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Investigating Blockchain Technology's Integration in Financial Services

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Abstract. This paper introduces a comprehensive analytical framework designed to assess the efficacy of blockchain technology in financial accounting and its broader implications for the financial sector. The analysis explores how blockchain can revolutionize financial accounting by enhancing both efficiency and accuracy, facilitating real-time financial reporting, and expediting audit processes. It also examines blockchain's current deployment across various financial domains, including insurance, banking, payment systems, asset trading, lending, and remittances, offering a detailed look at the technology's penetration and impact. The study identifies significant hurdles, such as elevated transaction fees and prevailing technical constraints, which currently impede broader adoption. It also discusses potential regulatory challenges and the need for sector-wide collaboration to realize the full benefits of blockchain. The results of this study provide critical insights for both researchers and developers within the financial sector, highlighting the transformative potential of blockchain and proposing directions for future technological advancements and application areas. This examination not only underscores the immediate benefits and challenges but also sets the stage for subsequent innovation in integrating blockchain into established financial systems, potentially leading to more robust, transparent, and efficient financial services.

Keywords: Blockchain; Integration, Financial Services.

1. Introduction

Blockchain technology has already demonstrated its capacity to reduce credit costs for payments, showing substantial benefits across various financial facets. Notably, for transactions involving multi-ledger coordination by banks and brokerage custodians, blockchain has reduced infrastructural costs by 30%, translating into an estimated savings of $8 to $12 billion. Moreover, the current cross-border payment system, characterized by its sluggishness and high costs, significantly hinders liquidity. The opacity inherent in these payments compounds problems such as pricing transparency, remittances, and foreign exchange operations.

As blockchain technology evolves, its applications in finance are becoming increasingly evident. It enhances security for existing user data and adds transparency to the auditing process, reducing the need for auditors in processing simple transactions, potentially leading to their redundancy. Blockchain serves as a digital ledger capable of handling multiple operations simultaneously by maintaining a single block database of transactions, contracts, and contacts. However, the opacity of the financial system may expose businesses to misinformation [1, 2], driving the need for more robust financial regulations and global cooperation to mitigate risks like hacker attacks and to strengthen financial supervision [3].

Compared to traditional financial systems, blockchain offers solutions to systemic issues, high fees, delays, and unreliability in cross-border payments. Trading fiat currencies such as USD, EUR, and Rupees directly on the blockchain represents a promising application, facilitating easier financial operations and enhancing both liquidity and security.

This paper delves into the role of blockchain in enhancing the transparency and trust of financial transactions, advocating for its potential to revolutionize traditional finance through cost reductions, improved efficiency, and enhanced security. It highlights the ongoing development of financial

technology, offering insights into current issues and solutions within the financial system, including payments. The discussion is structured into three sections: an overview of blockchain technology, its application in finance, and the conclusions and future prospects drawn from the study.

Key elements of blockchain include cryptographic hash functions, transactions, asymmetric key encryption, addresses, ledgers, and blocks, all interconnected in a chain structure. Cryptographic hash functions play a vital role by generating unique outputs that maintain data integrity and prevent tampering. Asymmetric key encryption allows users to sign data with a private key, while the public key is used by others to verify the authenticity of the signature. Addresses, short alphanumeric strings derived from public keys, facilitate the sending and receiving of digital assets. The ledger records all transactions, and each block, comprising a block header and block data, stores information such as timestamps and the hash value of the previous block header [4].

The paper also includes a generic architecture for blockchain, illustrated in Figure 1.

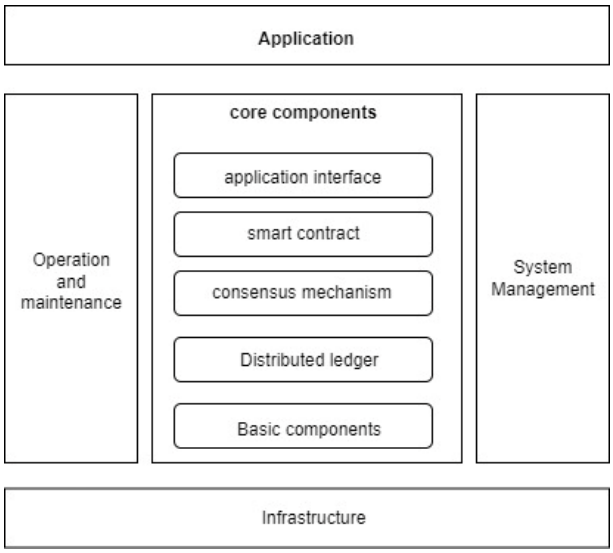

Figure 1. Structural Overview of Blockchain System Components (Photo credit: Original).

In this generalized framework, the core components are the foundation of the blockchain. It mainly includes application interface, smart contract, consensus mechanism, distributed ledger, basic components and so on. Among them, application interface is mainly used for interoperability with external programs, through which developers can more conveniently realize operations such as transaction submission query. Smart contract is an automated protocol, which is automatically executed when specific conditions are met, reducing the dependence on intermediaries and improving the efficiency and transparency of transactions. Consensus mechanism is an agreement to reach consistency for all nodes in the blockchain network, and common protocols include Proof of Work (PoW), Proof of Stake (PoS), and so on. The role of consensus mechanism is mainly to prevent data tampering and double spending. The main role of distributed ledger is used to record transaction data and ensure data security, this distributed ledger can be updated simultaneously by consensus mechanism. The basic components include some network communication protocols, encryption algorithms, etc. to ensure the normal operation of the blockchain system.

2. Blockchain-Related Technologies

Cryptography is the cornerstone of blockchain, while distributed ledger technology is the essence of blockchain that distinguishes it from other distributed data stores, and the distributed ledger of each node records the skeleton of the blockchain. Cryptographic methods, such as the HASH algorithm, digital signatures, and digital certificates, are employed to safeguard and anonymize data. In blockchain systems such as Bitcoin and Ether, the Elliptic Curve Digital Signature Algorithm (ECDSA) is employed extensively to ensure secure transaction authorization [5].

2.1. Distributed Ledger

The distributed ledger technology (DLT) facilitates the formation of a consensus among reliable nodes on a secure and nearly immutable record of transactions through the utilization of shared mechanisms. The advancement of DLT has been propelled by the advent of cryptocurrencies, such as Bitcoin, which were conceptualized primarily due to the necessity for customers to repose trust in banking and financial institutions that were required to return their funds after they were deposited. DLT is not just for cryptocurrencies, but can also store data other than asset values, and can even store programs, also known as smart contracts, that are used as part of a formalized business process, thereby automating and accelerating business processes and reducing transaction costs. Distributed ledger technology (DLT) has evolved in terms of both structure and capability, with applications in diverse fields such as supply chain management, health IT, access management, and identity verification. These advancements address the business need for enhanced throughput, confidentiality, and flexibility in developing DLT applications. The terminology associated with DLT encompasses various concepts that vary in how transactions are organized across distributed ledgers [6].

2.2. Consensus Mechanisms

Consensus mechanisms are at the heart of blockchain, the ability to be fault-tolerant to failures in a distributed system. The consensus mechanism was originally designed for decentralized cryptocurrencies. In order to maintain the fairness of the system and the sequential nature of its operations. Such a system must rely on some way of proving that it is the person who has acquired the right to pack a blockchain (or the right to keep track of it) and can access the rewards of packing that one block; or whoever intends to carry out a jeopardy will receive a certain amount of punishment, which is the consensus mechanism. The consensus mechanism is categorized into Proof-of-Work (PoW) consensus protocols, which involves miners competing against each other in order to create blocks that have been traded, and the winner will share the new block with other miners in the blockchain network in order to gain minting rights. In terms of security, security is guaranteed because users need to have 51% of the network's arithmetic power to spoof the entire chain. Ethereum currently uses the Proof-of-Equity Pos-based consensus protocol, which differs from the PoW consensus protocol in that the verifier creates the block. In a Proof of Stake (PoS) system, a validator is selected at random within each time slot to propose a block. The validator's consensus client collaborates with execution clients to bundle transactions into an "execution load," which is then compiled into consensus data and formed into a block. Subsequently, the block is disseminated to other nodes on the network. In return for their block production efforts, validators are rewarded with Ether. The security of a Proof of Stake (PoS) system is enhanced by the requirement that attackers risk significant amounts of Ether in order to control the chain. Furthermore, the system provides incentives for honest behavior through rewards, while discouraging malicious actions through penalties. A robust consensus protocol should be capable of effectively resisting attacks that are aimed at undermining its integrity.

2.3. Smart Contracts

A smart contract is a computer program that operates on the blockchain and can be executed correctly by nodes that do not trust each other, thereby eliminating the need for an external authority to verify its execution. Due to the automatic execution nature of smart contracts, they offer great opportunities in many areas that rely on data-driven transactions. Smart contracts are used in a wide variety of applications, including finance, game notarization, and many others. The number of deployed smart contracts is also increasing. For example, in March 2018 alone, the number of smart contracts deployed on Ether exceeded 2 million. The emergence of smart contracts has attracted more and more attention from the research community, with more and more researchers targeting smart contracts and publishing a large number of papers in various conferences and workshops. However, smart contracts still face potential challenges [7].

The complete life cycle of a smart contract can be divided into three distinct phases: contract generation, contract issuance, and contract execution. These phases are illustrated in Figure 2.

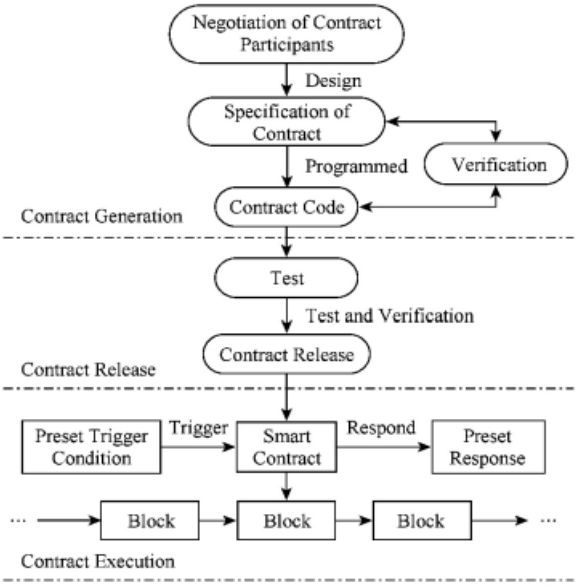

Figure 2. Smart Contract Lifecycle Process Flow (Photo credit: Original).

Among them, contract generation refers to writing and creating the smart contract code, defining the rules and logic of the contract; contract release refers to deploying the smart contract to the blockchain network so that it is visible on the distributed ledger and can be provided for invocation; and contract execution refers to the fact that after satisfying the triggering conditions, the smart contract automatically runs its pre-set code and executes the operations in the contract, realizing automated transactions.

2.4. Blockchain Scalability

Blockchain scalability refers to the ability of a blockchain system to process transactions and to scale to accommodate transaction growth. As the number of transactions grows rapidly, the issue of blockchain scalability becomes increasingly prominent. Traditional blockchains, such as Bitcoin and Ether, take a long time to generate each block on average, have limited transaction processing speeds, and suffer from insufficient transaction processing capacity, which has become an important obstacle to the scaling of blockchain applications. In order to solve the scalability problem of blockchain, some scalability methods are proposed, including efficient consensus algorithm, sharding technology, on-chain scaling and off-chain scaling. Sharding technology is an important scalability method, which improves the overall transaction processing capacity by dividing nodes into relatively independent slices, each of which independently processes smaller transactions in parallel, and finally summarizes the slice summaries to the main chain and generates new blocks by it. In addition, on-chain scaling and off-chain scaling are also one of the ways to solve the blockchain scalability problem. On-chain scaling improves the throughput of the blockchain by changing the underlying structure of the blockchain so that each block can accommodate more transactions. In contrast, off-chain scaling is to place the transaction process under the chain to complete, and the chain only records the final transaction results or arbitrates the divergent transactions, in order to improve the overall transaction processing efficiency [8].

2.5. Dual Payments in Blockchain

A double payment in a cryptocurrency system is when a buyer sends cryptocurrency to a seller's wallet, but the currency does not belong to the seller until the transaction information is recorded in the blockchain. To prevent double payments, sellers usually wait for the transaction to be confirmed in the blockchain before delivering the item to ensure the validity of the transaction. Buyers can

attempt a double payment attack, but this requires a series of mining efforts in the blockchain, which is costly. Alternatively, buyers can implement double payments by sending honest transactions and generating fraudulent transactions in the blockchain, but this requires additional transaction fees [9]. Overall, the prevention mechanisms and costs of double payments play an important role in cryptocurrency systems, affecting the security and efficiency of transactions.

3. Blockchain-Related Applications

3.1. Digital Currency Payments

Digital currency, known as cryptocurrency or crypto-currency. The advantage of trading with digital currency is that it reduces the risk of currency inflation. And it is completely independent of the state or institution. Financial transactions can be expedited through existing blockchain programs. Compared to the traditional financial sector, transactions through paper-based systems take 1 week or more. And blockchain technology can greatly improve the security of banks, including payments, asset management, and more. Blockchain technology can also improve regulatory compliance and can make finance more transparent while reducing costs [10].

In the year 2016, the Bank of Canada initiated Project Jasper, a blockchain-based wholesome Central Bank Digital Currency (CBDC) project. where the Jasper project developed a large-value interbank payment system while the second phase tested the Corda blockchain. As shown in Table 1 [11].

Table 1. A Summary of blockchain based on CBDC.

roject name	Project status	CBDC types	Blockchain	Blockchain types	Use cases	Country	Year
DNBCoin	Prototype	-	Bitcoin	Public	-	Dutch	2015
Dukaton	Prototype	-	Bitcoin	Public	Domestic payments	England	2016
RScoin	Prototype	Wholesale	Ethereum, Corda	Consortium	Inter-bank payments	Canada	2016
Project Jasper/CADcoin	Prototype	Wholesale	Ethereum, Corda, Hyperledger Fabric, Quorum	Consortium	Inter-bank payment and settlements, cross-border settlement payments, Delivery versus Payment, cross-border payments	Singapore	2016
Project Ubin	Prototype	-	-	Consortium	Cross border payments, securities delivery versus payment, cross-border payments	ECB and Bank of Japan	2017
Project Stella	Prototype	-	Quorum	Consortium	Inter-bank payments and settlement	South Africa	2018

E-krona	Prototype	Retail	Corda	Consortium	Domestic retail payments, inter-bank payment	Swedish	2018
Project Inthanon	Prototype	Retail and wholesale	Corda, Hyperledger	Private	Inter-bank settlements	Thailand	2018
Project LionRock	Prototype	Retail and wholesale	Corda	Consortium	Inter-bank settlements	HK, China	2018
Project LionRock-Inthanon	Prototype	-	-	-	Cross border payments	Thailand and HK, China	2019
Australia	Research	Wholesale	Ethereum	Consortium	Wholesale financial market transactions	Australia	2020
Sun et al	Research	-	Hyperledger, Ethereum	Consortium	Research community	-	2017
Panda	Research	-	-	-	Research community	-	2018
Han et al	Research	-	-	-	Cross-border payments	Research community	2019
AF Coin	Research	-	Ethereum	Consortium	Research community	-	

In an effort to explore more applications for blockchain, the Bank of Canada expanded the Jasper project in 2017 to develop a prototype blockchain-based central bank digital currency (CBDC), known as CADcoin. In addition to the Bank of Canada, a number of commercial banks have partnered to create an experimental interbank payment system for processing CAD payments.

Similarly, the Monetary Authority of Singapore (MAS) came up with a blockchain-based CBDC project called Project Ubin in 2016 [12]. The project aimed to explore the use of blockchain technology in payments and securities settlement. After five phases of experimentation, it was demonstrated that blockchain could be used for CBDC. The first phase used Ether for interbank payment support. The second phase investigated decentralized banking support using Corda, Hyperledger Fabric and Quorum. In the third phase, the use of smart contracts for delivery and payments was investigated. Experiments with blockchain cross-border settlement support were conducted in Phase IV. As a continuation of Phase IV, Phase V explored the development of a multi-currency support model using blockchain and CBDC for cross-border payments.

The Bank of China has proposed a financial technology in response to the rise of cryptocurrencies such as Bitcoin and Ethereum. In addition, the central bank has tested the digital currency, or CBDC, as a measure to modernize legal tender. Below is the two-tier system designed by China's DECP, as shown in Figure 3 [13].

The emergence of blockchain will also dramatically change the existing international payment methods and will save a lot of time and money. Users will be able to send and receive funds using mobile payment devices, without having to queue up at designated locations and pay for transactions. From the current development, blockchain is experiencing a historic revolution, the social demand

for blockchain is gradually increasing, and many international enterprises are also continuously investing in the field of blockchain [14].

J. P. Morgan launched JPMCoin, a US dollar payment product, on licensed Ether.BBVA issued a green structured bond on Hyperledger Habric, and Société Générale issued a €100 million guaranteed coupon on Ether MAS, the Bank of Canada, and the Bank of England to test cross-border and cross-currency CBDCs on licensed Ether Quorum Payments.

Figure 3. Two-Tier System of Digital Currency Issuance and Distribution in China (Photo credit: Original).

Based on the opacity of traditional payment methods and the inefficiency and inaccuracy of traditional finance, Ripple uses the Interleder Protocol, a blockchain-based protocol, to connect to the existing banking ledger to enable real-time cross-border payments. At the same time, Ripple can auction foreign currency in a timely manner to get the best price [15].

3.2. Supply Chain Finance

Blockchain technology can greatly improve the traceability of the supply chain. Transaction errors can be reduced through this online transaction, making it more transparent and simple. Businesses can regulate the quality of their products through blockchain technology, thus optimizing the shopping experience for users. Blockchain technology is revolutionary and can be used to verify the legitimacy of transactions through a block network. The transaction nodes can be various devices, which greatly improves the convenience of transactions [16].

Applications of blockchain in supply chain finance include solving KYC (Know Your Customer) issues, simplifying issuance, settlement and clearing issues, and streamlining the process of inventory financing, purchase order financing, and accounts receivable financing.KYC issues can be solved by blockchain technology's identity and transaction data tracking capabilities, and many blockchain projects offer KYC services, such as We. Trade (C29) and Contour (C6). Issuance, settlement and clearing issues can be accelerated by blockchain technology, e.g. the We. Trade (C29) platform offers real-time trade settlement services. Inventory financing, purchase order financing, and accounts receivable financing processes can also be simplified through blockchain projects, with accounts receivable financing being the most common, followed by purchase order financing and inventory financing. Blockchain platforms such as Hyperchain (C12) also provide supply chain finance solutions for SMEs, which reduces the cost of capital through blockchain technology [17].

3.3. Identity Management

Blockchain can efficiently carry out identity management for users, who can strengthen their secure digital identity through blockchain technology. In traditional identity management, usernames and passwords are susceptible to outside influence. Blockchain provides a more secure way to manage users' identities, and users can log in to websites or applications through digital signatures. For traditional finance, much of it relies on traditional corporate databases. The security of the database also greatly affects the security of finance. We can prevent tampering of transactions through

blockchain, a distributed ledger. With this fast verification and security, blockchain will change the financial sector in the future [18].

3.4. Fraud Prevention

Blockchain technology provides a new means of preventing fraud. As blockchain has tamper-proof technology, transaction information can be verified through blockchain technology, thus reducing the risk of fraud and ensuring the security of transactions. The introduction of blockchain technology helps to make transactions more secure. Financial institutions will reduce the risk after using blockchain technology [19].

Blockchain technology offers a number of advantages in the prevention of double payments, and thus also in the prevention of fraud. Danish listed companies are responsible for reporting dividend payments to VP Securities, which is also responsible for reporting these dividend payments to the Danish tax authorities (SKAT). If shareholders reside (pay taxes) in a country with a lower tax rate than in Denmark, they can claim a refund of the difference between the Danish tax rate and the tax rate in that country. To illustrate, if the shareholders of a Danish company reside in Germany, where the income tax rate is 15%, they can claim a tax refund equal to 12% of their total dividends (as shown in Figure 4).

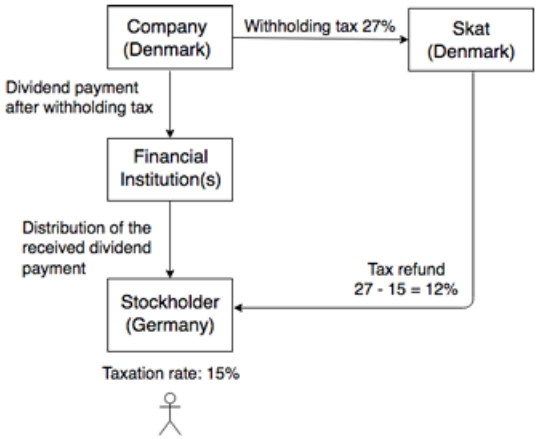

Figure 4. Cross-Border Dividend Taxation and Reconciliation Flowchart (Photo credit: Original).

The issue of double payments in Denmark arises from a lack of monitoring and information in the current system, which allows multiple individuals to claim the same dividend refunds without being detected. This problem enables applicants to claim dividend payments that have already been refunded and to use fraudulent bank statements to support their claims. Addressing this issue would prevent SKAT from paying multiple refunds for the same dividend tax payments, thereby avoiding significant losses to SKAT in the future [20].

To prevent the occurrence of multiple dividend refunds, a system can be created using blockchain technology. This would ensure that transaction records cannot be tampered with and prevent multiple individuals from fraudulently claiming dividend refunds. Additionally, smart contracts can be deployed on the Ethereum blockchain to automate the tracking of dividend flows. Secondly, foreign tax authorities could be involved in the blockchain to confirm the correct residency of tax refund applicants, thereby improving the current problem. To prevent the occurrence of multiple dividend refunds, a system can be created using blockchain technology. This would ensure that transaction records cannot be tampered with and prevent multiple individuals from fraudulently claiming dividend refunds. Additionally, smart contracts can be deployed on the Ethereum blockchain to automate the tracking of dividend flows. Secondly, foreign tax authorities could be involved in the blockchain to confirm the correct residency of tax refund applicants, thereby improving the current problem [21].

3.5. Managing Digital Assets

Blockchain technology can also be of great help in managing digital assets by encrypting and protecting each block. The blockchain network also provides a real-time and reliable transaction verification mechanism, which makes it possible to manage our assets more securely without having to go through a bank as an agent. With blockchain technology, the transparency of transactions is greatly increased, which can also be said to increase the confidence of traders [22].

Blockchain technology has similarly promising implications in the field of financial accounting. Various stakeholders who are nodes of the blockchain network will participate in the competitive mining process and record and submit information to the new block in time to broadcast it to the entire blockchain network. Institutional investors, who are more likely to become blockchain nodes due to their technological and financial advantages, are further incentivized not only by the mining rewards they receive from constructing blocks, but also by their informational advantage of earliest access to company information. Furthermore, intermediaries such as auditors and lawyers may also become blockchain nodes. Auditors, for instance, could audit the original documents and smart contracts released by companies and publish their audit opinions on the blockchain. In addition, regulators and stock exchanges will also be key nodes in the accounting blockchain, enabling them to fulfill their regulatory responsibilities more effectively.

A universal asset management system may be conceived as a blockchain-based solution to the dual payment and legitimacy challenges. This system employs the complementary mechanisms of a permissioned blockchain and an unpermissioned blockchain. The permissioned blockchain, maintained by a government office, serves as the foundation of trust, verifying end-user asset information registered on the unpermissioned blockchain. The use of smart contracts on the permissioned blockchain prevents the duplication of payments for assets and ensures that each asset is only registered on the unpermissioned blockchain within the framework of a verified smart contract. Furthermore, the permissioned blockchain also ensures the legality of asset transactions by embedding legal terms (e.g., tax laws) in the smart contract. In contrast, the permissionless blockchain serves as a marketplace for asset trading, facilitating transactions in currencies or other assets on the same chain or on other permissionless blockchains. This flexible trading model supports both single-chain and cross-chain transactions, greatly expanding the possibilities for asset trading [23]. Figure 5 depicts an architectural overview of the unified proposal for licensed and unlicensed blockchains.

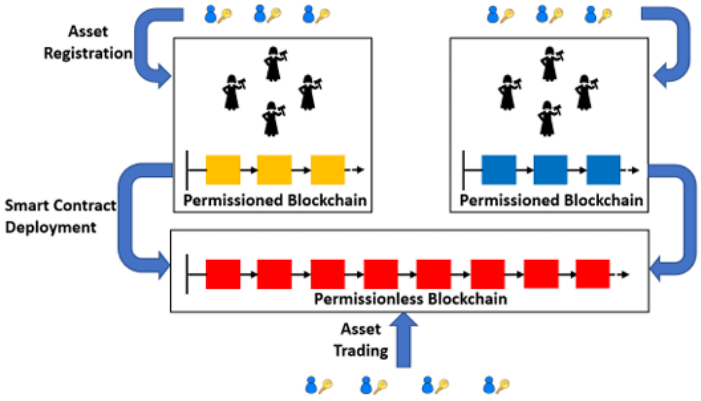

Figure 5. Blockchain Architecture for Asset Registration and Trading (Photo credit: Original).

The DMV office in California has innovatively adopted blockchain technology, specifically the Ether platform, to manage the registration and change of ownership of automobiles. First, the DMV crafted a smart contract on Ether to ensure that every transfer of ownership of a car follows established rules, including the automatic deduction of taxes due to the government. If Alice decides to utilize this new technology to register her car, she will be given a smart contract that corresponds to it to ensure that her car is not registered or fraudulently used. If some time later, she wants to sell her car to Bob, Bob will verify the authenticity of this smart contract before purchasing it, and if it is correct, Bob can

initiate a purchase request through the blockchain network, and when Bob's purchase request is confirmed, the smart contract begins to work by first ensuring that Alice receives payment in full, and then automatically calculating and deducting the taxes due to the government office. Once all these steps have been successfully completed, the smart contract also updates the ownership information on the blockchain, officially transferring ownership of the car from Alice to Bob [24].

4. Conclusion

Blockchain technology is fundamentally transforming the financial sector, catalyzing innovation and ushering in a new era of development. Its application extends beyond mere efficiency and cost reductions, significantly enhancing the security and transparency of transactions. In financial accounting, blockchain introduces decentralized and tamper-resistant systems that facilitate real-time reporting, rapid auditing, and improved accuracy. This technology is poised to revolutionize various financial services including insurance, banking, payments, asset trading, lending, and remittances. Despite its potential, the adoption of blockchain faces several challenges, including technological risks, the need for robust legal frameworks, and the imperative for innovative business models. These issues are particularly pronounced in cross-border payments and transactions involving digital fiat currencies, where blockchain could greatly enhance security, reduce costs, and expedite processes. As such, further exploration and development are crucial to address these challenges and fully leverage blockchain's capabilities. The ongoing evolution of blockchain promises to reshape the financial landscape by providing solutions that not only meet current needs but also anticipate future demands. This calls for continuous research, collaboration between stakeholders, and proactive regulatory engagement to ensure that blockchain technology can achieve its transformative potential in the financial industry.

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