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Blockchain-Based Secure Management of Digital Credentials for Interns

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Abstract: - Since the onset of the pandemic of COVID-19, the academic world has been making efforts to popularize micro-credentials. In medical education, medical interns would become doctors in their specific specializations. For becoming doctors, the medical interns would apply for a doctor's license which requires the authorities to verify the credentials of the medical interns. The present paper presents a secure application deploying Blockchain to manage the micro-credentials and the specializations earned by the interns. This paper highlights the stackability of the Medical Portfolio Management System for Medical Interns. It describes an innovative approach to develop a decentralized immutable secure personal details management for organizing the digital micro-credentials earned by the Medical Interns based on their skills/specializations. Most of the platforms have worked on the concept of the stackability of micro-credentials. The portfolio Management can request for certification, aggregation, and synchronization of Personal Profiles (MIP) in a local repository or wallet. Further, such a portfolio management network is feasible and immune to many of the vulnerabilities while sharing the credentials.

Keywords: Medical Interns, Portfolio, Blockchain, Personal Profile, Medical Education.

I. Introduction

In a global landscape where Medical Interns are those students who have received their medical degrees after successfully completing their academic coursework. However, in order to become full-fledged doctors, they should possess a license to practice medicine, which is finally granted once they have practiced and achieved suitable skills under the supervision of licensed physicians in the hospital or critical settings [1]. During their internship, the medical interns get an opportunity to be exposed to a diverse clinical setting with different medical specialties or emergency scenarios [2]. The primary duty of the medical interns involves performing medical assessments, carrying out physical examinations, ordering diagnostic tests to understand the condition of the patients more properly, and devising a treatment plan for the patients under the guidance and expertise of the supervising physician. Additionally, they may participate in procedures, attend lectures and conferences, and engage in patient rounds, where they present cases and receive feedback from their supervisors [3]. Medical interns can approach for their doctor's license in their selected specialization once they have successfully completed their internship since the internship program exposes Medical interns to get a practical experience in various medical specialties. However, Medical interns face a lot of challenges and stress during their medical internship, which can have a significant impact on their personal and professional lives. One of the most prevalent challenges is time management, as they must juggle clinical duties, attend lectures, and prepare for exams [4]. This time management becomes more difficult to handle when unexpected patient emergencies or urgent tasks arise. Therefore Medical Interns suffer from increased stress levels [5].

Moreover, medical interns often find themselves under immense pressure to excel both academically and clinically. This pressure can trigger feelings of anxiety and stress, especially during critical situations like exams or when caring for critically ill patients [6]. Additionally, as they transition from classroom learning to real-life clinical practice, they face a steep learning curve. Applying theoretical knowledge effectively in practical scenarios, sometimes with limited guidance or supervision, presents a significant learning challenge [7]. To ensure that the Medical interns are able to deal with the multitude of challenges and will develop into confident and resilient healthcare practitioners, today's medical institutions have started offering online micro-credentials that can be accessed by the medical interns at their convenience. Online micro-credentials are available in a variety of medical specializations, ranging from technical billing and communication skills for handling diverse patients to specialized

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fields of medicine. In this paper, we have proposed a Blockchain-based distributed ledger that can help to manage such micro-credentials along with the experience gained after attending patients. These micro-credentials help the Medical Interns get more real-life skills that will lead to gaining their Medical Doctor license.

Micro-credentials represent a type of certification that acknowledges specific abilities or expertise in a given domain [8]. Within the medical field, micro-credentials are increasingly popular as they enable medical students to acquire additional proficiency in a particular area, beyond what is typically covered in the traditional medical curriculum. Various examples of micro-credentials that could be advantageous for medical students are Medical coding and billing, Health Informatics, and point-of-care technology. Medical coding and billing micro-credentials can provide medical students with the knowledge and skills required to bill for medical services accurately, which is a skill of growing importance in the healthcare industry. Health informatics micro-credentials can help medical students with the expertise and aptitude needed to function with electronic medical records and other healthcare information systems, which are progressively increasing in healthcare settings. Point-of-care technology micro-credentials can provide medical students with the know-how and abilities necessary to use ultrasound or other virtual reality technology at the bedside, which can be valuable for diagnosing and managing different medical conditions in a convenient manner for patients. Clinical research micro-credentials can offer medical students the knowledge and skills necessary to design and execute clinical research studies, which is a domain of medicine that is increasingly crucial and allows medical interns to comprehend planning for individualized patient treatment instead of simply following standard protocols. Patient safety micro-credentials can offer medical students the knowledge and abilities necessary to recognize and mitigate potential safety hazards in healthcare environments, which is a crucial area of focus in modern healthcare. Overall, micro-credentials represent a beneficial means for medical students to acquire further skills and knowledge in specific domains, which can assist them in distinguishing themselves in a competitive job market and advancing their careers in the healthcare sector [9].

This paper provides an overview of the work done for the portfolio management of the medical interns in Section II. The paper describes the structure of the proposed methodology in Section III. Section IV describes the Communication of Medical Portfolios for Medical Students, whereas Section V discusses the results of the proposed methodology. Section VI describes the conclusion.

II. LITERATURE REVIEW

Portfolio management is becoming an increasingly important trend as a means of tracking and assessing the development of medical students throughout their training [10]. A medical portfolio is a collection of documents and evidence that demonstrate a student’s learning, growth, and development over time. It can include a wide range of materials, such as case reports, reflections, patient feedback, and other forms of evidence of learning.

Portfolio management in medical education comprises five important steps such as comprising of a collection of evidence, organization of evidence, Reflection and self-assessment, assessment by others, and use in career development.

1. Collection of evidence: Medical students collect evidence of their learning and development, such as case reports, reflections, and feedback from patients and supervisors.
2. Organization of evidence: Medical students organize their evidence into a portfolio, which may be in a physical or electronic format.
3. Reflection and self-assessment: Medical students reflect on their learning and development, using the evidence in their portfolio to identify strengths, weaknesses, and areas for improvement.
4. Assessment by others: The portfolio may be reviewed and assessed by faculty members, supervisors, or other assessors, who provide feedback and guidance to the student.
5. Use in career development: The portfolio can be used by medical students to track their progress throughout their training, and to demonstrate their skills and competencies to potential employers or residency programs.

Overall, portfolio management is a valuable tool in medical education, as it encourages self-reflection and self-assessment, which are critical skills for lifelong learning in the medical profession. Many researchers have proved the importance of portfolio management for medical interns. This paper discusses the use of portfolios in medical residencies, including electronic portfolios that allow for the understanding of medical inpatients [11]. A portfolio account can be used to store and collect feedback from patients to evaluate medical interns [12]. The use of portfolios in medical internship training encourages self-assessment learning and supports the acquisition of skills needed for professional practice [13]. Portfolios are being used as a tool for medical education and assessment for medical students, replacing logbooks [14]. This study found that using a portfolio for assessment during medical internships can be a reliable and feasible method that helps medical interns to understand and manage the practical implications of medical treatment [15]. This paper discusses the development and implementation of a portfolio assessment system specifically for postgraduate family medicine residents [16]. Portfolio-based learning is considered relevant to medical education as it improves medical and clinical learning and organization skills, and fosters collaborative learning among the medical interns [17]. The portfolio account is used to monitor and assess the skills of medical interns during their training and hospital placements [18]. This paper discusses the use of portfolios for assessing the competence and performance of doctors in practice than medical interns specifically [19]. Portfolios are increasingly used in medical education to support personal development, assessment, and appraisal for trainees and supervisors [20–23]. However, none of the papers have focussed on the secure sharing of the Portfolio data of the medical interns.

In the era of increasing digitization, it becomes imperative that the Portfolio of the medical interns is safely stored and accessed by the necessary authorities since the Medical interns have toiled hard to achieve the micro-credentials and practical skills through the internship. Many different techniques of cryptography can be implemented to make the Portfolio secure while storing and accessing. One of the solutions for making the portfolio of the medical interns more secure is to make use of Blockchain technology since Blockchain technology is a secure and decentralized way of storing and sharing data that is being explored in many industries, including healthcare. In portfolio management in medical education, blockchain technology could potentially provide a secure and transparent way of tracking and sharing student portfolios [24]. Blockchain technology uses advanced cryptographic algorithms to secure data, which can help prevent unauthorized access or tampering with medical intern's portfolios. Blockchain technology is decentralized, meaning that there is no central authority controlling the data [25]. This can help prevent data loss or corruption and can provide a more transparent and democratic way of managing student portfolios. Because blockchain technology is decentralized, all participants in the network can see the same information [26]. This can provide greater transparency and accountability in the management of medical interns' portfolios. Blockchain technology can potentially make it easier to share student portfolios with potential employers or residency programs, as the data is secure, decentralized, and transparent [27]. The Corvid Exsys rule-based system is an invaluable tool utilized for the construction of automated expert systems. The software implements both backward and forward chaining techniques for efficient processing. Furthermore, all diagnostic inquiries presented by the system are derived from clinical literature, ensuring the utmost accuracy and precision in the diagnostic process [28].

However, there are also some challenges to using blockchain technology in portfolio management in medical education which includes Blockchain technology can be complex and difficult to implement, requiring specialized technical expertise and resources. The widespread adoption of blockchain technology in medical education may require significant investment and collaboration across multiple stakeholders in the healthcare and education industries. While blockchain technology is secure, there may still be concerns about the privacy and confidentiality of student data in a decentralized system. Overall, while there are some potential benefits to using blockchain technology in portfolio management in medical education, further research and development are needed to fully explore its potential in this area.

III. STRUCTURE OF THE PROPOSED METHODOLOGY

The proposed Portfolio Management System for Medical Interns comprises the following fields:

ID: A unique sequence generated by the system. Name: Name of the Medical Interns

Type: Digital Micro-credentials

Description: A string describing the micro-credentials and the skills achieved from them.

Start Date: Date of starting of the Micro-Credential course

End Date: Date of completion of the Micro-Credential course Key-Cert: Public key certifier

Pub key: The public key generated by the certifier generated for the medical interns.

Private key: The private key of the Medical Interns

Date-of-Birth: Unique value of the Medical Interns

Legal Data: Legal Documents that prove the identity of the Medical Interns

In the context of creating a portfolio of micro-credentials for medical interns, the Medical Intern Portfolio (MIP) serves as a Personal Digital Archive (PDA) that organizes various skill-enhancing courses with unique IDs. Each course is associated with specific documents, forming the Skill-enhancing Course with Documents (SID) in the portfolio.

Hence MIP is the union of the PDA and SID MIP= {PDA ∪ SID} -(1)

3.1 Course Tools

A course tool is a code segment designed to fulfill a specific function essential for the Medical Intern Portfolio (MIP). It should incorporate the following fields:

MIP-ID: An automatically generated index that uniquely identifies the medical intern within the system MIP-Description: A description that provides insights into the nature and purpose of the course

MIP-Input: The conditions and parameters required for the course to be executed successfully MIP-Output: The results and outcomes produced by the course service

MIP-Condition: The criteria or conditions under which the course is considered complete or fulfilled

MIP-Date: The timestamp indicates the date and time when the course was undertaken by the medical intern.

A set, of course, tools is denoted as “C,” encompassing a diverse range of courses essential for the functioning of the Medical Intern Portfolio (MIP). These courses encompass tasks such as certificate requests, aggregation, and synchronization of Personal Profiles (MIP) in a local repository or wallet from the public ledger, along with granting permission to specific parties for inspecting the Personal Digital Archive (PDA).

Hence, MPMS (Medical Portfolio Management System) can be symbolized as MPMS= {MIP, C} -(2)

3.1.1 Blockchain Technology:

In the context of blockchain, various roles and functions exist, including miners, validators, and developers, involved in tasks such as processing transactions and securing the network. An “inquisitor” investigates the blockchain for auditing or compliance purposes, while a “certifier” verifies the authenticity of information or transactions, often utilizing cryptographic techniques like digital signatures or digital certificates issued by certification authorities (CAs). In the proposed methodology, mining and verification play crucial roles. The term “stake node” refers to a specialized node within a consortium-oriented blockchain network. Trust is established through a delegated proof of stake mechanism. Similar to “Mining and Verification” in the Bitcoin network, stake nodes play a critical role in validating transactions and maintaining the integrity of the blockchain by staking their tokens or coins as collateral. For example, the medical intern serves as the subject, while the medical institution acts as the third party responsible for verifying the intern’s documents. The third party, acting as the inquisitor, is responsible for conducting the verification process. Hospitals, in this context, are the clients of the inquisitor, and their information needs to be securely managed. To validate the micro-credentials, the inquisitor will contact various course certifiers who have the authority to issue the micro-credentials to the medical intern. The inquisitor will gather the necessary information from these course certifiers to ensure the authenticity and validity of the intern’s credentials.

3.1.2 Initial Trust and Genesis Block of the Consortium Network

In general, establishing the initial block or the first block in a blockchain, referred to as the initial state of a peer-to-peer (p2p) network, is a challenging endeavor. It requires a consensus among all peers on an acceptable assumption. In the context of MPMS, a consortium network is adopted, wherein states with certain reputations are included or subject to voting. Thus, the initial block in MPMS comprises data structures and initial stakes exclusively. While a Certifier can be one of the stakeholders, it is not a mandatory requirement. To attain the status of a trusted certifier, the certifier must provide stakes along with its identity to the network.

3.1.3 Proof-of-Authority (PoA)

Using Proof-of-Authority (PoA) in the portfolio management of micro-credentials for medical interns offers several benefits. PoA consensus algorithm requires significantly less computational power compared to other consensus mechanisms like Proof-of-Work (PoW). This leads to faster transaction processing, making the portfolio management system more efficient. PoA allows for high transaction throughput, enabling the portfolio management system to handle a large number of micro-credentials and medical intern records without compromising performance. PoA relies on authorized validators, or authorities, to validate transactions and add blocks to the blockchain. In the context of medical in-texts, these validators can be reputable institutions or certifying bodies, ensuring the integrity and legitimacy of the micro-credentials added to the portfolio. Unlike PoW, PoA does not require resource-intensive mining activities, resulting in lower energy consumption and a more environmentally friendly system. PoA ensures that validators have a known identity and reputation, which increases trust in the portfolio management system. Additionally, the blockchain's immutability and cryptographic security features provide enhanced data protection and data integrity. PoA allows for a consortium or community-based approach, where authorized parties collectively manage the network. This fosters a sense of collaboration and shared responsibility among stakeholders, leading to better governance and decision-making. Overall, by leveraging the benefits of PoA, the portfolio management system for micro-credentials in medical internships can achieve higher efficiency, scalability, security, and trust, providing a robust and reliable platform for managing and verifying medical intern qualifications and achievements. Hence, MPMS uses PoA.

3.1.4 Communication Of Mpms

In this section, we present an overview of the operational workflow for medical interns to acquire a micro- credential. Figure 1 provides a visual representation of the workflow, where the primary goal is to achieve the micro-credential after successfully completing the course. The consortium blockchain acts as the platform, utilizing registered nodes with proof of authority to record the outcomes in a global ledger.

The network nodes consist of medical interns, medical organizations, medical colleges, and hospitals. Certifiers of the course do not need to be nodes in the network, as their role is solely to issue certificates upon successful course completion. The blockchain network comprises reputable and credible medical organizations responsible for maintaining the blocks, as the consensus mechanism relies heavily on the validators' reputations. If validators verify fake documents, they are removed from the network, losing their credibility among the trustless entities in the network. Hospitals and government agencies are clients recruiting medical interns or issuing licenses to them.

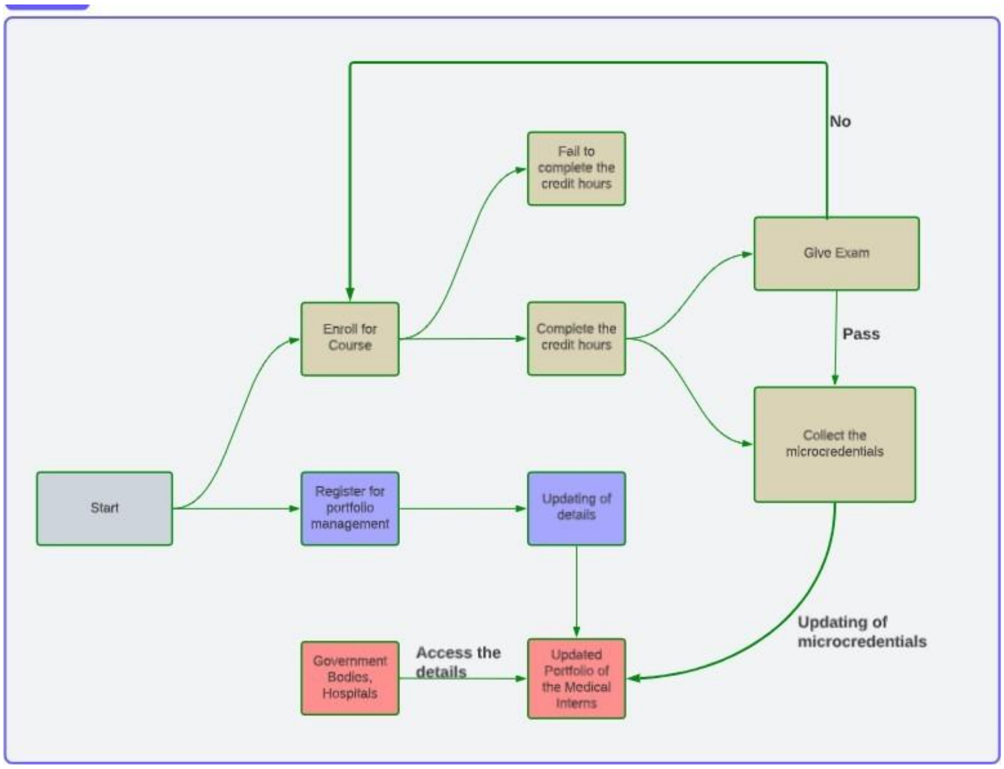

Figure 1. Diagram of the workflow of the proposed Methodology

Figure 2 depicts the sequence of events when a subject seeks to obtain a certificate and micro-credentials for their wallet address upon course completion. A registered and authorized certifier conducts checks on the course start date, duration, obtained marks, and overall course result within the specified timeframe. Once all parameters are verified, the certifier issues the certificate with encrypted information using their public key, ensuring that only the medical intern can access it. Additionally, the certifier shares the certificate with other nodes in the consortium blockchain network. The certificate includes details such as the certifier's digital signature with a unique identifier, a public key for the Personal Digital Archive (PDA), and more, which can be viewed by other participants. Upon receiving the certificate, any node performs verification and broadcasts the verification to other nodes. The certificate is then recorded in the global ledger by an authorized validator of the network.

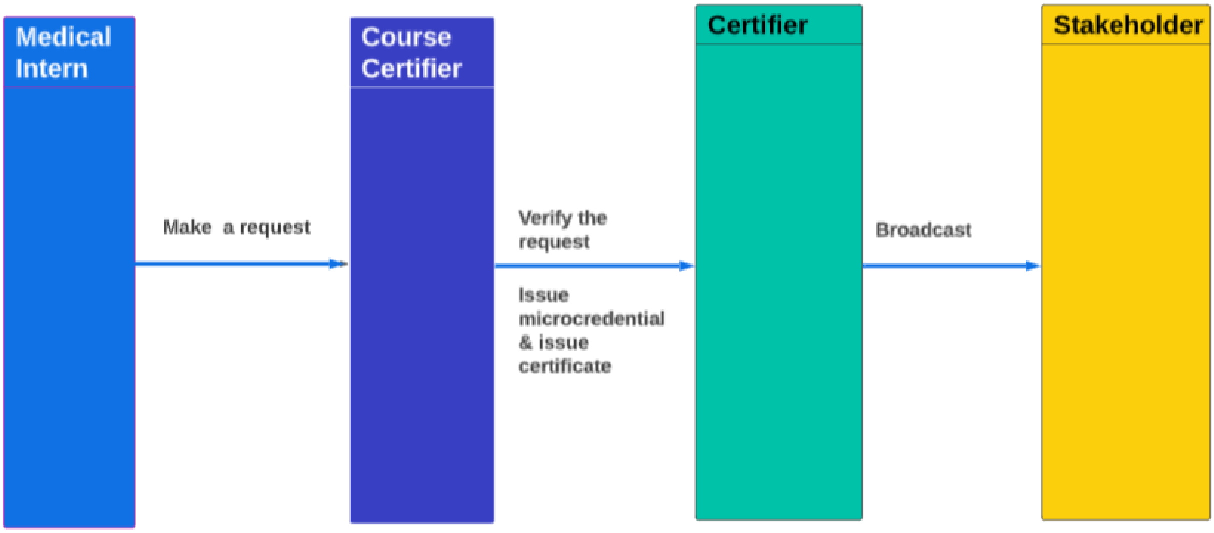

Figure 2. Time Sequence for PDA-Course

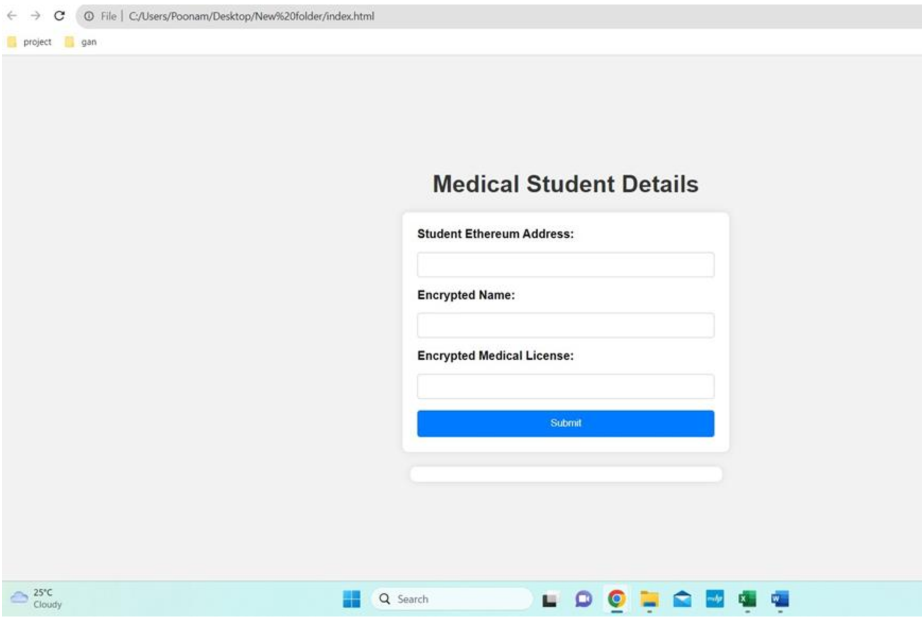

Figure 3. Screenshot of the Application

3.2 Service System:

The client, which requires access to some or all of the subject's Personal Digital Archives (PDAs) in the Portfolio Management System, can directly negotiate with the subject. Instead of hiring an inquisitor for verification, the client can engage in a smart contract with the subject. This smart contract enables the client to inspect requested signed documents, including degrees, transcripts, work experiences, identifications, and other relevant information about medical interns as shown in different phases of Figure 3 depicting the MPMS service process.

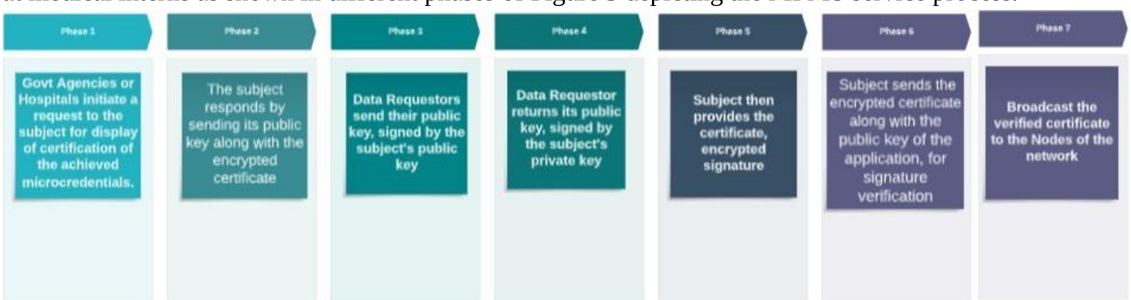

Figure 4. MPMS Service

The MPMS sequence for PDA verification can be summarized as follows:

1. Hospitals or government agencies initiate a request to the subject for displaying certification of micro-credentials.
2. The subject responds by sending its public key and an encrypted certificate containing the micro-credentials to the applicant or data requestor.
3. The applicant or data requestor sends its public key, signed by the subject's public key.
4. Additionally, the applicant/data requestor returns its public key, signed by the subject's private key
5. The subject provides the certificate, encrypted signature, and other necessary information to allow inspection of its Personal Digital Archives (PDAs).
6. The subject sends an encrypted certificate, including the public key of the applicant, for signature verification. This script remains locked until the application's signature matches the requirements.
7. A data requestor in the consortium P2P network checks if the subject has the required PDAs and proceeds only if they exist.
8. The data requestor broadcasts this information to other data requestors for verification purposes.
9. The application sends the unlocking script along with its signature
10. The data requestor uses the unlocking script to determine whether the verification is successful and communicates the outcome to the application.

This sequence demonstrates a secure and collaborative approach to verifying micro-credentials and accessing Personal Digital Archives. It can be adapted and applied in various other scenarios where PDA verification is required for specific applications. By incorporating encryption, digital signatures, and consensus mechanisms, the system ensures data integrity and confidentiality while enabling trusted parties to validate and verify the credentials.

IV. Results & Discussion:

The provided content showcases a medical intern registration system operating on a blockchain network. In the first interaction, the user selects the option to register a medical intern. They input the intern's name, age, and university, and the system records the details in a block mined by "Authority 2" The system confirms the successful registration of medical intern I1. Subsequently, the user is presented with a menu to choose between registering a medical intern, registering a hospital, viewing micro-credentials of medical interns by the government, or exiting the system. Similarly, the second option helps to register a hospital. They enter the hospital's name and location, which is then stored in another block mined by "Authority2." The system acknowledges the successful registration of hospital H2. The user is again provided with the menu of options to proceed with further interactions. As shown in Figure 4, government agencies can also view the micro-credentials of medical interns as shown in Figure 4 that medical intern named "John Doe" is provided and the system responds with encrypted data and successfully decrypts it, displaying the micro-credentials, including the name, age, and university of the intern, John Doe, which are stored in a secure and confidential manner using encryption on the blockchain network.

Select an option:
1. Register Medical Intern
2. Register Hospital
3. Government: View Microcredentials of Medical Intern
4. Exit

Enter your choice: 1

Enter the name of the intern: I1 Enter the age of the intern: 24 Enter the university of the intern: Univ 1

Block mined by Authority2: 008b67aa52f9bf0fdd62be081a2afaeede465bbe60453d19561099b8777f123d Medical intern I1 registered successfully.

Select an option:
1. Register Medical Intern
2. Register Hospital
3. Government: View Microcredentials of Medical Intern
4. Exit

Enter your choice: 2

Enter the name of the hospital: H2 Enter the location of the hospital: Delhi

Block mined by Authority2: 00d3b2eed514921587c9981a5b1fae0bb5d185d3bf534d5427f5285df95d05f7 Hospital H2 registered successfully.

Select an option:
1. Register Medical Intern
2. Register Hospital
3. Government: View Microcredentials of Medical Intern
4. Exit

Enter your choice: 3
Enter the name of the intern to view microcredentials: John Doe
EncryptedData: b'gAAAAABkvXr4TuW5S- TdQq77DlGWyB2UxAh0-FgvWCtbAfWH-qW31PraV2D sgiSpGzDq8oTJw4sFFV PQWZZ5qD0Le6 zfk6awT6k3hK2EOLnNBvk
Decrypted Data: {'name': 'John Doe', 'age': 25, 'university': 'Medical University'} Select an option:
1. Register Medical Intern
2. Register Hospital
3. Government: View Microcredentials of Medical Intern
4. Exit

Enter your choice: 4

Menu of the proposed MPMS

To represent the actions taken in the provided content using mathematical equations, we can use symbolic notations and mathematical operations. Let's define some variables and functions:

1. Variables:

- 'choice': Represents the user's choice from the menu options (1, 2, 3, or 4).
- 'name': Represents the name of the medical intern or hospital entered by the user.
- 'age': Represents the age of the medical intern.
- 'university': Represents the university attended by the medical intern.
- 'location': Represents the location of the hospital.

2. Functions:

- 'BlockMined(authority, data)':Representstheprocessofminingablockbythespecifiedauthoritywiththe given data.

Now, let's describe the actions using equations:

Medical Intern Registration:

User's Choice (Menu Option): 'choice = 1' Medical Intern's Name: 'name = I1' Medical Intern's Age: 'age = 24' Medical Intern's University: 'university = Univ 1'
Block Mined by Authority2 for Medical Intern Registration: {name, age, university})'

Hospital Registration:

User's Choice (Menu Option): 'choice = 2' Hospital Name: 'name = H2' Hospital Location: 'location = Delhi'
Block Mined by Authority2 for Hospital Registration: {name, location})'

Government: View Microcredentials of Medical Intern (Alternative Case:

User's Choice (Menu Option): 'choice = 3'
View Microcredentials for Medical Intern: 'name = John Doe'EncryptedData:
'Encrypted data = b'gAAAAABkvXr4TuW5S-TdQq77DlGWyB2UxAh0-FgvWCtbAfWH-qW31PraV2D sgiSpG PQWZZ5qD0Le6 zfk6awT6k3hK2EOLnNBvkd4ftNb 5r5fZ1zwTTnh5Ud0=''{'name': 'John Doe', 'age': 25, 'university': 'Medical University'}'process of adding data to the blockchain through mining, which ensures the security and integrity of the stored information.

The scalability of the proposed methodology can be observed from the given below Table 1.

Table 1. Performance Metrics

Transaction Submission (secs)	Block Confirmation(secs)	Data Retrieval(secs)
10 nodes 1.12	1.4	0.36
50 nodes 1.2	3.2	0.78
100 nodes 1.9	2.2	1.003
1000 nodes 1.16	2.05	3.21

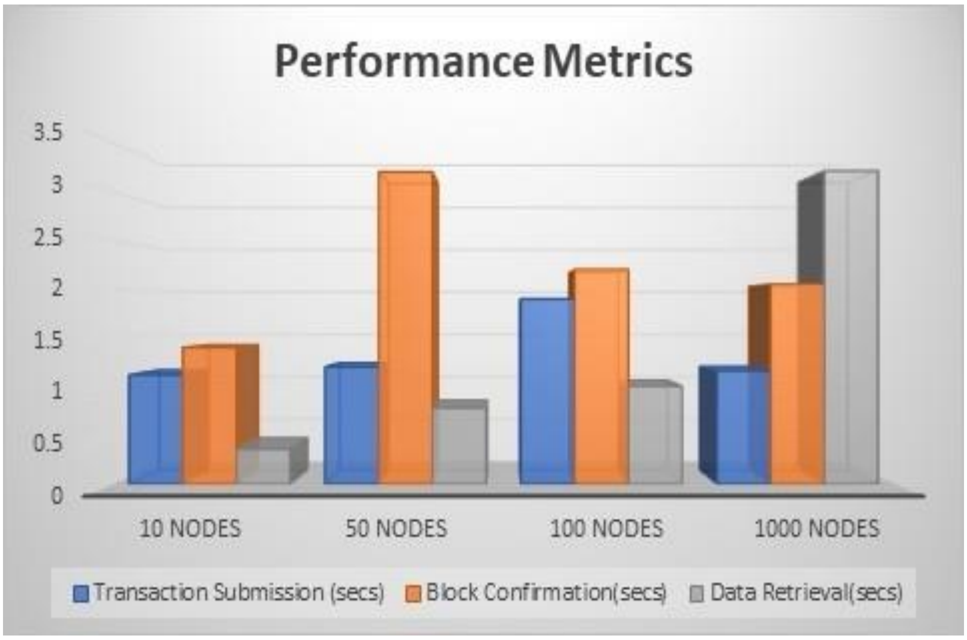

Figure 5. Performance Metrics in seconds from 10 to 1000 nodes in the private testnet

V. CONCLUSION

In this research paper, we present a secure method for personal document management utilizing blockchain technology, named MPMS. MPMS effectively harnesses the capabilities of blockchain, allowing individuals to immediately record their achievements or new attributes without the need to wait for an inquisitor at a later stage. This approach ensures real-time documentation and verification, enhancing the efficiency and transparency of the personal document management process. By leveraging blockchain's inherent properties, MPMS offers a secure and decentralized solution for managing and validating micro-credentials for medical interns in a timely and efficient manner. The potential applications of MPMS are widespread and versatile. It can be utilized in various online applications for medical licenses and interactions with different hospitals. By leveraging blockchain technology, MPMS removes the need for a third-party intermediary, while ensuring confidentiality and traceability of transactions. This decentralized approach enhances data security and accountability while maintaining the anonymity of users. The elimination of intermediaries streamlines processes and fosters a more efficient and reliable system for managing personal documents and medical credentials. Indeed, one of the main challenges in implementing a blockchain network like MPMS is to assemble a collection of reputable and motivated stakeholders. These stakeholders play a crucial role in maintaining the network's integrity and security through processes like block validation and consensus mechanisms. One of the primary challenges is that some medical interns may lack technical proficiency, making it difficult for them to obtain micro-credentials. Additionally, securely storing the unlocking keys is a crucial and widespread challenge. Without these keys, Personal Digital Archives (PDAs) cannot be accessed and utilized effectively. Establishing robust mechanisms to safeguard the keys is essential to maintain data security and integrity for the benefit of medical interns.

VI. CONFLICT OF INTEREST

We declare that there is no conflict of interest regarding this research.We have no financial interests or personal relationships that could influence the work reported in this paper.

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