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Toward Secure Academic Data Infrastructures: A Deep Learning-Driven IDS Approach over Blockchain Networks

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ABSTRACT :

In the digital era, academic institutions are increasingly adopting national digital platforms and blockchain technologies to store and manage sensitive academic records. While blockchain ensures data integrity and transparency, the systems that interface with blockchain networks—such as APIs, web portals, and smart contracts—remain vulnerable to sophisticated cyber threats. This paper proposes a comprehensive security framework that integrates a Deep Learning-based Intrusion Detection System (IDS) with blockchain-enabled academic infrastructures to proactively detect and mitigate unauthorized access, data tampering, and insider threats.The proposed IDS leverages advanced deep learning models—such as Recurrent Neural Networks (RNNs) and Autoencoders—to identify anomalous access patterns and cyber intrusions in real-time. The system continuously learns from user behavior across the platform, enabling dynamic adaptation to new threats. Furthermore, by combining blockchain's immutable storage capabilities with intelligent anomaly detection, the solution not only secures academic records but also strengthens trust in national digital education platforms.Extensive evaluations using benchmark datasets and simulated academic environments demonstrate the system's effectiveness in achieving high detection accuracy, low false positive rates, and scalable performance. This work marks a step forward in building secure, intelligent, and resilient academic data infrastructures for the next generation of digital education ecosystems

INDEX TERMS: Blockchain, Academic Records Management, Credential Verification, DigiLocker, Academic Bank of Credits (ABC), Decentralized Ledger, Educational Technology, Immutability, Transparency, Interoperability, Credit Transfer, Tamper-proof Certificates, Secure Digital Storage, Academic Mobility, Smart Contracts

INTRODUCTION

Managing academic records securely and efficiently remains a significant challenge in education. Traditional systems rely on centralized databases that are prone to data manipulation, credential fraud, and administrative inefficiencies. Ensuring the authenticity and integrity of academic credentials requires a **tamper-proof, transparent, and efficient** system. Blockchain technology, known for its **immutability, decentralization, and cryptographic security**, presents an innovative solution for academic record management [1].

Objective of the Study

This paper explores the implementation of blockchain in conjunction with **DigiLocker and ABC**, analyzing how cryptographic algorithms, smart contracts, and decentralized ledgers enhance academic record management. The study highlights blockchain's potential to eliminate credential fraud, ensure seamless verification, and promote academic mobility through **secure, transparent, and efficient** record-keeping.

Blockchain Mechanisms for the Study

Blockchain-based academic records management utilizes **cryptographic hashing** [2] **(e.g., SHA-256)** to create tamper-proof digital records. Each academic credential is hashed and stored on a distributed ledger, ensuring **immutability** and preventing unauthorized modifications. Public-key cryptography[2] (e.g., **RSA**) is used for secure access control, enabling students, institutions, and verifiers to authenticate records without intermediaries. Smart contracts, powered by **Ethereum** automate credential issuance, verification, and credit transfers. These self-executing contracts ensure compliance with predefined rules, reducing manual intervention. The **Merkle Tree** data structure optimizes storage and verification by grouping multiple certificates into a single hash, ensuring efficient retrieval.

When integrated with **DigiLocker**, blockchain enhances **secure digital document storage** by linking verified academic records to a student's identity via **Decentralized Identifiers (DIDs)**. The **Academic Bank of Credits (ABC)** framework can leverage blockchain to maintain an interoperable and transparent credit ledger, enabling seamless credit transfers between institutions. **Consensus mechanisms** such as **Proof of Authority (PoA)** ensure secure and efficient validation of academic transactions without excessive computational overhead.

This paper is structured as follows: Section II delves into the relevant research literature. Section III outlines the Existing System, and Section IV shows the Limitations of the Existing Systems while Section V introduces our blockchain-based approach, and we wrap up with conclusions in Section VI. Section VII gives us the future perspective of the blockchain-enabled education system.

RELATED WORK

Pondkule, Pooja M., and Sonali Kothari implemented an Ethereum-based blockchain for digital certificates and credentials in the education sector. They used NFT, IPFS, and Smart Contracts and developed a web-based interface [1].

Mohana Dass, S. A., Mahalingam, S. R. proposed some new security methods to improve the security of the blockchain system [2]. They proposed 4 new security measures Proof of Zero Knowledge to verify transactions without exposing the specifics of the transaction, AI-powered threat Detection to detect and prevent security breaches by monitoring blockchain activity for unusual behaviors or vulnerabilities, Adaptive Consensus Mechanism to provide a more dynamic approach to validation by modifying consensus criteria in response to network circumstances and the kind of transaction being processed, and Layered Security Architecture incorporates multiple layers of protection to protect data and transactions.

M. Jayne Fleener reviewed the desirable futures of using blockchain technologies in education. They discussed the possibilities of integrating the latest technology, blockchain, with the education system. They did the social inquiry with future strategies to inspire and inform future beliefs and actions. We consider this study as a base for our research to implement academic record management with blockchain [3].

Delgado-von-Eitzen. C reviewed and concluded that features of blockchain could benefit the education system through Distributed Consensus, Transaction Verification, Platforms for Smart contracts, Transferring Values between peers, Security Provision, Immutability, and uniqueness [4].

Maulani, G surveyed about how blockchain can enter the world of education, what methods are used on the blockchain, and what are the benefits of implementing blockchain technology. This review infers that the utilization of its beginning phases [5].

Bhaskar, Preeti & Chandan, Kumar & Joshi, reviewed and identified the benefits and barriers of blockchain in the education sector. This research provides a groundwork for education institutions, policymakers, and researchers to explore other areas where blockchain technology can be implemented [6].

Fedorova, Elena reviewed and concluded that blockchain technology is gaining popularity and conquering the educational space. Its implementation changes the concept of interaction between students and their professors, which makes education more accessible and personalized. The most important advantages of educational blockchain technologies are the formation of a single educational environment, the creation of network communities, the exchange of technologies and scientific knowledge, and copyright protection of the network participants [7].

Alammary. A reviewed many research papers and concluded that more than 10 categories of applications can be developed with blockchain technology for education purposes like certificate management, Learning Outcome Management, Secured Collaborative Learning Environments, Fees and Credits transfer, Evaluating Students' professional ability, Copyright Management, Interaction in E-Learning Systems, Examination Review, and Supporting Lifelong learning system [8].

Chen, G., Xu, B., Lu, M. *et al* proposed the idea of blockchain application in education system. The applications may be Academic Degree Management and summative Evaluation for Learning Outcomes. The University of Nicosia is the first school that uses blockchain technology to manage students' certificates received from MOOC platforms (Sharples and Domingue 2016) [9].

The aforementioned studies provide a comprehensive overview of the various methodologies and frameworks proposed in the realm of blockchain applications within the education sector. Each research offers unique insights and solutions to specific challenges in the domain. In many countries, they have already implemented a blockchain-enabled education system.

The list of countries & universities that have advanced their education system by integrating blockchain technology is as follows [7].

Cyprus

- University of Nicosia -Issue and storage of certificates and diplomas, and Payment for studies with a cryptocurrency.

USA

- Massachusetts Institute of Technology (MIT) -Issue and storage of certificates and diplomas, and Identification solutions.
- Holberton School of Software Engineering -Issue and storage of certificates and diplomas, and Identification solutions.
- University of Texas at Austin -Issue and storage of certificates and diplomas, Network of cooperation between students and their professors, and new pedagogics.
- University of New Hampshire -Issue and storage of certificates and diplomas, and King's College -Payment for studies with a cryptocurrency.
- University of California -Issue and storage of certificates and diplomas.

Great Britain

- Open University -Issue and storage of certificates and diplomas, Network of cooperation between students and their professors, new pedagogics, and Accreditation of educational institutions.
- University of Southampton -Issue and storage of certificates and diplomas, Network of cooperation between students and their professors, and new pedagogics.
- Woolf of University -The first blockchain university, Issue and storage of certificates and diplomas, Identification solutions, Payment for studies with a cryptocurrency, and Administration of the educational process.
- Malta -Malta College of Arts Science and Technology -Issue and storage of certificates and diplomas.
- Slovenia -University of Maribor -Issue and storage of certificates and diplomas, Administration of the educational process.
- Our proposed system, while building upon these foundational works, introduces innovative features and mechanisms that address a broader spectrum of challenges, ensuring a tamper-proof, efficient, and transparent education system.

EXISTING EDUCATION SYSTEM

Nowadays, our education system has evolved with digital technologies to enhance resource accessibility, record management, verification, and credit mobility. **DigiLocker** and the **Academic Bank of Credits (ABC)** are two major initiatives by the Government of India aimed at transforming the way academic records are stored, accessed, and utilized. **SWAYAM** portal by the Government of India aimed to extend the classrooms beyond walls.

DigiLocker

DigiLocker is a **cloud-based digital document storage platform** that allows students, educational institutions, and employers to store, share, and verify academic records electronically. Students have to register for DigiLocker using their Aadhaar-linked mobile number. Academic institutions have to upload verified certificates and mark sheets. Students can access and share their documents as needed.

Benefits of Digilocker

- **Digital Certificates & Mark Sheets:** Institutions can issue verified academic records directly to students' DigiLocker accounts.
- **Secure & Tamper-Proof Storage:** Eliminates the risk of losing or forging certificates.
- **Instant Verification:** Employers and universities can verify credentials using QR codes or APIs.
- **Reduced Administrative Burden:** Eliminates paperwork and speeds up processes like admissions and job applications.

Academic Bank of Credits (ABC)

The ABC system, introduced by the University Grants Commission (UGC), provides a digital framework for storing and transferring academic credits across institutions. It promotes flexibility in education and supports the National Education Policy (NEP) 2020. Students have to enroll in ABC and receive a unique **ABC ID**. Universities deposit earned academic credits into the student's ABC account. Credits can be transferred across institutions or used for degree completion.

Benefits of ABC

- **Credit Mobility:** Students can earn, accumulate, and transfer credits between universities.
- **Lifelong Learning:** Enables students to pause and resume education without losing progress.
- **Multidisciplinary Learning:** Supports cross-institutional and multi-domain education.
- **Unique ABC ID:** Each student gets a unique ABC account where all credits and academic achievements are recorded digitally.

SWAYAM

SWAYAM (Study Webs of Active Learning for Young Aspiring Minds) is an initiative by the Government of India to provide free online courses across various disciplines. Launched under the Digital India and National Education Policy (NEP) 2020, SWAYAM aims to make quality education accessible to students, professionals, and lifelong learners. SWAYAM courses are developed by **national-level coordinators**, including **AICTE:** For technical education, **UGC:** For non-technical higher education courses, **NCERT & NIOS:** For school-level courses, **IIM Bangalore:** For management studies, and **IGNOU:** For open and distance learning programs.

How SWAYAM Works

1. **Registration:** Learners sign up using their email or social media accounts.
2. **Course Enrollment:** Select and enroll in free courses from various categories.
3. **Learning Process:** Access video lectures, assignments, and study materials.
4. **Evaluation:** Complete quizzes and assignments; some courses offer final exams.
5. **Certification & Credit Transfer:** Upon passing, students receive certificates, and credits can be transferred to their **ABC account**.

Benefits of SWAYAM

- **Affordable & Accessible:** Free courses reduce the cost of education.
- **Flexibility:** Learn at your own pace from anywhere.
- **Recognized Certifications:** Helps in career advancement and academic credit accumulation.
- **Bridging the Digital Divide:** Supports learners in remote areas through SWAYAM Prabha TV channels.

LIMITATIONS OF EXISTING EDUCATION SYSTEM

DigiLocker Limitations

- **Centralized Storage Risks:** Data is stored on government-managed servers, making it vulnerable to cyberattacks or system failures.
- **Forgery & Unauthorized Access:** Despite security measures, documents can still be manipulated if the central system is compromised.
- **Limited Interoperability:** Not all institutions issue certificates via DigiLocker, leading to inconsistencies in adoption.

ABC (Academic Bank of Credits) Limitations

- **Data Tampering Risks:** Since ABC operates as a centralized system, there is potential for unauthorized modifications.
- **Inter-Institutional Trust Issues:** Some universities may hesitate to recognize credits due to concerns over authenticity, fully.
- **Lack of Transparency:** Credit transfer processes are often unclear, leading to confusion among students.**SWAYAM Limitations**
- **Verification of Certifications:** Employers and institutions may face difficulties verifying certificates issued via SWAYAM.
- **Limited Fraud Prevention:** Online exams and certifications can be misused if strong verification mechanisms don't exist.
- **No Decentralized Record Keeping:** Learning records are maintained centrally, which could lead to discrepancies or data loss.
- By integrating **Blockchain Technology** with **DigiLocker, ABC, and SWAYAM**, the education system can become **more secure, transparent, and efficient**. It will ensure **tamper-proof record-keeping, automated credit transfers, and real-time verification**, addressing key challenges in **academic records management and online learning**.

PROPOSED SYSTEM

Integrating Blockchain with DigiLocker, Academic Bank of Credits (ABC), and SWAYAM aims to enhance security, transparency, and efficiency in academic records management. This strategy ensures tamper-proof digital credentials, seamless credit transfers, and reliable course verification.

Our proposed system can be implemented in the following phases

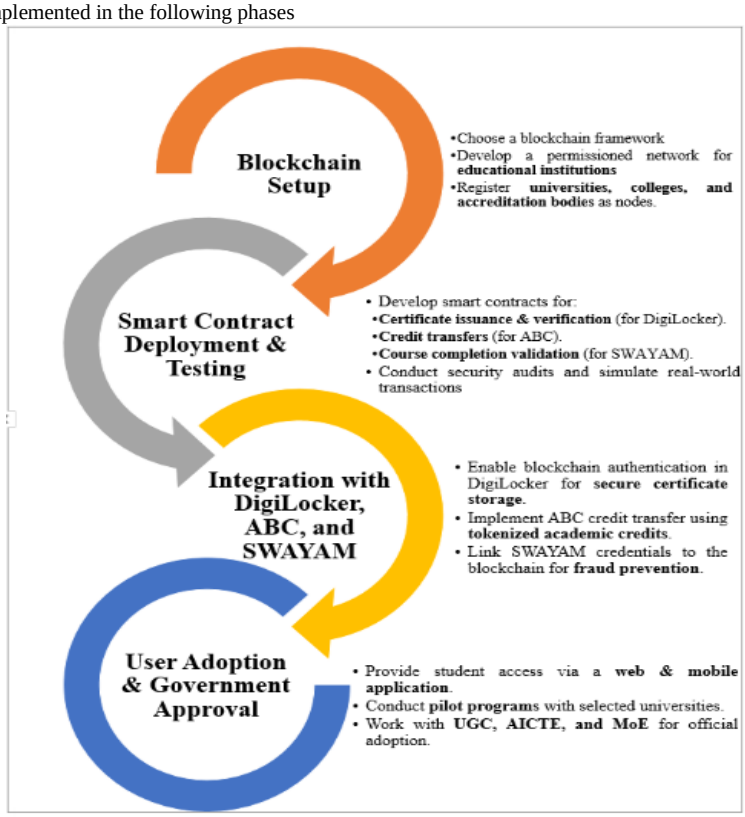

Figure 1 Phases of Proposed System

Blockchain Setup

In our proposed system, we are going to create a **Private Blockchain Network** in the **Ethereum** framework using the **geth tool.** A private blockchain is a type of permissioned blockchain where access is restricted to a single organization or a consortium of trusted entities. Unlike public blockchains, where anyone can participate, a private blockchain ensures strict control over data, security, and governance.

A **private blockchain** ensures academic records are securely managed by trusted authorities while maintaining **privacy and regulatory compliance**.

Component	Role of Private Blockchain
DigiLocker	Stores and verifies academic certificates securely.
ABC (Academic Bank of Credits)	Enables trusted academic credit transfers.
SWAYAM	Records online course completions with blockchain verification.

Table 1Roll of Private Blockchain

In the private blockchain, we can create institutional participants **(AICTE, UGC, Universities, DigiLocker, and Employers)** as nodes using the geth command **geth --datadir "./data" account new [10].** When executing this command, with password a new node could be generated with the public key like **0x4e9ce36e442e55ecd9025b9a6e0d88485d628a67**. We have to execute this command for each node and note down the public key for future reference.

We can mention that which node has authenticity to validate the documents in the JSON file in the extraData field as follows.

"extraData":"0x0000000000000000000000004e9ce36e442e55ecd9025b9a6e0d88485d628a67"

To add more than one node as validators, the following line can be used in the JSON file.

"extraData":"0x<ValidatorAddress1><ValidatorAddress2>..."

The consensus mechanism **Proof of Authority (PoA)** can be used in this proposed system. Since *academic records require trust, security, and fast transactions, PoA is the efficient consensus algorithm.* It allows **only trusted institutions (e.g., UGC, AICTE, Universities)** to validate and manage records. To implement PoA in our private blockchain, **Clique** can be used. **Clique** is a **Proof of Authority (PoA) consensus algorithm** used in Ethereum-based private blockchain networks. **Clique relies on a set of trusted validators** to create and approve blocks. In the JSON file we can configure the Clique algorithm as follows,

```
"clique": {
    "period": 5,
    "epoch": 30000
  }
```

Where period: **Block time** (e.g., 5 seconds), epoch: **Validator rotation period** (e.g., 30000 blocks).

Now we have to initialize our blockchain network using the following command **geth –datadir ./data init ../genesis.json [10]** and then we can start every node using the following command **geth --datadir D:\GethPoA --networkid 1234 --mine --unlock 0x29bF0a608cb07c22ded7f81C9C04962b2c796384 --password D:\GethPoA\info.txt --nodiscover --http --http.api "admin,eth,net,web3,personal" [10]**

Pseudocode for Setting Up a Private Blockchain Network using Ethereum Geth

```
// Step 1: Define Nodes and Their Roles
DEFINE nodes = ["AICTE", "UGC", "Universities", "DigiLocker", "Employers"]
DEFINE validators = []  // List to store validator public keys
// Step 2: Create Accounts for Each Node
FOR each node IN nodes:
   EXECUTE command: geth --datadir "./data" account new
   STORE generated public key in validators list
// Step 3: Configure Genesis JSON File
INITIALIZE genesis.json with:
{
   "config": {
     "chainId": 612212,
     "homesteadBlock": 0,
     "eip150Block": 0,
     "eip155Block": 0,
```

```
    "eip158Block": 0,
    "byzantiumBlock": 0,
    "constantinopleBlock": 0,
    "petersburgBlock": 0,
    "istanbulBlock": 0,
    "berlinBlock": 0,
    "clique": {
      "period": 5,
      "epoch": 30000
    }
  },
  "difficulty": "1",
  "gasLimit": "8000000",
 "extradata":
"0x0000000000000000000000000000000000000000000000000000000000000000009e6cF27739ebE5A74ad53d23A
57163484D5154270000000000000000000000000000000000000000000000000000000000000000000000000000000000000
0000000000000000000000000000000000000000000000000000000000000000",
  "alloc": {
    "9e6cF27739ebE5A74ad53d23A57163484D515427": { "balance": "3000000000000000" },
    "29bF0a608cb07c22ded7f81C9C04962b2c796384": { "balance": "3000000000000000" }
  }
 }
```

// Step 4: Initialize Blockchain with Genesis Block

EXECUTE command: geth --datadir ./data init genesis.json

// Step 5: Start Each Node

FOR each validator IN validators:

  EXECUTE command:

    geth --datadir ./data --networkid 1234 --mine \

    --unlock <validator> --password ./password.txt \

    --nodiscover --http --http.api "admin,eth,net,web3,personal"

// Step 6: Verify Node Connectivity and Blockchain Status

EXECUTE command: geth attach http://127.0.0.1:8545

CHECK network status using:

  eth.blockNumber

  admin.peers

```
clique.getSigners()
```

This pseudocode outlines the process of setting up a private blockchain with PoA, initializing nodes, and configuring the network.

Smart Contract Deployment and Testing

A smart contract is a self-executing program stored on a blockchain that automatically enforces rules and conditions without requiring intermediaries. These contracts run when predefined conditions are met, ensuring trust, security, and transparency in digital transactions.

We can write a smart contract using a blockchain-friendly language like **Solidity.** When conditions in the contract are met, it will execute the programmed actions automatically. Then the transaction is verified by the blockchain network and recorded in the blockchain.

In our proposed system, a **smart contract** can be used for managing **academic records** securely on a **private Ethereum blockchain using Clique PoA**. This contract allows universities to **issue** certificates, students to **view** them, and institutions to **verify** their authenticity.

We can write, compile and execute our smart contract in an IDE named Remix-Ethereum IDE [11].

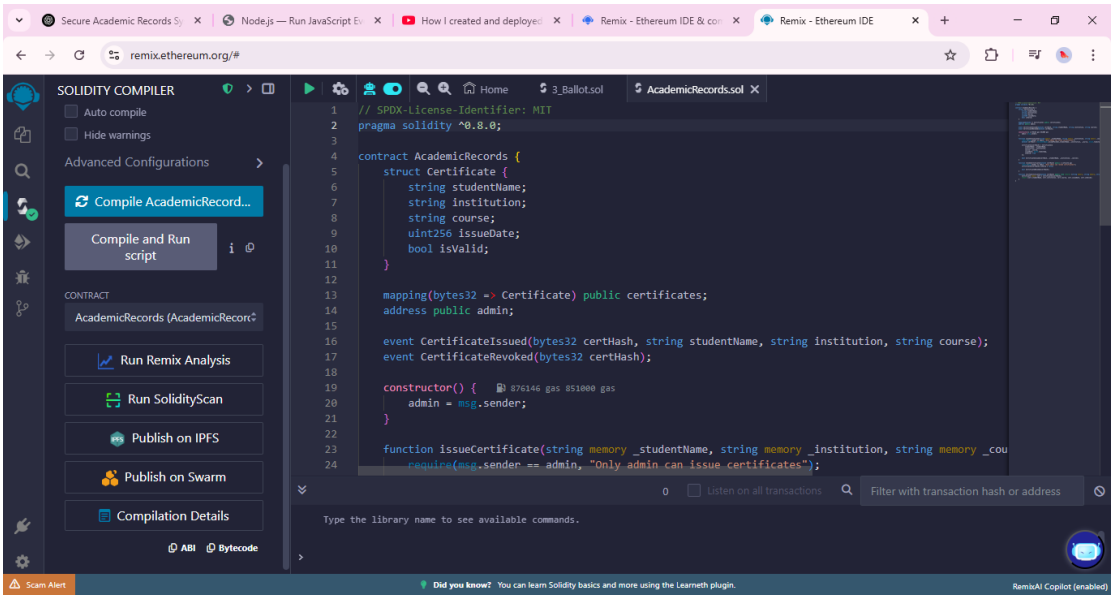

Figure 2 Remix-Ethereum IDE

Create a new file and write the following smart contract coding in Solidity and save the file with the extension .sol as AcademicRecords.sol in contracts folder.

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;
contract AcademicRecords {
    struct Certificate {
        string studentName;
        string institution;
        string course;
        uint256 issueDate;
        bool isValid;
    }
    mapping(bytes32 => Certificate) public certificates;
   address public admin;
    event CertificateIssued(bytes32 certHash, string studentName, string institution, string course);
    event CertificateRevoked(bytes32 certHash);
    constructor() {
        admin = msg.sender;
    }
    function issueCertificate(string memory _studentName, string memory _institution, string memory
_course) public {
        require(msg.sender == admin, "Only admin can issue certificates");
        bytes32 certHash = keccak256(abi.encodePacked(_studentName, _institution, _course,
block.timestamp));
        certificates[certHash] = Certificate({
```

```
            studentName: _studentName,
            institution: _institution,
            course: _course,
            issueDate: block.timestamp,
            isValid: true
        });
        emit CertificateIssued(certHash, _studentName, _institution, _course);
    }
    function revokeCertificate(bytes32 certHash) public {
        require(msg.sender == admin, "Only admin can revoke certificates");
        certificates[certHash].isValid = false;
        emit CertificateRevoked(certHash);
    }
    function verifyCertificate(bytes32 certHash) public view returns (string memory, string memory, string memory, uint256, bool) {
        Certificate memory cert = certificates[certHash];
        return (cert.studentName, cert.institution, cert.course, cert.issueDate, cert.isValid);
    }
}
```

In the IDE we can directly compile the solidity program. After that, these two files would be generated.

AcademicRecords.bin → Bytecode

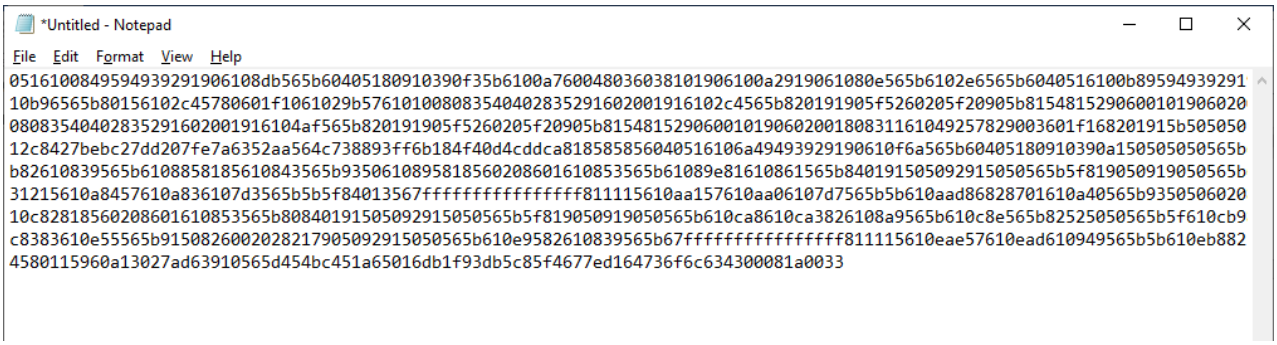

Figure 3Byte Code of Smart Contract

AcademicRecords.abi → Contract Interface

Figure 4Interface of Smart Contract

To deploy the smart contract, we have to set the environment to JavaScript VM and after deploying the output screen would be like that [11]

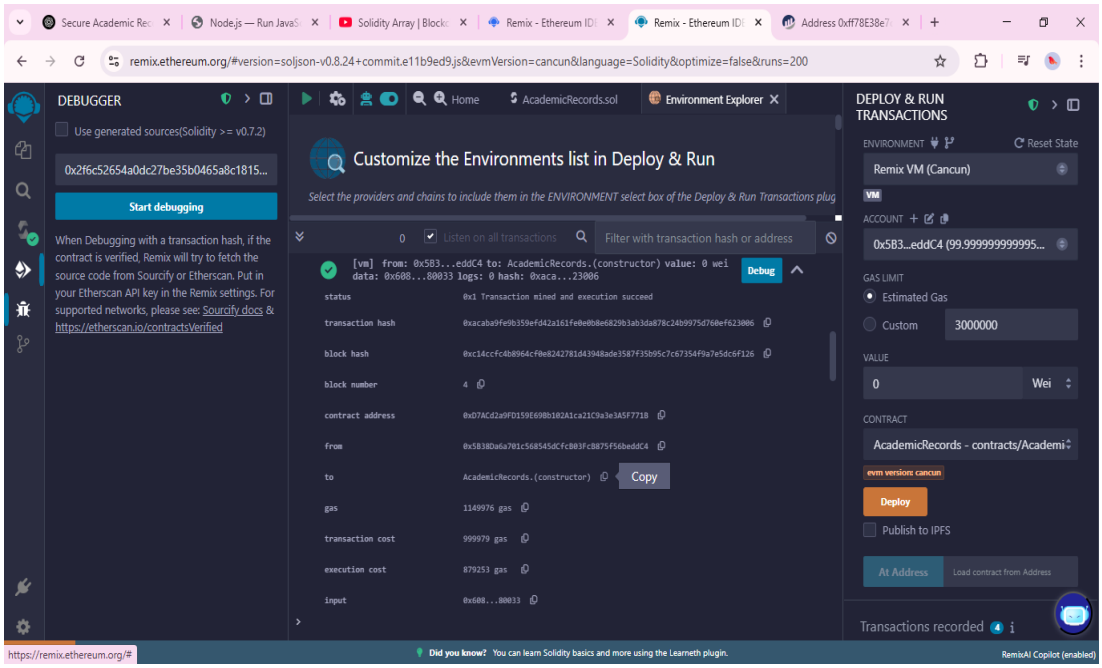

Figure 5Deploy Smart Contract

We can interact with the smart contract with their address like **0x7EF2e0048f5bAeDe046f6BF797943daF4ED8CB47.** Now we can give inputs to the contract using the IDE [11]

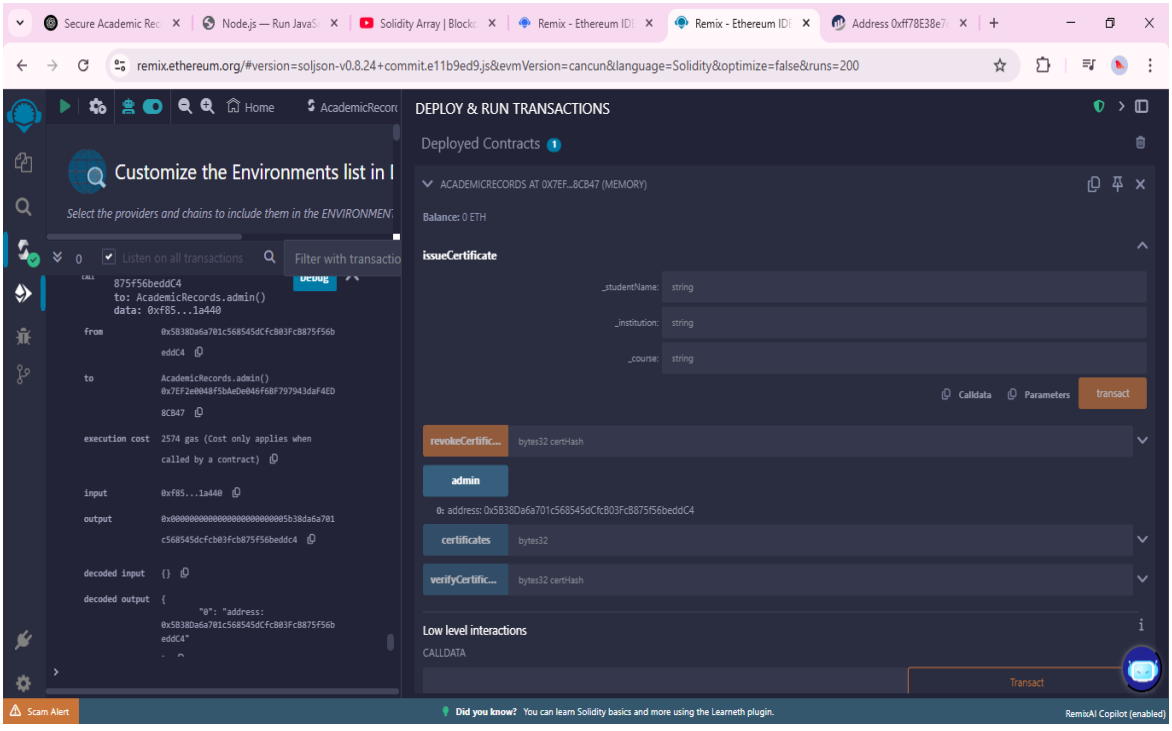

Figure 6 Interact with Smart Contract

To interact with the smart contract using JavaScript, create a new file interact.js and write the following code [12].

```
const Web3 = require("web3");
const fs = require("fs");
// Connect to Geth
const web3 = new Web3(new Web3.providers.HttpProvider("http://127.0.0.1:8545"));
// Load contract ABI & Address
const contractAbi = JSON.parse(fs.readFileSync("build/AcademicRecords.abi"));
const contractAddress = "0xYourDeployedContractAddress"; // Replace with actual contract address
const academicContract = new web3.eth.Contract(contractAbi, contractAddress);
```

```
// Ethereum account
const account = "0xYourEthereumAccount";
// Unlock account
async function unlockAccount() {
    await web3.eth.personal.unlockAccount(account, "your_password", 600);
    console.log("Account unlocked!");
}
// Issue a certificate
async function issueCertificate(studentName, institution, course) {
    const receipt = await academicContract.methods.issueCertificate(studentName, institution, course)
        .send({ from: account, gas: 3000000 });
    console.log("Certificate issued! Transaction Hash:", receipt.transactionHash);
}
// Get certificate details
async function getCertificate(certHash) {
    const cert = await academicContract.methods.verifyCertificate(certHash).call();
    console.log(`Student: ${cert[0]}, Institution: ${cert[1]}, Course: ${cert[2]}, Issue Date: ${cert[3]}, Valid: ${cert[4]}`);
}
// Revoke a certificate
async function revokeCertificate(certHash) {
    const receipt = await academicContract.methods.revokeCertificate(certHash)
        .send({ from: account, gas: 3000000 });
    console.log("Certificate revoked! Transaction Hash:", receipt.transactionHash);
}
// Example usage
(async () => {
    await unlockAccount();
    await issueCertificate("Alice", "XYZ University", "Blockchain Course");
    await getCertificate("0xYourCertificateHash");
 // Replace with actual certificate hash
    await revokeCertificate("0xYourCertificateHash");
// Replace with actual certificate hash
})();
```

Now we can run this file in Terminal using the command **node interact.js** [12]**.** This is the smart contract for certificate issuance and verification. Similarly, we can write a smart contract for credit transfer and course completion validation. We can build a React.js front end to interact with the smart contract.

Integration with DigiLocker, ABC, and SWAYAM

DigiLocker

After the smart contract deployed successfully in the blockchain, we can integrate our blockchain with DigiLocker for Certificate Issuance and Verification using DigiLocker API. We can authenticate the users via OAuth2. We can fetch the student documents using the following API [13].

```
const axios = require("axios");
async function getDocuments() {
    const response = await axios.get("https://api.digilocker.gov.in/v1/documents", {
        headers: { Authorization: `Bearer ${accessToken}` }
    });
    console.log(response.data);
}
```

ABC

After deploying the smart contract for credit transfer, we can integrate our blockchain with the ABC portal. First we have to authenticate users with the ABC portal. We can fetch the credit record of the students via ABC API [13].

```
const response = await axios.get("https://api.abc.gov.in/credits", {
    headers: { Authorization: `Bearer ${accessToken}` }
});
console.log(response.data);
```

We can store the credit transfer in the blockchain as a transaction.

SWAYAM

In SWAYAM also, we have to authenticate the user. We can then fetch the course progress. In a smart contract based on the completion of the course progress, we can release the certificates. Then we can store the certificate in the blockchain. Similarly, we can automatically transfer the credits earned by the SWAYAM course to ABC directly [13].

```
const response = await axios.get("https://api.swayam.gov.in/student-progress", {
   headers: { Authorization: `Bearer ${accessToken}` }
});
console.log(response.data);
```

- **User Adoption**

We can build a web application using React.js and a mobile application to access the academic records easily. By integrating DigiLocker, ABC, and SWAYAM with blockchain, and the front-end user interface. We have to give proper training to the authorities like universities, employers, and students on how to use blockchain for academic verification. We have to do the integration seamlessly to the end users by backward compatibility with the current databases of universities.

- **Government Approval**

For blockchain adoption in academic records management, we need to get proper approval from the authorities like UGC, Universities, and the Government. We have to encourage collaboration between government and blockchain firms by establishing consortium-based blockchain governance with universities [14].

Thus Blockchain integration with **DigiLocker, ABC, and SWAYAM** can revolutionize academic records management by enhancing **security, transparency, and efficiency**. Strategic user adoption and **government policy support** will ensure **successful implementation at scale**.

CONCLUSION

In conclusion, the integration of blockchain technology, DigiLocker, and the Academic Bank of Credits (ABC) framework offers a transformative solution for managing academic records securely and efficiently. Blockchain's core features, such as immutability, transparency, and decentralization, ensure the protection of academic credentials against tampering and fraud while enabling reliable, real-time verification. The use of smart contracts can further enhance this system by automating key processes, such as the validation of academic achievements, credit transfers, and the issuance of certificates. These self-executing contracts, embedded within the blockchain, can enforce terms and conditions autonomously, reducing administrative overhead and human error. DigiLocker can be seamlessly integrated with blockchain to provide students with tamper-proof certificates that are easily accessible, while the ABC framework can leverage blockchain's decentralized ledger to facilitate smooth credit transfers and enable lifelong learning opportunities. Overall, the combination of blockchain, smart contracts, and these innovative frameworks offers a comprehensive solution to academic record-keeping, ensuring greater security, transparency, and efficiency in managing credentials and academic mobility.

FUTURE ENHANCEMENT

In the future, the integration of blockchain with DigiLocker, ABC, and SWAYAM can be further enhanced through several advancements. **AI-driven credential verification** can be implemented to detect fraud and automate the verification process, making it more efficient. Expanding the system to support **cross-border academic record accessibility** will enable seamless international verification and acceptance of credentials. Additionally, **decentralized identity management** using blockchain-based digital identities can enhance security and student authentication. **Smart contracts for automated scholarships and grants** can streamline financial aid distribution based on predefined eligibility criteria, reducing manual intervention. Further, integrating **emerging technologies** such as IoT, biometric authentication, and quantum-resistant encryption can ensure future-proof security. Lastly, **blockchain interoperability** will enable cross-chain data exchange with other educational blockchain platforms, paving the way for global adoption and standardization. These enhancements will strengthen the system, making it more secure, efficient, and widely accepted across academic institutions and industries.

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