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Secure Cross-Border Collaboration in Language and History Research Using Blockchain Smart Contracts

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Abstract

A Smart Contract (SC) is a digital negotiation process between two or more anonymized participants without trusted middlemen. It is an autonomous SC manifested as software code. SC operates on the blockchain (BC). The program and the SC are immutable and preserved on a decentralized public registry. Many potential applications for SC exist within the digital economy, encompassing

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financial services, administration, medical care, and the Internet of Things (IoT). Ethereum and Hyperledger constitute the most prevalent open-source advanced cross-industry BC systems for cross-border collaboration. Significant technological concerns, including security, privacy, accuracy, and verifiability, remain unresolved and require further maturation in BC. This study thoroughly examines SC. The research provides a case study on a university test system characterized by a heterogeneous data structure. This implementation provides an in-depth comprehension of the SC architecture and has been utilized to identify and evaluate the deficiencies in the current state of SC technology.

Keywords: Smart Contracts, Cross-Border Collaboration, Language Education, Blockchain.

1 Introduction

Applications spanning financial industries, industrial studies, healthcare, farming, voting via the internet, digitally recorded property resources, legal compliance, and trading are being developed and implemented at an accelerated rate on a distributed Blockchain (BC) (Wang et al., 2022) system. A Smart Contract (SC) (Dixit et al., 2022) is a digital negotiation mechanism enabling anonymous individuals to exchange cash, content, shares, real estate, or other valuable assets electronically without needing trusted middlemen, eliminating the potential for fraud (Alizadeh et al., 2020).

A SC is used in BC applications to address various security concerns (Islam et al., 2022). Other academics provide potential remedies to these security vulnerabilities for cross-border collaboration. This article analyzes the security challenges of public and private BCs and presents a potential prototype mechanism to address them. Hyperledger Fabric is an open-source BC that facilitates the confidentiality of information and is maintained by the Linux Society (Shammar et al., 2022). The application utilizes Hyperledger (Shih et al., 2019).

In language and history education, examinations serve as a tool to evaluate pupils and rank them according to a standardized criterion (Sumithra & Sakshi, 2024). Educational facilities must retain pupil evaluation records for an extended duration (Trabelsi et al., 2023). This data is utilized to validate pupils' academic qualifications and for additional analysis to implement more efficient and beneficial reforms (Khalikova et al., 2024). Therefore, it is imperative to preserve such data in an encrypted format and ensure that it is neither altered nor erased (Kiruthika et al., 2019). The examination procedure must exhibit the highest degree of openness and integrity (Sethuraman & Radhakrishnan, 2024). The volume of this data type is perpetually expanding and is necessary for the continual provision of various services for cross-border collaboration (Moretti & Tanaka, 2025). In addition to adhering to security protocols, these amenities must be provided at a minimal cost. Services are executed via an SC between the educational institution and the pupils or between the academic organization and any permitted third party for language and history education. SC in BC enhances security, fosters trust, and reduces time and financial costs (Dhivya et al., 2023).

This research aims to implement and develop an encrypted, SC-based system to manage the examination framework of a big university with numerous connected colleges (Subrahmanyam et al., 2024). The system must be designed to eliminate different weaknesses and ensure the absence of a single point of breakdown (Aoun et al., 2021). The program must provide robust protection against hackers and forged transactions and facilitate the cryptographic exchange of the SC between the person who sends it and the recipient's computer (Shrivastava & Ahmed, 2024).

The research firmly asserts that a substantial university needs a safe online system to uphold its good name. Timely provision of services at little expense is the imperative of the day. This presents a

distinctive operating problem. The research withholds the name of the University under examination to maintain anonymity. The college selected for the empirical analysis is one of the biggest and oldest contemporary universities funded by the stay.

2 Background

BC and cryptography now offer the technical framework necessary for the secure storage, administration, and dissemination of digital identities. Researchers have utilized BC to develop various solutions for issuing, storing, verifying certificates, financing, and managing digital rights for cross-border collaboration. The papers are disseminated openly to third parties in a robust way against information loss or modification. The study recommended a project allowing members to enroll in training courses and earn funding. The participants' scientific contributions are acknowledged, and the corresponding records are preserved in a virtual wallet.

Blockcert is an open-source, BC-based framework for issuing and verifying educational credentials (Terzi et al., 2021). This project allows various sorts of institutions to join the network together. An institution can issue a certificate without a SC, although it cannot regulate and oversee the conferred credits. It is a certification solution that employs the Blockcert framework as its foundational design, incorporating multiple changes. It establishes a collective reference for the certificates issued to pupils enrolled in a specific course and records the hash of these collected connections on the BC. The primary benefit of this system is its reduction of necessary space for storage but at the expense of diminished security and privacy in access to information for cross-border collaboration. Likewise, It retains a singular hash of the BC certification. The project archives not just the certificate hashing but all the data for the entire verification procedure on the Cardano network.

A study introduced a BC system for maintaining learning data called BC of Learning Logs (BOLL) (Ferreira & Gonçalves, 2022). BOLL is a platform that delineates the permissions and ownership of logs within SC. Comparable studies have proposed practical options for BC-based documents governed by SC despite variations in substance. The study presented a digital rights administration system for an online education setting utilizing an amalgam of public and private BCs (Rahman et al., 2022). The study concentrated on storing hash values for biometric information, papers, photos, and other multimedia content within the BC.

Studies have explored the utilization of SC, concentrating on specific processes such as student grading and verification of documents (Rani et al., 2024). The research introduced a system based on the BC that preserves the digital hash of educational activities and regulates access privileges via SC on the Ethereum BC for cross-border collaboration. A single payment for a college degree encompasses all writing procedures under this system, including associated costs. The study establishes that consensus relies on Proof of Work (PoW); if speed is prioritized over security, SC is achieved through Proof of Authority (PoA).

3 Analyses of BC-Enabled Cross-Border Collaboration

BC has significantly advanced the realm of cross-border settlements, providing a more efficient, safe, and economical option for transactions across borders. Numerous BC systems have emerged as leaders in this domain, with RippleNet, Stellar Network, and BC World Wire each showcasing novel strategies to address the issues of conventional payments across borders. These case studies offer insights into how BC might optimize payment systems, promote monetary inclusion, and boost the overall efficacy of worldwide financial transactions.

RippleNet has emerged as a leading BC designed to revolutionize international payments for financial organizations for cross-border collaboration. Ripple, the organization responsible for RippleNet, was established to offer a decentralized, safe network enabling banks to execute real-time payments across borders with reduced costs and fewer middlemen. Conventional cross-border payments generally entail numerous banks, processors of payments, and exchanges, each contributing their respective fees and delays to the transaction for cross-border collaboration. RippleNet mitigates these issues by employing a distributed system of servers that swiftly and effectively verify and settle transactions.

Stellar's significant accomplishment includes its partnership with prominent remittance firms, like TransferTo and Tempo, to provide affordable cross-border payment options. Stellar has collaborated with banks and governmental organizations to establish a more inclusive financial environment. Stellar is facilitating financial inclusion in areas historically marginalized from the international banking system by offering access to inexpensive transfer services for cross-border collaboration. This can enhance the economic welfare of millions, allowing them to engage more comprehensively in the worldwide economy and obtain vital financial services.

BC World Wire is an advanced BC system that enhances currency compatibility and settlement effectiveness in cross-border transactions. BC World Wire is a BC-based payment system that links banks and financial companies globally, facilitating real-time cross-border transactions. The platform employs an online currency or a stablecoin as an intermediary to enable transactions across many currencies, providing rapid payment settlement at reduced costs relative to conventional systems.

These case studies underscore the revolutionary capacity of the BC system in international payments. RippleNet, Stellar Network, and BC World Wire exemplify how BC enhances the speed, safety, and cost-effectiveness of money transfers across borders, while simultaneously tackling the obstacles of monetary inclusion in disadvantaged areas. BC-based monetary systems are transforming the global payment environment by removing agents, lowering transaction expenses, facilitating real-time settlements, and creating fresh possibilities for cross-border collaboration for enterprises, individuals, and banks. As BC advances and achieves broader acceptance, its influence on international payments is expected to increase, further fostering creativity and enhancing the general effectiveness of worldwide financial institutions.

4 BC-based Security System

This section introduces the BC-based academic credential administration platform. The suggested platform disseminates student credentials across many colleges and institutions via a singular, permissioned, and permanent ledger utilizing SC. SC is used for certificate management, particularly for booking, issuance, and verification. The suggested system fulfills essential certification criteria, including privacy, security, ease of use, availability, and uniformity.

SC dictates and regulates the generation and access of certifications. When a SC has been placed on the BC, it is immutable and cannot be altered or disregarded. Any necessary modification must be executed by establishing a completely new contract. Computerizing the procedure through SC decreases the expenses and labor for all parties involved. Before exploring the specifics in the subsequent parts, the procedure is succinctly outlined as follows.

- Initially, a private BC consortium of colleges is established. Every college or institution possessing a legitimate and official identity and website may submit a BC membership application on the system.

- Network participants with adequate access will evaluate the college's proposal using SC surveillance.
- Students access this system by registering in an accredited university inside this system.
- Upon the assessment or conclusion of each course, the pupil's qualifications will be recorded on the BC.
- Provided the pupil is an authorized and registered user of one of the institutions within this system, they may submit a review demand for the acquired credentials to other colleges.
- The institution authenticates the credentials via the network's internet gateway and under the oversight of an SC.

The College manages several administrative functions, including admissions, finance, enrollment of learners, tests, and scholarship administration for cross-border collaboration. The procedure aims to provide mark sheets, provisional documents, duplicated certificates, records, and migration documents.

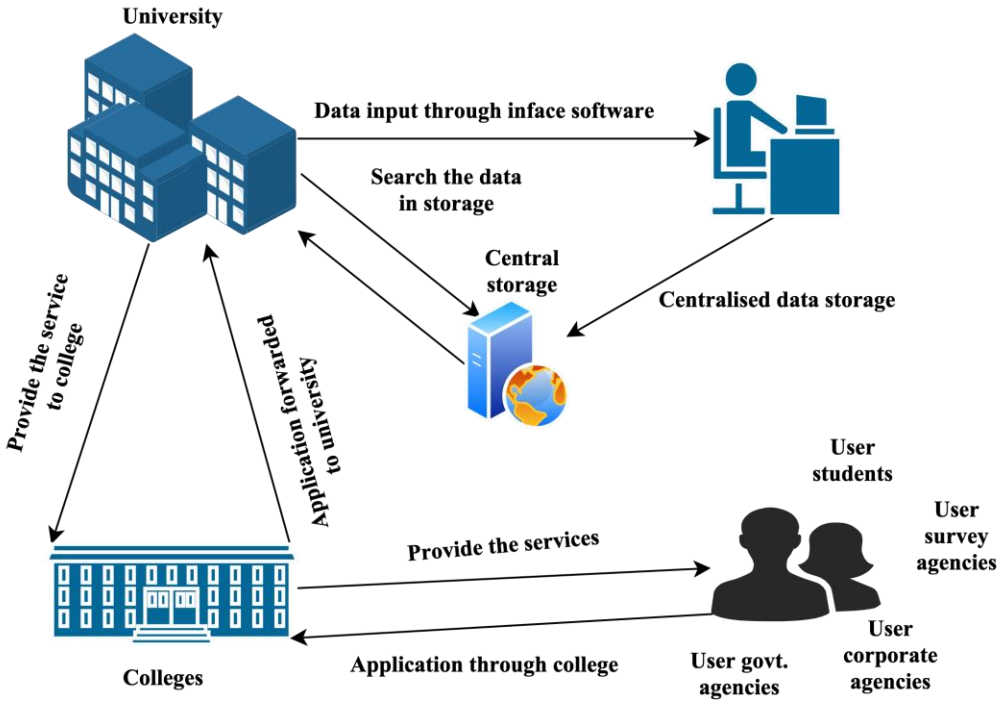

Figure 1: Workflow of the Proposed Model

The structure is currently fully manual or semi-automated, as is its safety. In the current system (Figure 1), customers (pupils, corporate entities, statistical organizations, and government departments) can submit requests to the relevant universities. The college submits its request to the University for language and history research. Upon receiving approval from the college, the customer must proceed with the payment. The college remits the money to the University. The institution needs time to go through and dispatch the paperwork to the institution for language and history research.

Academic Entities Integrate with the Network

The veracity of the producers is crucial, as they possess the capability to write to the record. In an encrypted BC, the nodes involved are identifiable to one another. A BC design with authorization

prohibits unidentified peers from joining the network. The person in charge incorporates universities into the valid college list within the SC, and those institutions access the system using their designated Internet addresses for language and history research. To become part of the BC system, an educational institution employs its BC wallet to create its address and public and private credentials. The candidate engages with a member of the BC network through SC.

In the Hyperledger Fabric framework, the BC system is segmented into multiple channels. A channel is a secret communication pathway between more than one networked individual intended for executing confidential operations. Every participant in the channel must endorse and implement the ledger and SC arrangements specified within the channel. New colleges establish BC networking nodes and SC. The BC's joining procedure is finalized upon the network node's installation, and the SC changes the ledger for cross-border collaboration. Figure 2 illustrates that procedure.

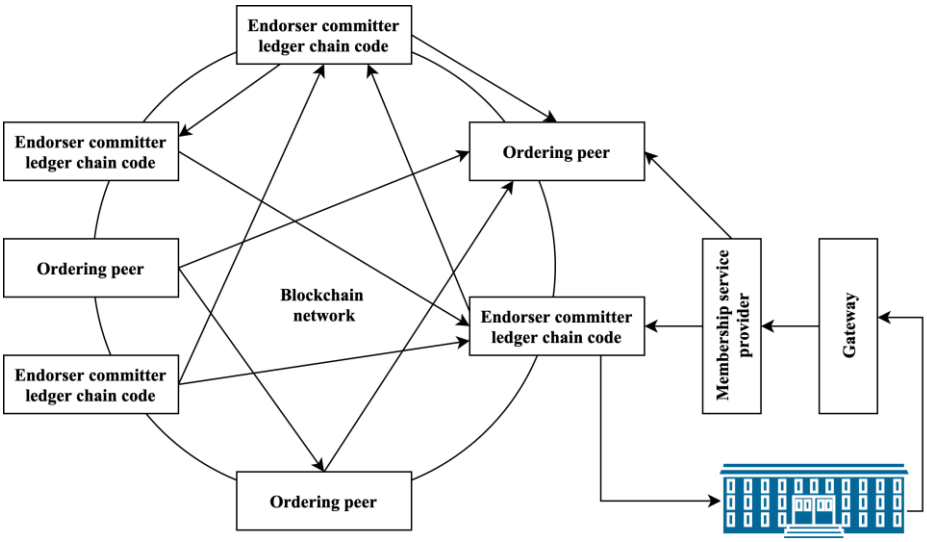

Figure 2: Process of Academic Issuers

Enrollment and Course Fulfillment

The two primary stages are enrollment by learners and course completion by pupils. The transaction about student records encompasses the registration of students into the educational system and their finishing of courses for language and history research. Upon a user's intention to enroll in an academic institution affiliated with the BC system, an identification is granted, and an additional multi-signature BC account is created for the pupil. The multi-signature location, along with the user ID, is recorded in the records. Alongside overseeing processes through SC, digital multi-signatures are an additional security feature, necessitating several confidential keys for transaction authorization. Moreover, both sides must establish a consensus before transmitting the data to enhance security for cross-border collaboration.

Upon completing the course, the lecturer must validate the findings and transmit the examination outcomes. The professor informs the administrative office to register the student's results in a computerized system manually. The administrative staff locates the pupil's BC addresses in the information repository for cross-border collaboration. It utilizes the student's BC wallets to send the specified value by the relevant SC stipulations.

The operation is executed via the system. Upon confirmation of the transactions, the management office logs the successful result transmission into the central system. The hashing algorithm of the certifications is retained in an SC implemented on the Hyperledger Fabric BC to safeguard the digital certificate conferred to the learner. The procedures for issuing and upgrading user profiles are essentially the same and are conducted by the management team. From the viewpoint of the pupils, their CVs will be assembled as an online resume.

Verification of Information

BC enables consumers to autonomously authenticate the legitimacy of certificates immediately on the BC, eliminating the necessity to engage with the issuing institution. It will eliminate colleges' need to authenticate certificates for language and history research.

Information can be kept on a BC in two manners: directly or as a link. The suggested technique stipulates that, due to the confidential nature of BC and security prerequisites, should a student wish to apply for a different university or company, an official review demand will be submitted to the institution by the pupil. The solution enables users to instantly validate the authenticity of certifications directly versus the BC, eliminating the necessity to contact the issuing organization for cross-border collaboration. It will eliminate the necessity for colleges to authenticate the documents. Suppose the user plans to seek a post or enroll in another college. In that case, the user will submit an inquiry for certificate evaluation to the university, granting permission to talk solely to the invited colleges.

The stages of this procedure are delineated as follows: The user initially applies to the target university or company to secure a schooling or employment opportunity. The user will choose the private BC handle and the multi-signature address provided by the college from the wallets and transmit them to the target entity or organization together with the redemption script.

The destination college or institution authenticates the student's assertion and examines the redemption script to validate the pupil's multi-signature addresses for language and history research. The target university/organization will require the pupil to sign a verification mail containing his address to authenticate his identification. The pupil authenticates the verification message utilizing his BC location and personal key, transmitting it to the university. This institution authenticates the signed communication, and if the applicant's BC location corresponds with the signed communication, the products (certification) are verified and validated. The procedure concludes without a result for cross-border collaboration. The digital signatures of the uploaded certifications uniquely identify the certificates, confirming that the file remains unaltered. SC is employed to authenticate the documents.

5 Results

To demonstrate the efficacy of the BCs, the research established two situations (i.e., the Supplier payments and not paying the remaining balance) across the three predominant EVM BC systems: Fantom, Ethereum, and Binance Smart Chain. The research offers the source material and installations for further language and history research development. The study examines two scenarios: the Demander makes the whole payment, and the Demander fails to remit the remaining money.

- Case 1: Supplier remits complete payment:
- Case 2: Supplier Fails to Remit Remaining Payment:

Discussion

The results indicate the gas expenses associated with setting up and implementing the three systems: Fantom, Ethereum, and Binance Smart Chain for the BC. Fantom's SC execution price is the lowest among the three, averaging 0.07 FTM, equivalent to $0.03. The most costly way involves around 0.6 FTM ($0.12), whereas the least expensive option costs $0.005 with 0.016 FTM for both eventualities. ETH is the priciest, with a maximum of $7.92 and a minimum of $0.12 across the two scenarios. The execution price for deploying the SC is $6.5, roughly 15 times greater than Fantom's, with a minimum fee of $0.39 for the two situations. The median gas cost for all eight methods in the two situations is $1.50 for installation on Ethereum and $1.30 for Binance Smart Chain.

Discourse on Safety and Confidentiality

This article presents the supply chain utilizing BC, emphasizing decentralization and openness over security and privacy concerns for language and history research. In these respects, the research endorses fundamental authorization through role-based access management, whereby the appropriate party can invoke the related functions for cross-border collaboration. The primary limitation is its restriction on the number of roles in massive systems. These systems may contradict or duplicate the new policy; intruders might target the system.

The research will utilize the Attribute-Based Access Control (ABAC) methodology to oversee the access control procedure. The study delineates a dual-layer policy for on-chain and off-chain operations, respectively. Specific methodologies divide the initial policy into sub-policies. Governmental and private regulations guarantee that data is accessible with authorization, even by partners involved in the same operation for cross-border collaboration. Query rewriting can be utilized in intricate scenarios where disseminated data is exchanged among numerous entities and within a dynamic environment. The researchers specifically recommended a dynamic query that adjusts the distinction in value (i.e., level of information) according to user attributes.

6 Conclusion

The provision of services has become an even more significant issue globally throughout this global epidemic. The majority of educational institutions are either closed or have restricted access. Remote work and educational activities are conducted online for language and history research. This scenario necessitates effective and secure methods for the distribution of information in a vast, decentralized setting. This article's work is essential during this epidemic, benefiting an enormous community of location-independent learners using the BC foundation to construct safe, cost-effective digital apps. This study analyzes SC technology's diverse domains and associated security concerns for cross-border collaboration. The research has examined and confirmed the need and advantages of an SC through a case investigation examining college results for handling data. The cost assessment serves as a foundation for future decision-making. The research will endeavor to integrate additional services into the SC to derive further benefits from the framework. Creating a comprehensive cloud-based meta-tool is among the planned feature developments for cross-border collaboration. It is essential to acknowledge that the future evolution of SC will not be confined to current systems for language and history research and must encompass the following:

- The even distribution of databases among various clusters alleviates the burden on the network components. It will enhance the effectiveness and sustainability of the whole BC network.

- The BC should be modifiable with appropriate authorization, identification, confirmation, and verification. The participants' information and the possessions of the encrypted BC are subject to modification. Private BCs permit modifications to data until a transaction is finalized. Although it permits certain flexibility, the essential reliability of BCs regarding transaction traceability stays intact.
- The research intends to augment the BC to accommodate a substantial volume of structured and semi-organized information. This endeavor necessitates substantial effort and must address numerous research challenges.
- The research wants to bolster the chain's safety by employing a game theory-based methodology to distinguish between honest and dishonest players and implement filtering mechanisms.

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