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BlockEP: A Blockchain Architecture to Record Academic Grades in the Peruvian Army

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Abstract*– Currently, blockchain technology is utilized in various sectors, one of which is higher education. Some of the benefits of this technology include streamlining the deployment of educational platforms where students and teachers can manage their data, financial transactions, and decide securely what content to share and with whom. Similarly, it enables the issuance of official certificates, ensuring the accuracy of evaluations and degrees attained by students throughout their academic journey. Furthermore, through the utilization of a decentralized system, academic credentials can be securely and transparently stored, posing a challenge for potential forgers attempting to alter academic grades. In this context, this paper proposes the design of a blockchain architecture for the academic grades record in the Peruvian Army, named BlockEP. The objective is to enhance security, transparency, and efficiency in the academic and administrative processes of both undergraduate and graduate military schools. The BlockEP architecture empowers authorized users to manage student grades, ensuring comprehensive control of the network, and features a graphical interface to facilitate understanding and interaction. This initiative provides an advanced solution and a valuable learning opportunity in blockchain technology for military institutions.

Keywords*-- Blockchain, academic grades, smart contract, BlockEP architecture, education platforms, Peruvian Army.

I. Introduction

Throughout history, education has undergone significant changes to adapt to the changing demands of society and culture. Educational methods have evolved from traditional lecture-based approaches to more contemporary methods that encourage active participation between students and teachers. These methods include collaborative learning, problem-solving, and fostering critical thinking. This evolution reflects a shift towards a more interactive and student-centered educational model, emphasizing problem-solving and critical thinking [1]. Additionally, technology has transformed the way information is accessed, and education and learning are conducted online [2], [3], [4], [5]. Military training is an intensive preparation process that provides individuals with the skills, knowledge, and aptitudes necessary to serve in any of the Armed Institutions they choose to enlist [6]

In the Peruvian Army, military training is conducted at two levels: (i) undergraduate, through training schools, and (ii) postgraduate, through advanced training schools. All academic education, training, instruction, and training are quantified through the grades obtained by each student. This result significantly influences the possibility of promotion within the military hierarchy. For this reason, it is of vital importance to ensure the integrity, security, privacy, reliability, and availability of this information. Considering the high rate of attacks that computer systems have endured throughout history, including methods such as identity theft and data manipulation, among others, which currently pose a real challenge for administrators of critical systems [7].

For several years, in the Peruvian Army, the procedure for recording academic grades is carried out using a conventional open-source platform and storing the data in a centralized database on physical servers. However, the current trend in developing robust educational systems in both the public and private sectors is to adopt Blockchain technology, which is a significant alternative for implementation in training and further education schools [8], [9], [10], [11], [12], [13]. The implementation of this technology offers multiple benefits, enhancing the security, transparency, and efficiency of academic and administrative processes, such as student records, credential verification, payment processing, among others. In this context, this article proposes the design of a blockchain architecture for the record of academic grades in the Peruvian Army, named BlockEP. This system will provide comprehensive security for the grades obtained by students in training and advanced training schools.

This work is structured as follows: Section 2 describes a comprehensive review of the state-of-the-art related to the use of blockchain technology in the education sector. Section 3 presents the design of the "BlockEP" blockchain architecture for the recording of academic grades. The results and discussions are presented in Section 4. Finally, Section 5 describes the main conclusions of the research.

II. State-of-the-art on Blockchain in the Education Sector

Blockchain technology is a decentralized and secure database, where digital information can be stored and managed, without the need to be under the control of any organization with the concept of centralization of information and can be applied in different fields [14]. There are many reviews about the application of blockchain technology in the field of education. In [15], the concept of blockchain and how it can be applied in the education sector are presented, mainly focused on the use of blockchain for reporting academic certificates and educational accreditation information. In [16], the implications of blockchain for education are explored, where distributed educational records are reliable, secure, accessible, and distributed across many institutions. In [17], a bibliometric and qualitative analysis of blockchain in education is presented, focusing on temporal development and practical case studies on adoption and integration with existing educational technologies. In [18], the study highlights the importance of blockchain technology in international payments, underlining its ability to store information securely and prevent security risks in funds transfers. The study examines how blockchain in cryptocurrencies secures transactions, generating debates in financial markets. In [19], the authors explore the vast potential of blockchain and its strategic benefits. These benefits lie in its ability to improve efficiency, transparency, security, and automation of business processes and explain blockchain in the context of business strategies, they also highlight its applications and illustrate how practitioners can integrate this technology into business providing new opportunities for innovation and revenue generation. In [20], the versatility of blockchain technology is highlighted for application in various sectors, such as healthcare, finance, cybersecurity, data science, and academic management. This approach offers security in information storage and decentralization, which makes it effective for building trust in untrusted environments. In [21], reviews the literature on how blockchain technology impacts mobility in smart cities. It highlights its ability to improve sustainable mobility by reducing pollution, travel time, and congestion. The analysis highlights the crucial role of blockchain in addressing urban and environmental challenges by supporting innovative projects in smart cities. Table 1 shows the companies that use blockchain technology in their processes.

TABLE I
COMPANIES USING BLOCKCHAIN TECHNOLOGY

COMPANY	SECTOR	USE OF BLOCKCHAIN
Walmart	Retail	Tracking the movement of produce from farmers to stores
Maersk	Shipping	Blockchain system for tracking shipments between ports
BHP Billiton	Mining	Enhancing supply chain management
Humana y UnitedHealthcare	Healthcare	Improving physician directories for insurance claims processing
Baidu	Search	Managing and securing intellectual property rights
FedEx	Shipping	Resolving customer disputes through transparent and traceable processes
Ford	Automobile Industry	Advancing mobility technologies through blockchain integration
Prudential	Insurance	Providing a blockchain trading platform for small and medium-sized enterprises
Perú Compras	Corporate purchasing and reverse auction	Recording purchase orders and associated offers across multiple nodes

Blockchain technology has the potential, capability, and flexibility to be applied in various contexts, including the revolutionary transformation of business models across economic sectors, educational processes, medicine, and transportation, particularly in logistics and supply chain management. This is due to the immutability of data and its distributed database accounting system [22]. In [23], researchers studied the use of blockchain technology to verify the integrity of data sets in government information systems, ensuring secure management without falsification or manipulation. Additionally, [24] examines blockchain platforms and their functionalities within supply chains, mapping and synthesizing key concepts and applications. Figure 1 shows the comparison between the decentralized network structure used in blockchain and the centralized network used in a client-server institution.

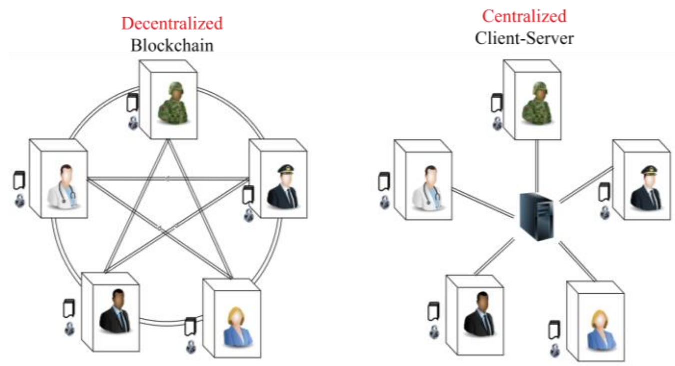

Fig. 1 Comparison between a decentralized and centralized network

B. *Grade recording platforms*

There are various platforms for recording student grades, all developed using different technologies. For instance, in [25], a software system using Microsoft Visual Basic 6.0 is proposed to enhance the recording and calculation of grade point averages in Nigerian educational institutions. In [26], the design of an application called Honest Grade is suggested. This application monitors, prescribes adaptive tests, and verifies answers, thereby easing the burden on educators and maintaining the integrity of examinations. The design offers a comprehensive testing environment for both students and teachers. In [27], the OESC educational platform is described, aiming to bring together diverse participants such as researchers, teachers, students, and the public at large. The platform includes a content repository and provides a technological solution for research and learning, harnessing digital technologies for effective collaboration. In [28], the analysis of the emergence of Massive Open Online Courses (MOOCs) is emphasized, examining their implementation models and platforms, as well as various business models being considered to make them profitable. The study provides a comprehensive overview of the evolution of MOOCs, underscoring their nature as free courses, open to an unlimited number of students with no admission requirements. The article makes a valuable contribution to understanding the changing landscape of online education and its potential impact on the accessibility and profitability of these large-scale courses. The DisPeL platform incorporates a combination of components that enables comprehensive learning. From organizing the learning process to assessing and completing learning [29]. In Saudi Arabia, like many countries around the world, distance learning, through the unified platform Madrasati, has been embraced as the new gateway to distance teaching and learning for all educational levels. This platform utilizes cloud services and encompasses academic programs, grade recording, and academic reporting [30]. Another alternative is Moodle, an open-source, web-based, collaborative e-learning platform that facilitates the administration of online courses and the recording of grades within a centralized information architecture [31]. In [32], a web platform named Levumi, designed for student monitoring, is introduced. This platform relies on data exchange between schools and educational centers, enabling the collection of highly valid information anonymously. On the other hand, PowerSchool is a comprehensive learning management and student information platform used by educational institutions worldwide. This platform offers a variety of tools for managing student data, grades, attendance, parent communication, class scheduling, and other aspects related to educational management. Table 2 displays the most popular platforms used by educational institutions for recording student grades.

TABLE II
MOST POPULAR GRADE RECORDING PLATFORMS

PLATFORM	MAIN FEATURES
Moodle	Tracking the movement of produce from farmers to stores
Blackboard Learn	Blockchain system for tracking shipments between ports
Canvas by Instructure	Enhancing supply chain management
Google Classroom	Improving physician directories for insurance claims processing
PowerSchool	Managing and securing intellectual property rights

B. *Blockchain applied to education*

Blockchain has emerged as a crucial concept in information technology and higher education [33]. It has the potential to transform various aspects of higher education by providing transparency, security, and efficiency in data and process management [34]. Blockchain is now being utilized in different domains, including government and education, owing to its reliability, scalability, and immutable distributed environment for performing and storing transactions over a network [35]. In [36], the authors conclude that blockchain technology has the potential to revolutionize higher education by enhancing security, transparency, and efficiency in academic and administrative processes. Additionally, [37] highlights the advantages of using blockchain in libraries, such as digital preservation and data tracking, despite recognizing challenges like architectural complexity and initial costs. Nevertheless, the relevance of research and development in this area is emphasized, as emerging technologies like blockchain could shape the future of libraries and information centers. This technology has been applied in the Media Lab of the Massachusetts Institute of Technology (MIT), which has produced bitcoin-based Blockcerts; meanwhile, the Knowledge Institute of the Open University of the United Kingdom has developed Ethereum smart contracts to document micro-credentials; both are open-source products [38]. In [39], the possible applications of blockchain technology in higher education institutions were investigated, presenting a proposal for a blockchain-based academic and professional records system in higher education. Additionally, Sony Global Education has generated individual data on the competencies and productivity of its students; a third case relates to the University of Nicosia, which was the first to use smart contracts and accept cryptocurrencies as a form of payment [40]. In [41], the objective was to create a blockchain that allows university professors to uniformly upload teaching materials, resulting in a unified and widely accepted university curriculum. The document also suggests using the Soft-Fork blockchain process to modify teaching materials at specific intervals. In [42], the UniverCert platform is introduced, developed on a consortium blockchain architecture to address the challenges universities face in storing and protecting student data. UniverCert is based on a consortium version of the decentralized and open-source Ethereum blockchain technology. In [43], a proposal for an educational records repository backed by blockchain technology is introduced, called BcER2. This system manages and distributes educational assets for academic and industrial professionals. The implementation of BcER2 facilitates the secure and uncomplicated transfer, sharing, and distribution of educational records, such as diplomas and electronic certificates, among the involved parties. In [44], the initial implementation of The Blockchain of Learning Logs (BOLL) is presented, being the first of its kind. BOLL addresses the "cold start" challenge faced by learning data analysis platforms, allowing students to transfer their learning records securely and verifiably between institutions, solving the problem of accessing learning records from other institutions. Currently, there are educational institutions that have already implemented blockchain technology in their academic processes. Table 3 presents some educational institutions using blockchain.

TABLE III
EDUCATIONAL INSTITUTIONS USING BLOCKCHAIN

INSTITUTION	USE OF BLOCKCHAIN
Massachusetts Institute of Technology (MIT)	Digital diploma issuance (Blockcerts)
University of Nicosia	Tuition payments in Bitcoin, academic programs
University of Melbourne	Verification of academic credentials
Georgetown University	Issuance of course completion certificates
University of California-Berkeley	Issuance and verification of academic credentials
National University of Singapore	Verification of academic qualifications for graduates

On the other hand, "CoinDesk," the leading company in news and information about cryptocurrencies and digital assets, has ranked the top 50 universities in its 2022 ranking, selected from a sample of 240 worldwide based on their academic, industrial, and pedagogical impact in blockchain. This story is part of CoinDesk's Education Week, highlighting universities in Asia and the Pacific Islands leading in blockchain education, with the highest overall average score of 63.7% and standing out as the main region in research. 60% of the top research universities are located in this region. Figure 2 presents the ranking of the best universities for blockchain, indicating that research, utilization, and implementation of blockchain in educational institutions are gaining importance.

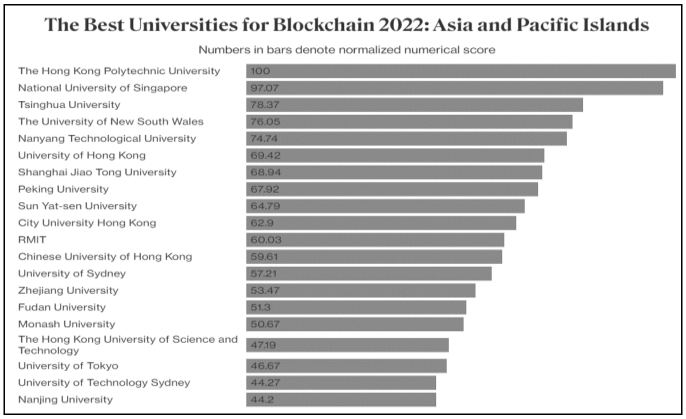

Fig. 2 Comparison between a decentralized and centralized network

C. *Blockchain and Grade Recording Platforms*

Blockchain is utilized for the implementation of higher education platforms, as in the case of EducaCTX. EducaCTX is a system designed with a decentralized architecture that offers security, anonymity, longevity, integrity, transparency, immutability, and simplification for the reliable recording of grades and credits in higher education [45].

EduChain is a high availability blockchain platform based on Hyperledger Fabric for an educational consortium designed and developed to enhance reliability and security in the exchange of educational data [46]. In [47], UniChain is proposed, a blockchain-based system for managing Electronic Academic Records (EAR). Its aim was to provide interoperable, secure, and efficient access to EAR while maintaining student privacy. UniChain utilizes timed smart contracts and advanced encryption techniques to manage transactions and ensure security.

III. DESIGN OF THE BLOCKEP ARCHITECTURE

Blockchain technology provides security, availability, immutability, among other advantages, and is constituted as a chain of blocks linked through a "unique hash" that references the previous block to ensure the continuity and security of the chain [48], [49]. Based on this concept, the design of the "BlockEP" blockchain constitutes a comprehensive project that involves different aspects, such as purpose, type of blockchain, consensus algorithm, data structure, network protocol, cryptography, creation of node clients, and smart contracts. The Peruvian Army is a military institution that complies with internal security policies and standards in information system management. Consequently, this work considers the configuration of access to the BlockEP network. The creation of BlockEP could be carried out using any platform available on the network, for example, (i) Ethereum, a platform that allows the creation of blockchains through smart contracts and decentralized applications, driven by its native cryptocurrency Ether [50], [51]; (ii) Stellar, a decentralized open-source blockchain platform that uses a distributed ledger and a network of nodes to validate and record transactions [52]; (iii) Ripple, which employs a consensus protocol called Ripple Protocol Consensus Algorithm (RPCA) to validate and record transactions on its network [53]; (iv) Hyperledger Fabric, an open-source enterprise blockchain platform developed by the Linux Foundation with a modular architecture [54]; (v) Cardano, designed with a focus on security and scalability, featuring a layered architecture, and its consensus protocol, called Ouroboros, is a key aspect ensuring network decentralization and security.

A. *Design of the Proposed Architecture*

The design of the blockchain architecture for the recording of grades in the Peruvian Army, named 'BlockEP,' is restricted, with limited access based on user profiles such as teachers, students, system administrators, and directors. Initially, participants must register through a web form to access BlockEP and carry out transactions, record-keeping, and/or view students' grade records.

Figure 3 illustrates the main architecture of the BlockEP proposal. To access the BlockEP network, there are two methods: (i) if the user is outside the institution's private network, through the front-end, using any device (mobile, web, etc.), after prior web registration and validation by the API; (ii) by using the institutional private network (back-end), after user registration and/or validation. This architecture includes the implementation of an application server where the graphical interface is deployed for users to interact with BlockEP.

Two types of smart contracts configured with network access profiles have also been considered. The BlockEP network integrates training schools and advanced training schools, which will enhance the security and integrity of information, as a greater number of connected nodes will make BlockEP more robust.

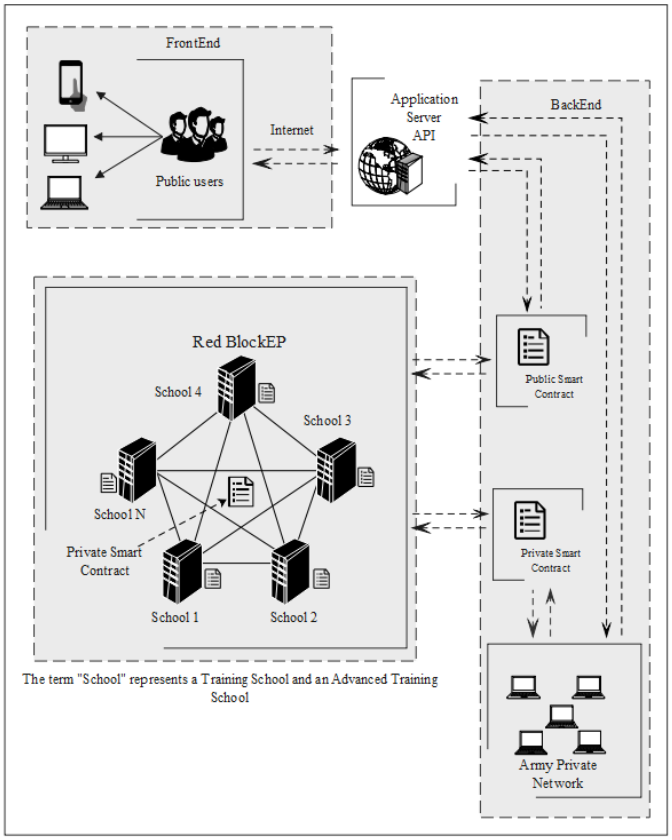

Fig. 3 BlockEP Architecture

B. *BlockEP API Structure*

The proposed BlockEP considers the structure and development of an Application Programming Interface (API) that centralizes web registration applications, validation configuration, user modification, and deletion, among other functionalities. Figure 4 illustrates the BlockEP API architecture.

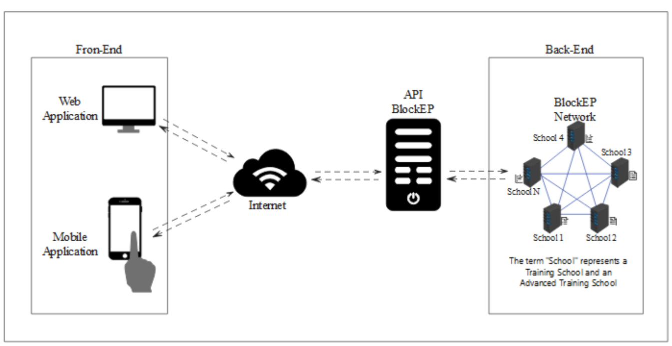

Fig. 4 Architecture of the API (FrontEnd and BackEnd)

In addition to consolidating the applications for managing external and internal users after validation, the BlockEP API will enable secure and transparent interaction between the BackEnd and the FrontEnd.

C. *BlockEP Creation*

The creation of BlockEP is based on the architectures shown in Figures 3 and 4, using the Python programming language. It involves three initial blocks, each identified by a unique name and code (unique hash). The pseudocode for creating the BlockEP blockchain is presented in Algorithm 1.

Algorithm 1: BlockEP Creation

Input: *L*: List of chains

Result: *BlockEP*: BlockEP created

1. **Procedure** BLOCKEPCREATION (*L*)
2. **List** chain (L)
   chain 🡸 [create_genesis_block]
3. **Function** create_genesis_block **()**
   Return Block (0, "0", get_current_time (), "Genesis Block")
4. **Function** get_last_block ()
   Return chain [-1]
5. **Function** add_block (new_block)
   new_block.index <- get_last_block().index + 1
   new_block.previous_hash <- get_last_block().hash
   new_block.timestamp <- get_current_time()
   chain.add(new_block)
6. **Function** minar_block()
   new_block ← block(length(chain), get_last_block().hash
   get_current_time (), "BlockEP"
   add_block(new_block)
   response ← {'message': 'Block successfully mined!',
   'index':new_block.index,'hash':new_block.hash,'data':new_block.data}
   Return response, 200
   response ← {'message': Student data successfully added!',
   'index':new_block.index,'hash':new_block.hash,'data':new_block.data}
   Return response, 200
7. **End procedure**

When initializing the BlockEP blockchain, its hash is calculated using the "mine_block" function, which employs a mining process to find a hash starting with '0000'. The "calculate_hash" function utilizes the SHA-256 hash algorithm to combine the attributes of the block and generate a hash. It also includes a list of blocks where the genesis block (the first block in the chain) uses the "create_genesis_block" function. Additional functions involve getting the last block, adding a new block to the chain ("add_block"), and maintaining the complete list of blocks ("chain").

D. *Proposed Smart Contracts*

Smart contracts are self-executing sequences that run on a blockchain and play a crucial role in automating and managing agreements, transactions, and business logic in decentralized environments. For the proposal, two configurations were used: (i) a private smart contract type for users accessing BlockEP through the Army's private network, and (ii) a public smart contract type for all users accessing the platform via the internet and can use it through any mobile device.

D.1. Public smart contract

In this Smart Contract Public, specific rules and constraints for users must be considered, and they automatically execute when certain conditions are met according to the established profiles. Smart Contracts Public run in an isolated environment, reducing the vulnerability risk of BlockEP. The pseudocode for the creation and configuration of the Smart Contract Public is shown in Algorithm 2. The configuration of the constraints is presented, where "grant_access" grants access to a specific user according to their established profile, "revoke_access" revokes access for unauthorized users, and "check_access" verifies if a user has access or not.

Algorithm 2: Public Smart Contract

Input: *U*: User address

Result: *PUBLICSC*: Public Smart Contract created

1. **Procedure** PUBLICSC (*U*)
2. **Function** revoke_access(user_address)
   IF user_address IN allowed_users
   Then
      allowed_users.remove(user_address)
      Display "Access revoked for user:" + user_address
   Else
      Display "User " + user_address + " does not have access"
3. **Function** check_access(user_address)
   IF user_address IN allowed_users
   Then
      Display" User" + user_address + "has access to BlockEP"
4. **End procedure**

D2. Private smart contract

In this private smart contract, rules and restrictions for internal users are considered according to established profiles. Private smart contracts run in an isolated environment. Algorithm 3 illustrates the process of creating and configuring the private smart contract, which uses a list of valid users with hashed passwords.

When attempting to grant access, the provided password is verified against the hashed password stored in the list.

Algorithm 3: Private Smart Contract

Input: *AU*: Allowed Users

Result: PRIVATESC: Private Smart Contract created

1. **Procedure** PRIVATESC (*AU*)
2. **Function** grant_access (user_address, password)
   hashed_password ← SHA256(password)
   If user_address is in valid_users and hashed_password is equal to valid_users[user_address] **Then**
   Then
      allowed_users.add (user_address)
      Show "Access granted for internal user:" + user_address
   Else
      Show "Invalid credentials for user:" + user_address
3. **Function** revoke_access(user_address)
   If user_address is in allowed_users **Then**
      allowed_users.remove (user_address)
      Show "Access revoked for internal user: " + user_address
   Else
      Show "User " + user_address +" does not have access"
4. **End procedure**

E. Security of BlockEP

The blockchain architecture for grade registration in the Peruvian Army uses the SHA-256 hash algorithm or secure hashing algorithm [55], which generates a 256-bit hash value, i.e., a string of numbers and letters that provides high collision resistance extremely difficult to reverse, ensuring data integrity and secure password storage [56]. The security of BlockEP is the same as conceived for the blockchain of Bitcoin, making it very robust. Each block is sealed with a cryptographic hash that depends on the data contained in the block and the hash of the previous block. The hash256 algorithm it uses provides immutability to the chain. Figure 5 illustrates the logical security scheme of BlockEP. The BlockEP chain has four nodes, each containing a different data "Hello x," and each node has a unique hash "000x" and the previous hash "000x" that links them. The first block is called the "genesis" and whenever a registration, update, modification, or deletion transaction occurs, the transaction is securely and immutably recorded.

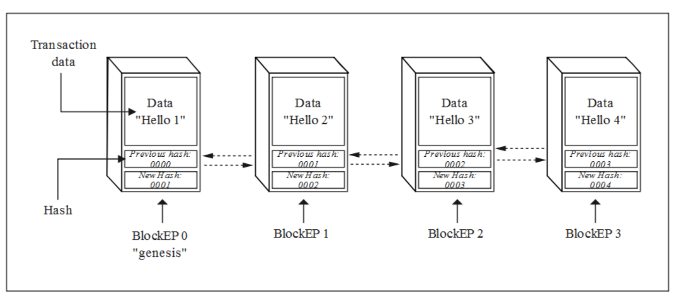

Fig. 5 Security Architecture of BlockEP

E.1. Hash256 Algorithm for BlockEP

Algorithm 4 shows the pseudocode to configure the hash256 encryption of BlockEP. The configuration with the complexity that prefixes four digits with zero "0000" to each transaction allows BlockEP to maintain the integrity, security, and immutability of the information in each block.

Algorithm 4: Hash256 for BlockEP

Input: *Elements*: index, previous_hash, timestamp, data, nonce

Result: *HASH256*: Hash256 for BlockEP

1. **Procedure** HASH256 (*Elements*)
2. **Function** calculateHash (*Elements*)
   return SHA256(concatenateStrings (Elements))
3. **Function** mineBlock (*Elements*)
   nonce = 0
   while not calculateHash (Elements).startswith ('0000')
   nonce += 1
   return calculateHash (*Elements*)
4. **Class BlockEP:**
   Function initialize (*Elements*)
   index = index; previous_hash = previous_hash; timestamp = timestamp; data = data; nonce = 0
   hash = mineBlock (Elements)
   Function calculateHash ()
   return sha256(concatenateStrings (Elements))
   Function mineBlock (Elements)
   while not calculateHash (Elements).startswith('0000')
   nonce += 1
   return calculateHash (index,previous_hash, timestamp,data,nonce)
5. **End procedure**

F. Technology used for the proposal

After presenting the design of the blockchain architecture for the grade registration in the Army, it is necessary to carry out verification tests of the proposed algorithms to obtain results that validate the performance of the research. For this purpose, Table 4 describes the technologies used to carry out the tests.

TABLE IV
TECHNOLOGIES USED FOR TESTING

PLATFORM	DESCRIPTION
Windows 11	Operating System: Base system for running the programs used.
Visual Studio Code	Development environment: For editing the source code.
Python	Script development: For creating blockchain, smart contracts, and hash256 scripts.
Postman	Testing interface: For testing BlockEP with end-users through a graphical environment.

IV. RESULTS AND DISCUSSION

A. Results

After completing the steps for creating BlockEP, which involved installing a local Flask server with the address (localhost = https://127.0.0.1:5000/), the goal was to link the Postman application, conduct functionality tests, and verify the practicality of our research. The following results were obtained:

A.1. Creation of BlockEP

Figure 6 shows the created BlockEP, which initially only contains one node called the "Genesis Block," with its corresponding hash256 encryption displayed in hexadecimal string format with 64 characters and the initial four zeros in the string. It also includes the mining configuration as more nodes are added. This result is the outcome of executing code from Algorithm 1.

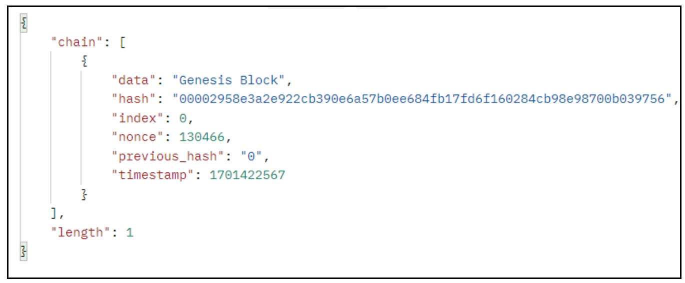

Fig. 6 Creation of BlockEP

A.2. Assignment of names and grades

Figure 7 shows the assignment of the last name, first name, and grade of a student using the Postman application, which will be recorded in BlockEP, generating an additional node to continue the growth of BlockEP.

Fig. 7 Assignment of names and grades

A.2. Mining process of BlockEP (Add Blocks)

In Figure 8, the process of adding blocks to BlockEP is illustrated, involving mining the chain to ensure integrity and security. Each added block contains additional information, such as names and grades, and is linked to the previous block using the hash256 algorithm. Additionally, Figure 9 presents the list of added blocks.

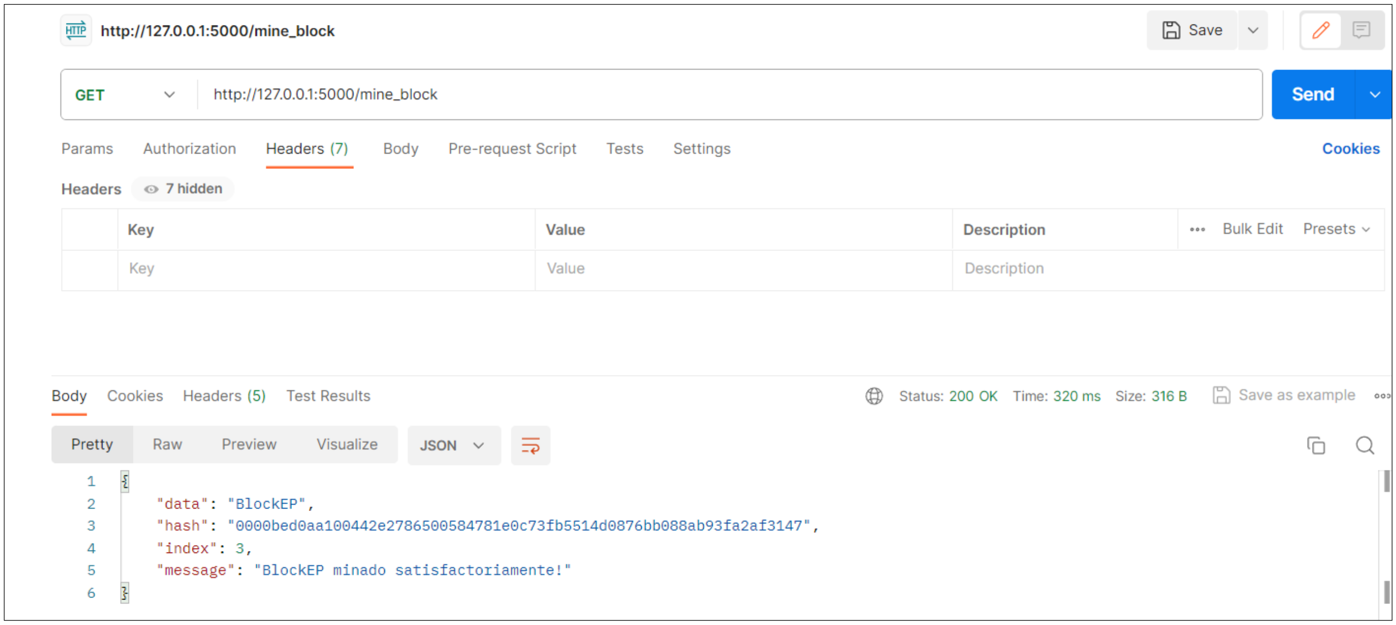

Fig. 8 Mining process of BlockEP

Fig. 9 Mining process of BlockEP

B. Discussion

The results obtained during the BlockEP creation tests, grading assignments, and addition of new blocks support the security of the proposed blockchain architecture for grade registration, making it resistant to potential malicious attacks. The proposal not only ensures the authenticity and security of the data but also opens new opportunities for collaboration between the Army's training schools and advanced training schools, facilitating reliable credential verification.

In comparison with traditional grade management systems, the blockchain architecture presents significant advantages, aligning with the benefits suggested by previous studies [25][26][27][28], where applications demonstrate a decentralized, secure, and available educational record. It is important to note that, despite the promising results of the blockchain architecture, there are challenges to be addressed. Scalability and network efficiency could be areas of concern in large-scale implementations. Additionally, addressing potential technological and educational limitations that may arise during the adoption of this new infrastructure in academic environments is essential.

VI. CONCLUSIONS

Blockchain technology presents a revolutionary potential for higher education by providing an immutable academic record that enhances security, increases trust through easy verification of records, gives students greater control and privacy over their data, and fosters continuous innovation in developing applications to enhance the educational experience. These benefits underscore the positive impact that implementing blockchain technology has on transparency, efficiency, and the overall quality of higher education.

The proposed design of a grade record architecture using blockchain for the Peruvian Army, named "BlockEP," offers several substantial benefits. It provides total control and customization over the blockchain, allowing adaptation to specific needs and configuration of privacy and security constraints. The scalability and innovation opportunities provide a robust framework for managing critical information efficiently. Furthermore, this initiative not only represents an advanced solution but also a valuable opportunity for learning and acquiring practical knowledge in the field of blockchain technology for our military institution.

The implementation of our own blockchain entails essential challenges that require significant commitment and collaboration from the institution. In addition to the necessary investment in training personnel in blockchain management, aspects such as infrastructure and computer equipment renewal need to be addressed. The responsibility to maintain the security and integrity of the network also stands out as a critical factor. Despite these challenges, overcoming them can result in successful implementation and the benefits.

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