



Addis Ababa University
College of Natural and Computational Sciences

Block-skill framework for a Mutable blockchain-based
data: in case of a Job-driven education system.

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Abstract

Blockchain is a list of records called blocks that collectively and sequentially stores information and that cannot be changed or deleted. However, in the context of the current conditions, the question of making modifications and deleting data in blockchain has recently been asked. Besides, this is again contrary to applications that need modifying storage. Numerous research efforts and methods have been proposed to address this limitation, but they are still being made to balance the limitations with other needs. For this reason, we proposed a Mutable blockchain-based data operation with Block-skill framework.

Block-skill is a Blockchain-based framework, in which blocks are used to store information using hash functions and it uses smart contracts to achieve the mutability of blockchain data and to fulfill the role and functions of applications that use the framework. As a result, the use of Block-skill Framework in case of job-driven education system started with studying the state of the art of the system using survey research design technique. The participants of the survey were 15 Businesses, 15 Employees, 8 Higher learning institutions, and 7 Recruiting agents, which are selected through Purposive and Convenience sampling techniques. Therefore, both quantitative and qualitative data were collected and analyzed. Our analysis of the survey data indicates the roles and activities of the participants, key points about skill gaps and the need for secure stakeholder collaboration. Consequently, in response to the importance of mutable blockchain that follows the practices of a job-driven education system, Block-skill Framework is found to be a promising solution.

The feasibility of the Block-skill Framework has been validated in the mutability of Blockchain data for multiple peers executing on the same on-chain data. This is as a result of the integrity maintaining function on the developed smart contracts to retain the original as well as the modified versions of data. Besides, Blockchain data is classified into off-chain and on-chain and its hash information is stored in the blockchain to control references to off-chain information. A prototype is developed for the implemented framework and a usage scenario is evaluated using questionnaires. The prototype evaluation result confirmed the viability of the framework as well as the assured integrity using the smart contracts.

Keywords: Block-skill Framework, Mutable blockchain-based data, Smart contracts, Integrity, Job-driven education system

Dedication

To my sister, Helen Berhane



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List of Acronyms

CIDs	Content Identifiers
DAOs	Decentralized Autonomous Organizations
DBFT	Delegated Byzantine Fault Tolerant
ETH	Ether
EVM	Ethereum Virtual Machine
HEIs	Higher Learning Institutions
DAOs	Decentralized Autonomous Organizations
IPFS	Inter Planetary File System
OPCODE	Operation Codes
PoW	Proof of Work
PoS	Proof of Stake

Chapter 1: Introduction

1.1 Background

Blockchain is public digital ledger that records transactions, promotes decentralization, transparency and information exchange [1]. Each block is a record of unique data transactions, which may range from business transactions to educational records and can that be shared securely. Once the transaction is recorded, the information is never lost. The main purpose of the blockchain is to build a trustworthy environment between autonomous actors in an unreliable distributed network [2]. So, a Blockchain's success stems from its groundbreaking use of hashing, consensus process, and distributed network design. In this regard, each block has its own unique hash as well as the previous block's hash. As a result, if we change any data inside the chain of Blocks, the hash will change, rendering the remaining blocks invalid. Hashes alone is not enough to avoid tampering. So, Blockchain has consensus mechanisms for achieving agreement on the blockchain network to validate transactions and produce new blocks to the chain.

Blockchains are also protected by their features, such as immutability which is a unique feature that prohibits modifying data. We are not able to modify block data unless, we choose to let others do it using the consensus protocol. Besides, decentralized management, transparency, verification and audit, can be used to ensure the accuracy, reliability and consistency of information and are used for business activities that support our modern society and economy [3]. Therefore, a new method of modifying or deleting blockchain information may help educational institutions and businesses to maintain safety, functionality and transparency. In addition, higher education institutions are showing interest in using blockchain technology to enhance collaboration with stakeholders [4].

Blockchain promises to provide transparent, secure authorization and secure systems, especially when combined with smart contracts [5]. Smart Contracts are computer protocols designed to facilitate, validate, or enforce contract negotiation or performance of contracts [6]. They had four objectives defined as observation, verification, privacy, and enforcement for secured transaction[7]. However, currently existing smart contract allows people to exchange and share documents fulfilling one or some of the objectives. In addition, smart

contract terms are invariant, and if the information is not true, the smart contract will not work properly.

Blockchains with specific domain concerns related to information fraud and security are used in business and educational institutions [8]. These are the sectors that can use this technology to reduce the limitations of a job-driven education system that provides education and training programs to meet current and future employment needs [9]. The expected role of blockchain technology is to first to obtain business skills and competency requirements and then to use this information to assess the needs of businesses and develop responsive education and training programs. Businesses, on the other hand, can be facilitated by the support of educational institutions. Therefore, we propose a Block-skill framework, which will develop smart contracts and a control panel to facilitate the efficient creation and operation of job-driven education system, enabling trusted collaboration across its stakeholders.

1.2 Motivation

Blockchain technology has been widely discussed as the second wave to change the world after the Internet [10]. Therefore, it is important to examine the unique characteristics of this technology, to examine the current state of the technology and its application, and to learn about the potential pros and cons of traditional educational and business practices [1]. Blockchain is not solely responsible for the success of completed applications, it is supported by other technologies. Currently, applications developers that use blockchain technology only focus on using one of the blockchain frameworks that suits their needs and maximize the components of the smart contract on the blockchain [11]. However, for wide range use the current architecture and technical features of blockchain based smart contract should allow adequate control for developers. In addition, since research in blockchain is still in its inception, a new mechanism is required for securing a blockchain based smart contract[12]. These has generated some concerns with regard to job- driven education system practicability and flexibility [13]. Such concern and inspiration to contribute to the body of knowledge of blockchain technology has motivated us to research a framework that include smart contract and a set of tools for smart contract processing and application development that focus on integrity maintaining strategy.

1.3 Statement of the Problem

Blockchain as evolving technology is making a difference in many sectors, and its demonstrated features such as immutability, decentralization, enhanced security, distributed ledger, stability, support for smart contracts are potential for application development [2]. In this regard, although smart contracts are providing useful services; their utility for various purposes is limited, since when they developed, they aimed to be conducive to one condition [14]. One of the core values of Blockchain is the development of immutable ledgers, which means if the information is written on a blockchain, no one will change it and remains there forever. But this feature is contrary to applications that need storage modifications [15]. It is true that blockchain's compliance with data mutability is difficult. To resolve this gap, a number of approaches and strategies have been proposed but they are still being made to balance the limitations with other needs [16] [17].

Blockchain-based Framework that is used to store, a query to add, or change data through smart contracts is found to be a promising solution for applications that make use of Blockchain features [18]. For instance, in the case of a job-driven education system request for information exchange between stakeholders and to made modification in data, whenever requested [19]. So, we need to get rid of the limitations in the Blockchain immutability feature and smart contracts [20]. Therefore, we proposed to build a Block-Skill framework solution that will develop smart contracts that include integrity maintaining function to retain original as well as modified versions of data and to achieve role and activity of job-driven education system participants.

Research Questions

- How to make modification of data of an application which deploy a smart contract while maintaining integrity of data?
- What are the security implications of smart contracts in Block-skill Framework?
- How can Block-skill Framework successfully implement smart contracts in a job-driven education system?
- What is the current state of the art of real-world job-driven education system?

1.4 Objectives

General Objective

The overall objective of this research is to develop Block-skill framework for a Mutable blockchain-based data using smart contracts capabilities, in case of Job-driven education system.

Specific Objectives

- Review literatures on application of blockchain frameworks in education and business
- Develop appropriate smart contracts to change data in the blockchain
- Design and develop a Block-skill framework that implement the smart contracts.
- Develop a prototype for validating the proposed Framework.
- Test and evaluate the smart contract and its integrity component using Ganache network.

1.5 Methods

In order to achieve the general and specific objectives of this study, we use the following methods.

- **Literature Review**

We perform a set of literature reviews from journals articles, conferences proceedings, reports, websites and books to understand about existing blockchain platforms that support smart contracts.

- **Data collection and Analysis**

Block-skill framework development start with the study of the current state of art of Job-driven education system using questionnaire and interview data. It aims to serve as an indicator of participants' current thoughts, feelings, and perceptions about the work and education system.

- **Developmental Environments and Tools**

The Development Environment and tools, we use includes Microsoft Visual Studio using web-based integrated development environment features, which includes code

editor, syntax highlighting, code completion and debugging. Besides, to develop the novel smart contract, we will use Solidity plugin on to visual studio code.

- **Prototype and Evaluation**

Test and evaluate the performance of the prototype.

1.6 Scope and Limitations

This research will focus on developing framework and smart contract for job-driven education on a blockchain secure format. It will contain a control panel, which consists of a set of facilities that include running and stopping webserver, manage configuration, connecting with software, controlling compiling and migrating smart contracts. Moreover, the proposed framework will offer viable structure for unlimited collaboration between intended participants. But we will be limited on Ethereum network and IPFS storage facilities, mainly associated with scale up.

1.7 Application of Results

The possible applications of this research are:

- To enable modifying data in Blockchain based applications.
- To achieve role and operations of job-driven education participants by using smart contracts and to be used in increased number of interconnected smart contracts.
- To use the Block-skill framework control panel for initializing and configuring web-servers, Interplanetary File System, connecting with public Ethereum network facilities and compiling and migrating smart contracts.

1.8 Organization of the Rest of the Thesis

The rest of the thesis is organized as follows. Chapter two presents the review of literatures on blockchain frameworks, their architecture, and features from Job-driven education system perspective. Chapter three presents latest related works that are done on Blockchain based data mutability. The fourth Chapter deals with the conducted Survey results. The fifth Chapter described the proposed Block-skill framework which is designed to bring into line smart contract potential with the mutability of data in case of job-driven education system. In chapter six, implementation and prototype evaluation result is analyzed and presented. Finally, chapter seven addresses conclusions and future work.

Chapter 2: Literature Review

2.1 Overview

In order to gain the knowledge necessary for the development of the blockchain framework, literature relating to blockchain frameworks, their architecture, and features from Job-driven education system perspective are studied. This includes a review of blockchain frameworks for the development of smart contracts and success of Blockchain applications with immutable Blockchain. Besides, the components of a typical Blockchain architecture such as data layer, network layer, consensus layer, incentive layer, contract layer, and application layer are reviewed in detail.

2.2 Blockchain Frameworks

Users can create and host applications using blockchain frameworks [21]. Blockchain 1.0 focuses on transactions, especially in the deployment of cryptocurrencies in financial applications such as money transfer and digital payment systems, while Blockchain 2.0 is a blockchain 1.0 extension that covers privacy, smart contracts, availability, On-native assets, and blockchain tokens [21]. Ethereum is a prime example of this stage of development, along with smart contract processing features. Systems have become more resilient, balanced, integrated, and user-friendly for the digital community with the introduction of blockchain 3.0 technology [22]. As a result of the increased implementation of the blockchain infrastructure, the government, education, and business pay special attention to the stages of blockchain development. Figure 2.1 shows the three Eras of Blockchain along with their distinguishing characteristics.

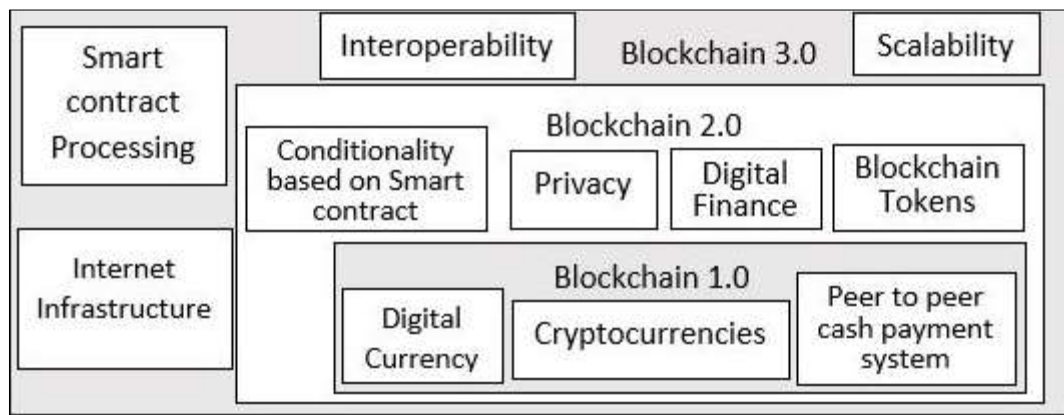


Figure 2.1: The three Eras of Blockchain

The current state of blockchain technology has allowed for the creation of a number of frameworks to address a wide range of applications [23].

Ethereum, Hyperledger Fabric, MultiChain, EOS, Ripple, Stellar, R3 Corda, Quorum, Monero, Waves, IBM Blockchain Platform, Hyperledger Sawtooth, IOTA, Neo Blockchain Platform, and Hyperledger Iroha, which is used in a variety of contexts, are the most commonly used blockchain frameworks and platforms for developing decentralized applications [24]. Yet, the major blockchain frameworks that have received significant attention in the education sector as well as in business are Ethereum, Quorum, Hyperledger Fabric, Hyperledger Sawtooth, NEO, OpenChain, and IOTA [25].

2.2.1 Ethereum

Ethereum is an open source, publicly available blockchain-based distributed computing platform and operating system for smart contract implementation that was announced in 2013 [26]. While sharing Bitcoin properties, Ethereum was developed mainly to add features on shortcomings of Bitcoin related development. It is found to be more operative than other frameworks due the customizable programming of smart contracts in the language Solidity [27]. Furthermore, as a result of its consensus protocol, there is a minor delay between transaction delivery and verification. Table 2.1 provides an overview of the Ethereum Blockchain.

Ethereum blockchain is being used to enable students in the education sector to transfer their learning records from one institution to another and to access records from students and / or the institution in a secure and authorized format [28]. The technology can be securely used by students to access educational materials, while the access permission in the decentralized network is set only for authenticated users.

The promise of Ethereum blockchain can be delivered, while addressing the technology's key limitations. The first limitation with Ethereum has raised concerns as to whether Blockchains are completely immutable and secure from external intrusion, and that it was able to retain historical blockchain data [29]. The second limitation is about incorporating transactions with high gas limit which is one kind of charging fee for Ethereum users depending on the value of the measurement can have a negative impact on the inclusion of contracts [30]. The above

restrictions indicate that Ethereum is immature to be used for a variety of conditions. Besides, 44 types of vulnerabilities accordingly Ethereum structure and development environment are enumerated in [31]. In addition, the analysis of the thousands of smart contracts source codes and their indicators of their relationships and behavior as well as their use in the Ethereum blockchain has not yet been completed [32]. So, this is an open research area in Ethereum blockchain seeking for innovative solutions to meet the requirements of new blockchain applications.

Table 2.1: Summary of Ethereum Blockchain

<i>Feature, pros and cons</i>	<i>Description</i>
Decentralized Network	Each node in the network serves as its own authority, making decisions independently about how it communicates with other systems.
Decentralized autonomous organizations	For democratic decision-making.
Ethereum Virtual Machine	It loads the bytecode compiled in the contract code and runs the program according to the smart contract code.
Ether	Token for operation of Ethereum.
Advantage	Decentralized applications and DAOs deployed within the network cannot be controlled by anyone at all.
Disadvantage	Prone to human error and any mistake in the smart contract code can make Blockchain system failed.
Future of Ethereum	It will be a disruptive technology that can change the way Internet works, transform services and industries.

2.2.2 Quorum

The Quorum is designed by Morga to support Turing-complete smart contracts on a permissioned ledger of Ethereum to build comprehensive purpose Blockchain applications [33]. It was built on the basis of the Ethereum code following the voting-based RAFT method to maintain settlement finality with a significant feature of the zero-knowledge security layer [34]. However, it differs from Ethereum in its Private Transactions, Performance and new consensus mechanisms making it more robust. Businesses can rely on the Quorum open-

source protocol layer and integrate it on top of its product modules from ConsenSys, to build high-performance and customizable applications [35]. Although Quorum has made improvements to Ethereum in terms of consensus mechanism and better confidentiality, its use is becoming more complex and is not suitable for privacy-sensitive solutions. Figure 2.2 shows a high-level architecture of Quorum [35].

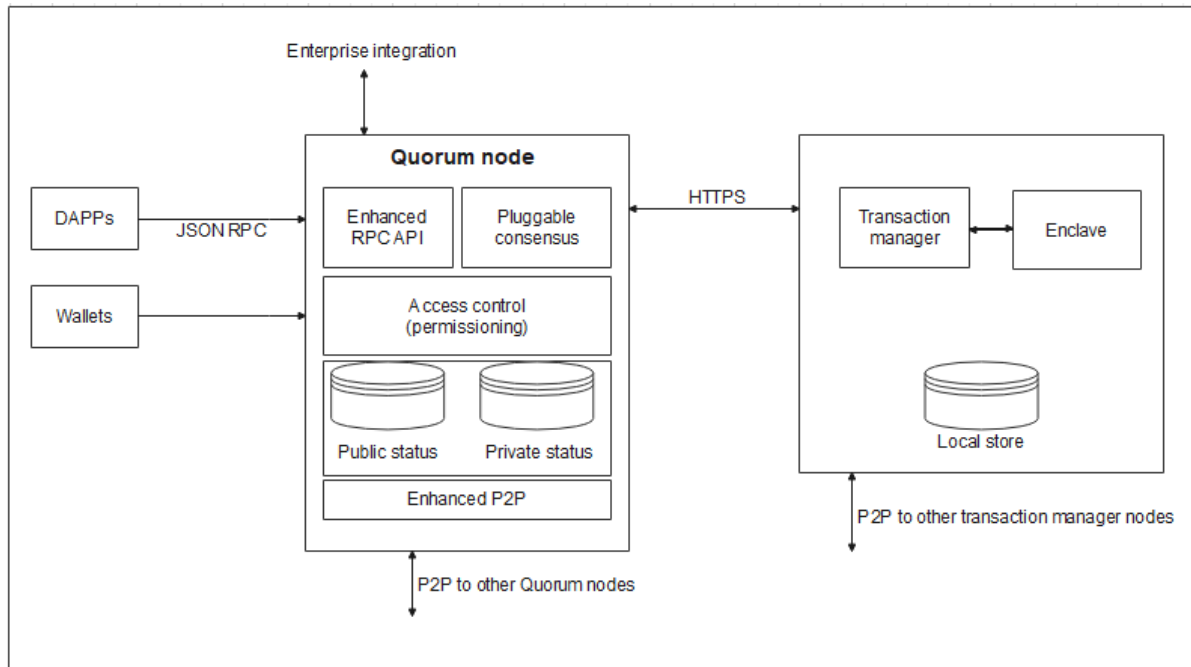


Figure 2.2: High level architecture of Quorum

2.2.3 Neo

Neo framework was created in 2014 by HongFei and Zhang using a consensus-specific algorithm called delegated byzantine fault tolerant (DBFT), that is more effective in terms of energy consumption than in the case of proof of work consensus [36]. The framework includes a smart contract that includes a set of line codes and a lightweight virtual machine introduced in the NEO 2.0 community. Figure 2.3 shows smart contract design in NEO framework for agricultural application [36]. Further, the framework is found to important, since they pay GAS that is cryptocurrency that users pay to use NEO for developers.

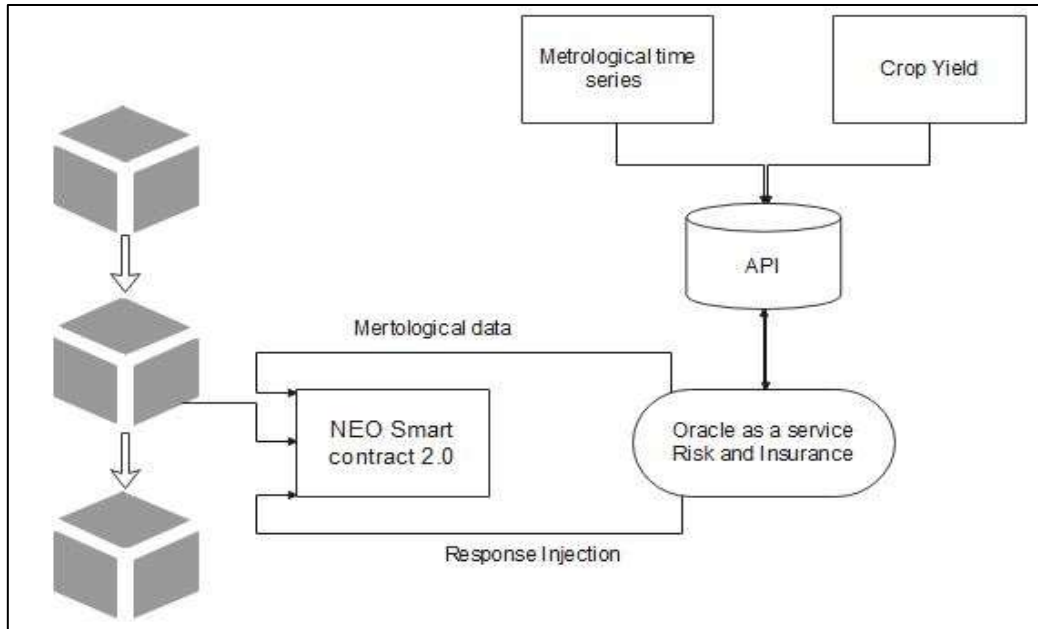


Figure 2.3: Design of a smart contract with NEO

2.2.4 Hyperledger Fabric

Linux Foundation in 2015, has established the first truly scalable blockchain system called Hyperledger Fabric to support distributed application protocols for adapting systems to specific usage issues and trust models [37]. It contains components for a variety of cryptography-enabled consensus mechanisms related to transactions and programming languages to capture and store transactions and to create smart contracts for immutable or dynamic business functionality that can be used during transactions [38]. Besides, it has a permissioned blockchain architecture providing a consistent distributed ledger, shared by a set of peers. As with any blockchain architecture, the principle of Hyperledger Fabric is that all peers should have the same view of the shared ledger, making it challenging to support personal information for different peers. Hyperledger fabric has been used in education and other applications, as shown in Figure 2.4 [39]. Its advantages include modular architecture, licensed block building, and scaffolding, but the disadvantages are proven usage problems and a lack of training programs that can be used.

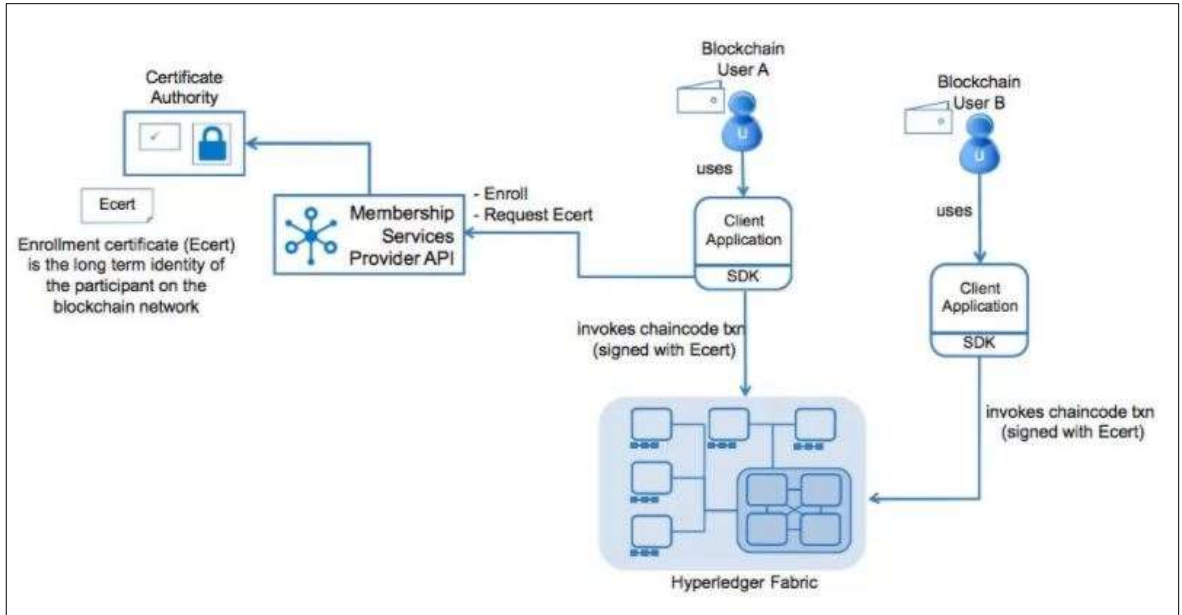


Figure 2.4: Hyperledger Fabric Educational application

2.2.5 Hyperledger Sawtooth

Hyperledger Sawtooth is an open-source platform developed by Intel that supports unique consensus method using a unique hardware security solution [40]. It has managed architecture to enable smart contracts to use business rules for applications. This is possible because the application is different from the blockchain system. One of the outstanding features of Hyperledger Sawtooth is support for permissioned and permissionless applications, as well as the deployment and use of a new consensus algorithm called Proof of Elapsed Time [41]. Besides, it supports available consensus mechanism and smart contract language. However, its requirement for larger network in order to have higher throughput and insufficient developer documentation are some of the shortcomings.

2.2.6 OpenChain

OpenChain is an open-source platform developed by Coinprism that connects one transaction to the previous transaction [42]. It is built on a client-server model with configurable blockchain scope and uses proof of authority rather than proof of work as a consensus algorithm [43]. It lacks mining fees, multiple control levels and transparency and auditability of transactions. In addition, it has advanced functions to reduce costs and transaction times. However, OpenChain has administrative and centralization concern, which are its disadvantages.

2.2.7 IOTA

IOTA is a new next generation public distributed ledger that emerged in late 2015 utilizing a novel invention, called a “Tangle”, which is a new data structure based on a directed acyclic graph, as it is shown in Figure 2.5 [44]. Tangle aims to verify transactions. Its distributed ledger is designed specifically for the design of the Internet of Things architecture, from where it gets its name. IOTA provides a completely new architecture that does not support blockchain and miners. However, it is preferred for the current blockchain development because it does not support smart contract and its requirement of proof of work consensus makes it cost ineffective.

2.2.8 Summary

The literature review of the blockchain frameworks showed the strengths, weaknesses and features of the frameworks as it is compared on Table 2.2. Therefore, when, it is wanted to use any of the frameworks, first we should compare needs to the capacity of blockchain frameworks. In our context, we have identified what the existing frameworks offer and their limitations that persist to this day that make them unsuitable for a job-driven education system. We have also seen the gaps to be filled by further research for the efficient use of blockchain technology.

Table 2.2: Comparison of the Reviewed Blockchain Frameworks [45]

Title	Ethereum	Quorum	Neo	Hyperledger Fabric	Hyperledger sawtooth	OpenChain	IOTA
Type of network	Public	Private and Public	Public	Private and Public	Public	Private	Public
Supported Languages	Solidity	Solidity	C#, Java, and Python	Python	Python	JavaScript	Rust, Go, JavaScript, Java and C++
Code type	Open-source	Open-source	Open-source	Open-source	Open-source	Open-source	Open-source
Ledger Type	Permissionless	Permissioned	Permissioned	Permissioned	Permissioned	Permissioned	Permissioned
Industry Focus	Cross-Industry	Cross-Industry	Smart Economy	Cross-Industry	Cross-Industry	Digital Asset Management	Smart Economy
Consensus Algorithm	Proof of Work	Majority Voting	Delegated Byzantine Fault Tolerance	Pluggable Framework	Pluggable Framework	Partitioned Consensus	Delegated Byzantine Fault Tolerance
Smart contract Functionality	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Popularity	High	High	High	Actively updated in GitHub	High	Medium	High
Best Projects	Ethlance, VeChain Thor, EtherTweet.	Banking & Finance, Healthcare	Pundi-X, IOStoken, Cosmos	Banking applications	Hyperledger Cactus	Adobe, Arm, Cisco, Comcast	IOTA Wallet, HORNET

2.3 Blockchain Architecture

Blockchain is a decentralized and public or private distributed ledger of transactions organized through peer-to-peer networks. In addition, the network is generally decentralized because it consists of more interconnected computers than a single server. This provides new solutions for designing and supporting client systems and applications. The technical architectures of blockchain-based services vary greatly between projects. For example, Hyperledger fabric introduces a new blockchain architecture that demonstrates resilience, flexibility, scalability and confidentiality, while Ethereum introduces software architecture designed to implement smart contracts in blockchain, as opposed to IoT applications. So, architectures must match the amount of traffic that such applications usually generate [46]. Below, we review a blockchain architecture that consists of six layers: data layer, network layer, consensus layer, incentive layer, contract layer, and application layer from an architectural standpoint. [47]. This layer classification is critical to presenting the basis of the technology, recent research findings, developments, and critical issues related to blockchain technology.

2.3.1 Data Layer

Data layer in Blockchain holds authentic data and cause subsequent blocks and transactions to act as modifications to previous blocks [48]. It is intended to encrypt the data first and then to store it after uploading it. This layer contains hash, Merkle tree and transactions as it is shown in Figure 2.5. In a blockchain-based system, the consensus-based process of recording and updating data over distributed nodes are central to enabling trustless transactions. This is for proper understanding of what and how the data are stored and manipulated that ultimately determine the degree of utility, performance, and cost of a blockchain-based application [49].

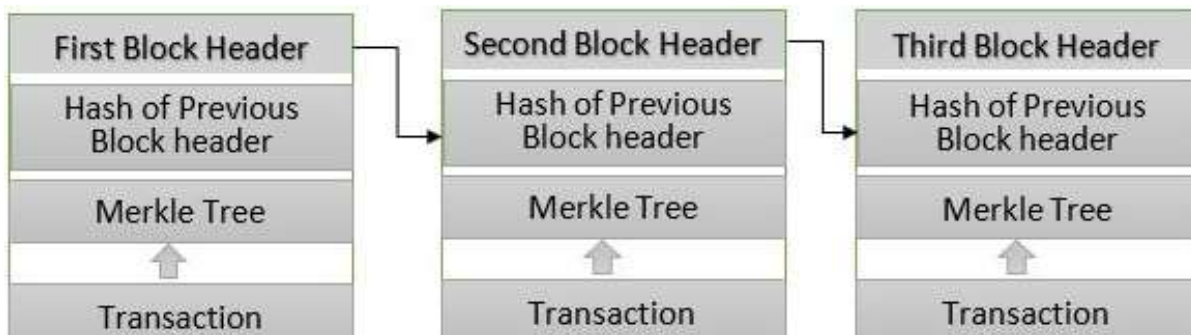


Figure 2.5: Data Layer Structure of a Blockchain

In Figure 2.5 Blockchain is composed of a block header and a block component, and the blocks stores multiple transactions that occur after the previous block. The block header stores the block hash used by Merkel's tree to generate digital certificates.

2.3.2 Network Layer

Blockchain is a peer-to-peer computer network that has procedures in place to ensure the accuracy of transactions under the given consensus algorithm. The purpose of this layer is to create collaboration between a decentralized or an independent Blockchain network [50]. It is a configuration that allows members to communicate with each other in a decentralized manner. In this regard, there are two categories of blockchain networks: Permissionless and Permissioned. In a permissionless blockchain network, anyone can involve and openly see all transactions in the network whereas Permissioned Blockchains are accessible to members with privileges. It has an advantage of being trusted and legal.

2.3.3 Consensus Layer

In this layer, to increase trust in blockchain applications, transactions can be verified by a consensus protocol. Increased trust can be achieved through the design and incentive of a distributed consensus system. Thus, a key understanding of blockchain work has been found to be a consensus algorithm that determines how the agreement will be implemented to support new blocks in all nodes in the network. In this regard, there have been about 30 agreement algorithms in the last decade, but their safety, stability and effectiveness are still lagging behind in real needs [51]. In addition, the existing consensus algorithms have their own advantages and disadvantages and cannot fit for every application criterion. Therefore, it is important to technically compare the available consensus algorithms to highlight their strengths, weaknesses, and usage issues. Despite this fact, the most commonly used consensus algorithms are PoW and Proof of Stake (POS) [52].

Proof-of-Work (PoW) is a very slow consensus algorithm and is generally not used in consortium or private chains where actors are generally recognized and trusted [53]. Each node requires to solve a cryptographic puzzle and uses a large amount of electrical power as well as mathematical hardware as part of their consensus procedure. It seeks to prevent an adversary attempt from creating multiple identities and using these false identities to influence the consensus process. Since the computational power required at one node and the effect of the consensus process in POW can be compared, it does not attract an opponent.

However, it is more likely prone to 51% attack, where the attacker can alter or reshuffle the order of the transactions if s/he takes control of more than half of the computational power of the system [54]. So, some researchers are exploring alternatives to PoW, such as proof of space, proof of stake and proof of elapsed time.

Proof of Stake (PoS) is an alternative consensus approach that gives the decision-making power to entities who possess coins within a system, by putting them on stake during transaction approval, where nodes are randomly selected to validate blocks, and the probability of random selection depends on the amount of stake held [55]. PoS eliminates the computational cost by choosing the node to be the official validator based on the proportional stake of the network value. This energy-saving nature of PoS has interested blockchain application developers. In this regard, Ethereum is planning to move from Ethash to Casper which is a partial consensus mechanism combining proof of stake algorithm and Byzantine fault tolerant consensus theory. However, PoS limits the hashing power of each node and the difficulty of mining is inversely proportional to coin age. In addition, it has its own problems, notably the Nothing at stake issue which in the event of conflicts could prevent a blockchain from convergence and results in forked chains.

Generally, from the consensus protocols and their properties, it is clear that further research is required on the algorithmic steps taken by each consensus algorithm, the scalability of the algorithm, the method the algorithm rewards validators for their time spent verifying blocks, the security risks present within the algorithms, their behavior towards different underlying network topologies, and their ability to withstand packet losses and their robustness to attacks where a malicious node aims to steer the result of the algorithm towards a desired value, without letting the other nodes detect the attack.

2.3.4 Incentive Layer

In this layer, network participants come to collaboration through a medium for transaction settlement called an incentive. The participants cooperate to accomplish a task operated by consensus of the peer-to-peer network that rewards participants in the form of acknowledgment for their effort. In such a system, the blockchain will work correctly under the process of hashing. The hashing can be done by incentive mechanisms that motivate people to mine blocks. Thus, mining participants should be satisfied by the rewarding mechanism to compensate their resource

usage for cooperation. However, suitable incentive mechanisms that can meet the diverse requirements of users in dynamic and distributed P2P environments are still missing [56].

2.3.5 Contract Layer

The contract layer is the core part of recent advancements in most of the currently existing top blockchain frameworks. It cooperates with the consensus layer in processing details of an entity and executing contracts. Its current feature includes support for smart contract [57]. It was originally proposed by Szabo in 1994, who states the smart contract general objectives to be satisfying common contractual conditions, minimizing both malicious and accidental exceptions, and minimizing the need for trusted intermediaries. A smart contract, when used in a peer-to-peer network, can implement agreement conditions without the need for a trusted third party.

Researchers are working on ways to fix key shortcomings and weaknesses in smart contracts, as well as to close security holes. Such as, formalizing the semantics as well as the security properties of smart contract at the level of byte code and using methods and tools that have emerged to support the development of secure smart contracts that aid the analysis of deployed ones [58]. So, in Smart contract, besides their correct execution, it is also crucial that their implementation is secure against attacks. Thus, more research is needed because smart contracts have got many limitations and drawbacks, as well as major technological issues like security [59]. The limitations and vulnerabilities are as a result of lack of reviewing the smart contract topic and due to the relative lack of research on the scalability issues of blockchain-based Smart contract systems.

2.3.6 Application Layer

The application layer allows applications to use the blockchain to its full potential. It is also responsible for creating, reading and updating digital value collection and value relationships. In addition, it brings end-to-end results for users of the blockchain architecture. Its flexible behavior is consistent and includes relative strength with security attacks. The next generation will need the right chain of action to further develop the blockchain architecture. Therefore, it is important to start with the application layer and define new architectural approaches to fill the gap [60]. Besides, it is required to come up with an advancement over existing architecture for applying it to domains that prioritize minimizing risks of making mistakes in the development of blockchain. Below in figure 2.6, we summarized the Blockchain architecture with six layers.

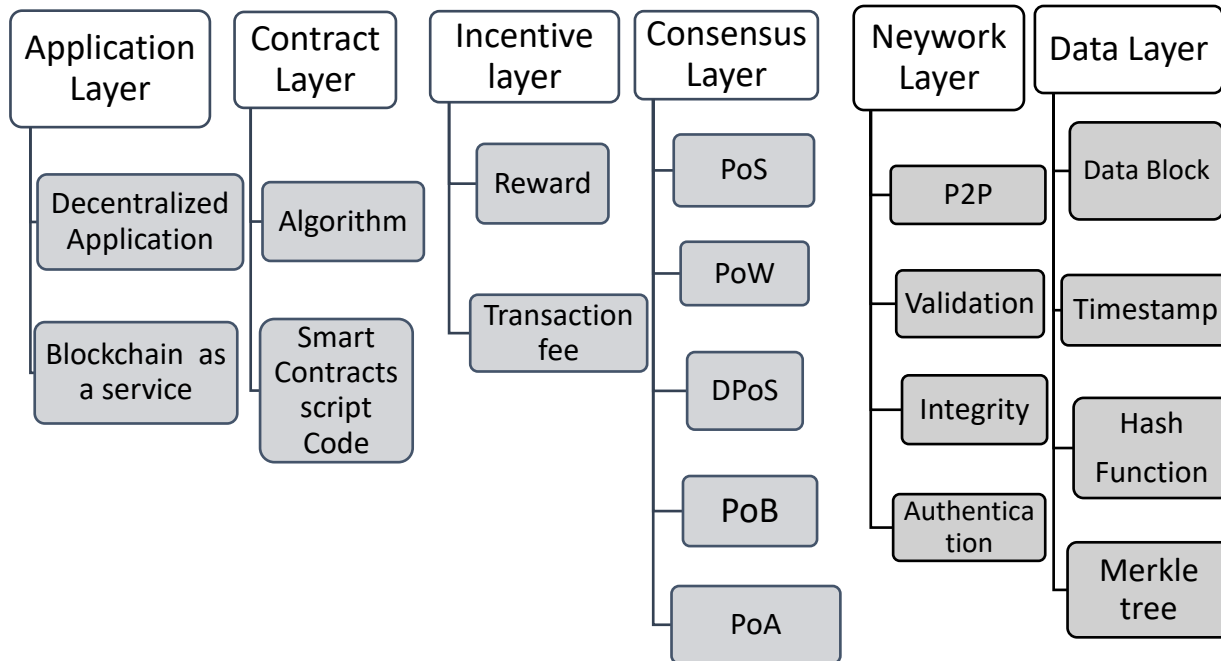


Figure 2.6: Typical Blockchain Framework architecture

2.4 Blockchain Technology Security Issues

Blockchain-based applications are gaining increasing acceptance in a variety of areas, including Education institutions, financial services, reputation management, and the Internet of Things. However, several issues with blockchain technology remain, such as transparency and security [61]. For this reason, it is important to examine the security and privacy issues and challenges behind this innovative technology. In this regard, a number of blockchain-based security services include immutability, authentication, confidentiality, privacy and access control data and resource verification, and verification that are critical to current distributed applications [62].

Immutability is defined as the characteristics of a data in Blockchain, in which once a data is entered in blockchain, it is irreplaceable or indelible and provides an indelible historical record in the system [63]. Besides, it is a property that cannot be edited, deleted. So, it is cornerstone to blockchain security. However, in light of the new extinguishing requirements imposed, the question of making modification and deleting data in blockchain has recently been asked. Further, in [64], it is stated that content improvements, enhancements or deletions are challenging in blockchain. So that, it shows a gap for further research effort in this area.

Blockchain frameworks have also suffered from several critical cybersecurity threats and vulnerabilities. First according to the authors in [65], it suffers from problems, challenges, and limitations such as information reliability, scalability, security, and privacy, compliance, and governance issues that have not yet been thoroughly explored and addressed. Second, modern Blockchain implementations have to adapt to additional technical challenges and limitations such as throughput, size and bandwidth, performance, usability and data integrity [66]. Third, many popular and promising blockchain techniques have not been developed, including blockchain credit worthiness, performance, efficiency, security, privacy, control, and offline integration [2]. Considering the security of the blockchain framework, smart contracts can be written by anyone, and anyone can make serious flaws in a smart contract or basic platform code, which could lead to huge consequences[67]. So, with further research it is needed to improve Blockchain based smart contracts that have security issues such as endpoint vulnerabilities and public and private key securities [68]. In Table 2.3, we summarized Blockchain technology security issues.

Table 2.3: Blockchain Technology Security Issues

<i>Blockchain Security Issues</i>	<i>Potential to either make Blockchain system successful or fail</i>			<i>Possible Effect</i>
	High	Medium	Low	
Centralization of miners or 51% Attack	✓			Compromising normal operation
Selfish miners		✓		Wasting time and computing power
Blockchain platform developer	✓			Faulty and exposed vendors.
Social Engineering		✓		Phishing
Malware	✓			Cryptojacking
Code issues			✓	Cyber risks
Disrupting node communications (False information)			✓	Compromise Network

2.5 The Need for Blockchain in Job-driven Education Systems

In recent years, governments have been increasingly concerned about improving the employment of university graduates, but most graduate employers are now relying on self-reported preferences [69]. As a result, even in the face of future changes, a system of education that strengthens the necessary skills is required. For such case, employers need to have a voice in determining what skills and abilities they need in the workforce[70]. Additionally, employers and higher learning institutions should lament the difference between what students learn in college and what is really expected of them to be ready for work. So, the importance of first obtaining skill and competency requirement of businesses for the use of other stakeholders must be emphasized.

Higher education institutions are becoming more and more focused on meeting the needs of their clients such as meeting the needs of students and employers [71]. Meanwhile, skills gaps in the workforce are commonplace in the current value of higher education supply and ideas are being sought to resolve the grievances. So, higher education as a sector, should highlighting examples of practice from industry and need to start engaging in collaboration [72].

Students have been questioning the extent to which higher educational institutions' curriculum responds to their employability. So, they are requesting concerned government bodies and research initiatives to study and make changes in the education system. As part of this effort, Blockchain can be a promising technology. Specifically, blockchain learning ledger records detailed information about the users' learning experience and follows the development of their knowledge and skills [73].

Recruitment agencies, as business-oriented companies, are playing a key role in connecting graduate students and employers. So, they could use blockchain technologies to make the recruitment process more cost-effective and with increased overall quality of recruitment [74]. In this regard, when graduates begin applying for a job, they can keep their e-portfolio on the blockchain and provide employers with a complete picture of the graduate's skills and experience [75].

Businesses are complaining about the qualifications of graduates. As a result, they are becoming a demonstration site for students, offering practical assignments. As part of this effort, researchers recommend that businesses use blockchain to store information, improve information transparency

and security, and support data sharing [76]. Despite this claim, existing research on businesses using blockchain technology to change their work is still in its early stages[77].

In general, in job-driven education system, data will be shared among participants of the system. Besides, there is a need of interoperability and verification and updating shared data. These are found to be encouraging conditions to use blockchain as a solution. In addition, the tremendous pressures from challenges associated with increasing rate of unemployment, stakeholders have started to advocate the notion of Job-driven education system research [78]. Therefore, higher learning institutions, students, recruiting agents, and businesses can use blockchain technology as an alternative in order to gain advantage of its unique bundle of trust, collaboration, organization, identification, credibility, and transparency [79].

Chapter 3: Related Work

3.1 Overview

In this Chapter, the latest related works that are done on blockchain mutability are described. Research efforts are being made to manage blockchain technology immutable to bring it into mutable collaborative environment. We would discuss the new blockchain approach for managing immutability with their respective scientific contribution and drawbacks. We classified the related works into two groups in this thesis. In the first section, we reviewed Architecture based mutable blockchains while in the second section, algorithm based mutable blockchains are discussed. Thus, once we have identified the limitations of related research efforts, we can see how effective our framework solution is for mutable Blockchain.

3.2 Architecture based mutable blockchain researches

The research work in[80], proposed to solve blockchain immutability features in accordance to the European union General Data Protection Regulation (GDPR). GDPR enforced that modifications and deleting data on a blockchain must be made, which is against Blockchain immutability feature. Thus, they proposed, three-layer blockchain architecture solution as it is shown in Figure 3.1 [80]. The first layer that keep current transaction management and store data of involved authorities. The next two layers use APIs, and they are not firmly connected with backend systems. The second layer serve as dashboard hosts, in which event logs are created and displayed to users from back-end systems and layer three blockchain. Besides, it is used to correlate the pseudonymous blockchain identification numbers with the specific identification numbers used in the back-end systems. The pseudonymization approach they used is a method for defining and identifying information fields that are uniquely identifiable and then substituting them by one or more fictitious identities.

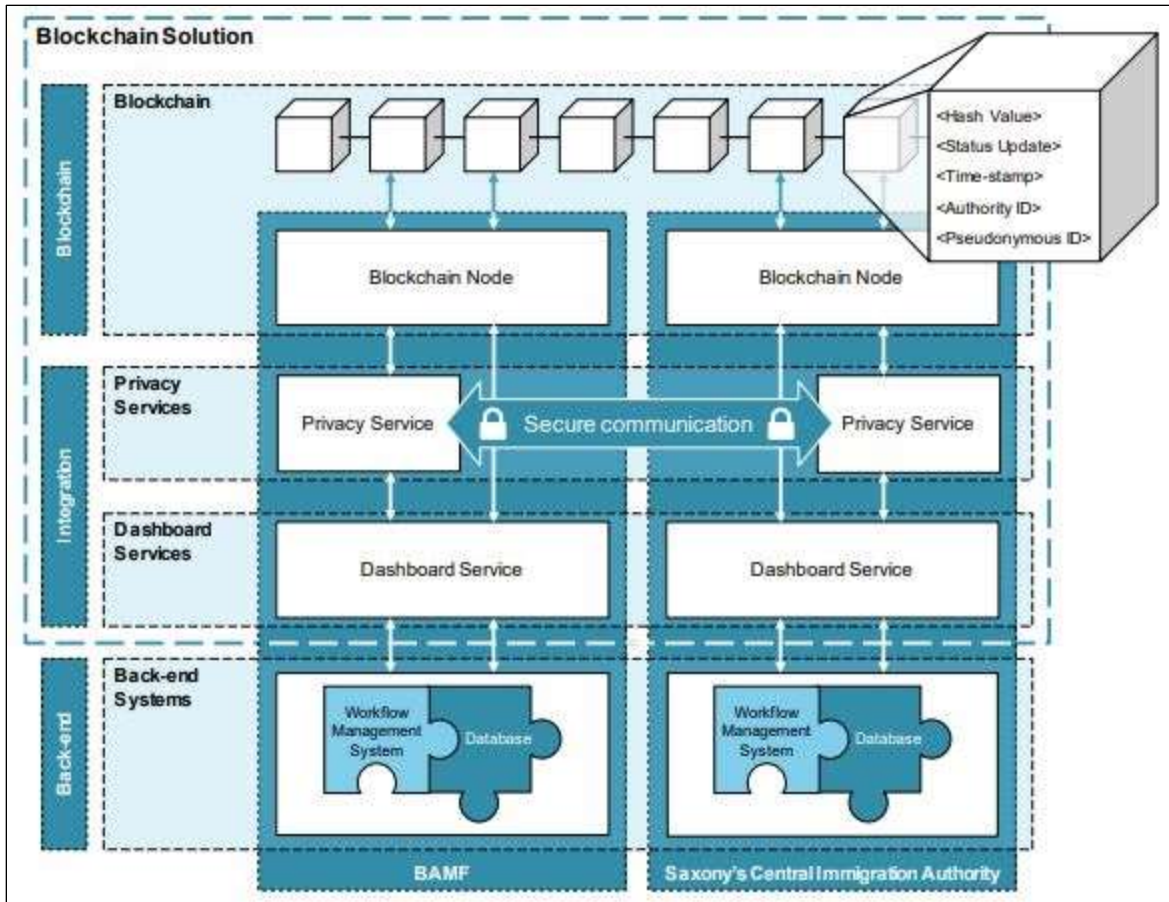


Figure 3.1: *Three-Level Architecture of the BAMF's Blockchain Solution*

In their implementation they have showed how to go in contradiction of blockchain's immutability feature only on stored private personal data. Consequently, they are limited on a private and permissioned network, and encryption and hashing, in cases of logging into Blockchain are impracticable in their approach. Besides, they are meant to specific domain use, which necessitate other technical measures to be taken in order to use their finding. Lastly, as they mentioned, for their research to be used on various domain problems, new reference architectures that ensure the interoperability of various blockchain technologies and solutions are required.

In [81], research work implements an architecture for handling and monitoring internet of things using a private blockchain. The system is based on Create, Read, Edit, Delete operations as well as encryption and access control. To do so, device configuration files are saved on Blockchain. When an update is made, configuration files will be kept. Besides, they succeeded on of chain code configuration reporting mechanism, for the possible to use of system administrators. Their findings

indicate that delivering of configuration changes on Internet of things devices can be verified by blockchain. The core to their approach is the sharing of Internet of things system configuration files through enterprise networks using blockchain technologies as it has shown in Figure 3.2 [81].

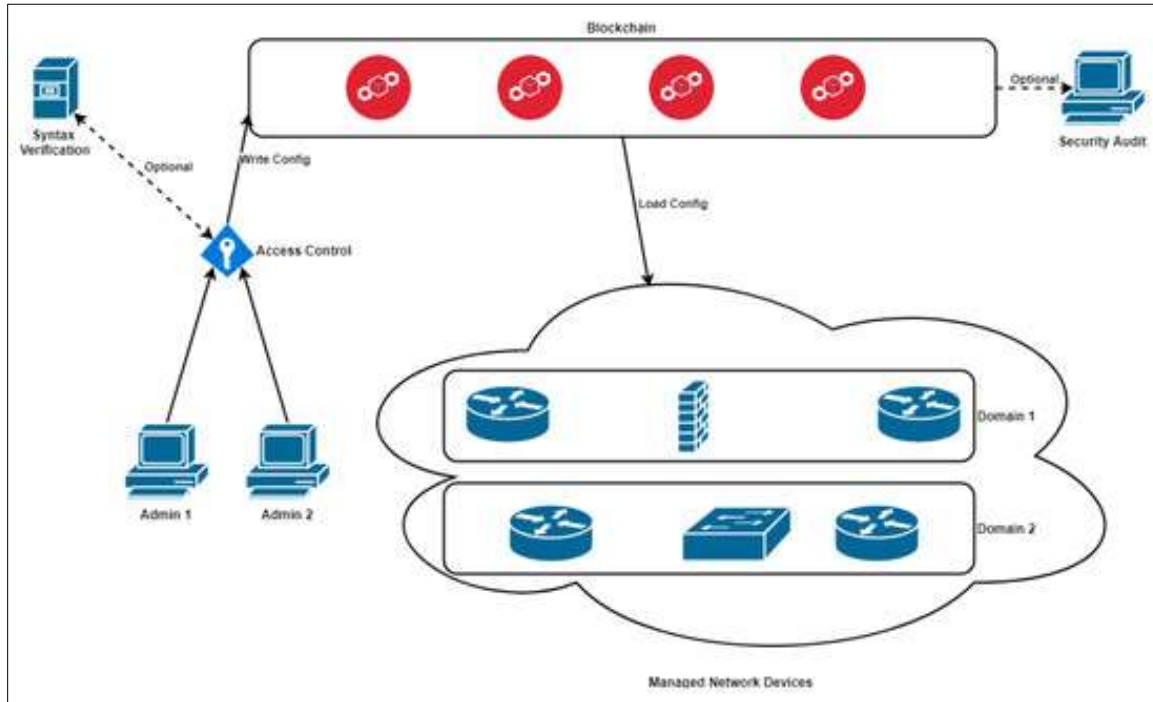


Figure 3.2: Proposed architecture for network management over blockchain.

This research work is limited in IOT based application and in cases of encryption key compromising, the relevant setup files must be encrypted again. Nevertheless, with regard to the blockchain feature, older configurations could still be technically available. This will increase security and performance problems.

3.3 Algorithm based mutable blockchain researches

The work of Farshid and et al. in [82], makes use of design science research approach, and identify immutability problem in Blockchains. That is the fascinating argument about the need to delete information from the Blockchain. Consequently, they proposed to resolve this problem, by building pruning algorithm that will run on limited nodes in peer-to-peer network. The pruning algorithm is developed to define customer-stored information which are not important for functioning of Blockchain. They did this step to identify and ensure a safe deleting process. Thus, according to the evaluation they conducted, their algorithm has enabled them to delete an

information in local node. Following, they test the algorithm using five hosts. Again, their algorithm has enabled them to delete old blocks. Even if this research undertaking has got the above contributions. They are limited on the number of new nodes to be added to the network, that it is appropriate only for few numbers of network nodes. This makes the algorithms inefficient. Besides, they didn't consider modification of data.

In [83], the researchers introduced a method to the minimize Blockchains distributed ledger size using selective pruning algorithm. The algorithm, as we can see in figure 3.3, functions in three stages. The aim of the first preparation stage is to identify blocks to be trimmed. Each transaction uses a preliminary task called mark in the stage two, which is provided by trimming Algorithm. In stage three that is sweep, every transaction identified to be removed is eliminated.

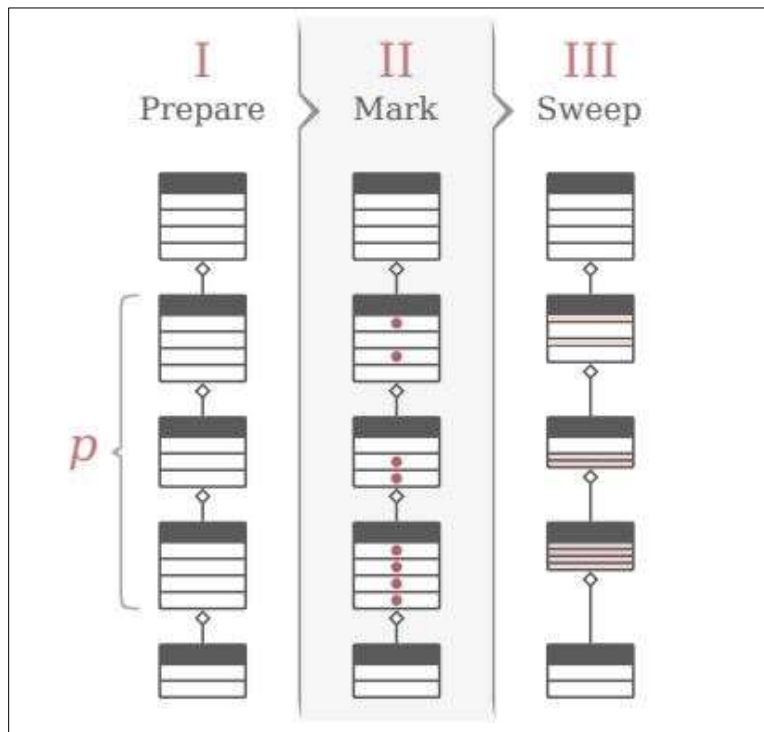


Figure 3.3: *Selective pruning algorithm*

The finding of the research has allowed any participant of a blockchain system to selectively remove previous transactions. However, what is found to be important in relation to our research is about getting unchanged state information from the rest of the transactions. Besides, this research work has limitations, since it removed transactions are not able to be revoked and modification of transaction is not included in their research. This shows, doing our research visible.

3.4 Summary

This chapter discussed the latest related works on blockchain mutability. It is understood that the research findings included in this research have been scientifically related to the problem of Blockchain immutability. However, they have are being made to balance the Blockchain's immutability limitations with other needs, such as regulation. In addition, they focus on deleting transaction data than modifying, which makes them inappropriate for our job-driven education system context. Further, as it has been discussed under each related work, it is required to take additional technical measures, in order to use their finding.

Chapter 4: Survey Result

The objective of this chapter is to gain detailed knowledge about the existing job and education system. In this regard, Block-skill framework for a mutable Blockchain based data for job-driven education system development starts with the study of the existing system using questionnaires and interviews. Consequently, sample size, sampling techniques, data collection tools and data analysis and results are presented in this Chapter.

4.1 Survey Design

We performed a survey in accordance with the fundamentals of research. A process model that resulted in the development of a framework with a well-defined structure is adopted. The process that we followed aims to build a Block-skill Framework that defines its ideas, technical capabilities as a product, by which the analysis, design, implementation, and use of information systems can be effectively accomplished.

4.1.1 The Population for the Study

The exact number of populations of our study is not known, so they have been identified as a group of job-driven education system stakeholders. The study was conducted in Addis Ababa which was selected purposively. Besides, the sampling frame, which is the list of sample units from which the sample is going to be drawn, is selected using convenience sampling, since in our case including the entire stakeholders is practically impossible.

4.1.2 Sampling Technique

The right choice of a sampling technique can help researchers to combine the strengths and adjust some of the inadequacies of any source of data, so that they are able to minimize the risk of irrelevant conclusion. Therefore, drawing the right inferences about a study population relies on the use of sampling techniques. For this reason, non-probability sampling techniques were used for this study. From non-probability sampling techniques, purposive and convenience sampling were selected.

4.1.3 Sample Size

The sample size is for the unknown population our study is obtained by calculating the minimum sample size required for accuracy in estimating numbers, taking into account the standard deviation at 95% confidence level (1.96), collecting percentage response (50% = 0.5) and the

confidence interval ($0.05 = \pm 5$) using Equation 1 [84].

$$n = \frac{z^2 (p)(1-p)}{c^2} \quad (1)$$

Where: z = standard normal deviation set at 95% confidence level, p = percentage picking a choice or response and c = confidence interval.

Once n is decided, it is allocated to HEIs, recruiting agents, businesses and employees proportional to size. The sampling frame and the sample sizes generated by Equation 1.

4.2 Methods of Data Collection

The methods of data collection for the purpose of this research were questionnaires and interview. We used both open- and close-ended questions as well as an interview for collecting information from the targeted job-driven education system stakeholders.

a. Questionnaire

A questionnaire is a convenient means of gathering information. However, the structure of a questionnaire has utmost importance to ensure that reliable data are obtained in such a manner that the responses are interpretable and generalized. In line with this, four semi-structured questionnaires are prepared (see Appendices A). The questionnaires were completed and returned by all respondents.

b. Interview

Semi-structured interview was used to collect qualitative data from respondents. Interview questions are aimed to identify, explore and understand the viewpoint of the participants. It was conducted with purposively and conveniently chosen respondents. We reach out to the interviewees face to face, by email, and via a phone call on a one-to-one basis. The interview includes questions whose substance was almost identical to that of the questionnaire in order to increase the reliability of the results (see Appendix B and C). Besides, an interview guide was developed, so as know what to ask for, and in what order. A total of 10 key informants were interviewed. The aim of interviews is to gather data from key stakeholders, such as higher education institutions and businesses with firsthand knowledge.

4.3 Methods of Data Analysis

There are several common types of data analyses techniques, depending on the scope of a study and the kind of data. Quantitative analysis procedure was used for the close-ended questions of the questionnaire. For measure of central tendency, we used mean and for measure of variability we used standard deviation. Before processing the responses, the major activities were data preparation through editing, coding, and cleaning. Data was edited, coded, classified and tabulated with a view of reducing it to manageable proportions. Besides, we used narrative methods of data analysis to evaluate content from the interview and open-ended questions of the questionnaires.

4.4 Characteristics of the Respondents

Background information includes sex, age, academic status, experience, skill and attitude, department, perception regarding the survey domain and experience with framework solution. The responses are summarized in Table 4.1.

Table 4.1: Characteristics of Respondents

No.	Characteristics		Respondents									
			HEIs		Businesses		Recruiting agents		Employees		Total	
			F	%	F	%	F	%	F	%	F	%
1.	Sex	Male	8	80	12	67	7	78	13	72	40	73
		Female	2	20	6	33	2	22	5	28	15	27
2.	Age	Under 30	-	-	2	11	-	-	8	44	10	18
		30-39	3	30	5	28	3	33	7	39	18	33
		40-49	5	50	6	33	2	23	3	17	16	29
		50 or above	2	20	5	28	4	44	-	-	11	61
3.	Academic Status	Primary	-	-	2	11	1	11	-	-	3	5
		Secondary	-	-	3	17	2	23	-	-	5	9
		Bachelor	6	60	7	39	6	64	8	44	27	49
		Masters	4	40	6	33	-	-	10	66	20	36
		PhD	-	-	-	-	-	-	-	-	-	-
4.	Experience	< 5 years	1	10	6	33	6	64	5	28	18	33
		6-10 years	3	30	3	17	2	23	3	17	11	20
		11-15 years	6	60	9	50	1	11	10	55	26	47
		> 20 years	-	-	-	-	-	-	-	-	-	-
5.	Skill and attributes	Technical Skills	3	30	8	44	2	22	4	22	17	31
		Domain Skills	5	50	8	44	4	45	12	66	29	53

		<i>Respondents</i>										
		<i>HEIs</i>		Businesses		Recruiting agents		Employees		Total		
		Soft Skills	2	20	2	22	1	11	1	6	6	11
		Undermined	-		-	-	2	22	1	6	3	5
6.	Department	GM & Administration	-		11	61	6	67	-	-	17	31
		HR & finance	-		4	22	2	22	-	-	6	11
		Academician, research & devt	8	80	-	-	-		2	11	10	18
		ICT	2	20	2	11	-	-	5	28	9	16
		Others	-		1	6	1	11	11	61	13	24
7.	Perception regarding the survey domain	Have awareness	4	40	14	78	5	67	12	67	36	65
		Unaware	1	10	2	11	-	-	-	-	3	5
		Recognizing	3	30	1	5	3	33	5	28	12	22
		Undetermined	2	20	1	5	-	-	1	6	4	7
8.	Experience with framework solution	No Experience	-		4	22	1	11	7	39	12	22
		Some Experience	2	20	4	22	5	56	5	28	16	29
		Well Experienced	8	80	8	44	2	22	6	33	24	44
		Undetermined	-	-	2	12	1	11	-	-	3	5

As indicated in Table 4.2, 40 (73%) of the respondents were male and 15 (27%) were female. Regarding age of respondents, 62% are young and middle age adults. This implies that most of the respondents are active and concerned body to the current research topic. When we see the academic status of respondents, the majority of them possess bachelor and master's degrees, which can provide us appropriate information our research goal, while, 67% are found to be well experienced. In line with academic status, the skill and attributes of respondents were not as it is projected. In this regard, several of them possess technical skills, more have general than domain specific skills and some of them have soft skills, so in general respondents do not possess all the required skills. Most of the respondents are at management position. This indicates that they can affect the current system. Thus, our research findings can possibly be used in their work plan. In addition, academics, research and development and ICT professionals are at the second level in their number, which can provide us enough information in the system development questions. On the other hand, most of our respondents are aware of the current skill gap. So, almost everyone is an active participant in our study. Finally, most of the respondents had experience with framework solutions.

4.5 Quantitative Data Analysis

Quantitative analysis is the method of gathering and analyzing observable and verifiable statistics in order to explain actions and success [1]. It is the analysis of the situations by means of mathematical and statistical modeling. It is carried out by the compilation, classification and analysis of data and gives insight into what has occurred. Consequently, HEIs, businesses, recruiting agents and employees were asked to respond to their level of agreement to a set of dichotomous questions that ask for a Yes/No and agree/Disagree response. The responses are analyzed based on [85], scale that is, a yes or Agree answer to a question Q is equivalent to the assignment of the truth value true, whereas, No or Disagree is equivalent to the assignment of the truth value False. Furthermore, 1 will be used to denote a yes and agree response and 0 will denote a No and disagree response to our questions. Consequently, from the descriptive analysis methods frequency and percentage analyses are applied on the collected data.

a. The analysis of responses of HEIs

This section presents responses on close-ended questions of questionnaires by HEIs. The summary is presented in Table 4.2. Based on Table 4.2, we conclude the following.

- To some extent, curriculum and technical workshops are being developed with feedback from experienced professionals. However, it is important to find a way to fill this gap, as professional feedback should be the main input.
- Respondents confirm that the current education system is not in accordance with alternate working conditions. This may again be related to the initial findings. If we do not have easy access to the latest qualifications, the education system will fail to produce enough work-ready graduates.
- Education and training programs that are designed for line workers are recognized as necessary for the success of emerging developments in job. This is found to be a good strategy to cope with future changes in the workplace.
- HEIs were interested in incorporating related skills into their core curricula.
- There is less communication between businesses and HEIs. Therefore, it would be helpful to establish a system of communication between businesses and the HEIs about their recent skills needs.

Table 4.2: HEIs response on their role of producing competent and work-ready graduates

No.	Question	n_i	Options	f	%
1.	Curricula and technical workshops have been designed with feedback from experienced professionals	8	Yes	2	25
			No	6	75
2.	The current education system is producing well-prepared workers that are able to keep up in the race with changing work condition.	8	Yes	4	50
			No	4	50
3.	Education and training programs that are designed for line workers are recognized as necessary for the success of emerging developments in job.	8	Agree	6	75
			Disagree	2	25
4.	Your institution is beginning to understand the importance of incorporating relevant work skills to its core instructional curriculum.	8	Agree	8	100
			Disagree	-	-
5.	There is a system of communication with business about their latest skill requirement?	8	Agree	3	38
			Disagree	5	62

b. The analysis report of businesses

Table 4.3 presents responses to close-ended questions of questionnaires replied by businesses. Based on Table 4.3, we conclude the following.

- The majority of business respondents agreed on the conventional emphasis of science and high-quality academic instructions of the current education system of HEIs. This indicates a gap in higher education institutions which is reflected in their disagreement to item number 2 that the competency of employees in their business is not as they expected and they said currently there are low number of job-ready graduates.
- Business participants agreed on the importance of employees to learn certain skills that will increase their job opportunities. Therefore, we can see it's important for employees to acquire additional skills on top of their formal education. Consequently, it will have been better, if these skills were included in the curriculum of higher education institutions.
- They, to some extent, agreed their current employees to keep up with potential job demands in the future. Therefore, if there is cooperation between HEIs and businesses in academic training, graduates can be ready for work. This is confirmed by their response

to item number 5, in which they agreed on setting up a large number of education and skills development trainings to meet their future demand.

Table 4.3: *Businesses response about employee's competence and the future of education and training*

No.	Question	n_i	Options	F	%
1.	Instead of producing "work-ready" graduates, most HEIs retain a conventional emphasis on science and high-quality academic instruction.	15	Yes	10	67
			No	5	33
2.	You found the competency of employees in your business as you expected?	15	Yes	5	40
			No	9	60
3.	It is increasingly important for employees to learn certain skills that will increase their job opportunities.	15	Agree	12	80
			Disagree	3	20
4.	Are your current skilled employees able to keep up with potential job demands in the future?	15	Agree	8	53
			Disagree	7	47
5.	Do you agree that a greater variety of educational and skills-building trainings should be built to satisfy future demands?	15	Agree	13	87
			Disagree	2	13

c. The analysis report of recruiting agents

Table 4.4 presents responses to close-ended questions of questionnaires replied by recruiting agents. Based on Table 4.4, we conclude the following.

- Recruitment agents agree on employers' expectation of graduates to contribute value sooner than ever before. This indicates that almost all jobs in the business world are looking for competent graduates.
- We have ensured that employers require job-ready skills that are expected of graduates from the introductory stage.
- Proxy recruitment level assessment alone is not enough. This is because, in most industries, the skills required in both old and new professions are changing and transforming how and where people work.
- Recruitment agents agreed on the choice of employers to have relevant work experience

for their candidates. In order to achieve this, we understand that employers can provide their employees with relevant work experience through higher education institutions and businesses collaboration.

- They also agreed on the question of whether their recruitment process will help identify the skills of the employees so that, in the future, recruiting agents can be an important part of the effort to close the skill gap.

Table 4.4: *Recruiting Agents responses on their role, recruitment trends, and challenges*

No.	Question	n_i	Options	f	%
1.	Employers expect graduates to contribute value sooner than ever before	7	Agree	1	14
			Disagree	6	86
2.	There are work-ready skills that employers expect from entry level graduates	7	Yes	6	86
			No	1	14
3.	In most industries, the skill sets required both in old and new occupations is changing and transforming how and where people work	7	Agree	7	100
			Disagree	-	-
4.	Employers choose to have appropriate work experience for their candidates	7	Yes	5	71
			No	2	29
5	Your recruitment process helps in identifying skills of employees	7	Yes	4	57
			No	3	43

d. Analysis of responses to closed-ended questions by employees

Table 4.5 presents responses to close-ended questions of questionnaires replied by employees. Based on Table 4.5, we conclude the following.

- Before they decide to study, they are not looking for and choosing the courses and industry relationships of the educational institution of their choice. This can lead to a lack of practicality. As a result, it will be difficult for businesses to find employees with the skills needed for the job.
- Employees do not have all the necessary qualifications during their education and are not able to demonstrate appropriate job skills when applying for their first job. Therefore, there is a mismatch between what is offered in higher education institutions and what businesses want. This is confirmed on their responses on item 3, that

employees are facing problems at work due to lack of skills. As a result, employees have begun to develop a positive attitude towards learning for personal and professional development. Thus, if there is a functioning job-driven education system, employees will benefit in developing their professional skills. This can be easy if they take into account the latest business requirements while developing educational programs.

- The contribution of recruitment agents is agreed in facilitating the recruitment process.

Table 4.5: Employees' responses to their graduate level competency and the Recruitment Challenges

No.	Question	n_i	Options	f	%
1.	You use the institution's education and industry relations as a criterion for your choice before you decide to study in an educational institution?	15	Yes	9	60
			No	5	40
2.	At your point of applying for first job, you were able to enhance your CV and demonstrate relevant work skills	15	Yes	4	27
			No	11	73
3.	Have you ever faced any on-job problem as a result of skill shortage?	15	Yes	13	87
			No	2	13
4.	I created and maintained a positive attitude to learning both for personal and professional development?	15	Yes	10	67
			No	5	33
5.	Recruiting agents play a facilitative role in your recruitment process?	15	Yes	12	80
			No	3	20

4.6 Qualitative Data Analysis

In this Section, we present the analysis of responses from open-ended questions of the questionnaires and the interview response using narrative analysis. Tables 4.6 and 4.7 respectively present the summary of the: open-ended questions and Work-based Education.

4.6.1 Analysis of the Questionnaire Responses

Table 4.6: Summary of open-ended questions

<i>No.</i>	<i>Item</i>	<i>Respondents</i>	<i>Mean</i>	<i>Total Mean</i>
1.	You have a role to play in helping students acquire the knowledge and skills they need to succeed in HEIs.	HEIs	4.5	4.2
		Businesses	4.3	
		Recruiting agents	4	
		Employees	4	
2	Higher education institutions courses' content, distribution, or delivery will possibly change in the near future?	HEIs	3.5	3.3
		Businesses	3.33	
		Recruiting agents	3	
		Employees	3.33	
3.	The most important skills that are required to excel currently and in the future workforce are included in the current education system.	HEIs	4	2.5
		Businesses	2.33	
		Recruiting agents	2.5	
		Employees	2	
4.	A business requirement of employers has an effect on their ability to hire and attract staff?	HEIs	4	4.2
		Businesses	3.66	
		Recruiting agents	4.5	
		Employees	4.66	
5.	Higher education institutions and businesses need more cooperation for a functioning job and education system.	HEIs	4.5	4.7
		Businesses	4.66	
		Recruiting agents	5	
		Employees	4.66	

a. On the role to play in helping students acquire the knowledge and skills they need to succeed in HEIs

All participants agreed that their participation is beneficial for students to acquire sufficient knowledge and skills in higher education. At the same time, they believe that they should contribute. They have been conscious that their role can have an impact on students' performance so that, it is important to establish a mechanism for these stakeholders to work together.

b. On course content, distribution, or delivery to change in the near future

Higher education institutions agree that their course content and distribution may change in the near future. A third of the participants said it could happen to some extent. They said the reasons behind this level of agreement are that higher education institutions follow a rigid system and there

is lack of cooperation between stakeholders. Because everything in the 21st century is changing, there must be a system in place between HEIs and other stakeholders.

c. On the most important skills that are required to excel currently and in the future workforce are included in the current education system

Three fourth of the participants, except HEIs, disagree on the inclusion of skills that are required to excel in the current and future workforce. But HEIs agreed that most of the skill sets are included. However, total mean result confirms the weak support of the current education system, since a larger variety of education and skills-building programs need to be developed to satisfy increasing needs.

d. If business requirement of employers has an effect on their ability to hire and attract staff

HEIs and businesses agree on the list of the most important business requirements to maintain their workforce. Besides, recruitment agents and employees are among the participants who have a strong agreement, and according to them, the idea is one of the most important things that enhance the ability to hire that attract employees so that the secret to successful business can be its well-defined business requirement recruiting.

e. If HEIs and businesses need more cooperation for a better functioning job and education system

This question is responded with agreement by all respondents, which indicates a shared perception that HEIs and businesses speak different languages. The difference between the realms of education and industry is clarified by the absence of a participatory system of HEIs. Hence, strong collaboration between them is important and must be seen as leading to information and system establishment.

4.6.2 Analysis of the Interview Responses

The interview was designed to provide feedback on the current and future education system and was conducted on ten key informants. Participants were randomly selected HEIs, businesses, recruiting agents, and employees. Participants' responses are shown in Table 4.7 and is followed by discussions.

Table 4.7: Summary of Work-based Education

<i>No.</i>	<i>Item</i>	<i>Respondents</i>	<i>Mean</i>	<i>Total Mean</i>
1.	HEIs are producing work-ready graduates.	HEIs	4	2.9
		Businesses	2	
		Recruiting agents	3	
		Employees	3	
2.	Adequate workplace practice for students must be included in the curriculum.	HEIs	4	4.3
		Businesses	4	
		Recruiting agents	4	
		Employees	5	
3.	HEIs should include tailor-made study programs for businesses to further upgrade their employees.	HEIs	3.5	4.1
		Businesses	4.33	
		Recruiting agents	4.5	
		Employees	4	
4.	It would be useful for HEIs to be able to engage in business during the curriculum design process.	HEIs	3.5	3.9
		Businesses	4	
		Recruiting agents	3	
		Employees	4.5	
5.	You are committed to unemployment and job problems	HEIs	4	3.7
		Businesses	3.33	
		Recruiting agents	3	
		Employees	4.33	
6.	Do you believe that recruiting agents will help you find the right professionals for the job	HEIs	3	3.7
		Businesses	3.33	
		Recruiting agents	5	
		Employees	3.66	
7.	Data from HEIs, businesses, recruiting agents and employers is becoming an increasingly integral part of recruiting.	HEIs	2.5	3.5
		Businesses	3.66	
		Recruiting agents	4.5	
		Employees	3.33	
8.	There is no difference between the skills expected from employees and the skills employees actually possess.	HEIs	2.5	2.7
		Businesses	2.33	
		Recruiting agents	2.5	
		Employees	3.33	
9.	There are particular steps taken by the employees to resolve the capability deficit?	HEIs	2.5	3
		Businesses	2.66	
		Recruiting agents	3	

<i>No.</i>	<i>Item</i>	<i>Respondents</i>	<i>Mean</i>	<i>Total Mean</i>
		Employees	3.66	
10.	There is increased cooperation between HEIs, employers and other stakeholders towards bridging skill gaps.	HEIs	3	2.5
		Businesses	2.66	
		Recruiting agents	2	
		Employees	2.33	

a. If HEIs are producing work-ready graduates

- All HEIs in the interview agreed that they were producing job-ready graduates. However, businesses did not agree, and to some extent, recruitment agents and employees agreed. However, when we compare the results of the analysis, total mean result of all participants become 2.9. As a result, the belief of HEIs in the availability of job-ready graduates, is found to be true to some extent. Consequently, this is an indication of the existence of skill gap.

b. If adequate workplace practice for students should be included in the curriculum

- Almost all participants agree that adequate work experience for students in the workplace should be included in the curriculum. They said this is because it provides practical knowledge and skills needed to be successful in work and promote personal growth. This is a call for increased cooperation between businesses and HEIs.

c. If HEIs should include tailor-made study programs for businesses to further upgrade their employees

- All interviewees agreed on the need for business-oriented study programs to enable businesses to keep abreast of changing working conditions. This means that the education system is not producing enough graduates to keep up with the changing working conditions. Therefore, in the future, it will be necessary to develop a collaborative principle and system for the provision of educational materials that will be up-to-date and improve over time.

d. If it would be useful for HEIs to be able to engage businesses during the curriculum design process

- Most participants agree on the importance of engaging businesses during curriculum

design in HEIs.

e. If they are concerned about unemployment and job problems

- About half of the interviewees agreed on their commitment to tackling unemployment and job skills problems. Businesses and recruitment agencies, on the other hand, have to some extent accepted this obligation. This underscores the need to increase stakeholder awareness in an effort to close capacity gaps.

f. If they believe recruiting agents will help to find the right professional for a job

- One-fourth of the interview participants agree that recruitment agents can help find suitable professionals. In addition, two-quarters of the participants agreed, and the remaining one-fourth said it is true to some extent. Therefore, it can be concluded that recruiting agents should be an integral part of the job-driven education system.

g. If Data from HEIs, businesses, recruiting agents and employers are becoming an increasingly integral part of recruiting

- There is an agreement that data from HEIs, businesses, recruiting agents and employers is becoming an increasingly integral part of the recruiting process. In this regard, HEIs and employees need to understand the advantage of data-driven decision-making for recruiting so as to create a better interoperability among participants.

h. If there is no difference between the skills expected from employees and the skills employees actually possess

- Three-quarters of the respondents disagreed with the question of whether there was a difference between the expected skills of employees and the actual skills of the employees. This gap is caused by a mismatch between employer expectations and what HEIs are teaching. Therefore, it can be solved by working together.

i. If there are particular steps taken by employees to resolve the capability deficit

- Three-quarters of the respondents disagreed that some measures had been taken by employees to address the skill gaps. The remaining one-fourth of the employees agreed. This underscores the need to increase employee's effort by primarily participating in job-driven education system.

j. If there is cooperation between HEIs, employers, and other stakeholders towards bridging skill gaps

- Most interviewees do not agree on the current cooperation between HEIs, employers, and other stakeholders to address skill gaps. One-fourth of the HEIs agree to some extent. This calls for strong relationships and partnerships to be established between stakeholders for improving the situation. It is well known that this can benefit stakeholders. It has become a promising solution by deploying a collaborative system.

4.7 Summary

The findings in this chapter can be used as an indicator of the usefulness of blockchain-enabled Block-skill framework for a functioning job-driven education system. This allows the system to gain advantage of its unique bundle of Blockchain technology while making mutable blockchain data that follow the practices of the system. Besides, facilitate collaboration among stakeholders, so as to narrow skill gaps, since the nature of the work is changing rapidly due to new technologies and other factors and the competency of employees is evolving and employers are unable to hire well-trained and skilled workers due to skill changes over time. In addition, the analysis is useful to find out what each participant of the system is looking for that gives us an advantage to design details of our framework in a way that allows all stakeholders in job-driven education system participate in a decentralized and impartial way without any third-party control.

Chapter 5: Block-skill Framework for Job-driven Education System

The sample survey result validated our problem statement and it helped us to identify what is important to do for job-driven education system participants through gathering their opinions, comments, and feedback. Besides, it assists us to directly address topics of importance, rather than waste time and valuable resources on areas of little or no concern. Consequently, critical decisions about the specifics of job-driven education system are made based on the analysis result.

Block-skill framework is designed to bring into line blockchain's potential with the recognized requirement of job-driven education system. A comprehensive solution that can run the framework and develop specific decentralized applications without depending on intermediaries is designed and implemented. Each component of the framework is also developed considering the need identified by the analysis result. Altogether, the framework is believed to contribute in the effort of solving skill gaps by allowing development of job-driven education system application on secured infrastructure while permitting mutable Blockchain data.

This chapter is divided into three sections. The first section presents the design considerations in the development of the framework. The second section presents the details of the components of the proposed framework. The last section summarizes the chapter.

5.1 Design Considerations

We take the below listed design consideration while developing Block-skill Framework, smart contracts and Block-skill control panel so as to solve the identified gaps in the statement of the problem. Besides, we present how the considerations are reflected in the design.

- Simple and coherent modularized smart contract code to solve only Job-driven education system identified problems. So that, only necessary data is available in the smart contract.
- Job-driven education system data is separated into on-chain and off-chain. Such that state variables are designed to have efficient storage for the on-chain data. The off-chain data will be managed by the application to be developed.
- Since we are using Ethereum Blockchain facilities, we design our code to avoid Gas costly patterns during deployment and running.

- Our smart contract code is designed for provision for upgrade and improvement. This design feature is to be realized through:
 - Separating rules and logic from the data structure via keeping the smart contracts modular. So, if we need to change anything, only the relevant contract will be updated. There will also be no need for all contracts for the participants of the system to be revised.
 - A contract forward calls and data to the new contract version, that is to connect with changeable smart contract address, every time we deploy a smart contract in the Framework.
- Ability to read all previous data from a smart contract. That is to be able to insert new versions, while allowing reading from the old version.
- Smart contracts are deigned to handle interaction with other contracts, such as when new smart contracts are created.
- The smart contracts are designed to use less string data type and more int data type, since Ethereum Virtual Machine is a 256-bit processor and it is best suited for integer computations.
- We deign to use access modifiers that define accessibility rules. To ensure only appropriate authority is performing critical functions affecting any smart contract.
- We design to use secure hashing for protecting data.

The above design considerations of Block-skill framework focus on security of information, particularly integrity maintaining development strategy. Besides, the framework is designed, first to share files between system participants. Second, to allow collaborations for connected participant nodes. Third, it contractually obligates validators and block creators to do their job for overall system functioning with different privileges. On top of this, the modules are developed for facilitating application development, without a need to code each bit of functionality of the application from scratch.

5.2 The Proposed Framework

Our framework includes four main modules, where each module contains components and sub-components. The components and sub-components are intended for performing many of the needed functionalities and provide easy plugin systems for picking the tools desired at the time of specific application development as shown in Figure 5.1.

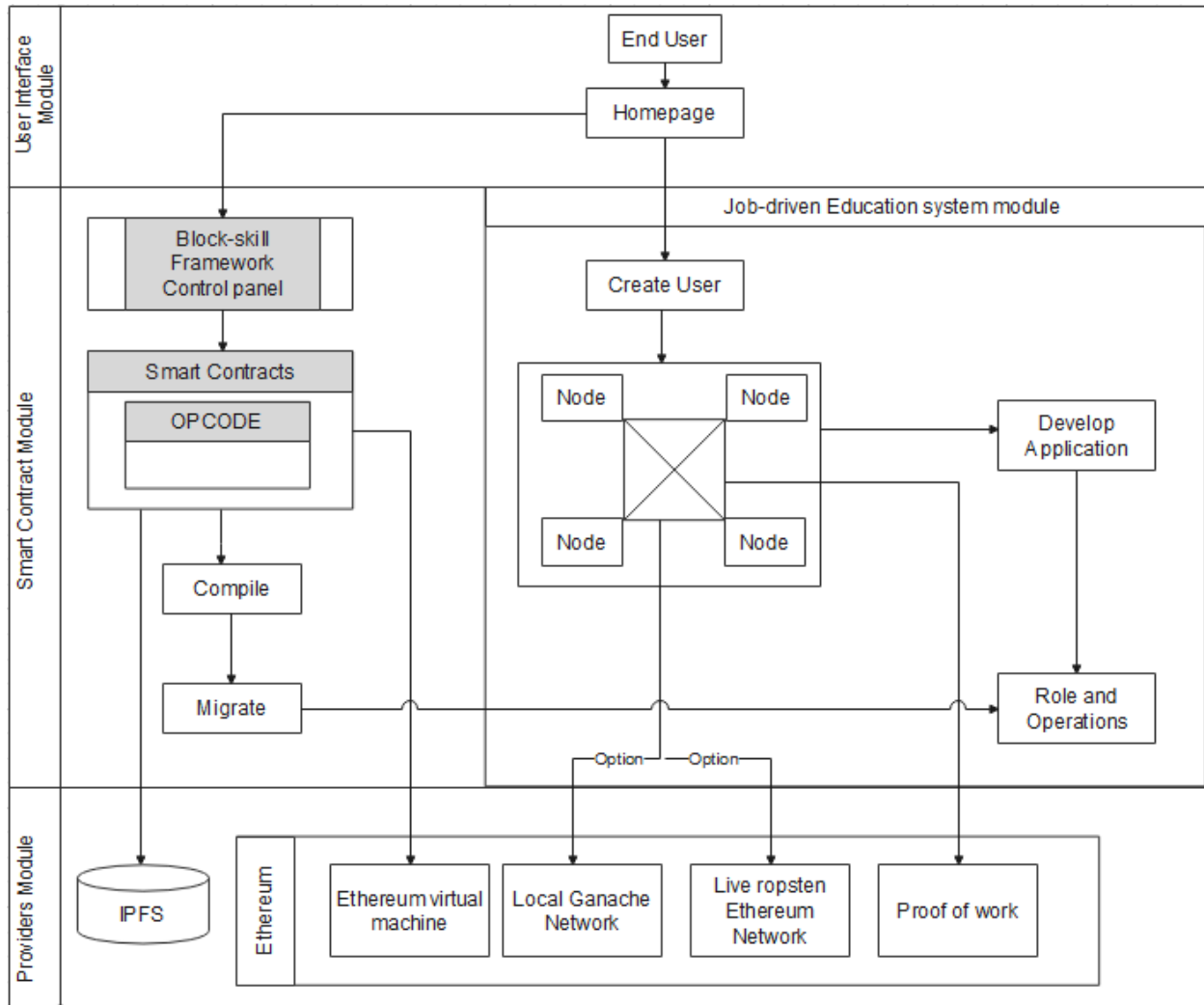


Figure 5.1: Block-Skill Framework Architecture

5.2.1 User Interface Module

The user interface offers an interface for the end user, which in turn Block-skill framework interacts with it. It is designed for versatile rendering of interfaces. Besides, it provides interface

for user to request a web server or Block-skill framework control panel, when will forward to sign up and sign in page. Sign up and sign in operations is conducted as it is presented below.

- During sign up the user is provided with a newly created wallet, which consists of private key and wallet address.
- The wallet is stored on the server side in a JSON encrypted file.
- The Wallet Password and Private Key will exist in job-driven application, where Wallet Password is the original password that the user enters during his/her sign-up.
- Wallet is encrypted in JSON format, where encryption of private key is done with SHA256, as it is shown in Algorithm 5.1.
- After signing in, browser session stores the users encrypted JSON downloading it from server.

Algorithm 5.1: CryptoJS.SHA256 encryption algorithm

Begin

```
<script src="crypto-js.min.js"></script>
function get_sha256(str, secret) {
    // calculate sha256
    var sha256 = CryptoJS.SHA256(str)
    sha256 = CryptoJS.enc.Base64.stringify(sha256);
    var digest = "SHA-256=" + sha256;
    // Get the format GMT format time
    var gmt_date = new Date().toGMTString();
    var qq = "x-date: " + gmt_date + "\ndigest: " + digest;
    // hmac_sha256 encryption
    var signature = CryptoJS.HmacSHA256(qq, secret);
    signature = CryptoJS.enc.Base64.stringify(signature);
    console.log(signature);
    return signature
}
get_sha256("Blockskill", "your secret")
```

End

5.2.2 Smart Contracts Module

This module is part of the entire Block-skill Framework module and is a fully autonomous module. Its status can be opened to other modules in Block-skill framework via the API. Figure 5.2 presented the components in smart contract module, and it consists of OPCODE and API.

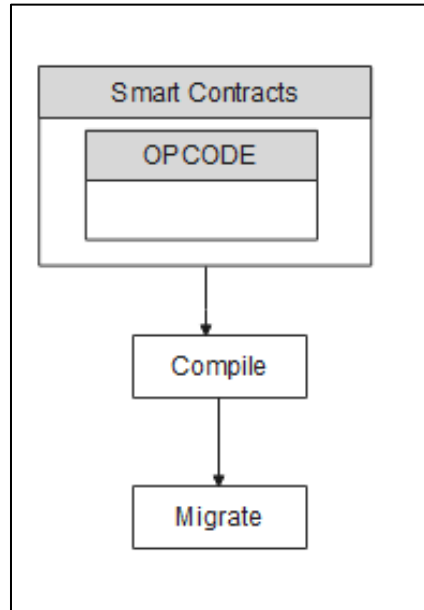


Figure 5.2: Smart Contract Module

A) Smart Contracts

Blockchain developers are very interested to implement smart contracts. However, emerging challenges, they are facing do not allow them to be used in a variety of contexts. In this regard, the gaps identified in this research work were incapability to modify on-chain block data and maintain integrity, while smart contracts have been deployed on blockchains. In addition, to develop an Ethereum blockchain based job-driven education system that stores and queries data through smart contracts. Consequently, what has been done as a solution to the identified gaps resulted in Block-skill Framework which consists of novel smart contracts, that has its own programmatic logic identified through the survey we conducted on stakeholders. Accordingly, four smart contracts are developed as a prototype. These are Business, Business requirement, Higher learning institutions and users' smart contracts. Figure 5.3 summarizes what we have done in this module.

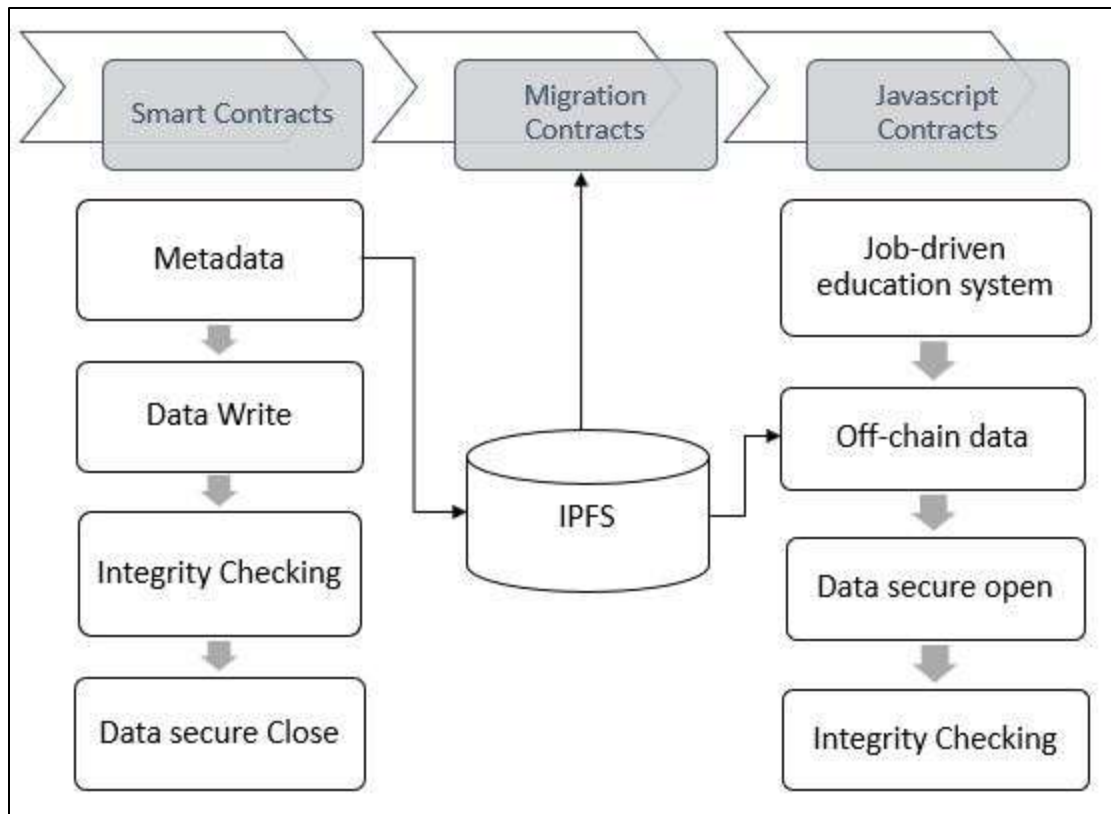


Figure 5.3: Newly added functionalities in the smart contract

i. Integrity checking function in smart contract

Block-skill framework allows for new smart contracts to be created in the Ethereum blockchains, creating a secure implementation environment that will maintain integrity. The developed new smart contract is suitable for job-driven education system applications where the most common blockchain functions are decentralization and immutability. This is especially true where information needs to be kept cryptographic integrity to allow participants to agree to use the smart contract and cooperate. In the survey result we obtained necessitated collaboration between job-driven education system participants for an information exchange, in such a way that any upcoming information change from any of the participants should be added as a new one and they need to track back all details and older information concerning a particular participant. So, in the Block-skill framework, the integrity in smart contracts is assured by:

- An integrity maintaining function on the developed smart contracts in order to ensure multiple peers executing on the same on-chain data and retain original as well as modified versions of data results are verified to be matched.

- Block-skill framework-based hash validation method. The created method is used to store actual data on IPFS. Consequently, IPFS is used to store data, and their hashed content identifier (CIDs), which is used to point to material in IPFS are referenced in a smart contract.

ii. OPCODE (operation codes)

An Ethereum smart contract code is written in a low-level, stacked byte code, called the Ethereum Virtual Machine code. The instructions for hexadecimal bytecode, which is readable to a human are called opcodes. Within the blockchain framework, smart contract opcodes are connected to receive a certain amount of Gas as a fee. Since it is important that the Gas reward be proportional to the required accounting resources in order to avoid incentives related to service attacks. In Ethereum, Etherscan API enables us to publish a smart contract source code in the form of an opcode. So, our smart contract implementation considers translation of the smart contract from its bytecode form into the opcode one.

B) API (Abstract Application Interface)

Block-skill Framework is integrated with a standard API in Node.js. In our Block-skill Framework architecture, we have a user that interacts with the job-driven education system that means the web-based frontend which then interacts with the backend APIs. The backend, then, on request interacts with the smart contract or blockchain through public nodes; these either run Node.js applications or the backend uses blockchain by directly running the Node.js software. Block-skill Framework by Node.js is integrated with API. In our blockchain framework architecture, we have a user interface that connects to job-driven education system, which means it interacts with web-based front-end and then with back-end APIs. The Backend, upon request, communicates with the smart contract(s) or Ethereum blockchain through public nodes.

C) Smart contract compilation and migration

Once we have written the smart contract, the next thing that is needed is to compile and migrate to the Ethereum network. This can be done in either local Ganache network or live Ethereum ropsten test Network. The process of compiling and migrating on both network options is the same. So that the compilation will result in bytecode. Then the Ethereum Virtual Machine parses the bytecode.

D) Block-skill Control Panel

This panel automates tasks to be undertaken by Block-skill framework. The tasks include starting web server, configure and start IPFS, starting local Ganache network and manipulate smart contract compilation and migration.

5.2.3 Job-driven Education System Module

The goal of this module is to create a decentralized system that can run autonomously and without any central authority regulating the Job-driven education system. Figure 5.4 presented Job-driven Education System Module. The system also encourages members to work together in a Job-driven education system.

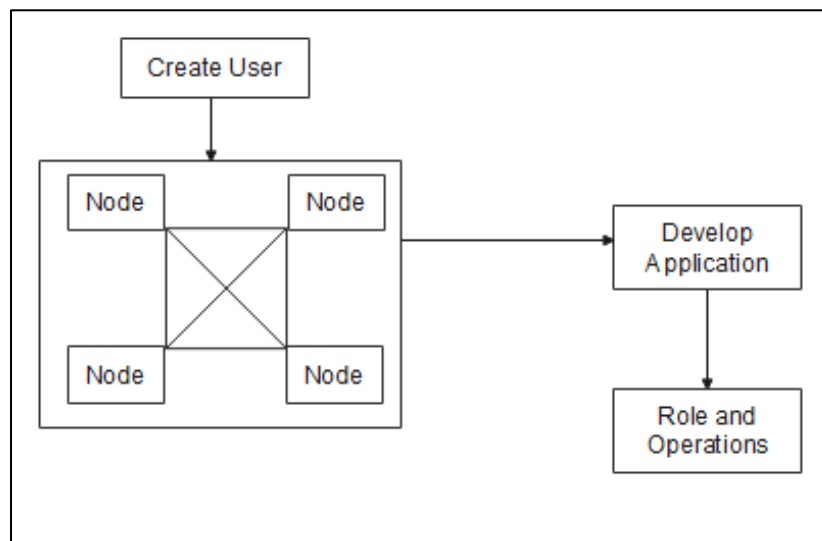


Figure 5.4: Job-driven Education System Module

A. Create a new user

The process for creating a new user in the Block-skill Framework is presented in this section. Accordingly, a user sends his/her request using Block-skill framework. A user ID is given, and a new blockchain address is created for the user with both public and private keys to identify the owner. A blockchain wallet is created and transferred to this new user so that each node can store it at the address of the blockchain. The created wallet address is then used to send and receive transactions linked to the user account. User IDs and private keys are stored securely in the wallet file. Users can securely view their logs and new transactions using their wallet interface, this presented in Algorithm 5.2.

Algorithm 5.2: Creating a new User

```
Input: user request  
Node N in the current network  
Output: A newly created user node  
Begin  
  (Kpub, Kpr) = generateKeys ()  
  createUserNodeID ();  
  createBlockchainAddress () + (Kpub, Kpr);  
  Safelystore (Uid, Kpr)  
  createBlockchainWallet () + (Kpub, Kpr);  
  for each n in N do  
    distributeWallet (n, Walt)  
  endfor  
  verifiedNewUserNode ();  
End
```

B) Connect users

Created users will connect with participants in job-driven education system using the Metamask plug-in and will then be given roles and privileges. The MetaMask plug-in is a script in our case built on a certified IPFS protocol. These scripts have zero privileges by default, but we requested various strong wallet APIs from the Metamask that we call the wallet API from the new API. The wallet API is an extension of the web3.currentProvider API, but with some extra features designed to facilitate some of our Job-driven education system cases.

C) Roles and Operations

This is the final component in the module that enable for the automation of the system's role by eliminating any third parties during the process and confirming the terms agreed upon on the smart contracts. This component creates a level of abstraction between the executing code and Block-Skill node. In order for an application to read blockchain data and send transactions to the network, it must connect to Block-Skill node. A Smart Contract-Based role and operation in Job-Driven Education System is presented in figure 5.5.

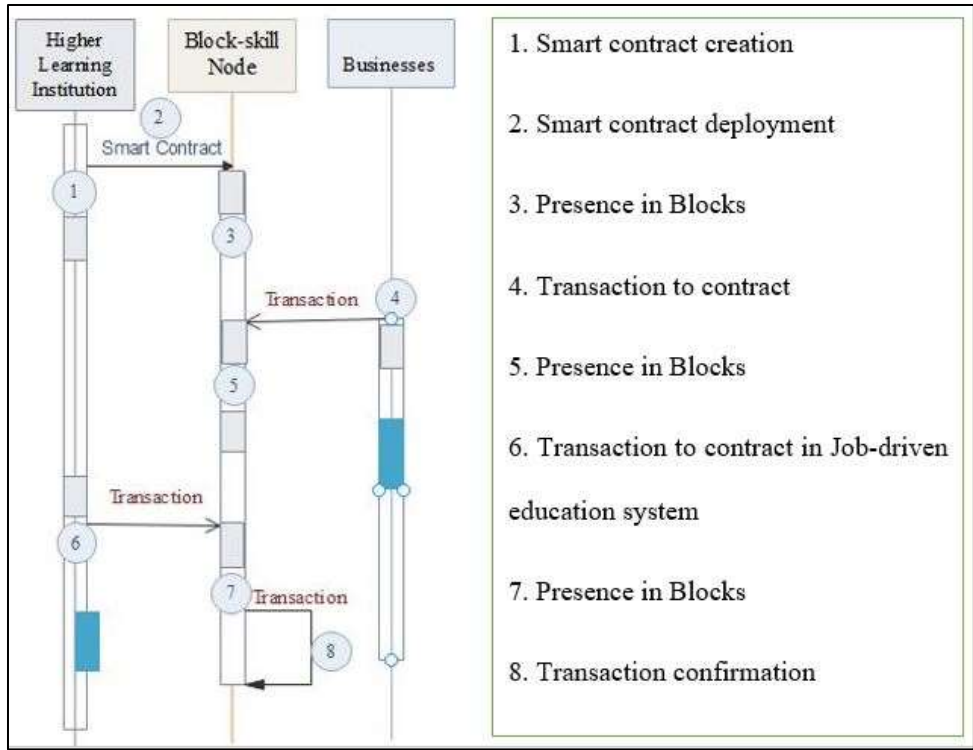


Figure 5.5: Smart Contract-Based Job-Driven Education System

5.2.5 Providers Module

This is module contains Storage and Network facility providers, as it is shown in figure 5.6

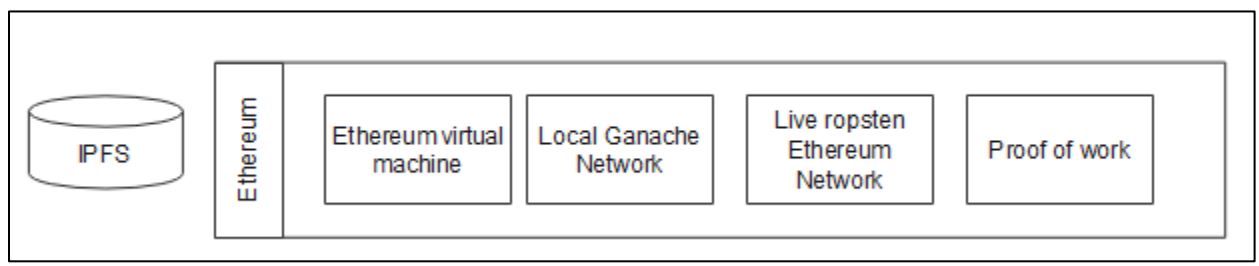


Figure 5.6: Provider Module

A. IPFS

IPFS is a peer-to-peer network storage facility. Content is open to peers around the world. It knows how to locate what is asked by using the content address rather than the location. It has a desktop application that provides a simple interface for adding, pinning, and sharing files. Besides, it lets us to send blocks we want and the blocks we request. Once those blocks arrive, we test their content to find CIDs and compare them to the CIDs we requested. This way, all the data in our system are sent to the IPFS and its hash values are stored on smart contracts.

B. Ethereum virtual machine (EVM)

The Turing complete calculation of the smart contracts are performed by this component. When the contract is deployed, the virtual machine loads the bytecode compiled in the contract code and runs the program according to the contract code. After fulfillment, the status of the entire contract storage changes and the hashes of these changes are retained in the chain. Each bytecode command that is implemented by a Ethereum virtual machine can charge a certain fee depending on the value of the measurement which is called Gas.

C. Local Ganache Network

Ganache CLI is used to simulate a fully functional blockchain network. It monitors the development of very simple and modern smart contracts and Ethereum based decentralized job-driven education system applications. Either using Block-skill framework control panel or the below command allows us to connect with the network.

First, run the truffle console ganache network in command prompt, second, migrate network ganache in command prompt and third, one by one get the latest address of each contract and put the address in their respective JavaScript file.

D. Live Ropsten Network

We deploy our smart contracts to live on the Ropsten network so that we can share our blockchain-based framework for job-driven education system with everyone. It allows us to test Block-skill framework in a live setting, but without the need for real Ether (ETH) and main-net 2KEY tokens. Ropsten is very similar to the main network because it uses the same Proof-of-work consensus algorithm.

E. Proof-of-Work Algorithm

In Block-skill framework, we adopted Ethereum blockchain distributed network of nodes. Consequently, for a given node to add a block to the blockchain, it must undergo the Ethereum proof of work algorithm process. This Algorithm has SHA256 hash function. This function takes an input that can be a string of text, bytes, any others and returns a fixed length value of 256 bits. The pseudocode of proof of work is shown in Algorithm 5.3.

Algorithm 5.3: Pseudocode of Proof of work Algorithm

Begin

Step 0: Concatenate block header data.

HeaderData = version + prevBlockHash + rootHash + time +
targetNumber +nonce.

Step 1: DoubleHash = SHA256_Of(SHA256_Of(HeaderData)): The header data is hashed twice with SHA256 hashing algorithm.

Step 2: ResultNumber = Number.from(DoubleHash): The 256 bits output is converted to a large integer value (BigInt value)

Step 3: Finally check if ResultNumber < targetNumber` If the condition yields true => we have found the right hash.

POW is complete, or else we increment the nonce integer and go back again to Step 0 until we find a result number that is smaller than the target number and this process can be repeated many times until the right hash is found.

End

5.3 Summary

In this chapter, we explained all components of Block-skill Framework for a mutable blockchain based data in case of job-driven education system. Every component in the Framework is described in detail including its operation and its focus on security of information, particularly integrity maintaining development strategy. In this regard, Block-skill framework allows Job-driven education system to create an independent, decentralized system that governs the education system. The framework also inspires participants of the system to work together without the intervention of third parties. Besides, it enables a file to be shared between stakeholder organizations and individuals. Second, it allows the intended collaboration between connected organizations and individuals. Further, system validators and block-creators are contractually obligated to do their job for overall system functioning with different privileges. Particularly, the developed smart contract and the framework can be used by businesses for submitting their business requirements to be reviewed, view security information of their submitted business requirement, and modify their business requirement. Higher learning institutions can review business requirements and view their revision. Businesses' job skill requirement will act as transactions mined as blocks are added to the longest chain.

Chapter 6: Prototype and evaluation

6.1 Overview

In this Chapter, first we describe the development environment and then the framework prototypes under two parts. On the first part, prototypes for Block-skill framework control panel, creating autonomous job-driven education system users as Blockchain nodes and connecting the created users without depending on intermediaries is simulated on local Ganache Ethereum network and it is presented with the support of screenshots. On the second part, prototype for the application development process of the framework is discussed with the support of screenshots based on the corresponding functionalities of the deployed smart contracts. Lastly, a brief usage scenario and its evaluation findings as well as summaries for the sections are presented.

6.2 Development Environment

Block-skill framework is built on Microsoft's Visual Studio code using web-based integrated development environment, which includes code editor, syntax highlighting, code completion and debugging. Besides, to develop the novel smart contracts, we have added Solidity plug-in on to visual studio code. Further, a collection of programming tools and procedures are used to create, run, test and debug the framework. The programming tools and procedures are arranged to provide application development with an organized interface and a convenient view. Our implementation uses the following software.

- JavaScript: On our Chrome's JavaScript engine, Node.js runtime is built, which uses a non-blocking input/output event-driven model. The package ecosystem of Node.js includes node package manager (NPM), which is used for downloading packages.
- Webpack: We used Webpack to bundle JavaScript files for browser use. Beside the plug-in interface inside the webpack is used.
- Truffle: It is used as an asset pipeline to Ethereum and for testing our framework.
- Ganache: blockchain server.
- Solidity: It is used to code the smart contracts.
- Web3j.js: It is a collection of libraries that enable us to communicate our web server with the local or remote Ethereum node.

- IPFS: It is used to create, connect to a group of nodes, stay connected to it, and reconnect to it. Besides, any application to be developed may peer embedded go-ipfs nodes with a set of services.
- Metamask: It is used as Ethereum Blockchain Wallet.

We developed four modules and a control panel, User interface module, Smart contracts module, Job-driven education system module, Block-skill framework control panel and Provider module. In the next section, we present system prototype, which demonstrates the Block-skill framework for a Mutable blockchain-based data: in case of a Job-driven education system.

6.3 Prototype

A prototype has been developed to implement the proposed Block-skill framework. It has the ability to develop job-driven education system applications using the Block-skills framework and has very limited interaction with users. Therefore, the system has user interfaces for all participants of the system using the Block-skill framework control panel as shown below.

6.3.1 Block-skill Control Panel

This panel, as it is shown in figure 6.1, automates tasks to be undertaken by Block-skill framework. The tasks include starting web server, configure and start IPFS, starting local Ganache network and manipulate smart contract compilation and migration.

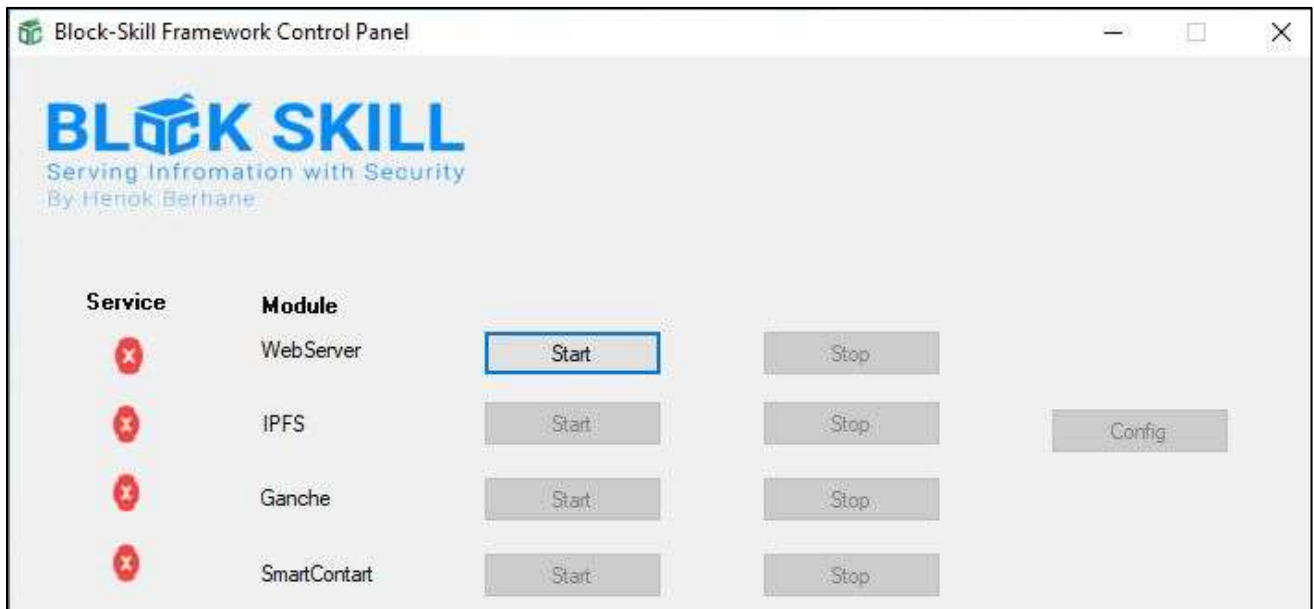


Figure 6.1: Block-skill control panel

6.3.2 Creating Users

The process of creating a new user within the Block-skill framework started with a user sending request to the blockchain framework. After this step a User ID will be issued by the system and a new blockchain address will be created, to identify the owner. Following, a blockchain wallet is created and passed to new user. Each node can store it at the blockchain address. It will be used later to send and receive transactions related to the user account as it is presented in figure 6.2.



The screenshot shows the 'Create User' page of the Block-skill Framework. The page has a teal sidebar on the left with the text 'Block-skill Framework' and 'A Blockchain based Job-driven education system'. Below this, there are links for 'Home' and 'Create User'. The main content area features the 'BLOCK SKILL' logo with the tagline 'Serving Information with Security'. The 'Create User' section includes a blue banner that reads 'To be part of Job driven education system'. There are three input fields: 'Full Name' with the value 'asd', 'Created as' with a dropdown menu set to 'Business', and 'Wallet Address' with the value '0xdc090667b0a12c92665361fef9b04a6066b'. At the bottom of the form are two buttons: a green 'Create' button and a grey 'Develop your Application' button.

Figure 6.2: *Creating User in Block-skill Framework*

6.3.3 Connecting Users

Connecting the created nodes without depending on intermediaries is simulated on local Ganache Ethereum network with metamask plug-in. Besides, Ganache is used for setting up Ethereum Blockchain and for testing our solidity Smart contracts as it is shown in figure 6.3.

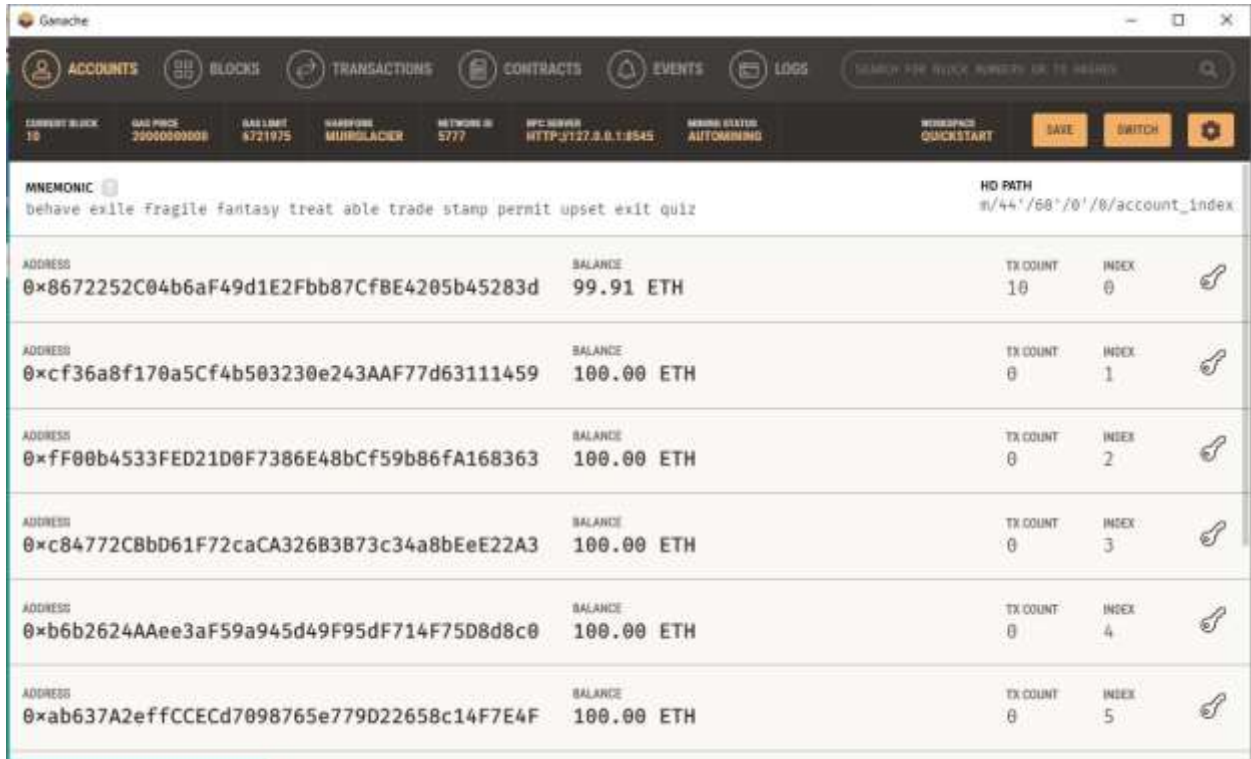


Figure 6.3: Local Ganache Ethereum Network

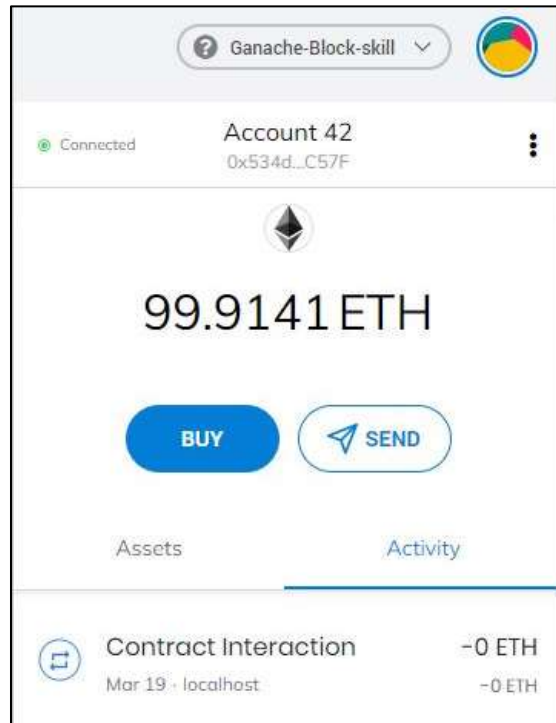


Figure 6.4: Metamask Plug-in for local Ganache network

6.3.4 Developing Application

Using Block-skill framework a decentralized and independent job-driven education system can be developed and run without the control of any central body. Below the prototype for the application development process of the framework is discussed with the support of screenshots based on the corresponding functionalities of the deployed smart contracts.

A. Smart contract deployment to Local Ganache Ethereum network

In block-skill framework, it is a precondition to deploy the smart contracts on the local Ganache network in order to make use of application functionality. The generated smart contracts' addresses are used inside JavaScript-contract libraries. The first few lines of smart contract deployment and then created Blocks and committed transactions are shown in Figure 6.5, 6.6 and 6.7 respectively.

```
Compiling your contracts...
=====
> Compiling.\contracts\Businesses. Sol
> Compiling.\contracts\Business requirements.sol
> Compiling.\contracts\Users. Sol
> Compiling.\contracts\Businesses. Sol
> Artifacts written to C:\Users\HENOBER\Desktop\BlockSR\src\SmartContract\build\contracts
> Compiled successfully using:
  - solc: 0.5.16+commit. 9c3226ce.Emscripten. clang
Starting migrations...
=====
> Network name: 'development'
> Network id: 5777
> Block gas limit: 6721975
l_initial_migration.js
=====
Replacing 'Migrations'
-----
```

Figure 6.5: Smart contract deployment

CURRENT BLOCK	GAS PRICE	GAS LIMIT	HARDWARE	NETWORK ID	RPC SERVER	MINING STATUS	WORKSPACE QUICKSTART	SAVE	SWITCH	
13	2000000000	6721975	MURGLACIER	5777	HTTP://127.0.0.1:8545	AUTOMINING				
BLOCK 8	MINED ON	2021-03-23 08:38:55				GAS USED	27363	1 TRANSACTION		
BLOCK 7	MINED ON	2021-03-23 08:38:55				GAS USED	1842784	1 TRANSACTION		
BLOCK 6	MINED ON	2021-03-23 08:38:54				GAS USED	27363	1 TRANSACTION		
BLOCK 5	MINED ON	2021-03-23 08:38:54				GAS USED	386585	1 TRANSACTION		
BLOCK 4	MINED ON	2021-03-23 08:38:53				GAS USED	27363	1 TRANSACTION		
BLOCK 3	MINED ON	2021-03-23 08:38:53				GAS USED	638578	1 TRANSACTION		
BLOCK 2	MINED ON	2021-03-23 08:38:53				GAS USED	42363	1 TRANSACTION		
BLOCK 1	MINED ON	2021-03-23 08:38:52				GAS USED	225237	1 TRANSACTION		
BLOCK 0	MINED ON	2021-03-23 08:28:43				GAS USED	0	NO TRANSACTIONS		

Figure 6.6: Created Blocks

TE HASH	FROM ADDRESS	TO CONTRACT ADDRESS	GAS USED	VALUE	CATEGORY
0x4c22ba3e5f095a6d1b774ea5d10f8eb48b10565c7240b05700aa650e4e62b267	0xb8a522389bd4b647bf368a4f40564212e2667719	0x09659cc255effcb1f66cb88f25dfcb46f80dc8f	27363	0	CONTRACT CALL
0xa3f86e58f3d3f19e7c26607428291adeb7caab8819a82c4e461740863edc4bb1	0xb8a522389bd4b647bf368a4f40564212e2667719	0x8a6029921ac1e5e2a6308a89b000f8c096fd32f7	386585	0	CONTRACT CREATION
0x38346f91b879edf35ea81b468b5bf047939d54a3636f6db7f1ac753f2d40a0fd	0xb8a522389bd4b647bf368a4f40564212e2667719	0x09659cc255effcb1f66cb88f25dfcb46f80dc8f	27363	0	CONTRACT CALL
0xc1df7986f717c556f18c55bbb3e4f6bb8f11cacdb5fc3b98264f70cb0bf7f5d	0xb8a522389bd4b647bf368a4f40564212e2667719	0x51f0732213c358d786f96b40a9ef70df57a2a826	638578	0	CONTRACT CREATION

Figure 6.7 Committed Transactions

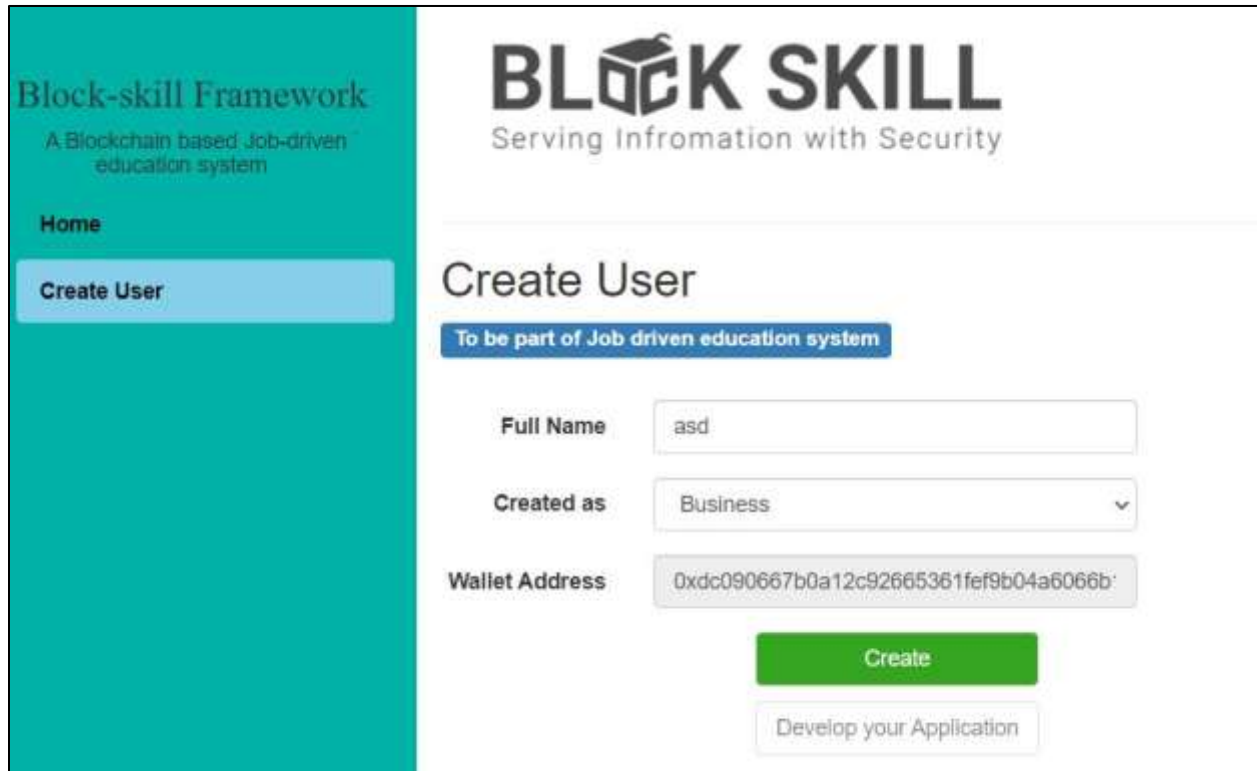
B. Data Integrity component in the smart contracts

The smart contracts are developed with major functionalities which include data integrity component over the inherent Blockchain security features. It achieves this feature by maintaining original and modified file histories as well as storing file hashes in it.

6.3.5 A brief usage scenario

The system prototype below demonstrates an application developed by higher learning institution for its collaboration with businesses. So that, new higher learning institution and/or businesses that want to take part in the system must first sign up and then sign in. When it gets verified, the user is requested to be created as either higher learning institutions or businesses node. Properly created nodes are then requested to be connected as peer network in either live Ethereum or local ganache network. When a user gets connected, in order to collaborate, it is required for an agreement over the smart contracts written for higher learning institution and business role and its operation. Such that we can:

A) Create Business user:



The screenshot shows the 'Create User' interface of the 'Block-skill Framework'. The left sidebar is teal and contains the text 'Block-skill Framework', 'A Blockchain based Job-driven education system', and navigation links for 'Home' and 'Create User'. The main content area has the 'BLOCK SKILL' logo and tagline 'Serving Information with Security'. Below the logo is a blue banner that reads 'To be part of Job driven education system'. The 'Create User' form includes three input fields: 'Full Name' with the value 'asd', 'Created as' with a dropdown menu set to 'Business', and 'Wallet Address' with the value '0xdc090667b0a12c92665361fef9b04a6066b'. At the bottom of the form are two buttons: a green 'Create' button and a grey 'Develop your Application' button.

Figure 6.8: Creating Business User

- **Submit Business requirements for Appraisal**

Businesses can upload and submit their Business requirements in word or Pdf formation for appraisal.

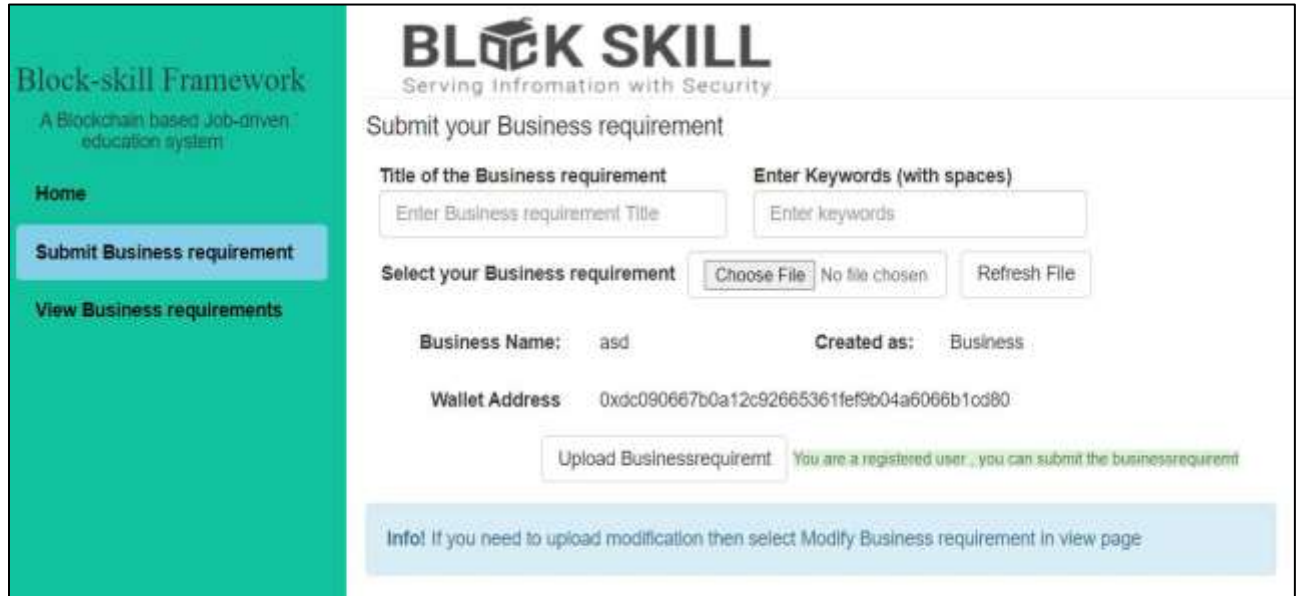


Figure 6.9: A Business submitting business requirements for Appraisal

- **View security information of their submitted business requirement**

Bussinesses can view their transaction ID, document ID as well as their bussiness requirement unique Id as their security information.



Figure 6.10: Security information of submitted business requirement

- View submitted business detail

Block-skill Framework
A Blockchain based Job-driven education system

Home

Submit Business requirement

View Business requirements

BLOCK SKILL
Serving Information with Security

Current user full name	Sarah Henock
User Role	Business
Current User wallet Address	0x42c2ee71667e800146d7574a0550776aa178f919
Total Submitted Business requirement(s)	1

Business requirement Name: Information Analyst

Keywords : info	Business Name :
Review Status : LATEST	Business AccountId :
Revision Version : 0	Reviewer : Higher learning NONE

Download Link: [Downloads Businessrequirement](#) [Modify Business requirement](#)

Figure 6.11: Details of Submitted business requirement

- Modify business requirement

Block-skill Framework
A Blockchain based Job-driven education system

Home

Submit a Modified Business requirement

View Business requirements

BLOCK SKILL
Serving Information with Security

Submit a Modified Business requirement

Title of the Business requirement
Enter Businessrequirement Title

Enter Keywords (with spaces)
Enter keywords

Select your business requirement No file chosen

Business Name: Abebe Tolosa **Registered as:** Business

Wallet Address 0x4d689c39c97a8d4c37cb22af457bc6fac0c61996

You are a registered user, you can submit the businessrequirement

Figure 6.12: A Business modifying business requirement

- View modified business requirement,

Block-skill Framework
A Blockchain based Job-driven education system

Home

Submit a Modified Business requirement

View Business requirements

BLOCK SKILL
Serving Information with Security

A Modified Business requirement is submitted

Your business requirement is uploaded successfully on the existing businessrequirement

The transaction id is : 0x4a81bc3a69f64899ac2e1e9dbfca7cf4087ed2eb87cfe56e9cae17f9162b18c
 Your document id is : QmVm8USDj7YHmpFHazARMMbgRUcHAYGpHuAgyMVGnFkqR
 Your businessrequirement Unique id is : QmVm8USDj7YHmpFHazARMMbgRUcHAYGpHuAgyMVGnFkqR

Figure 6.13: Details of modified business requirement

B) Higher learning institutions

- **Create Higher learning institution user**

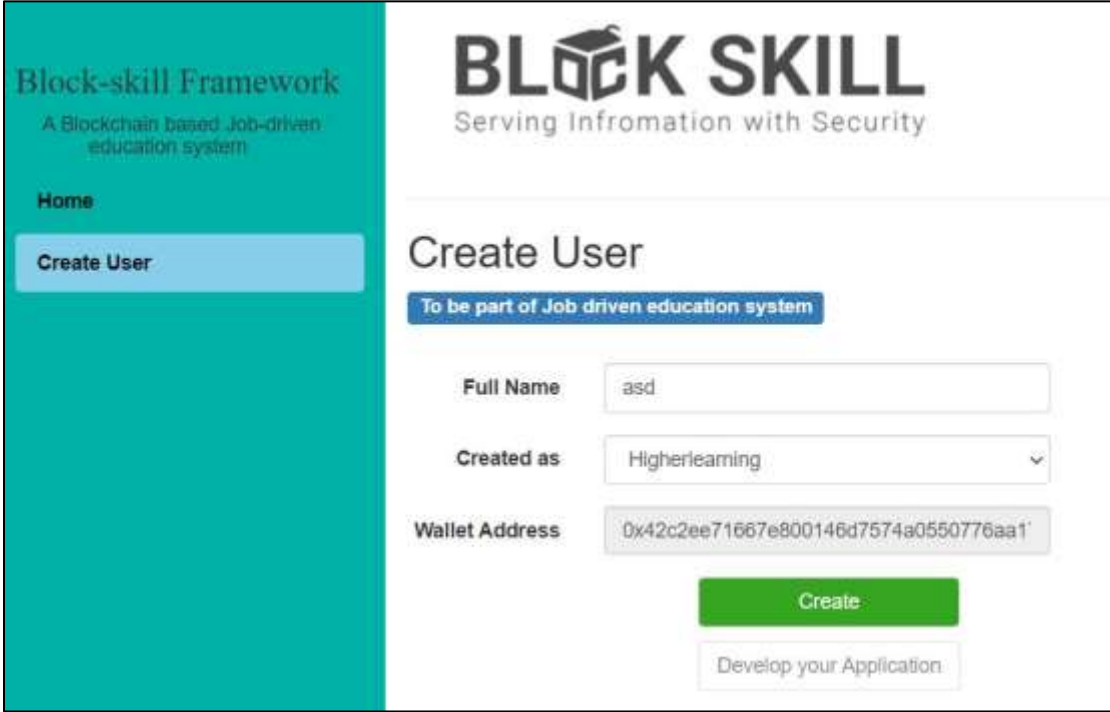


Figure 6.14: Creating higher learning institution user

- **Review business requirement**



Figure 6.15: Higher learning institution reviewing business requirement

- View their revision

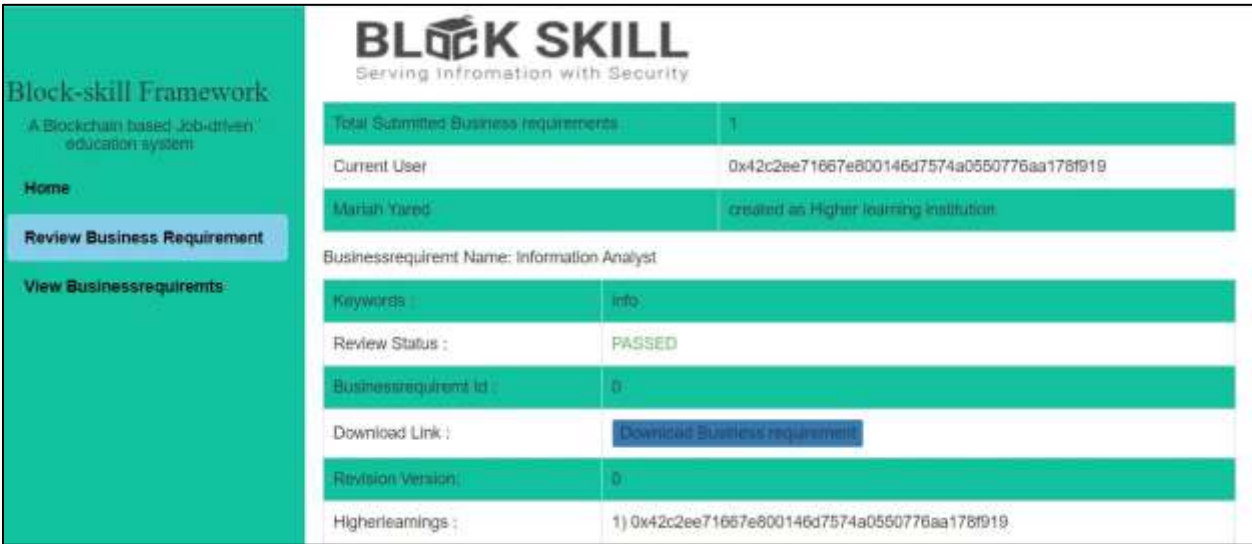


Figure 6.16: Higher learning institution viewing reviewed business requirement

- View details of their revision

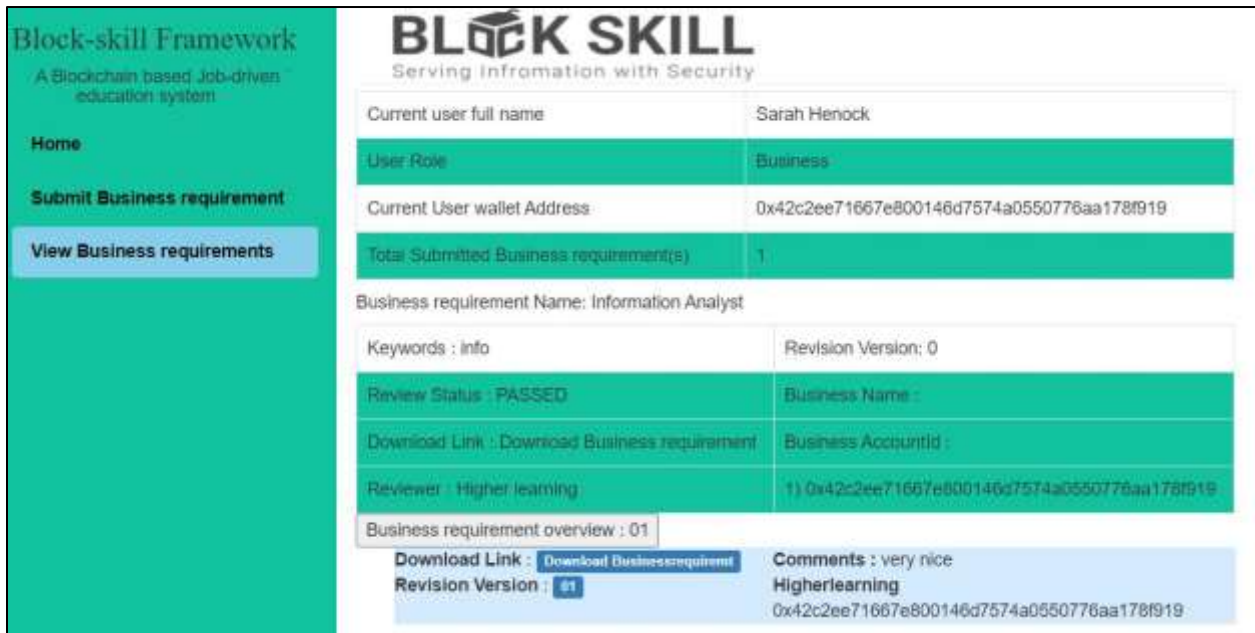


Figure 6.17: Higher learning institution viewing details of their revision

The comment or edited file of the higher learning institution is also sent to the IPFS and file hash and details of file revision is stored under the smart contract.

6.4 Evaluation

Once the prototype is developed, it is evaluated for the viability of the implemented Block-skill Framework. In this respect, we use a questionnaire to assess the general view point of users towards four main enquiries: Framework usefulness, Smart contract usefulness and the usefulness of the collaboration features as well as the general usability of the framework. We wanted to see if the framework would be useful and usable in general and to see if it would have significant contribution towards addressing skill gaps. Besides, a pre-Block-skill framework questionnaire was used to collect participants' demographic data, including their system usage experience. Totally 10 participants from higher learning institutions and businesses interacted with the prototype and performed job-driven education system operations using their privileges. Then they filled the questionnaire.

6.4.1 The Findings

A) Usefulness

This Evaluation finding helps us to measure the level to which Block-skill Framework helps a user to accomplish his or her goals and assesses the ability of the user in using the framework. In this regard, as it is depicted in Table 6.1, the majority of participants find the Block-skill Framework prototype useful in improving their understanding of job-driven education. They also have a strongly positive attitude toward the framework and smart contract usefulness as it is presented in Tables 6.1 and 6.2, respectively. In contrast, participants' responses to the usefulness of the collaboration features are less varied as it is presented in Table 6.3. Two underlying reasons have been recognized in this finding:

- 1) This variation in point of view is based on other external factors such as personal preferences. Hence, it is recommended to measure these external factors before involving job-driven education system participants.
- 2) This variation in point of view shows that although people like the Block-skill framework prototype and the smart contract usability, they need time to gain a better understanding of the collaboration features to really accept it.

Table 6.1: The Frequency table representing participants' responses to framework usefulness

Questions	Mean rating
Using the Framework, would contribute in the effort to bridge skill gap	80%
The Framework has nothing to do with job-driven education	20%
The Framework can conveniently provide the latest information that can be used in designing education programs	70%
Using the Framework has nothing to do with producing the current need of skilled-manpower	30%
I would find the framework useful in my job	70%

Table 6.2: The Frequency table representing participants' responses to Smart contract usefulness

Questions	Mean rating
Smart-Contract based role and operation is essential in the framework.	90%
Smart contract implemented in the framework can be a factor to lose the strengths of existing central authorization techniques.	20%
Smart contract in the framework offers immutable execution and record keeping.	80%
In a smart contract, terms and conditions are not correctly predefined and pre-embedded.	30%
In the framework no third parties are involved.	90%

Table 6.3: The Frequency table representing participants' responses to usefulness of the collaboration features

Question	Mean rating
The Framework involve higher learning institutions and Businesses	60%
The framework is not moving ahead smoothly and there are complications in collaboration	40%
The framework is effective in getting business requirement of businesses	70%
Higher learning institution's role is not appropriately implemented	30%
The framework can help identify various skills needs of businesses and can be an input for designing education programs	80%

B) Usability

Using this evaluation, we are able to measure the extent to which a Block-skill Framework can be used by specific users to achieve predefined goals in a specified context of use. In this regard, the questionnaire responses for the general Framework usability show that all participants were able to complete all the tasks without major difficulties on using Block-skill framework. The subjects' mean ratings on the general usability questions, based on a five-point Likert scale from "Disagree" (1) to "Strongly agree (5)," in the exit questionnaire are listed in Table 6.4.

Table 6.4: General Framework usability ratings

Questions	Mean
Overall, I am satisfied with how easy it is to use this framework	70%
I find this framework unnecessarily complex	20%
I thought this framework was easy to use	80%
I think that I would need assistance to be able to use this framework	20%
I found the various functions in this framework to be well integrated	60%
I thought there was a lot of inconsistency in the framework	10%
I would imagine most people would learn to use this Framework very quickly	80%
I find this framework inconvenient to use	10%
I felt very confident using this framework	60%
I had to learn a lot before I started going with this framework	30%

6.5 Summary

Block-skill framework prototype evaluation confirms the success of the new integrity assurance mechanism in smart contracts. Besides, it shows a blockchain-enabled Block-skill framework for a functioning job-driven education system is very useful in narrowing existing skill gaps. The framework is found to be useful, mainly because of its novel smart contract which supports collaboration without depending on third party. In this regard, the framework supports decentralized collaboration between job driven education system participants and is found to be acceptable. In addition, on the evaluation, Block-skill control panel, which is the major component of this system, is found to be easy to use. This is due to the provision of functionalities such as initiating web server, IPFS, Ganache and migrating and compiling smart contracts and others. However, based on the evaluation result, we need to improve the layout design of pages in the framework.

Chapter 7: Conclusion and Future work

7.1 Conclusions

In this thesis, we developed a Block-skill Framework, which is a comprehensive solution that can run the framework and develop specific decentralized job-driven education system applications. Smart contracts are becoming the main development components for the upcoming independently established blockchain based applications. Therefore, the framework implements our developed smart contracts to compensate role and operations of job-driven education participants. The Framework paves the way for additional smart contract development, which is a potential pioneering technology to revolutionize job-driven educations applications. Besides, as expressed by prototype evaluators, they were interested in the resulting Block-skill framework control panel which consists of a set of facilities that include running and stopping web-server, managing configurations, connecting with software, controlling, compiling and migrating smart contracts.

Block-skill Framework facilitates the implementation of a decentralized Job-driven education system applications. The facilities of the framework were first developed by studying the existing job and education system using questionnaires and interviews. The findings of the analysis were useful to find out what each participant of the system is looking for that gives us the chance to design each details of the framework. In this regard, the identified design issue was on security of information, particularly integrity maintaining development strategy. Besides, facilities are included to create users, then connect the users, then develops an application in secured infrastructure. The application can be prepared and processed independently without any central authority overseeing the system. Participants are then free to cooperate without relying on any third party.

The Framework is designed to brings into line blockchain potential with the recognized additional security requirement of job-driven education system. Blockchains have been planned to be immutable. If a block is written to a blockchain, it cannot be modified. However, Block-skill Framework uses the Smart contract for maintaining integrity of data. In such a way that, peers are controlled to execute on the same on-chain data and retain the original as well as the modified versions of data. Besides, hash verification method based on Block-skill framework is implemented, by storing actual data separated from the Blockchain. While their hashed Content Identifier are mentioned in the smart contract.

7.2 Contributions

- We developed smart contracts for job-driven education system.
- Block-skill Framework for the implementation of Blockchain-enabled Job-driven education system which enables modifying on-chain Blockchain data.
- New integrity assurance mechanism in smart contracts which is achieved through:
 - Multiple peers executing on the same on-chain data and retain the original as well as the modified versions of data.
- Survey result on real-world job-driven education system stakeholders.

7.3 Future Work

There are future works that follow from our Block-skill Framework for job-driven education system findings. The future works are due to limitations on the scope of our research and the expected ongoing progress in job and education system. Besides, important smart contract limitations concepts that have essential significance for future job-driven education system application are identified and discussed briefly.

- There is a gap in the facilities we used from providers, mainly associated with scale up to the level of whole country systems. So, how this framework can be applied to complex system structures.
- Further research is needed to determine relationship between smart contracts design and solving reentrancy attack, by taking attentions to external feeds from reliable sources.
- More research is needed to find out how Smart contracts use access modifiers that define accessibility rules. To ensure only appropriate authority is performing critical functions affecting any smart contract.

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Appendixes

Appendix A: Questionnaires

1. Questionnaire for Higher learning institutions on their role of producing competent and work-ready graduates

Dear Respondent;

Thank you for participating in this study. If you would like to tell us how you educate and fulfill general skill requirement as well as your plans of future education and training programs then please fill out the questionnaire below. Doing so will help us develop Block-Skill Framework for Job-driven education system.

Higher learning institution's current education system and your future education and training programs survey questions are meant to gain information from your institution about the education program you deliver. This study consists of 10 questions.

The questions ask for an information about:

- Your current education programs
- Your future education and training programs
- Any collaboration effort with businesses and other partners
- your beliefs and attitudes towards a system that workout between your institution and other stakeholders
- your institutional -assurance towards fulfilling current skill demands of the country

The questionnaire should be completed by you only.

- If you do not exactly know the answer, your best estimate will be sufficient for the purposes of the study.

Thank you for taking the time to complete this Questionnaire.

Part I Questions

- 1. Curricula and technical workshops have been designed with feedback from experienced professionals employed in a specialized area.
 Yes No
- 2. The current education system is producing well-prepared and capable graduates who can keep up with the ever-changing work environment.
 Agree Disagree
- 3. Higher Educational institutions, businesses and students collaborate on practice development skills.
 Yes No
- 4. Your institution is beginning to understand the importance of incorporating relevant work skills to its core instructional curriculum.
 Agree Disagree
- 5. There is a system of communication with business about their latest skill requirement?
 Yes No

Part II Questions

- 1. In what ways do you think that higher education institutions courses' content, distribution or delivery will possibly change in the near future?

- 2. If you have suggestions to equip graduates to compete in the world of work, please specify?

- 3. What are the most important skills that are required to excel currently and in the future workforce?

- 4. What is the effect of business requirement of employers on their ability to hire and attract staff?

- 5. What needs to be improved about the education and training system that you passed through?

2. Questionnaire for Businesses about employee's Competence and the future of education and training

Dear Respondent;

Thank you for participating in this study. If you would like to tell us what you think about employee's competence and your recommendation about future education and training programs, then please fill out the questionnaire below. Doing so will help us develop Block-Skill Framework for Job-driven education system.

Employee's competence and the future education and training programs survey questions are meant to gain information from Businesses on their work experience with employees and their opinion for the future education and training programs. This study consists of 10 questions.

The questions ask for information about:

- Your opinion on employee's competence
- Your viewpoint about causes of possible skill gaps.
- Your contribution towards building the competencies of employees
- Your collaboration with higher learning institution for preparing employees with all needed skill of your business.
- your recommendation about the future of skill and training programs
- The questionnaire should be completed by you only. It should take about 15 minutes to complete.
- If you do not exactly know the answer, your best estimate will be sufficient for the purposes of the study.

Thank you for taking the time to complete this Questionnaire.

Part I. Questions

1. Instead of producing work-ready graduates, most higher learning institutions retain a conventional emphasis on science and high-quality academic instruction.
 Agree Disagree
2. You found the competency of employees in your business as you expected?
 Yes No
3. It is increasingly important for employees to learn certain skills that will increase their job opportunities.
 Agree Disagree
4. Are your current skilled employees able to keep up with potential job demands in the future?
 Agree Disagree
5. Do you agree that a greater variety of educational and skills-building trainings should be built to satisfy future demands?
 Agree Disagree

Part II. Questions

1. In what ways do you think that higher education institutions courses' content, distribution or delivery will possibly change in the near future?

2. If you have suggestions to equip graduates to compete in the world of work, please specify?

3. What are the most important skills that are required to excel currently and in the future workforce?

4. What is the effect of business requirement of employers on their ability to hire and attract staff?

5. What needs to be improved about the education and training system that you passed through?

3. Questionnaires for Recruiting Agents on role, recruitment trends, and challenges

Dear Respondent;

Thank you for participating in this study. If you would like to tell us how you do your work and any problems you face around recruitment, please fill out the questionnaire below. Doing so will help us develop Block-Skill Framework for job-driven education system.

Recruiting agents work process and their role for jobseekers and employers survey questions are meant to gain information from recruiting agents about their step-by-step work procedures and how it can benefit jobseekers and employers. This study consists of 10 questions.

The questions ask for information about:

- Your recruitment processes
- Your candidate selection procedure
- Your job vacancy collection strategies
- Your job advertisement methods
- The problems around recruiting
- The questionnaire should be completed by you only. It should take about 15 minutes to complete.
- If you do not exactly know the answer, your best estimate will be sufficient for the purposes of the study.

Thank you for taking the time to complete this Questionnaire.

Part I. Questions

- 1. Employers expect graduates to contribute value sooner than ever before.
 Agree Disagree
- 2. There are work-ready skills that employers expect from entry level graduates.
 Yes No
- 3. In most industries, the skill sets required in both old and new occupations is changing and transforming how and where people work.
 Agree Disagree
- 4. Employers choose to have appropriate work experience for their candidates.
 Yes No
- 5. Your recruitment process helps in identifying skills of employees.
 Yes No

Part II. Questions

1. In what ways do you think that higher education institutions courses' content, distribution or delivery will possibly change in the near future?

2. If you have suggestions to equip graduates to compete in the world of work, please specify?

3. What are the most important skills that are required to excel currently and in the future workforce?

4. What is the effect of business requirement of employers on their ability to hire and attract staff?

5. What needs to be improved about the education and training system that you passed through?

4. Questionnaires for Employees for evaluating their graduate-level competency and their lifelong learning plan

Dear Participant;

Thank you for participating in this study. If you would like to tell us about the skill you obtained from higher learning institution study and challenges you face during recruitment, then please fill out the questionnaire below. Doing so will help us develop Block-Skill Framework for Job-driven education system.

The employees' skill competencies and their phase of recruitment survey questions are meant to gain information from Employees for the competencies they achieved from higher learning institutions and the recruitment process they passed. This study consists of 10 questions.

The questions ask for information about:

- Your initial education and growth in skills
- Your connection with recruitment agents
- Your job searching practices
- Your trust in the higher learning institution curriculum and training system
- Your insight towards building a system that work between you and higher learning institution, business and recruiting agencies.
- The questionnaire should be completed by you only. It should take about 15 minutes to complete.
- If you do not exactly know the answer, your best estimate will be sufficient for the purposes of the study.

Thank you for taking the time to complete this Questionnaire.

Part I Questions

- 1. Do you search for and make selections of institutions, courses and the industry connections they have before you decide to learn in a given institution?
 Yes No
- 2. At your point of applying for first job, you were able to enhance your CV and demonstrate relevant work skills.
 Yes No
- 3. Have you ever faced any on-job problem as a result of skill shortage?
 Yes No
- 4. I created and maintained a positive attitude to learning both for personal and professional development?
 Yes No
- 5. Recruiting agents play a facilitative role in your recruitment process?
 Yes No

Part II Questions

1. In what ways do you think that higher education institutions courses' content, distribution or delivery will possibly change in the near future?

2. If you have suggestions to equip graduates to compete in the world of work, please specify?

3. What are the most important skills that are required to excel currently and in the future workforce?

4. What is the effect of business requirement of employers on their ability to hire and attract staff?

5. What needs to be improved about the education and training system that you passed through?

Appendix B: DEMOGRAPHIC SURVEY

1. Please indicate your Gender

Male

Female

2. Please select the category that include your age

Under 30

40-49

30-39

50 or above

3. Academic status

Primary

Master's degree

Secondary

Phd or above

Bachelor degree

4. Experience

< 5 years

11-15 years

6-10 years

>20 years

5. Skill and attributes

Technical Skills

Soft Skills

Domain Skills

Undermined

6. Department

General management and
administration

Information communication
technology

Human resource and Finance

If Other, please specify?

Academician, Research and
Development

7. Perception regarding the survey domain

Have awareness

Recognizing

Unaware

Undermined

8. Experience with framework solutions

No experience

Some experience

Well experienced

Undermined

Appendix C: Interview Guide

Thanks for agreeing to be part of this interview.

The goal of this interview is to develop Block-Skill Framework for Job-driven education system. We will ask you questions and you will answer them, just like a regular survey. Nonetheless, our aim is to get a better understanding of the existing education and job system. After reacting to each question or a collection of questions, we are going to ask additional questions to explain how you came up with that answer.

Please bear in mind that we just want all of your thoughts and responses to be heard. We make the questions, but don't hesitate to say whether or not anything seems to be confusing, difficult to answer, or any other issues that can arise from the categories of questions.

We are going to take some notes, but we ask your permission to record your replies. All you're telling me is confidential and will be kept private. The information will be used only for the purpose of the research.

Organization

- Explanation to participants about the interview expectation
- Requesting permission for recording and taking notes
- Clarify the participants' rights,
- Develop a Participant Rapport
- Communication to follow-up with extra details
- Start with asking open questions in ways that encourage participants in their own words to elicit explanations.
- We make the interview more like a chat than an interview with respondents.
- We lead the conversation in order to obtain relevant information from a respondent.
- We encourage the interviewees to explore the same subjects, but the ways in which interviews unfold can vary.
- We formulate follow-up questions.

Tips

- We ask questions that does not provide alternatives for responding
- We ask open questions, rather than closed ones.
- We arrange the sequence questions from broad to narrow.
- We avoid asking questions that are multi-part.
- We ask one question at a time.

Length 15-20 minutes

Lists of questions and topics we hope to cover on the interview

Respondent's Age:

Respondent's age in completed years:

Respondent technical abilities

Respondent's educational attainment level:

Respondent's relevant experience:

Respondent's perception regarding the survey' domain knowledge:

Interview questions for HEIs, Businesses, Recruiting agents and Employees

1. HEIs are producing work-ready employees.
2. Work experience should be included in the business as part of the study program.
3. HEIs should include tailor-made study programs for businesses to further upgrade their employees.
4. It is helpful to involve businesses with higher education institutions curricula design.
5. You are committed to solving unemployment and job skills problems
6. Do you think that recruiting agents can help to find the right person for a job?
7. Data from HEIs, businesses, recruiting agents and employers is becoming an increasingly integral part of recruiting.
8. There is a difference between the skills expected from employees and the skills employees actually possess.
9. There are particular steps taken by the employees to resolve the capability deficit?
10. There is increased cooperation between HEIs, employers and other stakeholders towards bridging skill gaps.

Appendix D: Block-skill Framework prototype evaluation questions for higher learning institutions and businesses

Dear: -

Thank you for participating in this Evaluation. This Evaluation is about the viability of the implemented Block-skill Framework. For doing so, we prepare 15 questions:

A prototype in laptop is foreseen in the duration of the evaluation, so that your evaluation starts with interacting with the prototype and then performing job-driven education system operations using your privileges at least for 10 minutes. This part is used to collect information about:

- Framework usefulness,
- Smart contract usefulness
- The usefulness of the collaboration features
- The general usability of the framework.

We kindly request you to fill all parts of the questionnaire. So, that your response will be helpful to see if the framework would be useful and usable in general and to see if it would have significant contribution towards addressing skill gaps.

The questionnaire should be completed by you only. It should take about 20 minutes to complete.

Thank you for taking the time to complete this Questionnaire.

A) General Framework usefulness Questions

<i>General Framework usefulness Questions</i>			<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>		<i>NA</i>
1	Using the Framework, would contribute in the effort to bridge skill gap	Strongly Disagree							Strongly Agree
2	The Framework has nothing to do with job-driven education								
3	The Framework can conveniently provide the latest information that can be used in designing education programs								
4	Using the Framework has nothing to do with producing the current need of skilled-manpower								
5	I would find the framework useful in my job								

B) Smart contract usefulness questions

<i>Smart contract usefulness questions</i>			<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>		<i>NA</i>
1	Smart-Contract based role and operation is essential in the framework.	Strongly Disagree							Strongly Agree
2	Smart contract implemented in the framework can be a factor to lose the strengths of existing central authorization techniques.								
3	Smart contract in the framework offers immutable execution and record keeping.								
4	In a smart contract, terms and conditions are not correctly predefined and pre-embedded.								
5	In the framework no third parties involved.								

C) Collaboration features usefulness questions

<i>Collaboration features usefulness questions</i>		<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>		<i>NA</i>
1	The Framework involve higher learning institutions and Businesses	Strongly Disagree						Strongly Agree
2	The framework is not moving ahead smoothly and there are complications in collaboration							
3	The framework is effective in getting business requirement of businesses							
4	Higher learning institution's role is not appropriately implemented							
5	The framework can help identify various skills needs of businesses and can be an input for designing education programs							

D) Framework usability Questions

	<i>Framework usability questions</i>		<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>		<i>NA</i>
1	I think I want to use this framework.	Strongly Disagree							Strongly Agree
2	I find this framework unnecessarily complex								
3	I thought this framework was easy to use								
4	I think that I would need assistance to be able to use this framework								
5	I found the various functions in this framework to be well integrated								
6	I thought there was a lot of inconsistency in the framework								
7	I would imagine most people would learn to use this Framework very quickly								
8	I find this framework inconvenient to use								
9	I felt very confident using this framework								
10	I had to learn a lot before I started going with this framework								

Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all source of materials used for the thesis have been duly acknowledged.

Declared by:

Name: Henok Berhane Tadesse

Signature: _____

Date: _____

Confirmed by advisor:

Name: Mulugeta Libsie (PhD)

Signature: _____

Date: _____

Place and date of submission: Addis Ababa University, March 2021.