Implementing a Blockchain-Enabled Student Information System with Smart Contracts for Academic Institutions

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Abstract

Utilizing blockchain technology for different applications has seen a growing interest in recent years. Academic institutions can consider implementing a student information system (SIS) based on blockchain technology as a promising area. This research paper explores in detail the design and execution aspects of an SIS powered by blockchain technology implemented through ASP.net, C#, Ethereum, Solidity, Ganache and IPFS. The main goal of the proposed system is to tackle important problems concerning data security and accessibility in conventional paper-based or centralized systems. In the proposed SIS system based on blockchain technology there are five distinct user categories: students, stage managers, department managers, college managers, and super administrators. Every user possesses specific functionalities like accessing grades, attendance, subjects, schedules, and profiles. Data integrity and privacy are ensured by the system's design using cryptographic techniques and smart contracts implemented in Solidity. The paper also addresses the technical implementation aspects, involving using ASP.net and C# to develop both the user interface and backend logic. To store decentralized data, the Ethereum blockchain is utilized. The proposed system is evaluated through a series of experiments and performance tests. The assessment of the blockchain-based SIS includes evaluating its efficiency, security, and usability through these tests. The paper highlights the effectiveness of the system in enhancing data security, accessibility, and transparency by providing detailed results and findings.

Keywords- Blockchain, Student Information System, Decentralization, Data Security, Accessibility.

I. INTRODUCTION

The digital revolution has brought about significant changes in various sectors, including education [1]. Traditional methods of managing student information are being replaced by more efficient and secure systems [2]. One such technology that has shown immense potential in this regard is blockchain. Blockchain technology, initially designed for digital currency, Bitcoin, has found its application in various fields due to its decentralized, transparent, and immutable nature [3], [4].

Blockchain's architecture, depicted in Figure 1, is characterized by its decentralized and distributed nature [5]. It serves as a digital ledger that records transactions across multiple computers, ensuring that any involved record cannot be retroactively altered without modifying all subsequent blocks [6]. This enables independent and cost-effective verification and auditing of transactions by participants [7].

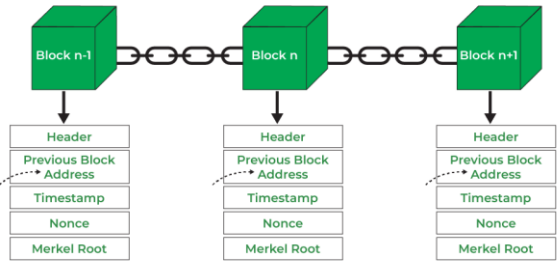

Figure 1: Blockchain Architecture.

Smart contracts, a fundamental component of blockchain, are self-executing contracts with the terms of the agreement directly written into code. They automatically execute transactions following predetermined rules, without the need for a central authority or external enforcement mechanism [8]. This paper presents an in-depth research study on the implementation of a Student Information System (SIS) using blockchain technology.

The proposed system is developed using ASP.net [9], [10], C#, Nethereum [11], Solidity [12], Ganache, and IPFS. It aims to provide a secure, transparent, and efficient platform for managing student information, thereby enhancing the overall efficiency of the educational institutions [13]. The proposed SIS comprises five types of users: students, stage managers, department managers, college managers, and super administrators. Each user has specific roles and responsibilities, ranging from accessing personal information to managing and validating grades [14], [15]. The proposed system leverages the power of blockchain technology to ensure the security and integrity of data. It uses Nethereum, a .NET integration library for Ethereum, to allow interaction with Ethereum clients like Geth, Parity, or any other Ethereum client which implements the Ethereum JSON RPC specification [16]. Solidity, a statically-typed programming language for writing smart contracts, is used to implement the business logic of the system [17]. Ganache, a personal blockchain for Ethereum development, is used for deploying contracts, developing applications, and running tests [18]. IPFS, a protocol designed to create a permanent and decentralized method of storing and sharing files, is used to ensure the permanence of data [19].

II. LITERATURE REVIEW

Sura I. Mohammed Ali, Haitham Farouk, and Hussien Sharaf conducted a study titled "A blockchain-based models for student information systems" (2022). Their study suggested a student information system (SIS) that uses blockchain technology to assure decentralized and open storage of student records. The study's models sought to do away with the requirement for a centralized authority by offering a safe environment for handling and using student information.

Han M, Li Z, He J, Wu D, and Xie Y explored the implementation of a blockchain-based education records verification solution (2018). They unveiled the McRhys concept, which integrates and records university activities using blockchain technology. The concept improves the verification of academic records and establishes a decentralized, internationally reputable system.

Z. Dong, F. Luo, and G. Liang discussed the EduCTX platform, a blockchain-based solution for higher education credit (2018). Built upon the European Credit Transfer and Accumulation System, EduCTX offers a decentralized credit and grading system. This platform intends to give students, higher education institutions, and other stakeholders a worldwide united perspective.

In her thesis titled "Study of Factors Influencing the Use of Blockchain Technology in Student Information System at Universities" (2022), Mrs. Rashmi Prashant Dongre examined the factors influencing the adoption of blockchain technology in university student information systems. To identify important adoption determinants and investigate possible blockchain applications in university information systems, the study concentrated on the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT).

Chen Weiru, Bohloul Mahdi, Ma Yifang, and Li Ling presented a case study of a blockchain-based information management system for academic institutions (2021). They created and put to test a prototype system that used blockchain technology to improve the effectiveness of data transfer and safeguard the privacy of information, notably in the workflow of foreign students.

Shadab Alam, Huda Abdullah Yousef Ayoub, Rafan Abdulhaq Ahmed Alshaikh, and Asmaa Hayawi Hussen ALHayawi conducted research on the secure management of educational credentials using blockchain technology. With an emphasis on document authentication and the difficulties of implementation, their study examined the possible uses, prospects, and difficulties of blockchain in education.

Chen Weiru, Bohloul S.M., Ma Y., and Li L. further investigated the implementation of a blockchain-based information management system in academic institutions (2021). Their study stressed the potential of blockchain technology to improve information privacy and security and highlighted the efficiency improvements in digital student registration.

Mingfeng Yang and Jianying Wang examined the security aspects of a student information management system based on blockchain technology (2022). Their study assessed the overall security and experimental procedures, suggesting areas for improvement in terms of methodology and efficiency.

Alok Kumar Jain discussed the impact of digital technology on the education industry in "Blockchain Goes to School, Digital Solutions, and Innovation & Domain consulting" (2018). The study emphasized the difficulties educational institutions have using digital technology to modernize, especially in higher education.

Stefan K. Johansen conducted a comprehensive literature review on the use of blockchain as a technological enabler for innovation (2018). In the realm of information systems research, the paper described the present status of blockchain technology and defined the elements required for its effective application. The report underlined that more work has to be done before blockchain technology can be adopted widely.

III. METHOD

1. Overview of Proposed System

The proposed system in this research is a blockchain-enabled student information system (SIS) designed to enhance the efficiency, security, and transparency of information management within academic institutions. The system leverages the benefits of blockchain technology, including decentralized storage, immutability, and smart contracts, to address the limitations of traditional centralized information systems.

2. Workflow of Proposed System

In accordance with figure 2, the proposed blockchain-enabled student information system (SIS) operates on a structured process that integrates diverse user roles and leverages blockchain technology for improved management of student information in academic institutions. The workflow incorporates the subsequent pivotal phases:

2.1. User Authentication and Authorization:
User authentication is where the system starts. Logging in with their relevant credentials is a requirement for every user (student. stage manager. department manager. college manger. And super admin). After successful authentication, the system confirms the user's role and provides suitable authorization based on predefined access levels.

2.2. Student Activities:
Various activities can be accessed by students within the system. They are permitted to view their results. Attendance records. Subject information. Schedules. And profiles. A comprehensive view of their academic progress and personal details is provided to students through these activities.

2.3. Stage Manager Activities:
Stage managers have specific responsibilities that involve managing stage subjects and grades. They possess the capability to exhibit stage subjects, enter grades for subjects, and utilize curve marks if needed. This facilitates efficient handling of grades and ensures precise recording of student performance.

2.4. Department Manager Activities:
Overseeing the student information system is a crucial role played by department managers. They possess the authority to create accounts for stage managers and manage student information (addition editing deletion) as well as display a master sheet of grades across all stages. Additionally they are able to enter subjects per individual stage while also configuring department settings. They also observe students' attendance. Efficient coordination within the department is ensured by these activities, facilitating streamlined management of student data.

2.5. College Manager Activities:
The responsibility of college managers is to validate the grades master sheet. Their task is to review the grades and ensure their accuracy and integrity. Validating grades is important for maintaining consistent and reliable grading process, which in turn ensures credibility of the academic institution.

2.6. Super Admin Activities:
Super admins have administrative privileges and oversee the overall functioning of the system. They have the authority to enable/disable master sheet editing, create department accounts, and access all information within the system. These activities provide super admins with the necessary control and supervision to maintain system integrity and security.

The workflow of the proposed system is designed to accommodate the diverse needs of different user roles within academic institutions. It ensures secure access, efficient management of student information, and facilitates transparent and reliable processes.

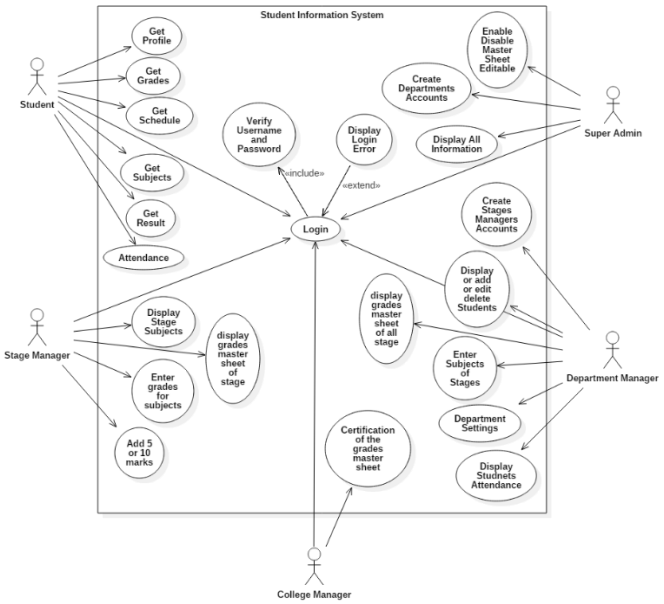

Figure 2: Use Case Diagram of Proposed System.

By leveraging blockchain technology and incorporating specific functionalities for each user role, the proposed system offers a comprehensive solution to enhance the student information management system within academic institutions.

3. System Development

The development of the proposed blockchain-enabled student information system (SIS) involves integrating different technologies and frameworks to build a strong and efficient solution, as indicated in figure 3. The system uses ASP.NET to construct the front-end application. The implementation of the back-end functionality utilizes ASP.NET and Solidity, with Ganache serving as the local blockchain network for testing and development.

ASP.NET, which is a web development framework, is employed for constructing sturdy and scalable web applications. ASP.NET was applied for both the front-end user interface and back-end logic within the context of the proposed blockchain-based student information system (SIS). The availability of various tools and libraries in this framework allows developers to design a user-friendly and interactive interface. The utilization of ASP.NET facilitated the seamless integration of diverse functionalities, including login authentication, data retrieval, and presenting information to the users.

Solidity, which is a programming language developed explicitly for creating smart contracts on blockchain networks, places special emphasis on the Ethereum platform. The execution of smart contracts occurs automatically when particular conditions are fulfilled. The regulations and logic of interactions within the blockchain-powered SIS were governed by smart contracts implemented using Solidity in the presented system. To ensure transparency, immutability, and security of data and transactions for the system, these smart contracts played a vital role.

However, ganache is a local development blockchain network through which developers can test and develop the applications of blockchains in a controlled environment. Existing crypto protocols can be simulated with pre-defined accounts and test tokens that are analogous to real Ether (cryptocurrency). In this regard, Ganache was utilized as a development and testing tool that allowed users to deploy and test their smart contracts without the needs for actual Ether (cryptocurrency) in the project. As such, ganache was used in this case as an extension towards developing a system through simulation of interactions and transactions between parties within the blockchain network. This helped at the evaluation stage to assess whether the proposed system meets all the intended functionality of the deployment on the underlying real blockchain network. SIS development integration ASP.NET Solidity Ganache overall successful implementation proposed blockchain-based SIS academic institutions

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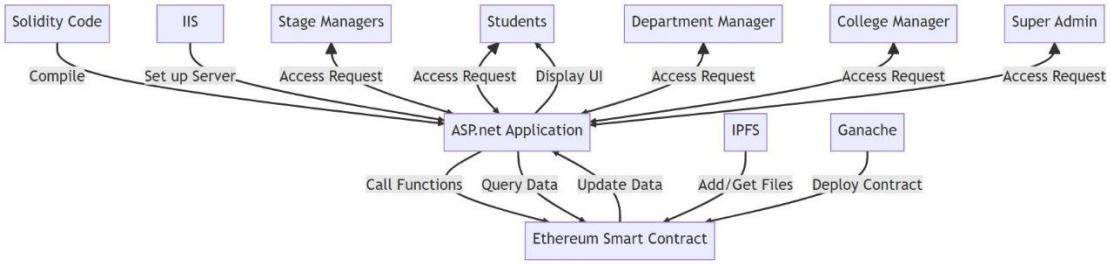


Figure 3: Block Diagram of Proposed System.

IV. RESULT AND DISCUSSION

The proposed system, a blockchain-enabled student information system implemented using ASP.NET, Solidity, and Ganache, was successfully developed and tested. The system aimed to provide a decentralized, secure, and transparent platform for managing student information in academic institutions. During the testing phase, various functionalities of the system were evaluated, including student registration, course enrollment, grade recording, and profile management. The system effectively addressed the key requirements outlined in the research objectives by exhibiting robust performance and functionality. Incorporating several essential figures, the implemented system aims to enhance both user experience and functionality. The login page is depicted in Figure 4 and it serves as the first point of entry for all system users. This page maintains data confidentiality and system integrity by verifying user credentials for secure access to the system. Figure 5 showcases the control panel, which functions as a centralized hub for navigating through various features and functionalities. With its intuitive and organized interface, users can effortlessly access different sections of the system. This design consideration enhances user efficiency and boosts overall system usability. The students' list is displayed in Figure 6, giving administrators and managers a complete overview of enrolled students and their associated information. This feature enables effective monitoring and administration of student records, facilitating efficient student data management. Accessing and managing information related to academic subjects is possible for users on the subject's page featured in Figure 7. This feature presents a structured outlook on the subjects that are accessible, thereby simplifying the process of scheduling and allocating courses. The provision of a centralized location for subject-related data contributes to effective academic planning and management with the help of this figure. The grades page is represented by Figure 8, which allows teachers and administrators to input and manage student grades. The grading process is made more efficient by this feature, guaranteeing precise recording and prompt access to student performance data. It encourages efficient evaluation and reporting of student development. Lastly, Figure 8 exhibits the schedules feature, showing users a visual presentation of class schedules and timetables. This figure offers a user-friendly interface for viewing and managing course schedules, promoting efficient organization and coordination of academic activities.

These figures collectively contribute to a user-friendly interface and enhanced functionality in the implemented system. They facilitate efficient student information management processes, improve accessibility to critical data, and support effective decision-making by stakeholders within academic institutions.

Figure 4: Login Page.

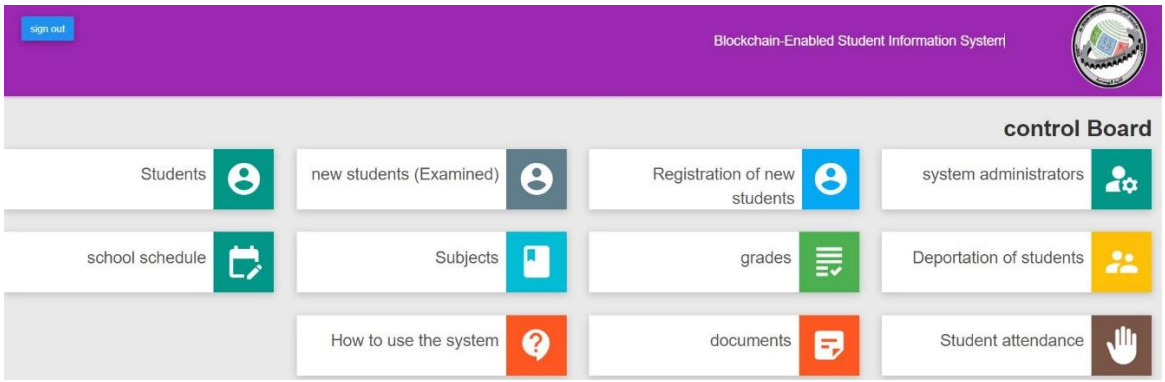


Figure 5: Control panel of SIS.

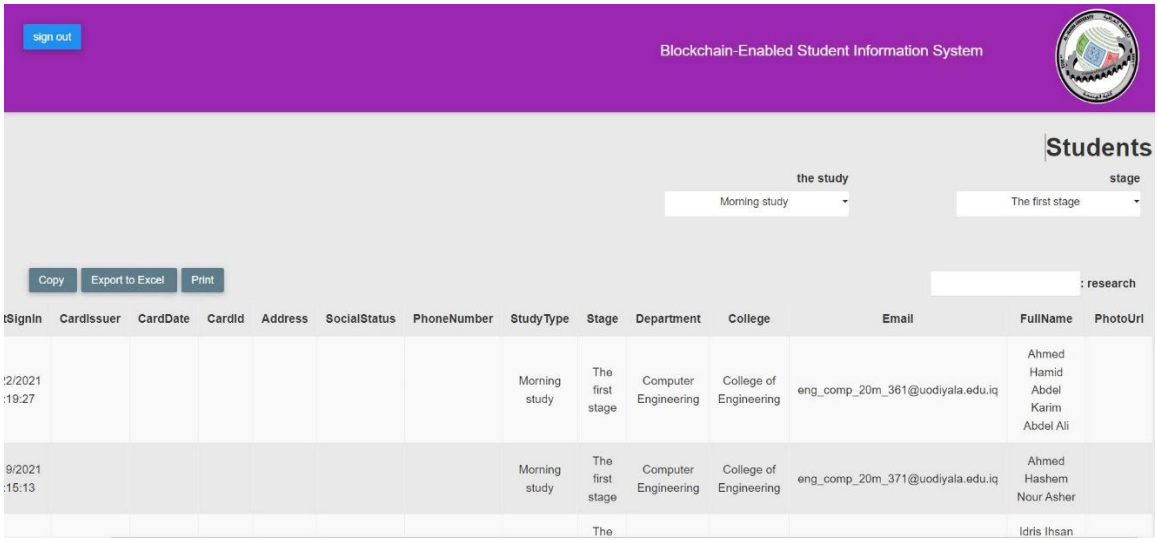


Figure 6: Student List Page.

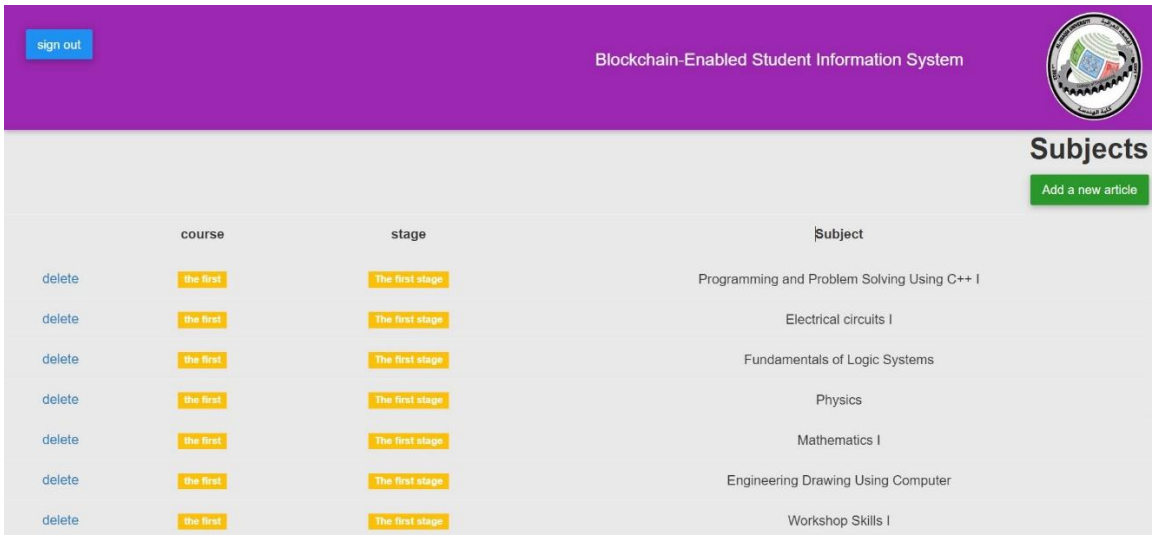
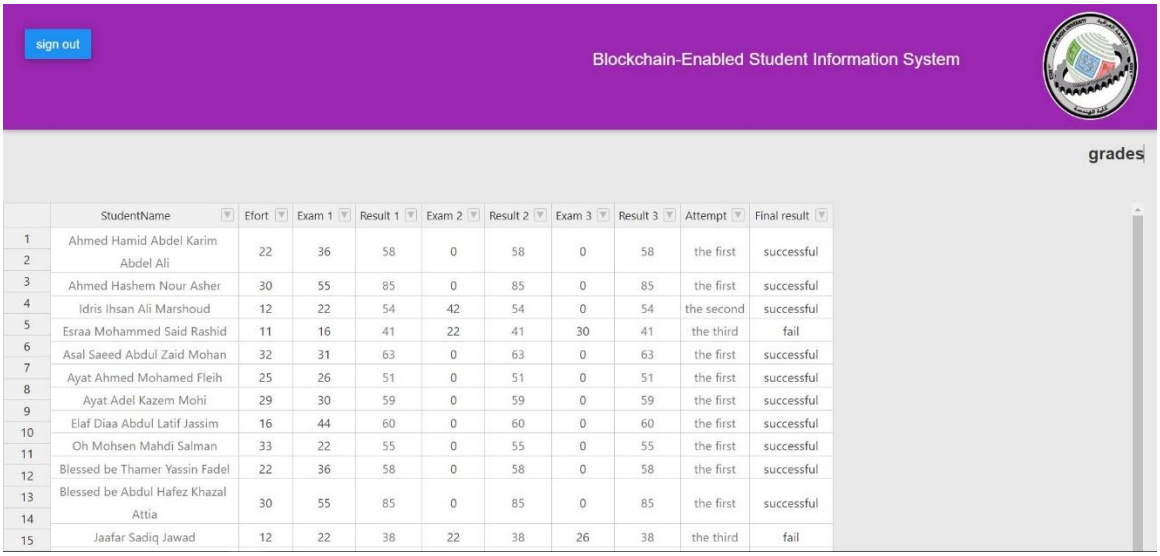


Figure 7: Subjects List Page.



	StudentName	Efort	Exam 1	Result 1	Exam 2	Result 2	Exam 3	Result 3	Attempt	Final result
1	Ahmed Hamid Abdel Karim Abdel Ali	22	36	58	0	58	0	58	the first	successful
2	Ahmed Hashem Nour Asher	30	55	85	0	85	0	85	the first	successful
3	Idris Ihsan Ali Marshoud	12	22	54	42	54	0	54	the second	successful
4	Esraa Mohammed Said Rashid	11	16	41	22	41	30	41	the third	fail
5	Asal Saeed Abdul Zaid Mohan	32	31	63	0	63	0	63	the first	successful
6	Ayat Ahmed Mohamed Fleih	25	26	51	0	51	0	51	the first	successful
7	Ayat Adel Kazem Mohi	29	30	59	0	59	0	59	the first	successful
8	Elaf Diaa Abdul Latif Jassim	16	44	60	0	60	0	60	the first	successful
9	Oh Mohsen Mahdi Salman	33	22	55	0	55	0	55	the first	successful
10	Blessed be Thamer Yassin Fadel	22	36	58	0	58	0	58	the first	successful
11	Blessed be Abdul Hafez Khazal Attia	30	55	85	0	85	0	85	the first	successful
12	Jaafar Sadiq Jawad	12	22	38	22	38	26	38	the third	fail

Figure 8: Master sheet of Grades Page.

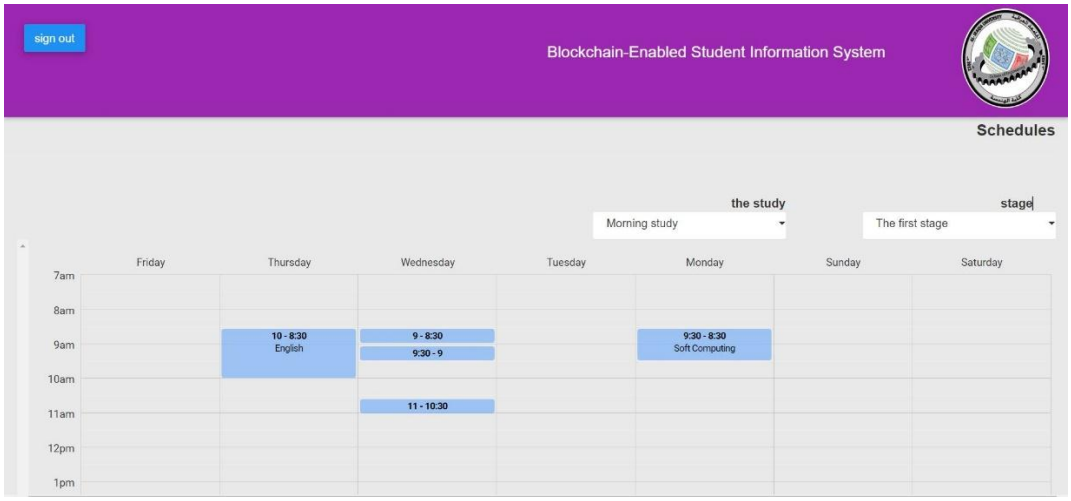


Figure 9: Week Schedules Page.

The results of the system implementation highlight several significant findings. Firstly, the integration of blockchain technology enhanced the security and trustworthiness of the student information system. The decentralized ledger ensured immutability and transparency, reducing the risk of data manipulation or unauthorized access. The integrity of student data and grades depends on this functionality. Second, the ASP.NET application provided an easy-to-use front-end interface for interfacing with the system. It supported easy navigation, making it possible for super administrators, stage managers, department managers, college managers, and students to quickly access and carry out their respective jobs. Additionally, the use of Solidity, a programming language for smart contracts, allowed for the automation of crucial procedures including grade computation, attendance monitoring, and result creation. The use of smart contracts insured correctness and did away with the need for manual intervention, which decreased administrative work and human mistake.

The testing phase yielded positive feedback from users, signifying both high user satisfaction and ease of system usage. Participants found it valuable that the system could provide real-time access to relevant information like course schedules, grades, and attendance records. Furthermore, the system's scalability and flexibility were highlighted, demonstrating its capacity to accommodate numerous users and conform to shifting institutional demands. Identified during the evaluation were certain limitations. The need for appropriate infrastructure and network connectivity to ensure seamless operation of the blockchain network was one limitation. Additionally, academic institutions may encounter initial challenges in adopting and accepting blockchain technology. Including resistance to change, these challenges also consist of the need for training and awareness programs.

V. CONCLUSION

In conclusion, this paper has introduced a student information system (SIS) that harnesses the power of blockchain technology. Developed using ASP.net, C#, Ethereum, Solidity, Ganache and IPFS. The purpose of this study was to tackle the difficulties related to data security and availability in conventional centralized systems utilized in academic institutions. The implementation of the suggested system revealed that blockchain technology presents notable advantages when it comes to data integrity, privacy, and transparency. Student information was securely stored and retrieved by using cryptographic techniques and smart contracts written in Solidity. The Ethereum blockchain's decentralized nature eliminated the need for a central authority by providing an immutable ledger. This improved trust and lowered the chance of data manipulation.

A user-friendly interface was provided to students, stage managers, department managers, college managers, and super administrators through the developed ASP.net and C# system. Confirmation of the system's efficiency, security, and usability came from performance tests and experiments. It maintained data confidentiality and accessibility while ensuring reliable and prompt data retrieval. The findings demonstrated that the blockchain-powered SIS effectively tackled the challenges identified and offered a valuable solution for managing student information in academic institutions. This research helps expand our understanding of how blockchain can be utilized in education. The introduction of a blockchain-enabled SIS offers organizations a transformative solution for managing student information with enhanced data security, transparency, and efficiency. Nevertheless, it is crucial to recognize that there are still aspects that need enhancement and additional investigation, including scalability, interoperability, and integration with current systems.

To summarize, academic institutions can greatly enhance their data management processes by adopting a blockchain-powered SIS. The provided system establishes a framework for future progress and fosters further examination of blockchain technology in educational contexts.

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