Learning System based on Decentralized Learning Model using Blockchain and SNS

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Keywords: Blockchain, E-book, SNS for Learning, Open Education.

Abstract: Learning needs to transcend traditional school education to cover the whole array of learning available, such as advanced technology, arts, or sports so that people can keep learning, training, and practicing at their own pace throughout their life. To fulfill these needs for learning, we have constructed CHiLO, a decentralized learning system, which utilizes e-books. We are now developing an entirely new learning system using blockchain to solve the issue regarding the copyright of CHiLO and to build a new learning model utilizing virtual currency. This paper reports the first phase of the implementation details of the new system, which allowed the ownership rights of the blockchain assets to be managed to create e-books by combining the posts on the SNS and paying in virtual currency.

1 INTRODUCTION

Developments in science and technology have highlighted the difficulties with the centrally managed centralized architecture of basic infrastructure such as water, energy, transportation, medical care, law enforcement and education.

Shrier (2016) claimed that centralized architecture is now outdated, which was developed initially to deal with the needs of the government and large enterprises during the industrial revolution in the 18th and 19th centuries.

Berners-Lee (2017) points out that the openness and creativity of the Web are threatened by the centralized architecture of the current Web services. Web service providers such as Google and Facebook require users to agree to a long and sophisticated contract to gather and manage their personal information and data in ex-change for the convenient and free services that they provide, using those data for their marketing. Also, many Learning Management Systems (LMSs) that have expanded with the spread of the Internet adopt a centralized learning model. Much of online education using LMS has the definite roles of teachers and learners; teachers determine learners learning processes as well as learning materials. This teacher-centered learning model worked as a very useful tool, which succeeded in efficiently leading learners to their learning goals and helped the teachers to prevent resource depletion. However, the system only contributes indirectly to the success of the learning (EDUCOURSE., 2015).

The disadvantage of conventional teaching and learning is that it also depends on the centralized architecture from a centralized school/university system (Illich, 1973). Traditional school and teacher-centered education can no longer respond flexibly to the diverse learning needs, technological advances, and uncertain issues currently sought by society.

To solve this problem, we developed a decentralized architecture for an e-learning platform called Creative Higher Education with Learning Objects

Hori, M., Ono, S., Miyashita, K., Kobayashi, S., Miyahara, H., Kita, T., Yamada, T. and Yamaji, K.
Learning System based on Decentralized Learning Model using Blockchain and SNS.
DOI: 10.5220/0006666901830190
In *Proceedings of the 10th International Conference on Computer Supported Education (CSEDU 2018)*, pages 183-190
ISBN: 978-989-758-291-2

(CHiLO) that utilizes encapsulation technology to produce an EPUB3 format e-book that retrieves content resources from the Internet to create the educational materials, and can be distributed on the web (Hori et al., 2016). Certainly, the major challenge with CHiLO is the copyright issue related to extracting content resources from the Internet. To solve this problem, CHiLO adopted a blockchain smart property to manage the Internet resources as an asset and record them in the blockchain, which is called the CHiLO Chain.

Adapting blockchain, which is a basic virtual currency technology, to the learning environment could be a paradigm shift in education to incentivize learners. This research is aimed at constructing a learning system that functions as a means of distribution to disseminate knowledge to society and an indicator of personal knowledge and experience.

Currently, as the first phase of the research, we have solved the issue regarding the copyright of CHiLO Book using smart property.

Figure 1 shows the structure of the CHiLO Chain. An article posted on social networking sites (SNS) is an Internet resource for the creation of CHiLO. Using the SNS as a user interface, the posted article is recorded in blockchain, and by combining the stored articles, an e-book is compiled and issued. The CHiLO Chain has adapted Mastodon for the SNS and Hyperledger Fabric as the blockchain protocol. In this paper, we report on the implementation of the CHiLO Chain.

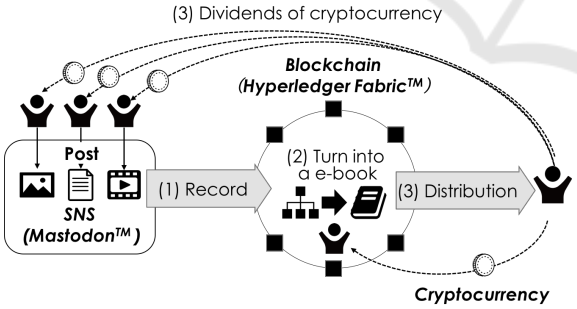

Figure 1: CHiLO Chain.

2 RELATED WORK

2.1 Decentralized Web

The decentralized web is a semantic web feature proposed by Berners-Lee that has P2P (Peer to Peer) service networks, for example, the extensible messaging and presence protocol (XMPP), Gnu Social, and Git.

Berners-Lee et al. (2016) claimed that today's web has moved away from the concepts behind the original web technology and has become increasingly more centralized, and highlighted the following main problems.

The following problem are indicated:

(1) **Silos:** Personal content has become enclosed in services that are provided exclusively by a specific corporate company.

(2) **Privacy:** In exchange for useful services, personal information is being used for corporate company purposes such as marketing.

(3) **Persistence:** When a specific company stops their service, the data disappears.

2.2 Blockchain

Blockchain is a decentralized architecture containing P2P-connected computers (Nakamoto, 2008), each of which shares a ledger. Blockchain was the fundamental technology developed to deal with encrypted electronic currency such as Bitcoin™, which was the first social blockchain implementation. Bitcoin has been in operation since March 2008 and has not suffered from any damage such as tampering, indicating that blockchain services are tamper resistant, authentic, and persistent. As Bitcoin can be traded without any third-party intervention, it has been studied widely in the finance domain.

Kahle (2015) noted that the technical advantages of blockchain would be a key component of the next generation web as it would overcome the problems associated with current centralized web services and has distinct advantages, as follows:

Transparency: Anyone can refer to the ledger records, and it is possible to check the data changes and additions by tracking the transaction information recorded in the ledger in a chronological order.

Anonymity: Access to the blockchain is by a unique character string "address"; therefore, no personal information is required, and as long as the principal does not disclose their address, the recorded data cannot be used to identify individuals.

Availability: The distributive ledger system is stored on different computers and continues to run even if some systems become inoperable.

Tamper Resistance: Computers in the blockchain network form a consensus and transaction information source providing information remittance sources, remittance amounts, and remittance destinations. Furthermore, the time stamp recorded in the ledger is in chronological order and

is always maintained for consistency. With this mechanism, the recorded transaction information cannot be traced back to any person or organization.

Authenticity: As the address of the user issuing the transaction using an encryption key is digitally signed, the authenticity of the transaction executor is guaranteed unless the encryption key is stolen.

In this research, we focus on the realization of smart properties. The virtual currency balances and the transactions are recorded to each ledger in the Bitcoin protocol; that is, reliable transactions are deployed without any third-party intervention. The smart property concept is that the data representing the assets, rather than the virtual currency, are recorded in each ledger. A transfer of the ownership of the asset can be realized by changing the owner of the data in each ledger. Then, expensive assets such as stocks, land, and precious metals can be traded without the need for third-party organizations; therefore, it can significantly transform social structures (Swan, 2015).

2.3 Smart Properties

The original protocol of the blockchain such as Bitcoin, which records the transaction of virtual currency with the balance of the virtual currency possessed by the user, can be relied upon without going through a third-party organization such as a bank and realizes the transfer of virtual currency.

In addition, a more recent protocol called smart property as a part of the attribute of the blockchain can have data representing an asset and unique data associated with the asset, and the assets owner can be rewritten by the property transfer. Using smart property, the attempt to transfer ownership of assets is also expanding.

Transactions with smart property do not mediate third-party institutions for high-value assets such as stocks, land, and precious metals, thereby significantly transforming social structures (Swan, 2015).

2.4 Application of Smart Property

An example of the application of smart property is the attempts being made to manage the copyright of digital contents as an asset in a blockchain.

Binded (https://binded.com/) provides authorship certification services for image files. When the creator sends the image file to the Binded system, creation date and author are recorded in the blockchain, and the author can prove his/her authorship.

Furthermore, similar image files on the Internet are automatically displayed so that unauthorized diversion monitoring can be performed. With this, Binded can assert rights by recording in the blockchain if there is a dispute about the attribution of the copyrighted work.

2.5 Application of Blockchain to Education

The application of blockchain to education has the possibility of changing traditional online education such as MOOCs, and could even have a significant influence on regular school systems (Swan, 2015).

Currently, blockchain is being used to issue and manage academic credentials or certifications. In Holberton School (a computer school in San Francisco) and Ngee Ann Polytechnic (a vocational college in Singapore), students record their academic credentials in the blockchain, manage them as their learning outcomes, and use them for job-hunting purposes (Campbell, 2016; Rohaidi, 2017). MIT Media Lab has also developed a certification management system in collaboration with Learning Machine, which is now available as open source software.

More in-depth applications have also been proposed. The Institute for the Future (IFTF) has the slogan "Learning is earning," and predicts that learning transactions will take place in blockchain within ten years. Specifically, learning in public education, the Internet, SNS communication, or from life experience can be traded as assets in virtual currency (ACT Foundation, 2016). This demonstrates the possibilities of an future education provided by blockchain; however, to date, the IFTF has not specified it as a particular method.

3 CHiLO

3.1 CHiLO's Architecture

CHiLO designed specifically as a decentralized application that does not require a centrally managed Server can be distributed through general e-bookstore such as the Apple Store™ and Google Play™, and can be delivered through any web server including LMS. In addition, the e-book reader application is designed to be browsable even from a web browser. Therefore, the design of CHiLO has realized the construction of an online learning environment that is oriented toward a decentralized architecture to deliver highly flexible online education without the need to rely on a specific LMS.

Even though CHiLO seems to be like an e-book written in the EPUB3 format, the interior structure has an encapsulated metadata to call for the educational resources such as videos, quizzes, digital badges, and video conferencing , and is distributed over the Internet as an e-book.

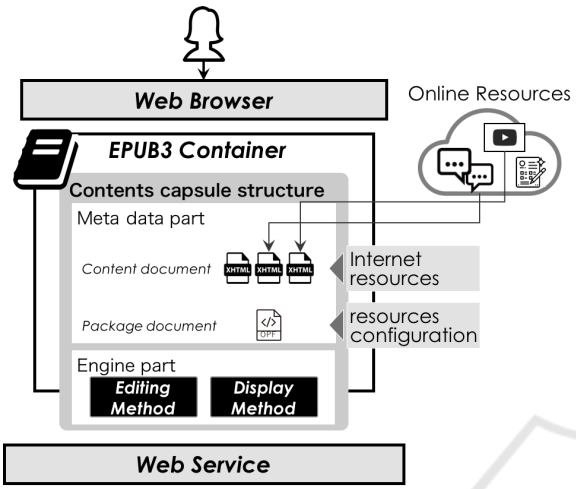

Figure 2: CHiLO Chain.

Figure 2 shows an overview of the CHiLO content capsule structure, which has a container metadata part and an engine part.

The metadata part consists of the metadata for the resource configuration and the metadata to call the Internet resources. In the metadata associated with the configuration of resources, data related to the composition of resources to be incorporated in the e-book, such as display order and layout, are recorded. The metadata to call the resources has an entity associated uniquely with a resource such as a URL as the location information and the title.

The engine part has an editing method that converts the metadata into the EPUB3 format and a display method that displays the e-book on the web browser.

3.2 CHiLO Challenges

The primary challenge with CHiLO is the need to have a copyright license for some of the resources on the Internet. Currently, CHiLO is provided under the CC BY-SA license of Creative Commons, which is an insufficient mechanism for using the content of licenses. Some people providing resources on the Internet do not clearly indicate their copyright but often allow their usage under certain conditions. It is necessary to use resources from a range of copyright licenses to acquire the diverse knowledge needed for CHiLO from the wide range of Internet resources.

4 PROPOSED METHOD

4.1 Using Blockchain

There are two reasons for using blockchain n this research.

One is to solve the challenges concerning the copyright of CHiLO Book to implement the smart property of the blockchain.

The other is to use virtual currency. The inherent functions of the currency are the circulation, measure of value, and preservation of value. This research aims for these features of virtual currency indicating personal knowledge and experience to serve as an incentive for knowledge acquisition and to function as a means of distribution to disseminate knowledge to society.

In this research, we first solved the problem concerning the copyright of CHiLO Book using smart property.

4.2 Hyperledger Fabric

As shown in Figure 3, copyright management of e-book materials and the e-book itself can be achieved by recording the CHiLO content capsule structure on the blockchain, which would include also the configuration of the resources in metadata format.

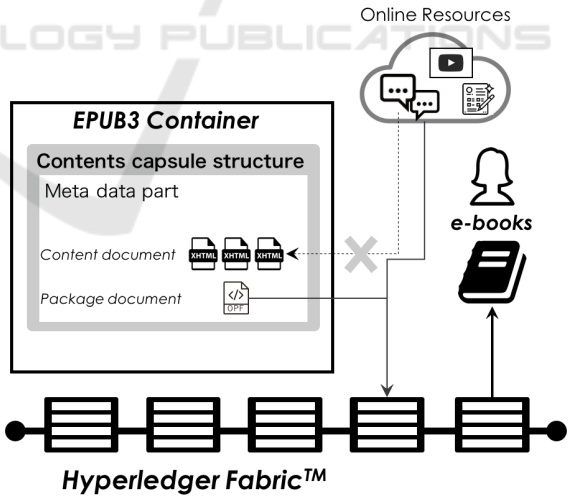

Figure 3: Implementation of Hyperledger Fabric.

The system is implemented using Hyperledger Fabric, one of the open source blockchain protocols. The Linux Foundation hosts Hyperledger Fabric, one of the blockchain projects within Hyperledger, and Digital Asset and IBM developed Hyperledger Fabric initially by Cachin (2016). Hyperledger Fabric has a key-value type data store called the world state, which

describes the state of the ledger at a given point in time, and a data area called chaincode, which describes the application level code and executes the program. The system records the metadata for the resources and the metadata for the configuration of the resources in the world state. In addition, access to these data is controllable by describing the code in the chaincode.

4.3 SNS

The system considers any article posted on the SNS as an Internet resource and creates e-books by combining other posted articles. In this process, Mastodon, which is distributed as an open source SNS and can be customized, has implemented a mini-blog service with a user interface similar to that of Twitter.

It has a characteristic that allows anyone to launch a Mastodon server called "Instance" and provide a decentralized architecture-oriented service. Each Mastodon Instance provides its own operation and service. The Instances are connected to each other, and Instance users can interact with each other.

Mastodon's decentralized architecture is suitable as a blockchain because it has the same functionality as a decentralized architecture. Mastodon Instance acts as a non-centrally organized user interface of the blockchain, and federated function of Mastodon realizes easy exchange of those learning contents with other Mastodon Instances.

4.4 System Structure

As shown in Figure 4, the Mastodon Instance and Hyperledger Fabric collaborate via an Agent that implements the Bot function, the edit method, and the display method.

Create a user object, which Mastodon Instance user account is the key, within the Hyperledger Fabric world state to link with the Mastodon Interface user account. Furthermore, the Bot of the Agent will detect any post the user posts using the built-in account in Mastodon Instance and records the post and its resource configuration to Hyperledger Fabric world state recognizing the user as the owner.

The e-book is output using the editing method and the display method, with the URL posted in the Mastodon Instance after the Agent obtains the data of the posts and their resource configuration recorded in the world state.

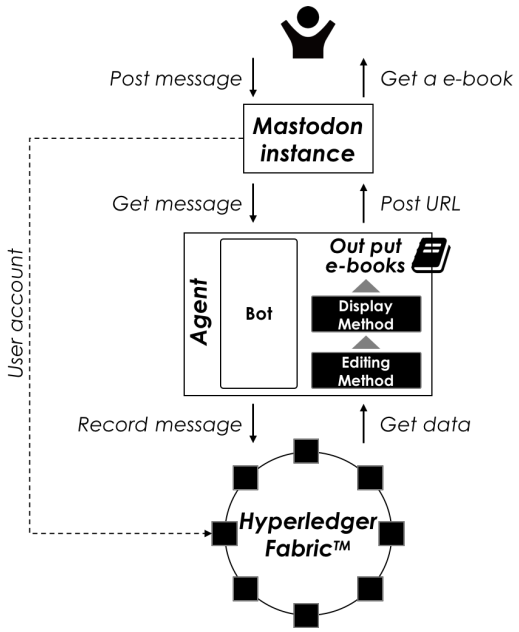

Figure 4: SNS.

5 EXPERIMENTAL RESULTS

5.1 Recording Articles on Hyperledger Fabric

To record an article on Hyperledger Fabric, the title of the article is specified as a hash tag and an image or a movie file is attached and posted to the article as an inbuilt account "clip," as follows. To post an article to a specific Mastodon user, "@account" is written at the top of the posted article.

```
Article log: @clip Article Body #article title
```

When a user posts an article, the Bot creates an object that has the posted article information as a value in the world state. The data format of the object in the posted article is shown in Listing 1. The object of the article created in the world state consists of the user ID and keys such as a Toot ID that uniquely represents the posted article. The user's ID is the ID of the user's object created in the world state.

```
1 type Resource struct {
2         ObjectType string 'json:"docType"' //field
              for couchdb
3         ResourceId string 'json:" ResourceId"' //
4         TootId string 'json:"TootId"' //Article's
              TootID
5         TootText string 'json:"TootText"' //Toot
              Text
6         OwnerId string 'json:"OwnerId"' //User ID
7         Title string 'json:"Title"' //tag's title
8         URL []string 'json:"URL"' //Media URL
```

```
9        Timestamp string ‘json:”Timestamp”‘ //
             timestamp of enrollment
10       Update string ‘json:”Update”‘ //timestamp
             of renewal
11   }
```

Listing 1: World State Post Article Object.

As shown in Figure 5, upon the successful creation of the object, the clip returns a transaction ID, a timestamp, and the value of the object created in the world state to the contributor.

To change the value of the article object recorded in the world state, a response for the posted article is posted to the clip. To prevent unauthorized changes to the article object by a third party, the condition can be changed only when the user ID responding to the chaincode and the user ID recorded in the article object are the same.

Figure 5: Record of articles in Hyperledger Fabric (Top: posting articles, Bottom: responding to the completion of registration from the clip).

5.2 Creating e-books

To create an e-book by combining the article objects recorded in the world state, the articles required are selected and combined and a response is sent to the embedded user “book” as follows:

```
Creating an e−book: @book #e−book title
```

When a user submits an article from the Mastodon account, the Bot records the data for the structure of the posted article as an object in the world state. Listing 2 shows the data format for the object. Similar to the object for the posted article, the object related to the structure also has a user object ID as a key in the world state, which uniquely specifies the author of the object. By selecting the article to combine and by repeating the response, articles can be added to this object. By adding a condition that the chaincode can be changed only when the owner of the object and the ID of the user contributing are the same, it is possible to enable a condition wherein only the author of the object can add an article.

```
1   // −−− Book Object −−− //
2   type Book struct {
3           ObjectType string ‘json:”docType”‘
4           BookId string ‘json:”BookId”‘
5           OwnerId string ‘json:”OwnerId”‘ //UserID
6           TootId string ‘json:”TootId”‘// TootText
7           AccessPolicy string ‘json:”AccessPolicy”‘
                // Book
8           Timestamp string ‘json:”Timestamp”‘//
                Tiemstamp of enrollment
9           Update string ‘json:”Update”‘// Timestamp
                of update
10          Title string ‘json:”Title”‘//Titile of #tag
11          Value int ‘json:”Value”‘ // The book price
12          ResourceIds []string ‘json:” ResourceIds ”‘
                // resource Ids as the book
13          SalesVolume int ‘json:”SalesVolume”‘ //
                Sales for the book
14  }
```

Listing 2: Object relating to article structure of world state.

As shown in Figure 6, when the recording is successful, the transaction ID, the timestamp, and the value of the object related to the structure recorded in the world state are returned from the book.

Figure 6: Creating an e-book (Top:posted article list, center: response of Book creation, bottom:response to the completion of registration from the book).

5.3 Purchase of e-books

The system pays a token to acquire an e-book; specifically, it sends the following message to the embedded user "book."

Purchase e−books: @book BUY_BOOK #e−book title

When the message is being sent, the Agent accesses Hyperledger Fabric, which then processes the buyer's token according to the chaincode description, such as transferring the purchaser's token to the object structure authors and the article object author, retrieves the data and sends it to the Agent, which outputs the received data to the e-book using the editing and display methods, and returns the electronic book download URL for the book (Figure 7).

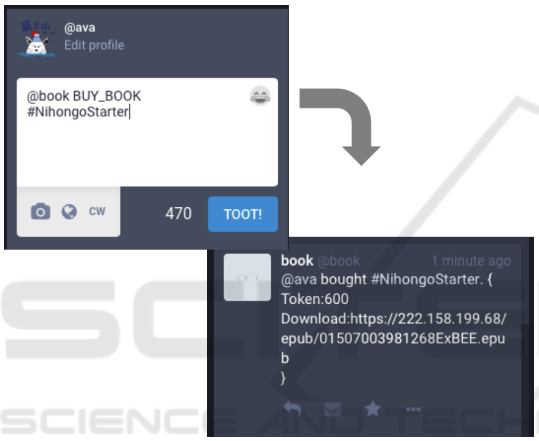

Figure 7: Acquire e-book (Top:Purchase e-book, Bottom:Response download URL from book).

Figure 8 shows the e-book downloaded from the URL described in the message transmitted from the embedded user "book." As the format of the e-book is EPUB 3, it can be displayed on a general EPUB3 reader.

6 DISCUSSION

In the system, the articles posted on Mastodon were recorded in Hyperledger Fabric, the e-books were produced by combining the articles, and the author of the data recorded in Hyperledger Fabric. Access control was then performed, which included instructions that the payment of a token was necessary for data acquisition, and only the author had the authority to change the data. The history of any data modification and data acquisition was tracked by the transaction ID recorded in the blockchain.

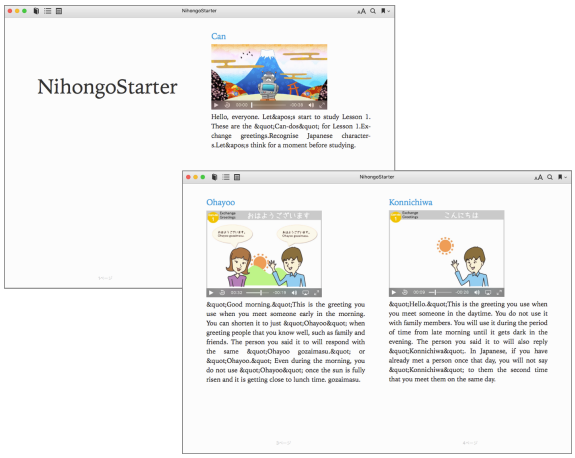

Figure 8: Output e-book.

As a result, by introducing blockchain, the challenges concerning copyright in the CHiLO system were resolved.

However, in the system, access restrictions have not yet been imposed on the URLs to obtain the e-books. Furthermore, once the e-books are acquired and downloaded, they can be redistributed easily; therefore, strict copyright protection has not yet been achieved. These problems will be resolved in the future by making it possible to download only the e-books from a dedicated local application and making it difficult to retrieve downloaded e-books.

At this time, this system handles the articles posted on Mastodon as resources. For articles posted on other resources such as blogs, YouTube, and Facebook, these can be incorporated into the e-books by storing the IDs associated with the user's objects on the blockchain in an area that can only be written by the author, such as the header, the body, and the keyword field of the resource.

7 CONCLUSIONS

By implementing the system using blockchain, several challenges have been overcome; (1) controlled copyright management of the learning resources, (2) easy composition of the e-books, (3) e-book transactions in virtual currency, and (4) the distribution of e-books .

As a result, we confirmed the feasibility of the P2P distribution of e-books. As a blockchain-based platform for higher education, Tapscott and Tapscott (2017) envisioned three stages:

> *"The first is content exchange. Professors share ideas and upload their teaching materials to the Internet for others to use freely.*

> *The second is content co-innovation, where teachers collaborate across institutional and disciplinary boundaries to co-create new teaching materials using wikis and other tools. By stage three, the college or university has become a node in the global network of faculty, students, and institutions learning collaboratively*"

This research provided a basic demonstration of the first stage "*content exchange*" and demonstrated the making of e-books while protecting copyright using an SNS such as Mastodon. This system could be used to develop a lifelong learning model where learners can communicate with each other while compiling their own ideas and learning outcomes into electronic books.

ACKNOWLEDGMENTS

This work was supported by JSPS KAKENHI Grant Number JP7H01844 and NII Joint Research Grant.

The authors would like to thank Enago (www.enago.jp) for the English language review.

REFERENCES

ACT Foundation (2016). Learning is earning. http://www.learningisearning2026.org. Last access Oct 10, 2017.

Berners-Lee, T. (2016). Keynote address:Re-decentralizing the web — some strategic questions. In *Decentralized Web Summit*. https://archive.org/details/DWebSummit2016_Keynote_Tim_Berners_Lee. accessed August 15, 2017.

Berners-Lee, T. (2017). ON OPENNESS. GREATEST LIVING BUSINESS MINDS. In *Forbes at 100 Innovating since 1917*. https://www.forbes.com/100-greatest-business-minds/person/tim-berners-lee. accessed August 15, 2017.

Berners-Lee, T., Hendler, J., and Lassila., O. (2001). The semantic web. In *Scientific American*, volume 284.5, pages 28–37.

Cachin, C. (2016). Architecture of the Hyperledger blockchain fabric. In *Workshop on Distributed Cryptocurrencies and Consensus Ledgers*.

Campbell, R. (2016). Holberton School Begins Tracking Student Academic Credentials on the Bitcoin Blockchain. https://bitcoinmagazine.com/articles/holberton-school-begins-tracking-student-academic-credentials-on-the-bitcoin-blockchain-1463605176. Last access Oct 10, 2017.

EDUCOURSE. (2015). 7 THINGS YOU SHOULD KNOW ABOUT .... https://library.educause.edu/~/media/files/library/2015/12/eli7127-pdf.pdf. Last access Oct 10, 2017.

Hori, M., Ono, S., Yamaji, K., Kobayashi, S., Kita, T., and Yamada, T. (2016). A Suitable m-Learning System using e-Book for Developing Countries. In *CSEDU*, pages pp.408–415.

Illich, I. (1973). *Deschooling society*. Harmondsworth, Middlesex.

Kahle, B. (2015). Locking the Web Open: A Call for a Distributed Web. http://brewster.kahle.org/2015/08/11/locking-the-web-open-a-call-for-a-distributed-web-2/. accessed September 23, 2017.

Rohaidi, N. (2017). Using Blockchain for student certificates slashes admin costs. https://govinsider.asia/digital-gov/patrice-choong-ngee-ann-polytechnic-campus-ecosystem/. Last access Oct 10, 2017.

Shrier, D. (2016). *Frontiers of FinancialTechnology: Expeditions in future commerce, from blockchain and digital banking to prediction markets and beyond*. CreateSpace Independent Publishing Platform. ISBN-13 978-1537248899.

Swan, M. (2015). *Blockchain: Blueprint for a new economy*. O'Reilly Media, Inc.

Tapscott, D. and Tapscott, A. (2017). The Blockchain Revolution and Higher Education. In *EDUCAUSE review*. http://er.educause.edu/articles/2017/3/the-blockchain-revolution-and-higher-education. Last access Oct 10, 2017.