BDoTs: Blockchain-based Evaluation Scheme for Online Teaching under COVID-19 Environment

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***Abstract*—Online teaching has become mandatory across the globe during the COVID-19 pandemic situations. Hence, there is a need to uplift the online teaching technology for data privacy preservation and transparency in the system. Various online teaching schemes have been proposed by various authors, but they lack in handling decentralised governance, transparency, trust and communication issues. Blockchain (BC) Technology has emerged to provide decentralised solution in solving the real-time problems. Motivated by these facts, in this paper, we propose a BC-based decentralised online teaching scheme known as *BDoTs*. The security and data privacy issues in *BDoTs* are resolved by developing smart contracts (SCs) over BC. Moreover, the data storage cost issues are handled by the Inter Planetary File System (IPFS) protocol for Off-Chain data storage. Moreover, we present a real-time BC simulation and deployment of SC in Truffle suite. Results show that the proposed scheme performs better in comparison to the state-of-the-art schemes in terms of scalability, data storage cost, and packet loss.**

***Index Terms*—Blockchain, Online Teaching, COVID-19, Security, Smart Contracts, Scalability.**

I. Introduction

The education industry is expanding with the invention of technologies to broaden knowledge distribution and skill evaluation. This is an ordinarily held origin inside the academic field. The fixed framework is strictly followed in the traditional education system. In the traditional system, students need to enroll in an institution and abide by the rules and regulations defined by that institution to pursue their learning. Accordingly, traditional education puts a need for the assurance of what subject-based information will be shown dependent on fair and square education. However, effective study or teaching is not a clear concept yet. Several attempts have been made to identify the characteristics of effective study and teaching using many theoretical, quantitative and qualitative approaches from teaching and studying point of view. The COVID-19 pandemic has resulted in the shutdown of schools and colleges; thus, teaching is continued remotely using various virtual online platforms.

With the advent of the Internet, the rise of online teaching has drawn increasing from education and teaching communities worldwide. To adapt new technologies and ways of education, the education system needs to evolve and develop continuously. Day by day, the number of students learning through OTP (online teaching platforms) increases and the number of participants is limited only by the technology used unlike in traditional systems. The Internet plays a pivotal role in effective learning and teaching tools. Teachers can store their video tutorials somewhere on the cloud through which students can access them easily and refer to it as often as possible, which is not in the case of the traditional system. The Internet is a boon to the people. It helps and has a significant impact on imparting education to students.

Perhaps the expense is the biggest hindrance in the education system. The Internet helps in teaching in being cost-effective, which is a pillar of sustainable development. Keeping video tutorials online makes education more safe and cost-effective. The Internet also helps students and teachers to be connected through several social and messaging applications. Moreover, it also allows parents to contact the teachers to supervise the student's progress more effectively and periodically. As technology is evolving rapidly, digital media has become an essential part of our lives. The Digital bulletin also helps to save paper and also allows new and advanced technologies to be showcased in an eco-friendly manner. Information is the greatest thing the Internet can offer, which is often cost efficient and information up-to-date of all the domains. Moreover, learning with multimedia is the new trend which helps in simplifying the learning process and making it more attractive to young students.

Currently, there are several online paid websites that provide online education rich in quality and turn out to be more practiced. Online learning is an excellent alternative to traditional learning systems for being cost-effective, but it has pros and cons. Students can learn at their own convenient time. Students can opt for several different courses of any field of interest. Moreover, it helps to increase the self-motivation level through upgrading the skills. Online learning also helps students to be more productive and contribute to finishing their homework and submission easily on the same learning online platform, which makes it easier to give time to their hobbies.

In an education system, teaching style or students' learning style is not the only factor affecting the student's productivity or learning. There are many other factors, like the school environment, home environment, school policies, and teacher behavior. Many researchers have given insights regarding this, Brickmann *et al.* [1] stated the pros of online teaching and how it can help increase the learning power for students as students could learn whenever and whatever they want

with new technologies. Later, Titan *et al.*[2] discusses the cons of online learning and gives suggestions to overcome it. However, with the flexibility of online learning, discipline is also what needs to be followed. Zhang *et al.* [3] points out the need for continuous monitoring of the student's progress and also continuous periodical evaluation is also important. Any college/ institution can provide the best quality of teaching, but the range of the subject or course may be limited [4]. The emergence Massive Open Online Course (MOOC) helped students to learn new things effectively. Nevertheless, MOOC cannot fully replace the traditional college/institution teaching [5]. To enhance the engagement of students in learning, the teaching system should be more learner-centered rather than teacher-centered, and to make it evenly interesting. Moreover, social media can help to develop interest among students as it will get more engagements Silva *et al.*[6]. Virtual experiment teaching is a challenge for online teaching. Still, it can be fulfilled by the upcoming new technologies by creating a platform for performing an experiment that will also be safe, fast and will be beneficial for learning and teaching as well [7]. Later, Duan *et al.* [8] introduced BC technology in the learning system through which students can avail the credits based on the online course completed and the credits can be transferred into higher education. Nevertheless, the emergence of new technologies will surely help to improve the learning and teaching process, but will not replace the old one [9] [10].

A. Motivations and contributions

1) Motivations: The online learning system has potential for many applications, but it also has many limitations and challenges. Due to the COVID-19 pandemic, online teaching and learning are gaining more interest in enhancing the knowledge and a source of income for many. We propose a system to overcome the mentioned limitations and challenges with the help of BC Technology. The proposed system focuses on the traceability and the quality of the courses provided by the various instructors across the globe [11]. To ensure the quality of the course, the ratings and reviews are stored Off-chain through IPFS protocol, which also ensure optimum data storage solutions. Instead of relying on the third-party payment gateways, the SC is included to provide secure payment through cryptocurrencies within the BC. Unlike any other online learning platform, the proposed system is decentralized to ensure full transparency among all the users.

2) Contributions:

- A BC-enabled decentralized online teaching scheme is presented by developing SC over BC technology to maintain transparency, trust among stakeholders and secured ERC-20 compliant payment system mitigating needs of third-party.
- The Inter Planetary File System based Off-Chain data management scheme is designed to achieve low bandwidth consumption and low storage cost for education data distribution.
- Finally, the performance of *BDoTs* is compared with traditional approaches considering scalability, data storage cost, packet loss, and network throughput.

B. Organization of the Paper

This paper structure begins with the introduction related to Healthcare 4.0, online teaching, and BC paradigms. In Section II, we present the proposed, *BDoTs*, a BC-based secure online teaching framework. Section III presents a case study of the proposed *BDoTs* framework and finally, Section IV concludes the paper.

II. *BDoTs*: The Proposed Scheme

In this section, we describe the working of the proposed scheme as shown in Fig. 1, and the description of each layer is as follows.

A. Instructor Layer

Instructor provides the teaching presence by facilitating the content needed to support the learning. In the proposed system, instructors first need to register to the platform by providing basic details like name, education and the specialization field as shown in Algorithm 1. All the details will be stored in the IPFS protocol and the hash key will be stored in the BC. To ensure privacy, only the professional details will be displayed on the platform and personal details will not be displayed [12], [13]. Still, they will be stored to ensure the authenticity and security of the system and users. After the registration is approved by network authority, a wallet will be created with a private key for that Instructor through which the Instructor will receive the credit when a student buys the course.

Next step will be to upload a course on to the system; the course should be well structured and easy to understand by the relevant students. Also, to attract more students, a small preview video should be made, which can be accessed before enrolling for the course by the students. Once the student enrolls, the amount which the student paid for the course will be reflected in the Instructor's wallet, which can be redeemed once the refund period is over. The proposed system has an easy way to access comment section for queries to be answered by the instructors. The course uploaded can be easily modified by modifying any single or multiple modules of the course.

B. Middleware Layer

Ethereum BC is an open-source BC featuring SCs functionality. Ethereum can be used as a platform for any other cryptocurrency. It also provides a virtual machine and is also decentralized known as Ethereum Virtual Machine (EVM), which uses a network of public nodes to execute scripts [14]. EVM is responsible for executing contract bytecode and is embedded within a full Ethereum node. The SCs in the proposed system *BDoTs* will be executed by the EVM, which is essential for the consensus engine of the Ethereum system. Each node of the Ethereum network is known as Eth client and executes the SC if it is a full node in the ethereum network. Moreover, the 6G network infrastructure enhances the data communication capabilities in *BDoTs*.

The IPFS is a protocol and peer-to-peer network for storing data in a decentralized and distributed manner [15], [16]. The IPFS uses content addressing, which means it cannot be retrieved based on location instead of its content. In the proposed system *BDoTs*, all the data is stored in the IPFS protocol to ensure security. IPFS protocol also allows users to

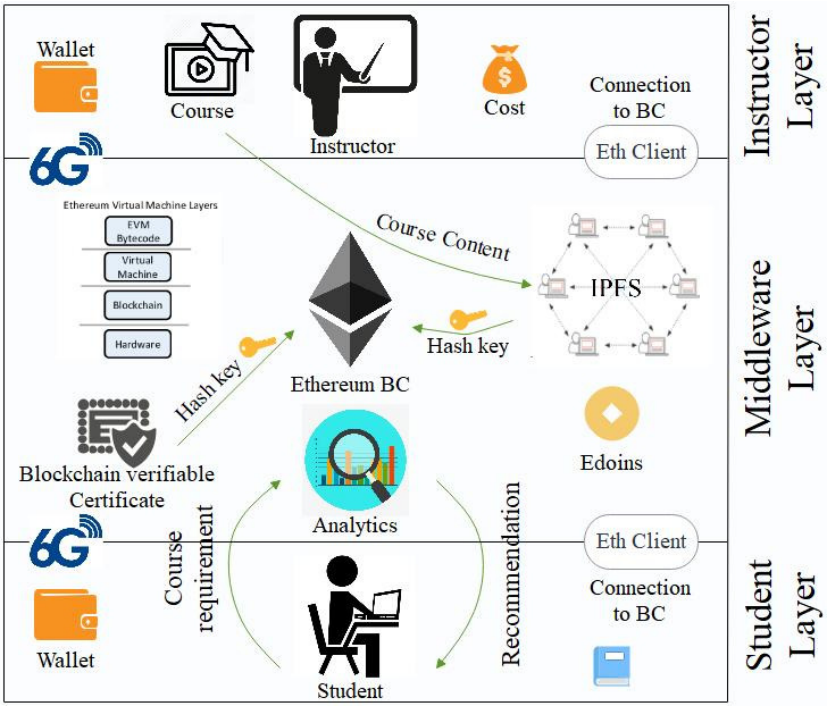


Fig. 1: *BDoTs* : System Architecture

host content. In *BDoTs*, the instructors can save the course's data and as it is decentralized, there will be no bottleneck of data storage [17]. As the data is stored in a decentralized manner, peers can fetch the data from other nodes with the help of a Distributed Hash Table (DHT).

The Ethereum BC is based on tokens; tokens can be bought, sold, or traded. Tokens can be a digital asset or vouchers or any tangible objects. One of the tokens is ERC-20, which is a technical standard used for token implementation and use of SCs. Each transaction in the proposed system is in compliance with ERC-20 and the *Edoin* is cryptocurrency generated for the means of transfer. *Edoin*s will be stable token; the stable token is similar to any item backed by a currency that will be constant. Data analytics or search analytics is used to investigate the searchers of particular searches or the content of the searches. It helps the system to understand the searches and improve the search results in the future. In the proposed system *BDoTs*, search analytics will help provide the best results to the student's searches.

C. Student Layer

Students take time to get familiar with the new environment of learning. In the proposed system, students first need to register by providing necessary details like name, profession, college, and age. The privacy will be maintained by not displaying the students' information to anybody in the system; the information will be stored in the IPFS protocol. Once the registration is completed successfully, a wallet will be created for the student to enroll in the course in the future. To register, students must have sufficient *Edoin* in their wallets. To buy *Edoin*, in *BDoTs*, instead of relying on third party payment gateways, the transaction will be done through SC.

Once the registration is done, the students can search for any course they want to learn and enroll in it. In the proposed system, this search is backed by Artificial Intelligence (AI) and Data Analytics (DA) [18]. The amalgamation of AI and DA will help to find the optimum result for the student [19]. Once the analytics is done, the result will be fetched from the prediction model. The suggestions shown will be of the best rating. To make the payment for the enrollment, instead of using any third party payment, the payment will be made through SC. A fraction of this course fee is returned of successful completion, of course, bypassing in the final exam. Later, if a student is unhappy with the course enrolled due to any reason, the student can unenroll and claim for refund if the refund period is not over. The refund period will be declared in the SC and will also be agreed by the student.

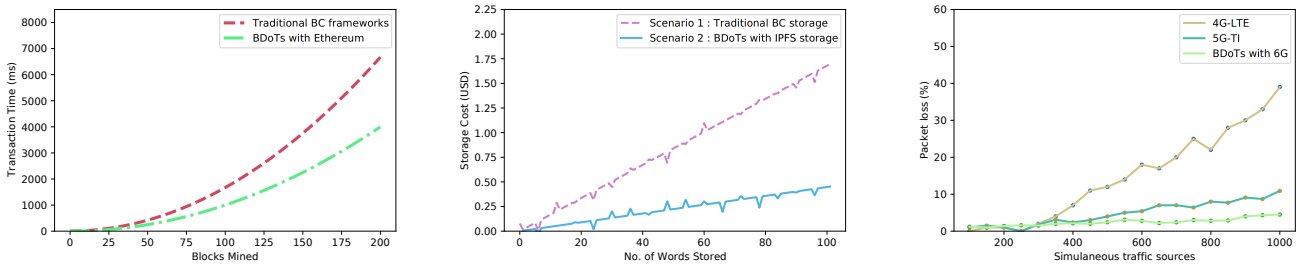
To complete the course, an evaluation is to be done of the students. In the proposed system *BDoTs*, Evaluation will be done through peer evaluation. In peer evaluation, the work of one student will be sent to three peers for constructive feedback. With the input, the peer reviewers will also give points if the total of the feedback points of all three peer reviewers is above the minimum required. The student will get the certificate of completion or else the student will have to revise and improve his/her work. The document will also be BC verifiable. A hash key will be generated while generating a certificate that will be stored On-chain.

III. Performance Evaluation

This section describes the performance evaluation of the proposed scheme and is divided in to two parts: the first part discusses the SC execution of the proposed scheme and the second part discusses the IPFS off-chain data storage cost.

A. BC & SC simulation and performance

Scalability can be defined as a system to handle the rate of increase in resources and handle the growing amount.



(a) Scalability (b) Data Storage Cost Comparison. (c) Packet Loss

Fig. 2: *BDoTs*: Comparative Performance Evaluation

Algorithm 1 *BDoTs*: Decentralised Teaching

Input: Entities E_{NA}, wallets $W_I W_S$, IPFS storage accessed through $IPFS_{key}$, and session keys S_h^l and S_h^n.
Output: Transfer of funds after course selection through SC between W_S to W_I and incentive generation after course completion for W_{BO}.

procedure ADMIN_REGISTRATION(S_h^n, S_h^l, W_I, W_S)
  $E_{NA} \leftarrow$ Request_Registration(E_{type}:{E_I, E_S})
  R_m = *Map*($ID_S, ID_I, Course_L, T$)
  $IPFS_{key} \leftarrow$Register_Requirement_Details()
  if ($E \in E_{NA}$) **then**
    $E \leftarrow$Process_Request()
    $E^{key} \leftarrow$ data.Store($IPFS_{key}$)
    $E \leftarrow$Emit Event("Registration Successful")
  else
    $E \leftarrow$Emit Event("Invalid credential details")
    $E \leftarrow$Registration_Abort()
  end if
end procedure
procedure COURSE_RECOMMENDATION($E_{budget}, Sub[list]T_{cp}$)
  if ($E \in E_S$) **then**
    if ($E_{budget} > B_{min}$) **then**
      $Analytics_{req} \leftarrow$ Compress(Sub[list], E_{budget}, T_{cp})
      $Analytics_{fee} \leftarrow$ EDN.transfer($E_{I \leftarrow fee}$)
    else
      $E_S \leftarrow$ Emit Event("Error: Buy Edoins for budget")
    end if
  else
    $E_S \leftarrow$ Emit Event("Error: Not Registered in SC")
  end if
end procedure
procedure COURSE_MANAGEMENT
  if ($E \in E_S$) **then**
    if ($Recipient_{address} \in E_I$) **then**
      $Recipient_{address} \leftarrow Course_{req}(T_{cp})$
      $E_{I \leftarrow wallet} \leftarrow EDN.transfer(E_S, Course_{fee})$
    end if
    if ($Tcp+Block_t > T_p$) || ($E_{cstatus} ==$ "$Finish$") **then**
      $E_S \leftarrow$ Reward($Certificate_{hash}^{key}$)
      $E_S \leftarrow Incentive(10/100 \times Course_{fee})$
      $E_S.transfer(EDN, amt)$
    end if
  else
    $E_S \leftarrow$ Emit Event("Error: Not Registered in SC")
  end if
end procedure

Fig 2a shows the improved scalability with the number of blocks mined concerning transaction time during the request processing of search in *BDoTs* vs. any other BC framework. As *BDoTs* is 6G enabled, it can accommodate large numbers

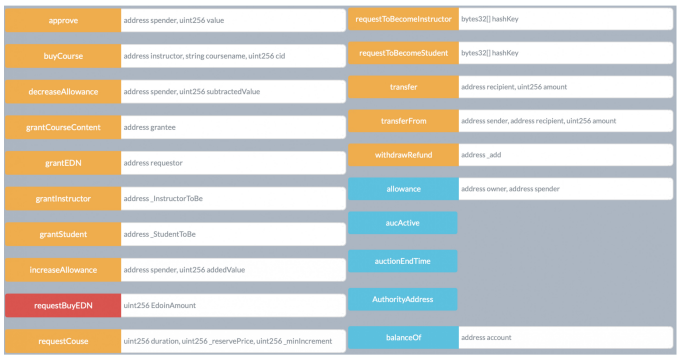


Fig. 3: SC implementation interface in Remix IDE.

of transactions in the chain with ultra-low latency and ultra-high reliability in the same period. Hence, *BDoTs* improves scalability in the overall of the Online Teaching Platform.

Remix is an Integrated Development Environment(IDE) used to write, compile and debug code written in Solidity [20]. Solidity is a programming language used for writing SCs. Fig 3 shows the implementation interface of *BDoTs* in the Virtual Machine of Remix IDE of different modules for testing and debugging the SC of *BDoTs*. SCs are developed to implement the process flow by using Solidity. The debugging is performed by deploying it into a test simulation BC environment provided by Remix IDE. The transactions of these SCs are traced, and the Ganache CLI tool generates an output log file [21].

B. IPFS off-chain data storage cost

IPFS is a protocol that helps the user store the data in a peer-to-peer network in a distributed system. The data is stored in the IPFS and a *Hash key* is generated. Ethereum BC is also compatible with IPFS [22]. Here, in the contract, we only take the *Hash key* instead of the whole data. The *Hash key* is stored in the BC with which we can access the data stored in the IPFS. Fig 2b shows the comparison of the storage cost in dollars of data in the traditional approach in Ethereum BC with the storage cost of data in *BDots* in IPFS. The graph depicts the proposed system outshines the storage cost of the Ethereum BC and proves *BDots* as cost-effective.

The reliability of the network to send and receive data accurately is also important. Packet loss can occur due to many factors like error while transmitting the data or network congestion. Packet loss occurs when one or more than one

packet fails to reach its destination. Fig 2c shows the packet loss in the 4G-LTE enabled network, 5G-TI enabled system [23] and *BDoTs* with 6G enabled network. The graph has packet loss in percentage and simultaneous traffic sources as X-axis and Y-axis, respectively. This graph portrays the 6G enabled system is more reliable as the regression line shows that the packet loss increases when the number of sources reaches near 400, but is significantly less than the 4G-LTE and 5G-TI enabled network.

IV. Conclusion

In this paper, a BC-based online teaching scheme is presented to introduce transparency, trust, and data privacy among the system's stakeholders. We explain how the convergence of 6G, public Ethereum BC, IPFS, and data analytics can uplift the online teaching scheme. Moreover, we implement by developing SC needed between students and instructors for data exchange. For financial transactions, we build *Edoin*, which is an ERC-20 compatible stable token for BC secured payments. We simulate by deploying the SCs over the local Ganache network, in order to test the functionalities. Finally, we compare the performance of *BDoTs* with traditional approaches considering scalability, data storage cost and network packet loss for communication.

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