

# Blockchain for Controlling Hajj and Umrah Permits

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## Summary

Saudi Arabia is the home for annual Hajj and ongoing Umrah pilgrimages. About eight million people from nearly two hundred countries perform these pilgrimages. To perform hajj, it is mandatory for a pilgrim to acquire a valid permit. The hajj permits are regulated by the Hajj Ministry of Saudi Arabia. Foreign pilgrims also require a valid visa to travel to Saudi Arabia. Foreigners in these pilgrimages constitute more than eighty percent of all pilgrims. Due to high demand, there is a quota for each country and also a moratorium of five years for individuals to perform Hajj. Similar restrictions are also in place for Umrah pilgrims. To obtain a permit, a pilgrim must furnish a health certificate and meet other criteria. In the past some cases of fake permits have been caught; and so, preventing and controlling this activity is an immediate need for hajj management. In this paper we propose the use of modern technologies to control and manage permits and visas efficiently. In particular, we propose a system that would use the Blockchain technology and smart contract platform to better manage the Hajj and Umrah permits and visas grants which would also efficiently address the problems of fake documents. As Saudi Arabia Vision 2030 calls for increasing the number of pilgrims to thirty million, our research is a timely solution to combat the menace of fake documents.

## Key words:

*Blockchain, Hajj, Umrah, Smart Contract, Consensus, IoT, Pilgrims.*

## 1. Introduction

Hajj is an annual pilgrimage while Umrah (a lesser Hajj) can be performed at any time of the year. Both of these pilgrimages take place in Makkah (Mecca), Saudi Arabia. The Kingdom of Saudi Arabia (KSA) is well known for its fossil fuel and is the largest exporter in the world. The KSA has great infrastructure and has all the facilities, technologies and other features required for modern visitors. Like other countries, it is important for visitors to familiarize themselves with basic information in order to make their stay as pleasant as possible. The KSA government is adopting technology in order to provide high care services specifically for Hajj and Umrah pilgrims towards achieving its Vision 2030 [1][2][3]. It has the target to increase the number of Umrah pilgrims by 15 million within 2022, and 30 million by 2030. The projected number of Hajj pilgrims would be five million

by the year 2030 [4]. This will require an effective and reliable approach to facilitate the grant and delivery of the Hajj and Umrah Visas/Permits electronically. As a rule, every visitor to Saudi Arabia must apply for a business, work, short-stay, or resident visa. This can be done through various agencies approved by the Ministry of Foreign Affairs of KSA or directly by the Saudi Arabian Embassies and Consulates in various important cities across the world [5].

According to the report from Geronimo [10], in recent times, the Ministry of Communications and Information Technology (MCIT) of Saudi Arabia organized a Blockchain bootcamp in order to present the participants with information how Blockchain works from the perception of strategy and business, its enormous uses and attributes which makes positively powerful, unique, and disruptive technology. Blockchain is considered to be a groundbreaking system which has extreme potential to save cost and time. In order to attain its Vision 2030, aggressive steps are being taken by Saudi Arabia which primarily aims to diversify the economy and modernize the entire services. An exciting progress in this area is that Saudi Arabia is reportedly collaborating with United Arab Emirates in order to investigate the probability of making a digital currency which enables transactions across borders. These countries have understood the potential of Blockchain technology in making a fundamental change in the method of performing business transactions in the future [11]. So, this research is looking forward to using Blockchain technology and its smart contract platforms to manage Hajj and Umrah Visas/Permits assurance and verification, while protecting the Hajj and Umrah pilgrims from any attempts of Hajj and Umrah Visas/Permits scamming and fraud. Furthermore, the current study also discusses the Hajj and Umrah Visas/Permits validation that needs to be converted as a digital and automated process with little time for validation in the pilgrims' origin country in order to achieve Saudi Arabia Vision 2030 [1].

### 1.1 Hajj and Umrah

Hajj for Muslims is a compulsory religious duty which should be performed at least once in their life time. However, it is only obligatory for those who have financial and physical abilities to take the journey to perform the pilgrimage and can provide living expenses to their

families in their absence [12]. Although the Hajj activities span over five days, most foreign pilgrims end up staying in KSA for four to six weeks due to the shortage of travel means. The primary difference between Umrah and Hajj is their level of significance and the method of observance. The Hajj is carried out during 9-13 Dhul-Hijjah, an Islamic month. Umrah can be carried out at any time. However, they have some rites in common i.e., performing Umrah takes a much less amount of time whereas Hajj consumes more time and involves more rituals.

Pilgrims from different countries visit Mecca in order to fulfill their responsibilities. Based on the report [13], the number of pilgrims who travelled to Saudi Arabia to perform Hajj is mentioned in the Figure 1. It has been reported that about 1,752,014 pilgrims from outside KSA and 600,108 KSA citizens, which in total equates to 2,352,122, performed Hajj in the year 2017 [14]. Hajj is something related to social and religious significance [15]; hence the number of visitors in Hajj has increased in the recent years.

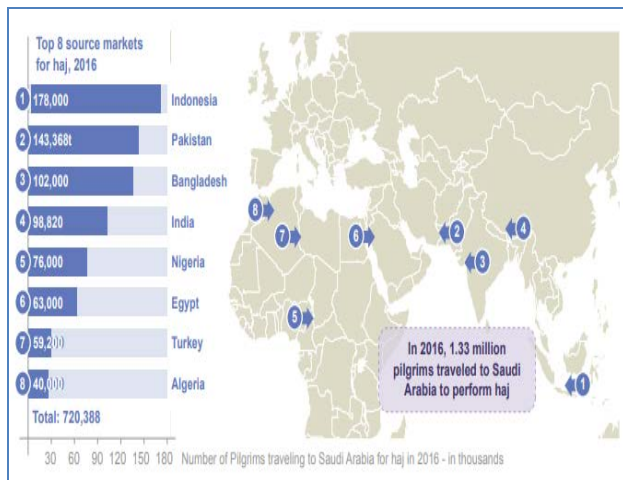


Figure 1

## 1.2 KSA Vision

With religious tourism remaining the key origin of non-oil revenue, many developments all over Makkah and Medina, another city associated with the Hajj journey, in the future will directly be connected with the objectives planned in Vision 2030, which involves plans to remarkably stimulate the number of pilgrims and also raise the appeal of the country as an extensive tourism destination. It has been reported that the Ministry of Hajj and Umrah of Saudi Arabia has signed a Memorandum of Understanding (MoU) in order to endorse Vision 2030 objective of the Kingdom of developing its volume for more than 30 million pilgrims with the help of intelligence resources and

tools, travel expertise and Agoda's technology, and marketing platform capabilities. As per the Saudi Vision 2030, which was declared in 2016, the previous decade has experienced an increase in the number of pilgrims and visitors of Umrah arriving to the country from abroad. The yearly pilgrimages have an important role in the tourism industry of Saudi Arabia with the government focusing on increasing this area by 15 million visitors of Umrah and Hajj yearly by 2020 and 30 million by 2030. Moreover, nowadays the government is looking to enlarge the Umrah pilgrim numbers significantly in order to consistently meet the Kingdom's annual goal of Vision 2030 to reach 15 million visitors within 2020 and 30 million within 2030 [16].

A comprehensive and strategic plan has been included in the Vision 2030 in order to progress the area to let a huge amount of Muslims to do Umrah and Hajj [17]. According to the aspirations of Vision 2030, the main aim of the government is to provide high-quality services for pilgrims and also be involved in the execution of the open skies policy at the seasons of Umrah and Hajj in order to provide accommodation for the rising number of pilgrims. Furthermore, it includes the attempts made to provide enhanced services which involve air transport for the pilgrims of Umrah and Hajj [18].

## 1.3 Smart Hajj

At present, Ministry of Hajj and Umrah in Saudi Arabia presented a video which displayed its smart vision of Hajj on how the pilgrimages are assisted using numerous technologies which include wireless earphones, contact less cards, and wireless wrist bands. This is the Fourth Industrial Revolution era (or IR 4.0 era) in which the cyber world becomes united with the physical world. Smart Hajj aims to offer peace of mind to their pilgrims throughout their journey while carrying out the Hajj rituals.

Those who have done their pilgrimage in Umrah or Hajj know the complexity when an enormous number of people gather in one place. There is difficulty experienced by the officials in handling the comfort of their pilgrims and keeping them safe and healthy. The KSA government initiated Smart Hajj so that these issues can be disabled. It is easy to wear and robust and facilitates Fitness, Safety, Health, and Peace of Mind.

## 2. Literature Review

In this section, we will give an overview of definitions and available literatures on Blockchain Technology and cases of Smart contract platforms uses. Also, we will give some related work and the initiatives of smart Hajj and Umrah management solutions.

## 2.1 The Definition of Blockchain

Blockchain is well known for its core technology of Bitcoin crypto currency [19]. It works as a Distributed Ledger Platform (DLP) which includes the principles of platforms and record of every transaction from the start. Immutability of the Blockchain is the most symbolizing property. All the blocks have a hash of the previous block. This forms a chain of block from the initial block to the present one [20]. This results in impossibility of it in changing the information which is already in chain since all the following blocks must also get redeveloped [20]. Furthermore, Blockchain is present in more access-controlled and limited variants which have the ability to get separated in completely private Blockchain and in consortium Blockchain [21]. As like Blockchain technology, even smart contracts are of extreme interest for the businesses. The Blockchain technology growth lets the businesses to develop decentralized models, starts latest approach for businesses in order to make agreements and manage the transactions. This recording and verification process is known as 'proof of work'. If the transaction produces more 'proof of work', then the transaction Blockchain will be more secure. It can also be said as, if the block chain is lengthier, then it is considered to be more reliable. Using cryptography lets the technology become more secure through providing immutability [22]. Blockchain has been described with many definitions. However, we can describe it as a digital ledger that is decentralized, which keeps the records of all the transactions either digital currency transaction bidirectional or smart contracts lifecycle in a chronological order and can be validated by Blockchain network members [23].

There are four types of Blockchain networks: Public, private and Federated/Consortium and Hybrid Blockchain. In each type of Blockchain network there are different permissions of viewing the transaction and validating it [24].

A public Blockchain contains members from anywhere and anytime from any device without any restriction. Any member is able to join the Blockchain network. In addition, every member has the same permission to verify the transaction by consensus algorithm, and to perform it on the digital ledgers. However, no one can view the transaction because each Blockchain member has a unique encryption key [25].

On the other hand, Private Blockchain network is designed to give some network members such as private organizations to have the privilege to join the network and validate the transactions through consensus algorithm. Private Blockchain have some advantages such as maintaining the privacy and quick transaction speed [26].

Third type of Blockchain network is Federated Blockchain, also named as Consortium Blockchain. It is designed to get the benefits over both public and private Blockchain networks. No member can join the Blockchain network without permission from specific members. Furthermore, the verification process privilege assigned to some members who perform the validation process through the consensus algorithm. However, the members in the integrated public Blockchain can have viewing permission [24].

The last type of Blockchain is the Hybrid Blockchain that has the advantage of both Public and private Blockchain. The Hybrid Blockchain members decide the authorization matrix once the network is built. Furthermore, it lists all tasks and transitions that are made in private or in public. The advantage of this type is providing a controlled network and gives the flexibility to change the authorization matrix any time. Furthermore, it can be used to communicate with public for some selected transactions [24].

## 2.2 Consensus

Blockchain technology gives high significance for consensus algorithm because the bitcoin purpose was to transmit the value in a distrusting, unregulated environment in which a definite way for validation of transaction was required.

Consensus is the process which is utilized by computer science for attaining the agreement over one data value within the distributed systems is called consensus algorithm. This algorithm is said to be the basis for every DAGs/Blockchains. Consensus algorithms are those that make every sequence of Blockchain consensus to be different from others. Enormous numbers of people were facilitated by the Blockchain network in the same place [25].

Consensus algorithms are a validation process inside the Blockchain network to ensure all the transactions are true and updated between Blockchain network members. There are different Consensus Algorithms which can be used: Proof-of-Work, Proof-of-Stake, Delegated Proof-of-Stake, Leased Proof-Of-Stake, Proof of Elapsed Time, Practical Byzantine Fault Tolerance, Simplified Byzantine Fault Tolerance, Delegated Byzantine Fault Tolerance, Directed Acyclic Graphs, Proof-of-Activity, Proof-of-Importance, Proof-of-Capacity, Proof-of-Burn and Proof-of-Weight [31]. Consensus algorithms are the process of decision-making for a group in which every person of the group supports and constructs the decision that does great work for the remaining individuals. It is a resolution type in which the people should assist the common decisions, whether they are okay with it or not [25].

The consensus algorithm aims to make sure that there is at least one transaction history and this history should not have contradictory or invalid transactions. For instance: none of the accounts should try to spend more than the money comprised in the account or to spend the similar token two times which is said to be double-spending. Table 2 shows the comparison within the different significant consensus algorithm. A brief introduction for several of them has been given below the authors referred by the readers to get more information [19] [26].

### 2.3 Smart Contract

Smart contract is a misleading name for something that is neither smart nor a contract in the usual sense of the word. In the confines of Blockchain, smart contract is simply logic that is published on a Blockchain, can respond and undertake like any address (transactions need specific arguments to function or may be rejected) and also act as a rigid agreement. Smart contracts are useful as they act as a “computerized transaction protocol that executes terms of a contract” [27] and was first named so by cryptographer Nick Szabo. Violation of such transactions are either implausible or costly as some part of the contracts can be included in the software and this feature is what lends it its name contracts in the full term and is also its basic idea. Smart contracts are often assumed to be similar to Ricardian contracts [28] which is the recording in digital form and connection to other systems of a contract at law. This is a common misconception of smart contract as they are in no way connected to outside systems or need to be legal in any such way.

Smart contracts to be truly called so must possess specific features as per the opinion of Szabo. Visibility, online enforceability, verifiability and privacy are some of these features. Visibility (or observability as Szabo prefers to call it) is the ability of participants in the contract to view each other’s performance in terms of the contract or be able to lay witness to the fulfilment of their own terms to other participants. It means laying bare all actions taken by logic in the contract; unlike a point of sale screen that although shows the amount to be paid by the customer, conveniently hides the fact that data is being saved from the credit card amounting a hidden action. Online enforceability means making sure that terms of a contract are executed. Proactive and reactive measures are the two categories of measures that can be made use of to achieve the enforceability task. Making it technically difficult to renege on terms or to allow either party to drop out of the contract in case of a valid breach on another part is revered to as a proactive measure. Reactive measures, on the other hand, discourage hostile behaviour by reputation or enforcement, and also getting back potential assets after

the contract has been breached. In case of a conflict, smart contracts need to be verifiable or auditable.

### 2.4 Related Works

In recent years, Blockchain has been one of the interesting subjects for researchers and developers to use the advantage if this technology for different purposes. It includes the benefit of Blockchain and presents some business and government use cases that are considered as successful stories.

One of the scientific papers is titled “Scripting smart contracts for distributed ledger technology” [29]. This paper described the different programming languages that are used to develop some Blockchain platforms such as Bitcoin and Ethereum and including technologies for verification. Also, the authors evaluated the Blockchain programming language and list some advantages and disadvantages of this programming language.

According to the scientific paper “SoK: Unraveling Bitcoin Smart Contracts” [30], the authors describe bitcoin that uses Blockchain network, its transactions, scripts, and transaction signatures. Furthermore, they presented an explanation of smart contracts on bitcoin. Also, they listed some of research challenges and perspectives such as the operation limitation of Bitcoin scripting language and disabled opcodes without clear justification and the complexity of modelling Bitcoin smart contracts.

In the scientific paper “A Semantic Framework for the Security Analysis of Ethereum Smart Contracts” [31] the authors identify the smart contract overview that is used during financial transactions without needing any third party. As per the authors, this might lead to vulnerabilities that can be used by attackers to perform critical attacks. In the same paper, some recommendations and guidelines were made to develop the smart contract platform that works in Blockchain in a secure way by using multiple security properties such as call integrity and atomicity.

On an International conference, “The All-Pervasiveness of the Blockchain Technology” [32] is a paper that presented an explanation of the Blockchain technology from the concept perspective. Furthermore, it showed all the Blockchain generations that started with Blockchain 1.0 that was built for digital currency. Then Blockchain 2.0 in 2015 to introduce the smart contract platforms. The last Blockchain version as per the paper is Blockchain 3.0 that was developed to integrate the Blockchain technology with internet of things (IoT) and can be interacted with Machine to Machine (M2M). At the end, the authors listed security concerns that can destroy the Blockchain network such as “51% attack”, which is also called double-spend attack when more than 51% of the hash rate is controlled by a single node. Another type of attack is the double-spending attacks that are performed to make multiple transactions

with a small difference in time. The authors presented the prevention control against these types of security attacks by adding complex mathematical problem to be solved at the transaction verification phase which is called "Mining". According to the scientific paper "An Exploratory Analysis of Blockchain: Applications, Security, and Related Issues"[33], two researchers analyzed the Blockchain technology, its advantages, its applications and the involved security concerns and issues with this technology. As per the authors, the Blockchain is a distributed and decentralized solution for data management that uses cryptography with hashing algorithm to maintain integrity. Also, it uses consensus to provide the reliability to the transaction/block. The authors described details for the transitions/block built mechanism in the Blockchain network and ledger which are stored as blocks with a new hash value and connected to previous blocks through its hash value. This can be done by calculating the new hash value of the new block using the hash value of the previous one. The authors listed some of the current Blockchain application such as "Learning is earning" which is a smart contract that is used in the education fields. In addition, Bitcoin as another Blockchain application that is used financially as a digital currency. Furthermore, Internet of things devices' data access can be controlled by smart contract platform that is running on the Blockchain technology. FollowMyVote is another Blockchain application that provides one time voting by each user that cannot be changed using the advantage of the immutable feature of the block chain technology. In the same paper, the Blockchain related issue is one of the researchers' concerns. One of these issues is the scalability as the Blockchain might need more computer resources and bandwidth to handle the block/transactions distributed in the Blockchain network. Another concern is the throughput of transactions as only seven transactions per second can be done in Bitcoin. So, in case of the number of transactions increasing, the throughput of transactions will be an issue and lead to unsuitable performance. Privacy is another concern as it is not completely maintained as all transaction are distributed and updated to all Blockchain members so it will be visible and seen. Security issues can be considered as a big impact source that one of its example is the 51% attack, which is described as a Blockchain node having full control of the majority of the Blockchain network's mining hash rate that will give an advantage to manipulate the Blockchain network. Other types of attacks have been listed such as DAO attack, BGP hijacking attack, and Eclipse attack.

In the Article titled "Hybrid Blockchain- the Best of Both Worlds" [24], the author presents all Blockchain types that are: Public, Private, Hybrid and Federated. As per the author, Public Blockchain is designed for anyone to join and participate in the Blockchain network. Private

Blockchain is designed to allow specific members to join and perform any transaction as per the authority of who is managing the Blockchain network. The third type is Hybrid Blockchain that can take the advantage of both public and private Blockchain as its members can assign different authorization to the members such as the members who have the ability to make the transaction either in the private or public network. The last type is Federated/Consortium Blockchain which has different consensus processes to be used and managed by selected node "authority" while public members can join the Blockchain network and have some tasks as per the authority of the Blockchain.

## 2.5 KSA Vision 2030 and Smart Hajj and Umrah Management initiatives

Saudi Arabia has put in its objectives and prioritizes it to serve the Hajj and Umrah pilgrims and treat them as its guests. Saudi Arabia included in its Vision 2030 [1] to provide maximum care to Hajj and Umrah pilgrims with support of digital solutions to achieve that. As the Ministry of Hajj and Umrah announced that it is adopting technology to transfer the whole cycle of Hajj and Umrah management process to be digitized and will call it Smart Hajj and Umrah [2][3].

There is an initiative to use the Blockchain technology to manage the Hajj and Umrah. This was planned during the partnership agreement between Augmate company and Salam Technologies who signed a partnership to provide Hajj and Umrah solutions based on Blockchain technology, distributed ledger and IoT. However, no more information is presented for which approach they intend to use [34].

The effort taken by the ministry helps to provide support for the journeys of the pilgrims and reduces the pre-planning. The Kingdom believes that it can attract over 30 million Umrah pilgrims under Vision 2030 and offer them high-quality services.

Saudi Arabia demands the use of ICT and digitalization to increase the implementation of the plans and programs envisioned in the blueprint of Vision 2030 and drive social and economic development, improve national security and support good governance. ICT can accelerate, enable, and facilitate the change envisaged through the initiative of Vision 2030. If the given initiative is executed with enough diligence, Saudi Arabia is predicted to have a bright domestic IT industry by 2030. Some of the other major objectives of Vision 2030 are given below; raise 3.8% of foreign direct investment to 5.7% of GDP in order with more advanced economies; increase the efficiency and effectiveness of the government and enhance the rank of Saudi Arabia in the Government Effectiveness Index issued by the World Bank and enhance the ranks of Saudi Arabia on the annual Global Competitive Index announced

by the World Economic Forum (WEF). These objectives can be accomplished using numerous executive programs that are outlined in the blueprint of Vision 2030 [35].

On 26 July 2018, the Ministry of Communication and Information Technology launched the latest initiative called “Smart Hajj”. This initiative involves the digital services and many vital interactive applications which help the pilgrims to perform the Hajj pilgrimage rituals. It further provides health applications, guidelines, and technical guides along with many government applications which help the Umrah and Hajj pilgrims in Mecca and Madinah. The ministry reported that this initiative was introduced to publicize the beginning of the new stage in the digital change under Vision 2030 of Saudi Arabia. It is worth highlighting the Kingdom as a mass of Muslims’ Qiblah, lying in the heart of the Islamic and Arab digital world and showing a strategic intensity for the Islamic and Arab worlds which demands harnessing the entire potential and efforts to help the Hajj pilgrims and offer them an experience with all comforts. The press release revealed that the Ministry had confirmed all the preparations which also includes the best set of infrastructure to exploit its abilities of providing services to the pilgrims [36].

Vision 2030 is considered as the roadmap and methodology for developmental and economic action in the KSA. In order to give the Kingdom a top rank in all sectors, Vision 2030 must recognize the general policies, directions, objectives and goals of the Kingdom. The council of Ministers assigned the council of economic and developmental affairs to monitor and establish the essential measures and mechanism in order to execute Vision 2030. This initiative includes many domains like commitments, outcome-oriented indicators, strategic objectives, and targets that are accomplished through nonprofit, public and private sectors. An integrated and effective governance model was established by The Council of Economic and Development Affairs, aiming to interpret the Vision into different execution programs which will achieve its directions and goals. These programs will depend on the latest operating models which were modified according to the needs of every program and also the general national goals associated with the Vision. Consequentially, the programs will be initiated as per the needs of Vision 2030. The National Transformation Program 2020 was introduced throughout 24 government bodies which operate in the economic and development field in its initial year for developing the institutional capabilities and capacity required for accomplishing the ambitious aim of “Saudi Arabia’s Vision 2030”. The National Transformation Program was established in order to help achieve “Saudi Arabia’s Vision 2030” and also for recognizing the problems experienced by the government bodies in the economic and development field. For improving the transparency level according to the Vision

2030, make sure to follow-up on development of initiatives, and recognize the gaps rapidly, an integrated performance-measurement dashboard was made including all the indicators, targets, and goals of the every entity [37].

### 3. System Requirements and Design

#### 3.1 System Requirements

The current requirements are designed to work on Blockchain technology and smart contracts platform for Visa issuance and verification and support the Saudi Arabia initiatives to enhance the Hajj and Umrah pilgrims experience [1], such as speed up the verification process in the immigration centers either inside or outside Saudi Arabia. In addition, protect the Hajj and Umrah pilgrims and immigration clearance staffs from visa scam attempts. Furthermore, the System should be a support to join all the pilgrims, Hajj and Umrah agencies, immigration clearance centers and the Hajj and Umrah representative in all the countries. In addition, the System should give Hajj and Umrah representatives, such as Hajj and Umrah ministries, the authority to set the Blockchain functions. Also, allow the Hajj and Umrah agencies to issue the Hajj and Umrah visas to pilgrims. Furthermore, the visas verification should be automated and use the consensus methodology in the smart contract that will reject any wrong transaction or record the right transaction to the distributed ledger and distribute it to the private Blockchain members. In addition, allow the pilgrims in the Public Blockchain members to view and validate their Hajj and Umrah visas. Also, give immigration clearance and the ability to verify the visas if needed. At the end, the pilgrims’ privacy should be maintained.

#### 3.2 System Design

We are looking to manage properly the Hajj and Umrah visas issuance and verification using Blockchain technology. In addition, we will use the smart contract platform that will be running in the Blockchain network. But which Blockchain network type will be used? First of all, although there are some advantages of public Blockchain such as autonomy, transparency, availability, Mined and Immutability; there are some disadvantages such as the needs of a lot of resources to validate the Blockchain transactions means high transaction costs. Furthermore, the speed of validation is a bit long - ten transactions per second [13]. On another hand, Private Blockchain will not allow any public member to see and get information about transactions from the distributed ledger [14]. This type is not suitable to solve the issue as

we need to serve the public users. So, we have decided to use the Federated/Consortium Blockchain.

For creating the smart contract, we need to choose either Ethereum or Hyperledger Fabric. The Ethereum have some disadvantages that let us to not select it in this design. These disadvantages are expensive and contain a lot of security issues and bugs. For that we will select the Hyperledger Fabric as it is free, supported by IBM which make it more reliable and offer a high level of performance. After we selected the Blockchain type and the suitable smart contract platform, we can design the system that will be based on a new Blockchain network that will be a creation with the Federated/Consortium Blockchain type and using the Hyperledger Fabric platform to manage the Smart contract [16].

The System will contain the application layer that can be the interface between the Blockchain member and the Blockchain and Smart contract platform. In the Application layer, the member registration can be made, a smart contract that will be used as Hajj and Umrah visas can be made, a digital wallet will be made that will number of smart contracts/visas the Blockchain members have. It will also contain, the control panel to register Blockchain members, deactivate any Blockchain member and assign a number of smart contracts/Visas to the private Blockchain members. However, The Blockchain application Servers and databases that will store the Blockchain configurations and Blockchain member's details and credentials which are encrypted in distributed servers among the Hajj and Umrah representatives.

The Blockchain network members will be the Hajj and Umrah representatives in all countries, Hajj Agencies as privileged members in the private Blockchain, the public Blockchain members is pilgrims and immigration clearance in the world.

The Hajj and Umrah visas in the system will be represented by smart contracts that contain terms and an expiration date to revoke it once the Hajj and Umrah is complete so the ownership of the Hajj and Umrah visas/smart contract will return to the privileged members (the Hajj and Umrah representatives) in the Blockchain network as mentioned in the figure 2. The Blockchain technology by default will restrict Hajj and Umrah agencies so they cannot provide the Hajj and Umrah visas/smart contracts more than they have as the Blockchain consensus and verification will prevent such attempts. Furthermore, the Hajj and Umrah visas/smart contracts will be sent to the pilgrims via their digital address, which is the pilgrim's wallet address.

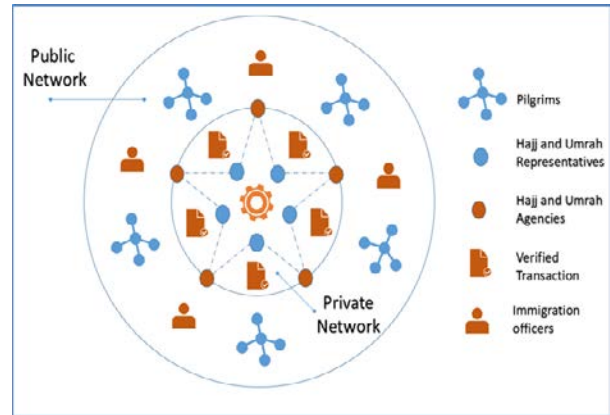


Figure 2

The Hajj and Umrah representatives will register the Hajj and Umrah agencies as private Blockchain members and both of them will be part of the validation process of transactions/Block -consensus-. On the other hand, the immigration clearance centers and Hajj and Umrah pilgrims will be public Blockchain members. The system by default will accept the Hajj and Umrah pilgrims and create their own wallet but only have the ability to view the smart contract in its digital wallet. They will not be part of block/transaction validation and consensus. However, the immigration clearance members will not have their own wallet but they have the ability to verify Hajj and Umrah Visas. Also, the immigration clearance members' registration and acceptance to join the public Blockchain network should be from Hajj and Umrah representatives. The Block/transactions in the Blockchain network distributed ledger will be started after an agreement between Hajj and Umrah representatives to distribute a number of smart contracts/visas to Hajj and Umrah agencies' wallets. Then, the Hajj and Umrah agencies can provide the Hajj and Umrah smart contract/visas to pilgrims. Then the public Blockchain members –pilgrims in the world- can view the smart contract/visas in their own digital wallet via their digital address, which will not show any pilgrims private information and will maintain the pilgrims' privacy. At the end, the immigration clearance staff inside and outside Saudi Arabia as public members in the Blockchain can easily and quickly verify the Hajj and Umrah smart contract visas and compare it with the pilgrim's passport for example.

This design will prevent any fake Hajj and Umrah visas to exist as scammers won't have a chance to convince the pilgrims to buy fake permits as they will not have access to the protected Blockchain network. Furthermore, no one can use fake Hajj and Umrah visas as all the original visas are stored in the distributed ledger in the Blockchain and will be linked to the real owner. So, the immigration clearance staff will be able to detect it quickly and easily.

## 4. Discussion

The main aim of this research is to analyze how the Blockchain technology can solve the Hajj and Umrah Visas/Permits issuance and verification via designing the system. This chapter further made a discussion based on the study objectives.

In this research, a system has been designed using the Blockchain technology and smart contract and it fulfils the current requirements of Hajj and Umrah pilgrims during the Hajj and Umrah Visas/Permits issuance and the pilgrims can be verified in automated ways using the Blockchain consensus features. Furthermore, it will speed up the Hajj and Umrah Visas/Permits verification for the immigration clearance staff either inside or outside Saudi Arabia. In addition, it maintains the Hajj and Umrah pilgrims' privacy as the public Blockchain members are known by the wallet address and not by personal information, except for the immigration clearance staff who need to verify the Hajj and Umrah pilgrims' personal information and their Visas/Permits. Also, no scammers can provide the Hajj and Umrah Visas/Permits as they cannot access the Blockchain network without any approval from Blockchain network authority. In addition, no duplicate Visas/Permits can be provided as every Hajj and Umrah has a limited number of Visas/Permits as a shape of smart contract that cannot be provided to more than one pilgrim. Furthermore, the security attacks that can be performed in the Blockchain network is as low as the "51%" and "double spending" attacks will be prevented as the design is not given to the public Blockchain member to perform any transitions. So, they cannot modify the distributed ledger in the Blockchain.

## 5. Conclusions

In this research, we have discussed the issues faced by the Hajj and Umrah management, and in particular the problems associated with the fake Hajj and Umrah Visas/Permits issuance and verification. Moreover, we have discussed the long duration taken in issuing Hajj and Umrah Visas/Permits. Furthermore, the security and privacy concerns are also mentioned which are presented in the Blockchain technology.

We have discussed the Blockchain and Smart contract concepts, their advantages, disadvantages, types and the security attacks. We have provided solutions to these issues by making use of Blockchain technology. Our contribution in this article is the exploiting Blockchain technology and applications to establish the Smart Hajj and Umrah management. We have proposed a system in this article to leverage Blockchain technology and smart contract platform to solve the current issues of fake permits

and related corruptions in Hajj and Umrah management. We have provided the system functions and user roles. Many functions of hajj can be accomplished and simplified by doing any of the following:

- Implement and test the system functionality.
- Integrate the Internet of things technology-based bracelet with this System to automate the immigration clearance process.
- Use the system to record the blacklist pilgrims.
- Integrate the system with the Islamic Center to validate the Hajj and Umrah pilgrims.
- Integrate the system with pilgrims medical records to get the health records and diseases information.
- Join the hotel staff as public members to integrate the Hajj and Umrah Visas/Permits with hotel reservations.

## References

- [1] Saudi Arabia Government (2016), "KSA Vision 2030, Strategic Objectives and Vision Realization Programs", Riyadh.
- [2] "Strategic Partnerships | Ministry of Haj and Umrah", Haj.gov.sa. Retrieved Feb 28, 2019, from <http://www.haj.gov.sa/english/about/Pages/StrategicPartnerships.aspx>.
- [3] "Ministry of ICT launches, (2018), 'Smart Hajj' initiative", Mcit.gov.sa, Retrieved Feb 27, 2019, from <https://www.mcit.gov.sa/en/media-center/news/99762>.
- [4] "Hajj ministry begins planning for 2030 season (2018), to target 30 million pilgrims", English.alarabiya.net, Retrieved March 1, 2019 from, <https://english.alarabiya.net/en/News/gulf/2018/09/03/Hajj-ministry-begins-planning-for-2030-season-to-target-30-million-pilgrims.html>
- [5] Saudia Airlines. (2019). Saudia Arabia Visa And Customs. Retrieved March 18, 2019, from <https://www.saudia.com/TRAVEL-INFORMATION/About-Saudi-Arabia/Visa-and-Customs>
- [6] "Hajj Visa", Saudia.com. Retrieved March 1, 2019 from, <https://www.saudia.com/TRAVEL-INFORMATION/About-Saudi-Arabia/Hajj-and-Umrah/Hajj-Visa>.
- [7] "Busted: fake hajj pilgrimage campaigns exposed by Saudi authorities", {2013} English.alarabiya.net, Retrieved Feb 22, 2019 from, <https://english.alarabiya.net/en/special-reports/hajj-2013/2013/10/07/Several-fake-hajj-campaigns-busted-by-Saudi-authorities-.html>.
- [8] E. Alsaggaf, O. Batarfi, N. Aljojo, and C. Adams, 2015. Secure Hajj Permission Based on Identifiable Pilgrim's Information. IJ Information Technology and Computer Science, 5, pp.67-76.
- [9] Sadler, K. (2016). Blockchain technology: passport to the future? Retrieved March 18, 2019, from <https://www.internationalairportreview.com/article/23364/Blockchain-technology-passport/>
- [10] Geronimo, A. (2018). Blockchain among key enablers of Saudi Vision 2030: official. Retrieved March 18, 2019, from <https://www.tahawultech.com/news/Blockchain-among-the-basic-enablers-of-saudi-vision-2030-official/>



- [11] Younus, K. (2017). Blockchain For The Realization of Saudi Arabia's Vision 2030. Retrieved March 18, 2019, from <https://www.einpresswire.com/article/422581866/Blockchain-for-the-realization-of-saudi-arabia-s-vision-2030>
- [12] Cavendish, M. (2010). Islamic Beliefs, Practices, and Cultures. Marshall Cavendish. Retrieved from [https://books.google.co.in/books?id=H\\_m14NIQQMYC&dq=+ISBN+978-0-7614-7926-0&source=gbs\\_navlinks\\_s](https://books.google.co.in/books?id=H_m14NIQQMYC&dq=+ISBN+978-0-7614-7926-0&source=gbs_navlinks_s)
- [13] Thomson Reuters, & DinarStandard. (2017). Haj and Umrah: Developments and Opportunities. Retrieved from <https://repository.salaamgateway.com/images/iep/galleries/documents/201701120749099835.pdf>
- [14] General Authority for statistics. (2018). Limited to actual Haj. Retrieved March 18, 2019, from <https://web.archive.org/web/20180620024237/https://www.stats.gov.sa/en/28>
- [15] Sheikh, A., & Gatrad, A. R. (2008). Caring for Muslim Patients. London, United Kingdom: Radcliffe Publishing. Retrieved from [https://books.google.co.in/books?id=mgwiloFTrKwC&source=gbs\\_navlinks\\_s](https://books.google.co.in/books?id=mgwiloFTrKwC&source=gbs_navlinks_s)
- [16] Oxford Business Group. (2019). Saudi Arabia aims to increase pilgrim numbers and non-religious tourism. Retrieved March 18, 2019, from <https://oxfordbusinessgroup.com/overview/grand-plans-sustained-focus-raising-pilgrim-numbers-and-expanding-beyond-religion-oriented-tourism>
- [17] Arab News. (2018, May 2). Vision 2030 aims to improve pilgrim experience: Saudi Hajj minister. Arab News. Retrieved from <http://www.arabnews.com/node/1295096/saudi-arabia>
- [18] Hamdan, L. (2018). Saudi aims to receive 30m Haj, Umrah pilgrims by 2030. Retrieved March 18, 2019, from <https://www.arabianbusiness.com/transport/410334-saudi-aims-to-receive-30m-haj-umrah-pilgrims-by-2030>
- [19] Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. Bitcoin. Retrieved from <https://bitcoin.org/bitcoin.pdf>
- [20] "Hajj Scams: What Muslims Will Do to Get to Mecca - The Media Line", (2016), The Media Line, Retrieved Feb 20, 2019 from <https://themedialine.org/featured/hajj-scams-muslims-will-get-mecca/>.
- [21] Buterin, V. (2015). On Public and Private Blockchains. Retrieved March 18, 2019, from <https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains/>
- [22] Subassandran, R. (2018). Blockchain And Smart Contracts: Today And Tomorrow. Retrieved from <http://www.courtsofthefuture.org/wp-content/uploads/Blockchain-Smart-Contracts-Today-and-Tomorrow.pdf>
- [23] S. Brakeville and B. Perepa (2018), "Blockchain basics: Introduction to distributed ledgers", IBM Developer. Retrieved Feb 27, 2019 from, <https://developer.ibm.com/tutorials/cl-blockchain-basics-intro-bluemix-trs/>.
- [24] N. Singh, (2018) "Hybrid Blockchain- The Best of Both Worlds", 101 Blockchains, 2018. Retrieved Feb 2 , 2019 from, <https://101blockchains.com/hybrid-blockchain/>.
- [25] H. Anwar, "Consensus Algorithms: The Root of the Blockchain Technology", (2018) , 101 Blockchains, 2018. Retrieved Feb 6, 2019 from, <https://101blockchains.com/consensus-algorithms-blockchain/>.
- [26] Fischer, M. J. (1983). The consensus problem in unreliable distributed systems (a brief survey) (pp. 127–140). [https://doi.org/10.1007/3-540-12689-9\\_99](https://doi.org/10.1007/3-540-12689-9_99)
- [27] Szabo, N. (1996). Smart Contracts: Building Blocks for Digital Markets. Retrieved March 25, 2019, from [http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart\\_contracts\\_2.html](http://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html)
- [28] Grigg, I. (2015). On the intersection of Ricardian and Smart Contracts. Retrieved March 25, 2019, from [https://www.researchgate.net/publication/308788639\\_On\\_the\\_intersection\\_of\\_Ricardian\\_and\\_Smart\\_Contracts](https://www.researchgate.net/publication/308788639_On_the_intersection_of_Ricardian_and_Smart_Contracts)
- [29] P. Seijas, S. Thompson, and D. McAdams, (2016). Scripting smart contracts for distributed ledger technology. IACR Cryptology ePrint Archive, 2016, p.1156.
- [30] S. Lande, and R. Zunino, (2018). SoK: unraveling Bitcoin smart contracts. Principles of Security and Trust LNCS 10804, p.217.
- [31] I. Rishchenko, M. Maffei, and C. Schneidewind, (2018), April. A semantic framework for the security analysis of ethereum smart contracts. In International Conference on Principles of Security and Trust (pp. 243-269). Springer, Cham.
- [32] Efanov, D. and Roschin, P., (2018). The All-pervasiveness of the blockchain technology. Procedia computer science, 123, pp.116-121.
- [33] D. Kamboj, and T. Yang, (2018). An Exploratory Analysis of Blockchain: Applications, Security, and Related Issues. In Proceedings of the International Conference on Scientific Computing (CSC) (pp. 67-73). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp).
- [34] A. Corporation, (2018) "Augmate and Salam Technologies Partner to Improve the Hajj and Umrah Experience with Blockchain Technology", GlobeNewswire News Room, Retrieved Feb 18, 2019 from, <https://globenewswire.com/news-release/2018/03/13/1420964/0/en/Augmate-and-Salam-Technologies-Partner-to-Improve-the-Hajj-and-Umrah-Experience-with-Blockchain-Technology.html>.
- [35] Al-Helayyil, A., Claps, M., Rajan, R., & Schaller, O. (2016). Saudi Arabia Vision 2030: Envisioning a Technology-Led Transformation – IDC's Initial View. Retrieved from [https://images.idc-cema.com/mail-image/1156030/cema41301016\\_saudi\\_arabia\\_vision\\_2030\\_idc\\_insight.pdf](https://images.idc-cema.com/mail-image/1156030/cema41301016_saudi_arabia_vision_2030_idc_insight.pdf)
- [36] Ministry of Communications and Information Technology. (2018). Ministry Of ICT Launches 'Smart Hajj' Initiative. Retrieved March 18, 2019, from <https://www.mcit.gov.sa/en/media-center/news/99762>
- [37] Ministry of Communications and Information Technology. (2018). National Transformation Program 2020. Retrieved from [https://www.yesser.gov.sa/ar/Documents/NTP\\_En-1.pdf](https://www.yesser.gov.sa/ar/Documents/NTP_En-1.pdf)



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