Integrating Blockchain Technology in Healthcare via Active Learning

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ABSTRACT

As the healthcare industries move into the digitalization of health records, blockchain application could be a significant game-changer in the healthcare sector, creating a secure and flexible ecosystem for the exchange of records. Making healthcare clearer by creating a blockchain system to eliminate fraud and improve data accuracy is vital. Blockchain can securely interoperable record data such as organs, blood, critical drugs, and keeping medical licenses and certificates. With the emergence of Bitcoin, the first popular blockchain decentralized application, blockchain has become a viable solution for recording transactions in a growing list called blocks which are linked and protected using cryptography. However, with the ever-increasing demand for blockchain professionals and developers, there are few hands-on labs/modules available for training current students, the future developer professionals. The objective is to develop a framework including a series of hands-on labs that would fit individual student's needs for blockchain in public health.

This framework will help students to find their current level and propose an appropriate level of the hands-on lab for developing blockchain decentralized - applications in public health. This approach will help students to learn and comprehend the fundamental blockchain concepts systematically. A set of hands-on labs would be built based on real-life scenarios, to enhance their ability to understand and solve real-life cybersecurity problems in healthcare. This integrated approach would expose the students to the cost to risk involved at each stage of the blockchain application for electronic health records.

CCS CONCEPTS

• **Security and privacy** → Human and societal aspects of security and Social privacy aspects of security and privacy

KEYWORDS

Blockchain, Cryptography, Healthcare, Electronic Health Records, Decentralized Application, D-Apps, Active Learning

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1 INTRODUCTION

Since the dawn of the internet, virtually every key industry has invested substantially in computerization. Prior, many Americans brought airline tickets, booked a hotel, and rented cars in persons or over the phone. Now, practically everything can be automated through the internet; the plane ticket can be booked, updated, and viewed online. The rental cars can be rented with little human interaction as well as hotel rooms. The internet has made many things more self-effacing and convenient. However, regardless of the advancement that the internet has created, most patients are given handwritten medication prescriptions, and very few patients can email their physician or even schedule an appointment to see a provider without speaking to a live receptionist [3,14].

The Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009, was signed into law as part of the "stimulus package" represents the most significant US initiative to date that is designed to encourage widespread use of electronic health records (EHRs). Shown in Figure 1, since the (HITECH) Act of 2009, there has been a drastic increase in the adoption of Electronic Health Record. Despite the growing benefits of EHR functionalities, there are some significant disadvantages associated with this technology. These include financial issues, change in workflow, privacy, and security concerns.

Introducing Blockchain into electronic health records could reduce the barriers that are involved in complex data-sharing agreements between hospitals, physician providers, public health departments, and the Centers for Disease Control (CDC), allowing organizations to quickly and securely move patient data in a transparent and legally compliant manner. Healthcare use cases often converge with identity use cases, allowing individuals to promptly approve the sharing of pertinent information without sharing non-essential or unneeded information. For example, if an X-ray is required, the parties interested in the result might include the insurance provider, a general physician, the MRI technician, and the individual. However, the MRI technician does not need to know that the employer provides the insurance. All the technician needs to know is you are a valid customer and are covered for the procedure [19].

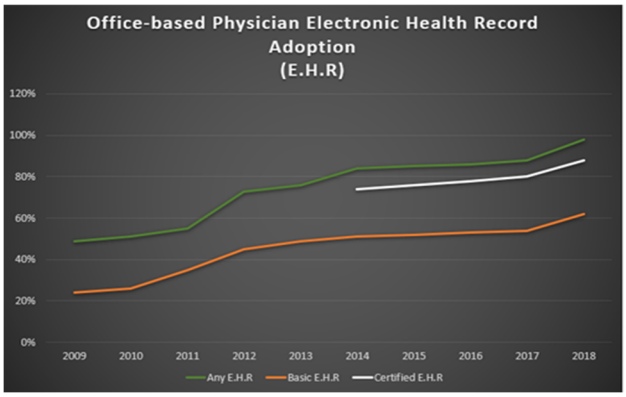

Figure 1: 2009-2018 Office-based Physician Electronic Health Record Adoption [1]

Currently, recording and sharing patient data have several limitations that restrict patients' access to their clinical records, reduce the availability of essential data to care providers, and ultimately present a barrier to transforming U.S. healthcare into a learning health system. One best solution is to keep patient healthcare data in a blockchain-based storage scheme that can remediate these shortcomings [17].

The rest of this paper is organized as follows. Section 2 presents a background to blockchain adoption in electronic health records. The related works is discussed in Section 3. Challenges faced in students' learning curve and principles for adopting active learning are described in Section 4. Design hands-on labs with real-world scenarios are presented in Section 5. The feedbacks from students are show in Section 6. The final Section provides the conclusions and future works.

2 BACKGROUND

The widespread adoption of electronic health records has seen an increase in the unknown level of data breaches. As seen in Figure 2, the number of individuals affected by health information breaches by hacking and other non-hacking incidences has sky-rocketed in 2014. Leaving many patients alarmed and concern about privacy and security of medical records, and other patients suppress vital information from their healthcare provided due to those concerns [1,4]. IoT devices and mHealth apps have been a widely used technology rapidly growing to become an everyday necessity. Its application has been popular in different sectors such as mHome, mHealth, mCommerce, etc. Mobile health (mHealth) are playing a greater role in medical practice. Although the development of IoT and mHealth app are advantageous to the society, it also contains flaws which attackers exploit to create a cyber attack of massive magnitude [7,9].

Currently, widely adopted mHealth apps collect electronic medical records by using smartphones and store those data in server or cloud. Blockchain serves as a tamperproof system for mHealth [8].

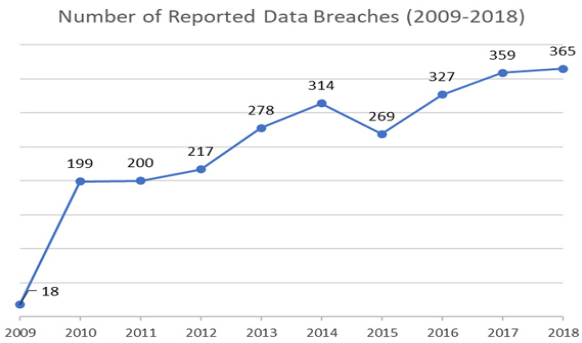

Figure 2: Number of Individuals Affected by Health Information Breaches [15]

The healthcare sector has been the most targeted and plagued by perpetual persistent attacks from numerous unknown malicious hackers, intent on exploiting vulnerabilities in their insecure and antiquated next to exfiltrated patient health records. According to the digital security company Gemalto's report "Data Breach Index for the first half of 2015," of the 16 critical infrastructure sectors, the Healthcare industry suffered from the most recent data breaches, an estimated ~21% (188 out of 888 reported events) [4, 18]. Many have stated that malicious cyber groups mainly target the healthcare sector; to move data into the black market. Attackers could use private health information to extort money or influence from victims. What would an HIV patient pay or do to not have their condition revealed to coworkers? Private health information could also be combined with the data stolen in the OPM breach to create a database of United States intelligence personnel [18].

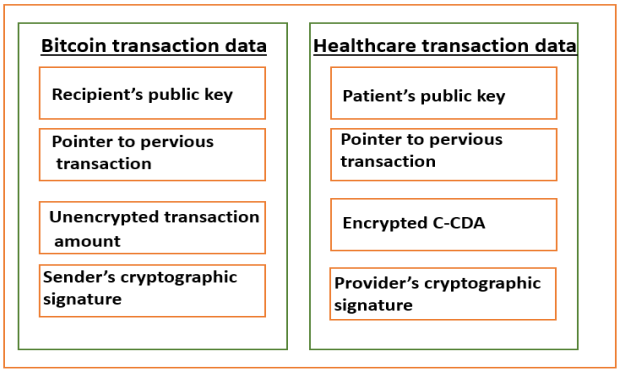

Figure 3: Financial vs. Healthcare Blockchain Transactions

Thus, incorporating blockchain the technology behind the popular cryptocurrency Bitcoin, would drastically revolutionize electronic health records since Blockchain technology is an immutable transaction ledger, controlled in a distributed network that has secure encryption [2, 4].

As shown in Figure 3, real-world cases of incorporating blockchain technology in EHRs is increasing, and patients become the platform, owning and controlling access to their healthcare information. Moving as many obstacles as the patient requires copies of their medical records or transfer the data to another

healthcare provider. Allowing patient's data to be securely stored on a decentralized network, guaranteeing no single point of failure and no one institution has ownership of the data. Data is encrypted in the Blockchain and can only be decrypted with the patient's private key. Even if the network is compromised by a malicious party. There is no practical way to read the patient's data. Lastly, the infrastructure is self provides auditing and non-repudiation capability [6,7]. The methods used to add the data to the Blockchain also includes a tamperproof timestamp, account IDs, and purposes of determining if the contents have been altered.

3 RELATED WORK

There are many published research papers related to design and implementation of cybersecurity hands-on labs. However, there are few research papers about designing hands-on labs that address blockchain technology development and implementation for the public health sector. Mainly due to the infancy of blockchain technology, students are highly unaware of the use of its applications.

The approach of these hands-on lab heavy models after the SEED projects also known as Security Education, which, covers a wide spectrum of security practices. To attain an effective education, to tech security principles that are grounded on hands-on understandings. Dewey (1938) defined that learning is attained through actives participation in the interaction between the individual and the environment [16]. SEED Projects have developed a novel laboratory environment, which, are inordinate opportunities for students to develop indispensable skills for secure computing practice. Learning from these philosophic views, we should engage students in hands-on experience in security education, and therefore, having effective and well-designed laboratory exercises (or course projects) is critically important to the success of security education [10].

The SEED projects are designed on a set of objectives based on two teaching philosophies: The first philosophy, computer security education should emphasis on both the fundamental security principles and security-practice skills. To allow students the chance to apply, to integrate, and to experiment with these principles and skills. The second philosophy, cyber security education should be integrated into many other courses, including Operating Systems, Networking, Computer Architecture, Compilers, Software Engineering, etc. [5,12].

Meaningful laboratory activities are difficult to create and assess. As such, the Labtainers framework can simulate a variety of security-relevant scenarios on a standalone student machine, without the need for elaborate infrastructure [3, 13]. However, laboratory exercises in which students learn fundamental concepts through exploration can help attract students, and ultimately into the cybersecurity workforce. There in few hands-on labs to train our future workforces to understand blockchain related cybersecurity concepts. This Framework for blockchain lab exercises was developed for bridging the gaps.

4 ACTIVE LEARNING

The overview of this hands-on lab is to have our undergraduate – security level students develop an Electronic Health Record D-apps (Decentralized Applications); using the Hyperledger fabric environment. This active Learning module lesson is to engage students in a real-world scenario, to enhance their ability to understand and solve real-life cybersecurity problems in healthcare.

Figure 4: Blockchain Technology Stack

4.1 Online Hands-on Lab Design

Before students begin developing the D-Apps, students will engage in learning more about the various blockchain concepts and terminologies. Using several open-source e-learning tools, we have created a series of lessons for our students to learn blockchain technology systemically.

Using Articulate 360, a cloud-based e-learning platform that helps firms build online courses, we have created a user-friendly module that students can complete at their learning speed. M-learning courses using the approach of adaptive response modulization is created. We present the learner with a lesson, then introduce the learner with a question regarding the lesson, if correct, the learner will move on to the next experience or if incorrect learner then returns to repeat the experience until they have fully comprehended the lesson.

Once students have completed the several lessons. Following, students' learning progress on to completing one of the three hands-on labs: Developing Cryptocurrency using Ethereum Smart Contracts, computation behind blockchain technologies, and Creating a Blockchain Electronic Health record. Thus, exposing students to real-life scenarios.

4.2 BlockEdu Framework

Since, blockchain technology is in its infancy and students are generally unaware of its complexity. Thus, creating a m-learning module to teach blockchain technology systematically. These modules are created for students to work at their own leisure and pace. Each module is developed using an adaptive learning as students are reading and listening to the lectures they will be immediately presented with a question related to the pervious slide, once successfully answered the presented question they will move to the next slide in the lesson. Each module covers various

subject and concepts with the objective for students to develop a well-rounded understating of blockchain technology and its various use cases.

In addition, a few real-world cases studies in healthcare sectors are given so that students can catch the scenarios in healthcare fields. As shown in Figure 5, course objectives are displayed.

Figure 5: BlockEdu Framework Course Objectives

4.3 Active Learning

The "learning tree" shown in Figure 6 begins with the initial exposure, where the student witnesses the use of blockchain technology in healthcare to explain or explore a problem in a blockchain technology topic. Interested students will be afforded additional opportunities to learn to apply blockchain technology to solve a problem or do an experiment. The next level of learning is an adaptation, where one has become familiar enough with a blockchain concept or model to alter the parameters of the blockchain. The application and adaptation stages mark the onset of research. Advanced research involves creating new Blockchain apps, e.g., creating new models or new blockchain apps.

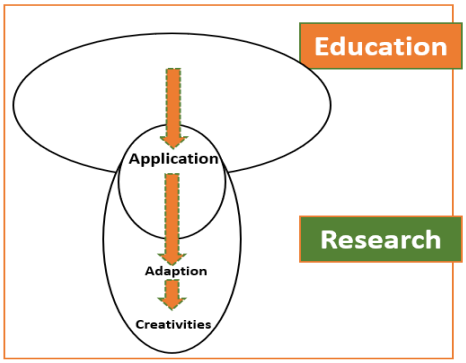

Figure 6: Active Learning Tree

Figure 6 shows the series of progressively more engaging exposures by which students move from the state of being aware of the existence of instances of blockchain in science to varying degrees of competence (can use, can adapt, can create). STEM students are exposed to blockchain concepts in the foundational and discipline-specific courses they take. The extent of their exposures depends upon the maturity of those students' level, and the amount of blockchain the instructor integrates into the course

5 HANDS-ON LAB DESIGN

During this lab, students' objectives are to learn about how to create a secure, immutable, and decentralized electronic health record database. With the patient owing to their health information. Creating a singular point of factual record verified using the consensus of the doctors/hospitals. Easily sharable with the patient's consent. Also, developing a full medical history of the patient in one signal interface, thus, increasing transparency while potentiality decreasing insurance fraud.

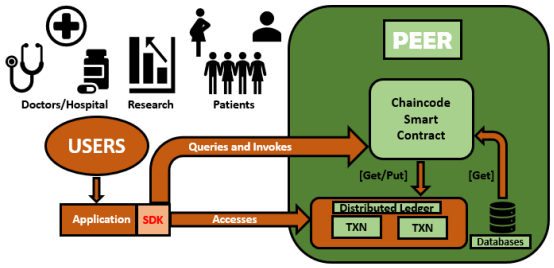

Figure 7: D-App Architecture

As shown in Figure 7, students will be developing a decentralized application (d-app) for three types of users: Doctors/ Hospitals, researchers and patients. All users will be accessing the main user interface. Next, users will invoke queries from the chaincode smart contract. The SDK will verify the global state of the blockchain, and queries will be submitted to the blockchain via restful service-based API. Then the blockchain will send the request to other peers for consensus. After the successful consensus, the transaction will be submitted to the blockchain and the subsequent key-value pair will be created or modified according to the request [14].

6 STUDENTS' FEEDBACKS

Students were asked to complete a pre-survey and post-survey to assess and comprehend the current need of our students. The hands-on lab develops to fill the gap between students' current academic track and new and emerging technologies. Many students have heard of the popular cryptocurrency Bitcoin, however, largely unaware of the blockchain the technology Bitcoin and have not heard of the Ethereum cryptocurrency/ platform. Thus, introducing students to these series of hands-on labs will adequately increase awareness of the various intricacy of developing decentralized applications (d-apps).

Shown in Figure 8, students were also asked about their interest in blockchain development. Most students (63%) stated that they are interested in learning about blockchain to increase career prospects. Creating a lab focus on healthcare aids students in understanding the various implementation and uses cases for Blockchain. More importantly, students are engaged in learning about new development tools such as NodeJS, Hyperledger

Composer, Hyperledger Fabric, and Couch Db. 94% of students have found those hands-on labs are useful. It is encouraging message, shown in Figure 9.

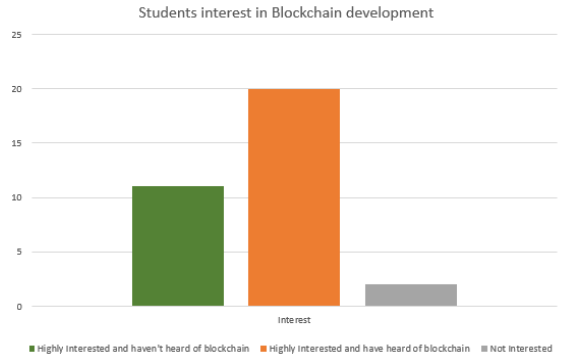

Figure 8: Feedback from Students about Interest in Blockchain

During the post-survey students stated, they found the hands-on lab as very useful. Does one student describe why the lab was useful? "Because blockchain is an emerging technology and it's good to learn about it," and another student stated, "It was good to see how the blockchains work and why it is considered secure." Moreover, the student generally expressed how useful the hands-on lab benefited them in learning about Blockchain, tools and implantation.

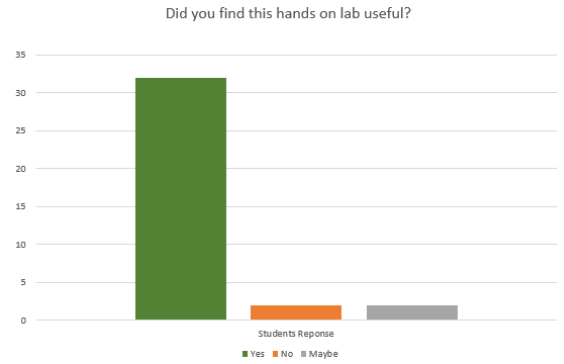

Figure 9: Feedbacks from Students about Lab's Contents

7 CONCLUSIONS AND FUTURE WORK

To summarize, our objective is to increase our IT undergraduate students interested in working in healthcare industry awareness and prepare them for the emergent of the blockchain revolution and Web 3.0. Students overwhelmingly expressed they would like to learn more about blockchain technology to enhance their career prospect opportunities. Thus, creating a framework that contains comprehensive hands-on labs will bridge the gaps and between the rapid advancement of technology and the classroom. Under our framework, we will develop various hands-on related blockchains. SEED project is an excellent example for us to follow.

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