over Encrypted Data for e-Commerce. ACM Transactions on Internet Technology, 21(1), 1–17. https://doi.org/10.1145/3408309

He, H. (2020). The mechanism for intellectual property protection under Chinese e-commerce law: more powerful than necessary. Queen Mary Journal of Intellectual Property, 10(2), 217–237. https://doi.org/10.4337/qmjip.2020.02.04

Hongmei, Z. (2021). A cross-border e-commerce approach based on blockchain technology. Mobile Information Systems, 2021(4), 1–10. https://doi.org/10.1155/2021/2006082

Huang, J., He, D., Obaidat, M. S., et al. (2021). The application of the blockchain technology in voting systems: a review. ACM Computing Surveys, 54(3), 1–28. https://doi.org/10.1145/3439725

Kunar, A., & Folfas, P. (2018). How does the protection of intellectual property rights affect hi-tech exports from the most advanced economies? Argumenta Oeconomica, 41(2), 277–296. https://doi.org/10.15611/aoe.2018.2.12

Liang, Z. (2020). Regulatory exclusivity protection for undisclosed test data in China: an innovative approach to implementing the trips agreement. Queen Mary Journal of Intellectual Property, 10(1), 115–127. https://doi.org/10.4337/qmjip.2020.01.05

Liu, C., Xiao, Y., Javangula, V., et al. (2018). NormaChain: A Blockchain-Based Normalized Autonomous Transaction Settlement System for IoT-Based E-Commerce. IEEE Internet of Things Journal, 6(3), 4680–4693. https://doi.org/10.1109/jiot.2018.2877634.

Saito, Y. (2018). On the trade, growth, and welfare effects of intellectual property rights protection. Southern Economic Journal,

85(1), 235–254. https://doi.org/10.1002/soej.12277

Su, X., Liu, Y., & Choi, C. (2020). A blockchain-based P2P transaction method and sensitive data encoding for e-commerce transactions. IEEE Consumer Electronics Magazine, 9(4), 56–66. https://doi.org/10.1109/mce.2020.2969198

Sun, Y., Xue, R., Zhang, R., et al. (2020). Rtchain: a reputation system with transaction and consensus incentives for e-commerce blockchain. ACM Transactions on Internet Technology, 21(1), 1–24. https://doi.org/10.1145/3430502

Wan, Y., & Lu, H. (2020). Trademark protection of single-colour trademarks: a study of the Chinese Louboutin case. Queen Mary Journal of Intellectual Property, 10(2), 255–264. https://doi.org/10.4337/qmjip.2020.02.06