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Block-ED: The Proposed Blockchain Solution for Effectively Utilising Educational Resources

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***Abstract* – In this day and age, access to the Internet has become very easy, thereby providing access to different educational resources posted on the cloud even easier. Open access to resources, such as research journals, publications, articles in periodicals etc. is restricted to retain their authenticity and integrity, as well as to track and record their usage in the form of citations. This gives the author of the resource his fair share of credibility in the community, but this may not be the case with open educational resources such as lecture notes, presentations, test papers, reports etc. that are produced and used internally within an organisation or multiple organisations. This calls for the need to build a system that stores a permanent and immutable repository of these resources in addition to keeping a track record of who utilises them. Keeping in view the above-mentioned problem in mind, the present research attempts to explore how a Blockchain based system called Block-ED can be used to help the educational community manage their resources in a way to avoid any unauthorised manipulations or alterations to the documents, as well as recognise how this system can provide an innovative method of giving credibility to the creator of the resource whenever it is utilised.**

***Keywords* – Bitcoin, Blockchain, cryptography, digital currency, Ethereum Virtual Machine, smart contracts.**

I. Introduction

November 2008 saw the publishing of a white paper by a researcher who went by the name of Satoshi Nakamoto. In this paper, he proposed a new method of developing digital currency, which was fully distributed and cryptographically chained together in the form of blocks. The technology that powered this system went unnoticed for several years, but today, this innovative technology known as Blockchain is considered the next big thing in distributed digital networks and is making its way into a number of diverse fields [1].

A. Understanding the Blockchain Technology

One of the major problems in transferring data from one place to another in digital networks is verifying that the information coming in from a network is authentic and up-to-date. The solution to this problem usually involves trusting a third or intermediary party for authentication. While this may work most of the times, but in some cases it does not. Even in cases, where it does work, it is often expensive to look out for a third party for verification and authentication of information and it would definitely be cheaper if one did not have to do it. The reason behind this technology to be so unconventional is wrapped up in its ability to resolve the authenticity problem by eliminating the need of a trusted third party. It gives its users the freedom to verify the integrity of information independently irrespective of what the source of the data was or who had sent it in the network [1], [2].

The Blockchain can be described as a distributed database or a public ledger that contains a list of all digital events or transactions that were executed and essentially shared to everyone participating. Each of these transactions or digital events in the public ledger can only be verified if a majority of the participating parties form a consensus that it is a valid transaction. Once the information is verified and entered it can never be erased. An analogy in non-technical terms; it is very easy for anyone to steal a cookie from a cookie jar that is kept in a hidden place than to steal from a jar that is placed in a market place, where thousands of people are keeping an eye on [3]–[5].

In a traditional database, client-server architecture is usually adopted, where the user (client) has the capability of modifying the data stored on the centralised server. This database is controlled by an authority that grants access to the clients based on their privileges after authenticating them. Due to this designated authority granting access to all the users, a compromise to this authority would lead to data alteration or even deletion. On the other hand, a Blockchain database is made up of many decentralised nodes. There is no central authority that administers other nodes, but instead every node participates in the administration process and is able to add new data to the database, but adding new data to the Blockchain can only be allowed if a majority of the nodes form a mutual consensus to allow the addition. This mechanism of forming a consensus can be done through mining (used by Bitcoin), by providing proof-of-state (used by Ethereum) or by some other process which provides security to the network [6], [7].

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The network formed by a Blockchain follows the peer-to-peer (P2P) [8] concept for the exchange of assets. It acts as a kind of transaction ledger that works on a decentralised system for maintaining a history of all the transactions that took place. This special network utilises a consensus mechanism or some proof of work to establish ground for trust, transparency and accountability [9]. The individual nodes operating in the network do not have to trust each other; hence, the environment is also referred to as 'trustless' [10]. Although Blockchain was born with the idea of Bitcoin in mind, its applications found their way into the non-financial world as well, such as the medical, manufacturing and educational sectors. This emerging technology is perceived as very promising due to its decentralised and distributed nature, which produces products that are very different from the traditional internet-based developments. One particular interesting domain of Blockchain application is the education sector, which will be explored in the present research. Areas within the educational domain where Blockchain can be used are the following:

- awarding of qualifications;
- accreditation and licensing processes;
- managing student records;
- managing payment and transactions.

These are some of the niche areas, where Blockchain can be applied to help revolutionise the process, but the list does not end here as the technology is still at its promising phases and one can only assume it will improve with time [11].

B. Advantages of Storing Records Using Blockchain in an Educational Environment

- It works towards ending the paper-based method of issuing certificates. Qualifications awarded by educational institutes can be reliably and permanently stored using Blockchain. Further advancements may include automating the certificates, transferring credits or even storing the complete record of students' achievements throughout their educational career.
- It provides its users the capability of verifying the record's validity against the Blockchain eliminating the need to involve the issuing organisation.
- The records are publically available and easily verifiable.
- The costs accrued by the educational organisations in managing data can be significantly reduced by implementing the Blockchain technology. Additionally, it allows reducing liability issues that usually arise while managing records [11].

C. High-Level Architectural Overview of Blockchain

The report in [11] explains a high-level architectural overview of the Blockchain technology as described in Fig. 1, which shows the operation of a Blockchain step by step.

1. Party A is willing to send a digital asset to B.
2. This transaction is represented online in the form of a block.
3. This new block is broadcasted on all the nodes in the network. Each computer retains a copy of this block.
4. The participating nodes approve whether the transaction is valid or not by a consensus method.
5. Once the transaction is approved, it is saved in the chain as a non-erasable and transparent record.
6. The digital asset can now be transferred from A to B.

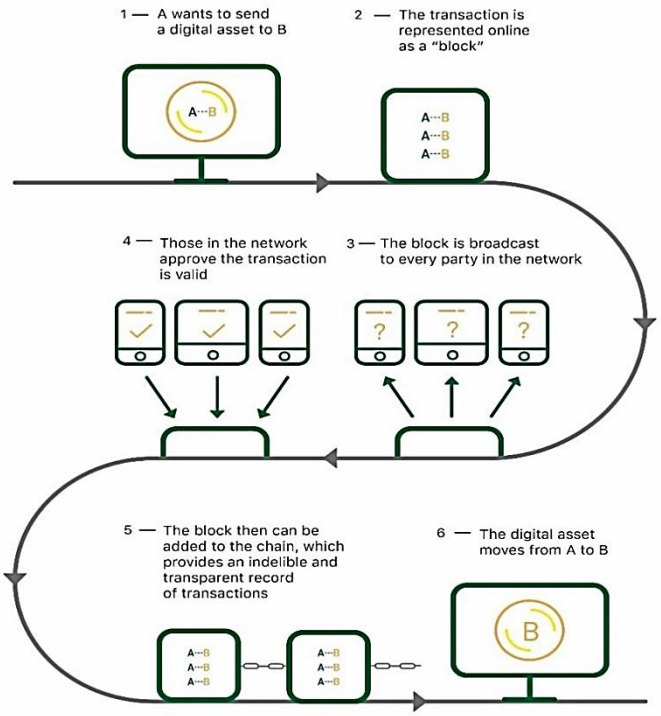

Fig. 1. How a Blockchain works [11].

The scope of this research is limited to how the Blockchain technology can be utilised in the field of education specifically to maintain the integrity, authenticity and track record of usage of educational resources, such as lecture notes, test papers, presentations, videos etc. Due to the limitations of time and resources, by the end of the research, the authors will come up with an architectural solution for Block-ED that will help support the mentioned problem. The outcomes of the present research aim at creating awareness among the educational community to utilise a better and more secure platform, such as the Blockchain technology to retain the authenticity of their educational resources and maintain a track record of their usage.

This paper is organised as follows. Section 2 covers the literature review, listing various Blockchain based applications that are currently being developed in the educational domain. Section 3 sheds light on the research methodology used along with the objective of the survey conducted. It is followed by Section 4, where the results of the survey are discussed; the proposed architecture of Block-ED is presented along with its use cases. The last section highlights the future work that needs to be done.

II. Literature Review

Although the hype of Blockchain technology keeps increasing day by day, a certain set of individuals have their own concerns with this emerging field and have maintained a sceptical view on it. On the one hand, there are people who believe that this technology has the capability of introducing a new era of freedom by replacing currencies used by national governments; on the other hand, there are individuals who predict that the technology will yield to its own impracticality. This difference in opinion is clearly marked in how each of them perceives the technology [1]. After almost three decades, Bitcoin found its way within the marketplace by replacing the concept of central server with a consent mechanism based on some proof-of-work [12]–[14]. The Blockchain technology has shown an immense potential in various sectors and domains ranging from finance, healthcare, banking to government agencies, rental services etc. [15]. Some of the applications where Blockchain proves to be beneficial are listed below.

A. The Famous Bitcoin

The application of Bitcoin works on the concept of Blockchain. It is a virtual network in which one user can transfer digital cash (coins) to another user. Every Bitcoin is composed of a unique list of digital signatures effectively stored inside a digital wallet. This wallet is installed on every participant's computer and helps in the generation of keys for receiving and sending coins. For a transaction to take place, the private digital key is used by the current owner of the coin who uses it to approve the recipient's key in order to add it to the previous chain of transactions. After the successful completion of this event, the coin is added to the recipient's wallet along with the full recorded history of each event.

The application of Bitcoin is one that is very controversial due to the obvious reason of allowing a multibillion market to work on anonymous transactions having no governmental control. This leads to regulatory issues with financial institutions and governments. Despite the brain behind the Bitcoin application, the Blockchain technology is not controversial at all. In fact, over the years it has been successfully running in the financial and non-financial sectors flawlessly. In 2015, Blockchain was listed as the most significant invention since the Internet was invented by Silicon Valley's doyen Marc Andreesen. Similarly, Johann Palychata went on to write in the Quintessence magazine that the Blockchain invention could be considered as important as the invention of steam or combustion engine that possessed the capability of transforming various domains [3]. Just as any other valuable resource, Bitcoin is a scarce and limited resource standing at about a total of 17 million at the moment and it is estimated that it will only reach a total of about 21 million [16]. The market price of a Bitcoin is mainly determined by the supply and demand of those Bitcoins being traded at any market [16], [17].

B. Data Malls

A data marketplace can be thought of as an online repository, where customers can buy and sell different types of data, such as personal information, research and market statistics, advertisements, demographics, business intelligence or stock market data [18]. One of the issues with these data markets is their wide scope. For example, convincing a professional working in capital markets to purchase stock market data from a market place that has all forms of heterogeneous data types will be very difficult. These data are usually stored in crude form and often require processing, cleaning and formatting by the end user, which is a time-consuming task. Data malls are decentralized marketplaces that store different types of financial information, which is not disparate as in the traditional data market. Each of the vendors of data can normalize and format the data according to standards and practices so that data are easily marketable and usable. The vendors or providers host these data on private nodes and have full control over what to make public and what to keep private [19].

C. Proxy Voting

The ability of Blockchain to be fraud-resistant makes it very apt to be used in the corporate voting systems to detect proxy voting. In corporate sectors, each of the stockholders has a voting right, which they can use to give their opinion on matters of implementing corporate policies, deciding who makes up the board of directories, making changes in the organisation etc. [20]. It comes as no surprise that small stockholders in a company are often deprived of this right either because they do not actually vote or their vote is casted by someone else. This causes larger stockholders to have more control over the company. To cater to this problem, Blockchain can essentially play a role in managing all of the stockholders and keeping track of who is casting the vote [19].

D. Smart Property

Smart property combines the concept of Internet of Things with the infrastructure of Bitcoin. The smart property can be any physical asset, such as a car, dwelling or a phone, whose ownership is controlled within a Blockchain using *smart contracts* [21]. To better understand the concept of smart property, let us look at an example of when someone gets a speeding fine on the road. Instead of the person showing a bunch of paperwork to the police to prove his ownership of the car, he will use the Blockchain. The Blockchain will contain two keys: a manufacturer key and the ownership key along with the history of all owners who had owned the car previously. This Blockchain network will be authenticated using the ownership key [22].

E. Blockchain in Education

An exploratory study conducted by the authors of [11] attempts to bring out the potential benefits of applying Blockchain in the educational environment particularly focusing on the digital accreditation of academic and personal learning. The stakeholders that will benefit from this implementation are shown in Fig. 2.

The author in [23] explains the possible areas in education, where Blockchain could be used. One such area is issuing certificates. An example of multiple universities implementing

this scenario was given where they created a codeshare-like agreement for certification.

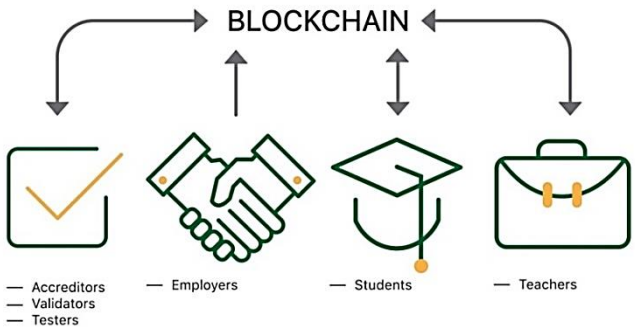

Fig. 2. Stakeholder beneficiaries [11].

This formation could further be used to link with organisations that deal with certificate issuance. This provides a cheap and shared resource repository. The paper-based system of issuing certificates poses a lot of difficulties. The certificates might get lost or may be forged. Thus, there should be a system that will maintain a secure repository of these documents even if the individual moves to a different location or institute. It is most beneficial for refugees who do not have a hard copy of their degrees and certificates with them. Another area where Blockchain could play a significant part is in maintaining assessment scores. Sony Global Education has developed a Blockchain based application that provides services to schools and universities for maintaining assessment scores and giving the freedom to share them with external parties such as employers [24].

Blockchain-Based Applications in Education

a) Blockcerts Wallet

Blockcerts Wallet is a Blockchain based application developed by the Massachusetts Institute of Technology that issues virtual diplomas to all the students who complete their courses. These diplomas are accessible on their smart devices and are an additional service to the traditional paper-based certificates. This gives students the freedom to easily share their certificates with employers, schools, friends etc. [25], [26]. Fig. 3 shows the layout of Blockcerts process [27].

b) ChainScript

ChainScript is a Blockchain based application developed by the University of Texas aimed at creating an unchangeable portfolio for each student at their campus. This portfolio would contain information such as certificates, credits, degrees and various other records of achievement [28].

c) Blockchain Based School Information Hub

A Blockchain based application for managing school information has been proposed by the authors from IBM Research Africa in [29]. This system would manage all the entries and records of students and store them permanently on the Blockchain. Any changes to these records could easily be verified against a block that has all the historical data of students. This block acts as an identifier representing historical events of records previously conducted.

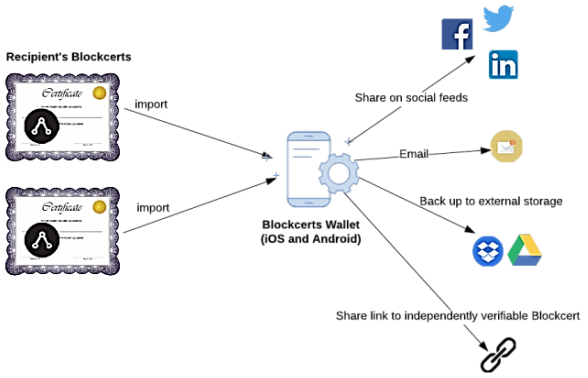

Fig. 3. Blockcerts [27].

d) Blockchain for Education Platform

The authors of [30] describe a system implemented using the Blockchain technology aimed at improving the processes of issuing certificates in an educational setting. In addition, they also propose to provide protection against counterfeit documents along with secure access and management of certificates for multiple parties involved, such as learners, institutions, certification authorities and companies. Their application works on a system of hierarchy starting from the accreditation authorities to certification authorities down to the certifiers themselves.

III. Materials and Methods

The research starts off with the qualitative part in which it first goes through all the relevant secondary research that has been done in the field of Blockchain using various sources, such as journal publications, articles, periodicals, conference proceedings etc. As the topic of Blockchain is fairly new, some useful discussions and information were also found through authentic websites and reports on the latest events. Firstly, the paper describes what Blockchain essentially is and different ways in which Blockchain can be implemented. Secondly, the paper proceeds to present the advantages of storing records using Blockchain as compared to traditional databases followed by a high-level architectural overview of Blockchain.

To cover the quantitative part, which is a minor part of the research, a Web-based survey was distributed to gather some primary data for the study. The questionnaire comprised about ten questions and the main objective of this survey was to get an idea of how important it was for people working in the educational environment to keep their resources secure and free from any manipulations. The reason for using a web-based survey was to reach a wider audience belonging to the education sector through various means of social media sites, such as Facebook, Twitter, Instagram and LinkedIn pages and groups, as well as though emails. The survey was released officially on 15 March 2018 and ended on 30 July 2018.

The final section of the research consists of the proposed system architecture of Block-ED that will be required to build a Blockchain-based application in future to securely store educational resources and help the creators of these resources gain some credit when their resources are utilised by other members of the community. The study also presents various use cases to better understand how this Blockchain-based application works.

IV. Findings and Data Analysis

The first section of the present research looks into the results obtained from the survey conducted to collect the primary data for the research. The second part describes the requirements that will be needed for possible implementation of the Block-ED application, from platform to protocols, network requirements, smart contracts etc.

A. Survey Results

The Web-based survey named "Importance of Protecting the Authenticity and Originality of Educational Resources" accumulated a total of 50 responses from a targeted audience belonging only to the educational sector. Before the actual survey was rolled out, the survey was first tested with a small audience to remove any ambiguity from the questions and to make sure the respondents understood the objective of the survey. The majority of the responses were received from Asia (92 %) followed by Australia (4 %), North America (2 %) and Europe (2 %) out of which 80 % were females and 20 % were males. Out of this sample of population, 28 respondents were associated with primary school, 18 belonged to universities, 5 belonged to secondary school, 3 belonged to institutes, and 2 belonged to some colleges. The occupations of these participants were as follows: 24 of them worked as teachers, 11 of them worked as subject leaders, 7 of them worked as lecturers, 5 of them were associated as students, 2 of them worked as teaching assistants, 2 of them as professors, while there was one participant in each of the positions of Head of department, support teacher, admin staff, learning support assistant and procurement.

When these participants were asked about the educational resources they dealt with in their daily work routines, 40 of them said they dealt with lesson plans, 39 said they used power point presentations, 38 of them said they worked with test/exam papers, 32 of them dealt with timetables and schedules, 24 worked with lecture notes, 21 dealt with research papers, 19 of them worked with educational reports, 17 utilized educational certificates, 2 of them used worksheets while one of them worked with videos, games or open online courses. As many participants dealt with more than one educational resource, the numbers were higher than 50. The next question was related to the previous question of educational resources which asked the participants whether the resources that they used were created by them or not. 78 % of respondents said "yes", 2 % said "no", and 18% said that they occasionally created them. The follow-up question inquired the respondents' opinion about protecting the originality and authenticity of documents in an educational domain. 100 % of them replied affirmatively.

Being asked if the respondents were willing to be credited for their work if their resource was used by other faculty members, the statistics showed that 64.9 % definitely wanted some credit for their work, while 35.1 % were not sure but no one said that they did not want any credit. The last question in the survey was related to the respondents' experience in case of a situation, where their educational documents/resources were forged, copied or counterfeited. The statistics showed that 80 % of them were never a target, while 20 % claimed that they had been in such a situation at some point in time.

Requirements for Possible Implementation of Block-ED

1) The Ethereum Platform / Ethereum Virtual Machine

The Ethereum is essentially a protocol that allows a virtual computer called Ethereum Virtual Machine to be executed in a distributed and open way. The Ethereum platform is a transaction-based state machine that begins with a genesis (initial) state, which transforms into a final state by executing transactions incrementally. This final state is accepted as a genuine version in Ethereum and can be in the form of information, such as reputations, account balances, physical world information or any other information that can effectively be represented in digital form [31], [32]. Ethereum acts as a decentralised platform that has the capability of running smart contracts. The Ethereum platform allows the application built on it to run on a custom-built Blockchain without any fraud, downtime or interference from third parties [33]. Similarly, as the Block-ED application will be a decentralised application, it can take help of the Ethereum platform and utilise its capabilities to achieve the desired result. The application can be built on the Ethereum platform, in which different processes will be controlled by smart contracts.

2) Solidity

Solidity is a contract oriented high-level language owned by Ethereum. It is similar to C and JavaScript languages, which help code smart contracts to be compiled into Ethereum Virtual Machine byte code [34].

3) Smart Contracts

Ethereum has a capability of providing the functionality of running programs called smart contracts on the Ethereum Virtual Machine [32]. Smart contracts allow digital assets to be moved automatically according to a pre-specified set of rules. For example, below are some conditions in a smart contract:

- A is allowed to withdraw a maximum of X currency per day;
- B is allowed to withdraw a maximum of Y currency per day.

These smart contracts are a product of Ethereum's built-in programming language based on Turing-completeness and can easily be implemented by coding up the logic in a few lines [35], [36].

In traditional contracts, the terms and conditions mentioned are enforced by law, whereas in a smart contract these terms are

enforced by a cryptographic code. Smart contracts can also be thought of as a digital vending machine, where a value of data is input and the output is in the form of a finite item. In Ethereum, the users can transfer any amount of Ether (Ethereum currency) to another person on a specific date with the help of a smart contract. Smart contracts were originally supported by Bitcoin as it allowed transferring value from one node to another, when particular conditions were satisfied, but Bitcoin was limited to the use case of currency. Smart contracts can function in a number of ways such as:

- 'multi-signature' accounts, where value is only transferred, when a certain percentage of involved parties agree;
- helps manage agreements made between users, for example, buying insurance;
- provides utility to other related contracts;
- helps store information related to an application [37].

These smart contracts in Ethereum are executed on the Ethereum Virtual Machine [32].

4) Smart Contracts Required in Block-ED

a) File Type

The first Smart Contract needed for the Block-ED application is called FileType. The purpose of this Smart Contract is to check whether the resource that is being uploaded is of accepted format or not. Accepted formats for file type can be pdf, word document, PowerPoint presentations and mp4. If the resource being uploaded is not in any of the accepted format, the user's request for uploading the resource will be rejected; otherwise it will be accepted. Once accepted, the resource will be stored in the document management module or repository.

b) Approving/Disapproving Requests

This smart contract will decide whether the request for accessing a resource coming in from one user will be accepted or rejected by another user. When one user sends a request to another user for a specific resource, this smart contract will send a notification on behalf of the user. Depending on the response from the requested user, the smart contract will send back a notification to the requester.

c) Credit/Debit of Tokens

Once a user has accepted the request of another user, there will be an exchange of tokens between them. The user whose resource is being used will have tokens credited to their wallet, which will in turn increase his credibility in the form of some points. The user who will be utilising another user's resource will have tokens debited from his account. There will be no increase or decrease of points from his/her profile.

B. The Proposed System Architecture

Figure 4 below shows the proposed system architecture for the application. To help user easily interact with the application, the user interface will be available through a browser. One of the many operations that a user can perform are uploading a resource and requesting a resource. Both these functions along with many others will be performed with the help of smart contracts deployed on Ethereum Virtual Machine. The whole system works on a peer-to-peer network with each node having a copy of the Blockchain installed on their computers.

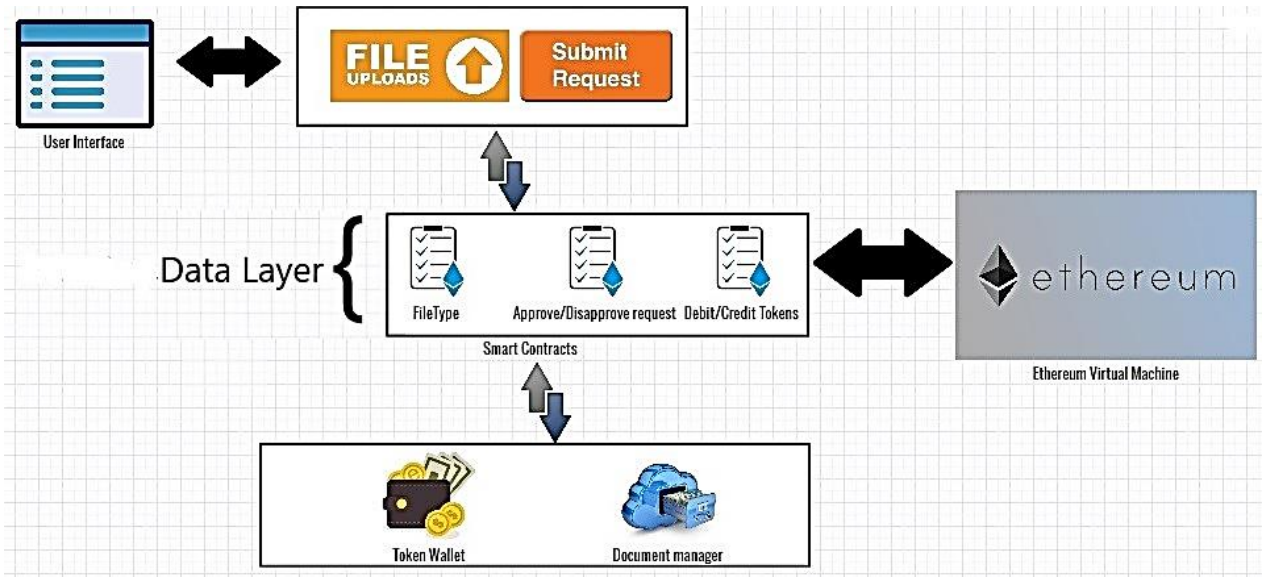

Fig. 4. Block-ED architecture.

This application comprises various modules that perform different functions described below.

- **Registration:** Before a user can become part of the Blockchain, he/she needs to install the application on their computer to download the entire or part of the Blockchain.
- **Login:** The user then creates an account with a valid user ID and password.
- **Uploading resource:** The user can upload an educational resource to the Blockchain repository.
- **Requesting resource:** A teacher or a lecturer can request access of a resource from another faculty member.

- **Wallet:** This e-wallet holds tokens for each individual teacher that is exchanged between transactions of resource.
- **Hash generation:** This process of generating a unique ID for each resource is done in the Ethereum Virtual Machine. This hash ID is stored on the Ethereum Blockchain with a timestamp indicating when it was uploaded. This hash ID will be unique for each resource. Once the resource is uploaded on the Blockchain, it will be permanent and immutable where no changes can be made to it from then onwards.
- **Ethereum Blockchain:** This is a public ledger or a decentralised database that stores a permanent and immutable record of all transactions. Transactions once recorded can never be deleted or modified, but new versions can only be appended to the Blockchain after a consensus from other participating nodes.
- **Document Manager:** This module is used to store all the resources uploaded to which access is controlled by smart contracts.

C. Use Cases

The following use cases of "Block-Ed" are discussed from Table I to Table V.

1) Login

TABLE I
LOGIN USE CASE

Use case name	Logging into Block-ED application
Primary actor	Teacher/Lecturer
Description	The teacher logs into the system successfully
Pre-condition	The teacher must have the correct username and password credentials
Post condition	The teacher can see the welcome screen
Course of Action	
1. The teacher opens the Block-ED application on the browser 2. The system prompts the user for a username and password 3. The teacher enters the username and password and clicks Enter 4. The system authenticates the teacher 5. The teacher logs in successfully	

2) Uploading a Power Point Presentation (Educational Resource)

TABLE II
UPLOADING A POWER POINT PRESENTATION USE CASE

Use case name	Uploading a PowerPoint presentation into Block-ED
Primary actor	Teacher/Lecturer
Description	The teacher successfully uploads a power point presentation into the system
Pre-condition	The teacher must successfully log in and have a PowerPoint file ready
Post condition	The power point presentation is successfully uploaded
Course of Action	
1. The teacher logs into Block-ED 2. The teacher clicks the upload resource option 3. The system prompts to upload the file 4. The teacher uploads the power point presentation 5. The smart contract checks if the file is of an accepted format 6. The system accepts the file 7. The system adds the resource to the repository 8. The Ethereum Virtual Machine generates a hash ID for the file 9. The Hash ID is stored on the Ethereum Blockchain with a timestamp	

3) Requesting to Access a Resource

TABLE III
REQUESTING TO ACCESS A RESOURCE USE CASE

Use case name	Requesting to access a resource already uploaded
Primary actor	Teacher
Description	The teacher wants access to a particular resource
Pre-condition	The teacher must successfully log in
Post condition	The teacher successfully sends a request to another user for a resource
Course of Action	
1. The teacher logs into Block-ED 2. The teacher browses the list of uploaded resources 3. The teacher clicks the 'request resource' option 4. The smart contract sends a request to the original creator of the resource for access 5. The Ethereum Virtual Machine appends the hash ID of this request with a timestamp to its Blockchain	

4) Accepting a Request Made by Another User

TABLE IV
ACCEPTING A REQUEST MADE BY ANOTHER USER USE CASE

Use case name	Accepting a request submitted by another user to access a resource
Primary actor	Teacher
Description	The teacher accepts the request of another teacher who wants access to a particular resource
Pre-condition	The teacher should have received a request by another teacher
Post condition	The teacher who made the request can access the resource
Course of Action	
1. The teacher logs into Block-ED 2. The teacher checks his pending requests tab 3. The teacher clicks the 'approve request' option 4. The smart contract sends a notification to the requester that his request was approved 5. The system increases the credibility points of the original creator of the resource 6. The Ethereum Virtual Machine appends the hash ID of this accepted request with a timestamp on its Blockchain.	

5) Debit/Credit of Tokens

TABLE V
DEBIT/CREDIT OF TOKEN USE CASE

Use case name	Debiting and crediting of tokens
Primary actor	Teacher A, Teacher B
Description	Debiting and crediting of tokens from wallet when Teacher A approves the request of Teacher B to access a resource
Pre-condition	Teacher A must approve the request of Teacher B
Post condition	Tokens correctly credited to Teacher A's wallet and debited from Teacher B's wallet.
Course of Action	
1. Teacher A logs into Block-ED	
2. Teacher A checks his pending requests tab	
3. Teacher A clicks the 'approve request' option for Teacher B	
4. The smart contract sends a notification to Teacher B that his request was approved	
5. The smart contract credits a set amount of tokens to Teacher A's wallet	
6. The smart contract debits a set amount of tokens from Teacher B's wallet	
7. The system increases the credibility points of Teacher A	
8. The Ethereum Virtual Machine appends the hash ID for the credit of tokens to Teacher A's wallet on its Blockchain with a timestamp	
9. The Ethereum Virtual Machine appends the hash ID for the debit of tokens from Teacher B's wallet on its Blockchain with a timestamp.	

V. DISCUSSION AND FUTURE WORK

The objective of conducting the Web-based survey was primarily for understanding the importance of protecting the originality and authenticity of educational resources that are circulated within an institute or multiple organisations on a daily basis. It was also an attempt at finding out how important it was for people working in the educational sectors to give credit to someone who created something as small as a two page lecture note, which was used by other faculty members of the organisation. In places like schools and institutes, where educational resources are generated on almost daily basis by various staff members and used by other members for educational purposes obviously, it becomes very easy to not give someone the credit they deserve for their work.

The statistics received from the survey conducted to gather our primary data showed that most of the responses were received from females than males out of which most of respondent were from Asia followed by Australia, Europe and North America. Most of the respondents worked at schools more specifically in primary sections followed by people working at university levels, secondary school, institutes and colleges. Further statistics from the survey showed that the majority of the population was associated with their organisations as teachers, subject leaders and lecturers, while the minority was associated as teaching assistants, professors, head of departments, support teachers and admin staff. Moreover, the survey revealed that in educational domains the most frequently used pieces of resources were lesson plans, power point presentations, test/exam papers and timetables. Other resources that were used included (in decreasing order); lecture notes, research papers, educational reports, certificates, worksheets, open online courses and video games. This result indicated that a wide variety of educational resources were utilised by various members of an organisation and obviously shared and manipulated. Extending on the aspect of educational resources, the respondents were asked if they were the creators of these resources to which 78 % replied affirmatively, which meant people usually created their own resources and there should be a way to protect their integrity and originality because it took time and effort to produce a material that not only benefited them, but others as well.

The next part of the survey asked the participants if they thought it was important to protect the originality and authenticity of resources they created to which 100 % replied affirmatively, which meant people were aware that it was crucial to keep their hard work protected and free from forgery or manipulations. However, the problem is that there is no such a platform, where this security can be maintained. Furthermore, 64 % agreed that there should be some system of providing credit to the original creator of resource in case his resource is used by others for educational purposes. One additional question was asked at the end of the survey to determine how many of the respondents were a victim of forgery or counterfeit in regards to the documents they created. Although the number was not very high, but 20 % of the population said they had faced such a situation at some point, which showed that these things did happen and they would only increase with time until something was done.

The accumulated results of the survey clearly indicated that there was a need to bring in a system, where people could easily distribute their work within a professional community with trust that they will be credited for their work. Keeping this problem in mind, this study introduced a possible Blockchain based solution called Block-ED, where educational resources could be circulated within an organisation with a sense of trust that every resource would be protected from manipulations and unauthorised changes; embedded through the use of Blockchain. In addition, every creator of resource would get a fair share of credit for his or her work being utilised by others.

The technology of Blockchain no doubt has the capability of revolutionising industries across many domains. A lot of them have already starting digging into it, while some are still figuring out its monetary and economic benefits. It has been observed over time that when a new technology emerges it takes time before finding its place into the mainstream market. Similarly, Blockchain will take some time before people start utilising it in their daily routine work. However, unlike other technologies, Blockchain has seen some rapid advances in its usage starting from Bitcoin to various startups introducing applications in the field of logistics, manufacturing, education etc. in a very short span of time.

Companies and enterprises around the globe are looking to find developers, idea generators and analysts who are skilled in building Blockchain based application because they realise its potential in the upcoming years and how beneficial it will be in

the long term. As more and more people are moving towards exploring the Blockchain technology, its pros and cons are becoming even more evident.

Initially recognised with Bitcoin only, Blockchain has now found its way to be acknowledged separately. Moreover, Blockchain was introduced because of applications like Bitcoin, and people initially thought that its usage was restricted to only applications involving virtual currency. However, this notion has been proven wrong as companies and startups are investing in this technology and improving their systems to gain vast benefits of decentralisation.

One such industry is the educational sector, where work is carried out to see how Blockchain can improve the processes within educational institutions. The present research was also an attempt to visualize how Blockchain can be used to secure and properly manage the utilisation of educational resources, such as lesson plans, presentations, test papers, videos etc. More importantly, there was an attempt to reveal how the original creators of these resources could be given some credibility, when their resources were used by other faculty members.

As the study introduced the high-level architecture of the Block-ED system, future work would require to provide a working implementation of this system. This can only be achieved with workforce, who is skilled in Blockchain development, with ample amount of time as the technology is itself at its budding phases.

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