



Universidad Autónoma de San Luis Potosí
Facultad de Ingeniería
Centro de Investigación y Estudios de Posgrado

Blockchain technology applied to health care supply chain

Para obtener el grado de:
Maestría en Ingeniería de la Computación

Presenta:
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San Luis Potosí, S.L.P

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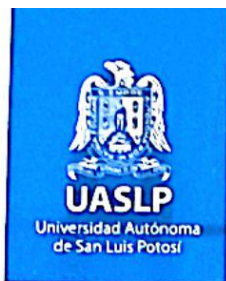


Abstract

Supply Chain Management (SCM) has grown in the last years due to the changing and evolutionary environment. The SCM has become fundamental for gaining financial and social, among others, benefits. Currently, the traditional SCM mechanisms have some areas of improvement, such as the transparency and lack of information, long waiting times for information retrieval and data fidelity. The past months our daily lives have been changing in a drastic way due to COVID-19 and some industries were affected but with this change there has been some opportunities to improve. In this article we describe the main concepts about the blockchain technology, the smart contracts, and their main use. We talk about different areas that these technologies could help to improve in different ways of their internal and external processes. Our main discussion is the description and improvement in the performance inside a supply chain, how it could be possible to speed up the information sharing, how a smart contract could be applied to a consumer-supplier relationship in the healthcare supply chain and the benefits that it would bring to it due to the quick times that this area demands because of the nature of their transactions and operations that are critical to maintain the needs of the industry.

Resumen

Supply Chain Management (SCM) ha crecido en los últimos años debido al entorno cambiante y evolutivo. El SCM se ha vuelto fundamental para obtener beneficios financieros y sociales, entre otros. Actualmente, los mecanismos tradicionales de SCM tienen algunas áreas de mejora, como la transparencia y la falta de información, los largos tiempos de espera para la recuperación de la información y la fidelidad de los datos. En los últimos meses, nuestra vida diaria ha cambiado de manera drástica debido al COVID-19 y algunas industrias se vieron afectadas, pero con este cambio ha habido algunas oportunidades para mejorar. En este artículo describimos los principales conceptos sobre la tecnología blockchain, los contratos inteligentes y su uso principal. Hablamos de diferentes áreas que estas tecnologías podrían ayudar a mejorar en diferentes formas de sus procesos internos y externos. Nuestra discusión principal es la descripción y la mejora en el desempeño dentro de una cadena de suministro, cómo podría ser posible acelerar el intercambio de información, cómo podría aplicarse un contrato inteligente a una relación consumidor-proveedor en la cadena de suministro de atención médica y los beneficios que lo traería debido a los rápidos tiempos que demanda esta zona por la naturaleza de sus transacciones y operaciones que son críticas para mantener las necesidades de la industria.



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21 de julio de 2022

**DRA. ALEJANDRA GUADALUPE SILVA TRUJILLO
P R E S E N T E.**

Por medio de la presente me permito informarle, que en sesión ordinaria del H. Consejo Técnico Consultivo celebrada el día 21 de julio del presente, fue analizada su petición en la cual solicitó autorización para que el **Ing. Diego Alejandro Ochoa González** de la **Maestría en Ingeniería de la Computación**, se titule mediante la modalidad: **Publicación de Artículo en Congreso Internacional con Arbitraje o en Revista Indizada**, con el artículo denominado: **"Blockchain technology applied to health care supply chain"**.

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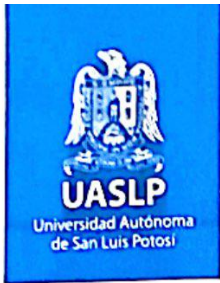
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ATENTAMENTE



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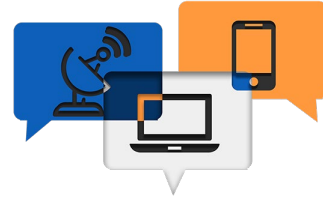
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Chapter 1

Paper

This chapter contains the acceptance letter for the “*The 11th International Congress in Telematics and Computing*” and then the paper submitted to the conference.



ACCEPTANCE LETTER

Conferences and Workshops in Telematics and Computing (Hybrid Format WITCOM 2022)

Dear

Diego Ochoa and Alejandra Silva

Paper ID: 0327

Title: [Blockchain technology applied to health care supply chain](#)

It is our pleasure to inform you that the paper referenced above, has been accepted for virtual/presential presentation at WITCOM 2022, provided the requirements listed below are fulfilled.

Congratulations!

Please review the email carefully since it contains important information regarding the inclusion of your paper in the Proceedings of WITCOM 2022 to be published in Series of Journal Springer CCIS (<https://www.springer.com/series/7899>).

Yours faithfully

A handwritten signature in blue ink is written over the text 'Yours faithfully'. The signature is stylized and appears to read 'Félix Mata'.

Félix Mata

Chair WITCOM conferences 2022 (Hybrid format)

Blockchain technology applied to health care supply chain

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Abstract. Supply Chain Management (SCM) has grown in the last years due to the changing and evolutionary environment. The SCM has become fundamental for gaining financial and social, among others, benefits. Currently, the traditional SCM mechanisms have some areas of improvement, such as the transparency and lack of information, long waiting times for information retrieval and data fidelity. The past months our daily lives have been changing in a drastic way due to COVID-19 and some industries were affected but with this change there has been some opportunities to improve. In this article we describe the main concepts about the blockchain technology, the smart contracts, and their main use.

We talk about different areas that these technologies could help to improve in different ways of their internal and external processes. Our main discussion is the description and improvement in the performance inside a supply chain, how it could be possible to speed up the information sharing, how a smart contract could be applied to a consumer-supplier relationship in the healthcare supply chain and the benefits that it would bring to it due to the quick times that this area demands because of the nature of their transactions and operations that are critical to maintain the needs of the industry.

Keywords: Supply chain, blockchain, health care, smart contract, management systems.

1 Introduction

Blockchain technology has become an important field of study and growth in the last years, this study aims to give an overview of the way we make transactions in our daily professional or personal life and the security of this transactions that becomes important for the use of this technology.

In the industry or in the business operation the transactions rely mostly on a centralized process or need the authorization from third parties, some of them are an extra step in the chain that they are used to follow. In the healthcare Supply Chain Management some actors are involved and take part in the decisions made to achieve a

goal, in this case provide the needs to the final consumers. This process is important as we are involving the people's health and life, thus, the processes that the supply chain follows must be accurate and efficient. The past years we have been involved in a global situation where the communications and transactions were affected due to COVID-19, the pandemic has brought to the industry many challenges such as lack of distribution in raw materials, consumables, times of delivery, etc.

The blockchain technology might bring new insights in the way transactions are made and how to redesign the model of operations with decentralized characteristics [2]. Moreover, the smart contracts are a helpful application of the blockchain technology capable of tackle most of the issues and challenges that the supply chain could face in the daily operations.

This technology presents some challenges such as law regulation, that in the future will help the present issues with the communication. This article is organized as follows; some preliminaries are provided in Section 2 where an overview of the blockchain technology and its main characteristics are described, usage of the smart contracts and the benefits provided. Potential uses of the smart contracts applied to different areas such as an overview are described in Section 3. A more detailed definition of the smart contracts applied to supply chain and how the BMPN could help in this application are described in Section 4. An overview of the challenges that healthcare Supply Chain Management is described with the comparison of different topics involved in some studies is shown in Section 5. Related works are presented in Section 6. Summary and conclusions are presented in Section 7.

2 Preliminaries

2.1 Blockchain

Blockchain is a decentralized chain of registers, agreed and distributed in several nodes of a network. Thanks to the nature of the blockchain it is not possible to modify an existing node, the structure of the blockchain data relies in timestamp, block version, a hash that will be used as a digital fingerprint of data[23]. Every block contains a hash to identify the previous block, and this provides a strict order to the blockchain [3][21].

2.2 Main Characteristics of Blockchain

In a blockchain there are mainly the following characteristics.

- Decentralization. This characteristic allows the users of the blockchain to avoid the need to validate the transactions with a central user and reducing the cost that this

process generates. Third parties are no longer needed in the blockchain. To maintain the data consistency in the network consensus algorithms are used.

- This improves data validity as the transaction stored in the blockchain cannot be deleted or modified. Invalid information in the transactions added to the blockchain could be discovered and deleted. [4]
- Anonymity. Users can interact with the blockchain without revealing their real identity.

However, there are some improvement points that we could find in the blockchain domain, such as:

- The lack of the regulation in this proposed technology.
- Technological immaturity
- Asset digitization, which will allow the users to integrate this type of system.
- There must be a collaboration between different agencies involved.

2.3 Smart contracts

Since the 90's the smart contracts have been seen as an impossible way to operate things, but thanks to the blockchain technology this concept has become reality which aim is to automate contractual relationships between people or machines without the intervention of a trusted intermediary. The concept of smart contract was proposed by "Nick Szabo in 1994". In theory, the blockchain is a dual register share information between network nodes. [20]

The smart contracts are a technological innovation born after the creation of bitcoin in 2009 that aims to eliminate intermediaries, simplify processes, and save costs. Smart contracts are special code instructions stored in a blockchain that can self-execute actions based on a series of defined and programmed parameters, in an immutable, transparent, and secure way.

Smart contracts work in a similar way to a conventional contract, stating what can be done, how it can be done, and the consequences of an action not being executed, define the interaction that will take place between the interested parties but without the need for intermediaries, for example, removing lawyers or notaries. One of the most important qualities of smart contracts is that they are capable of being executed by themselves and do not need the review or interpretation of any of the parties involved. Smart contracts, being based on blockchain technology, are distributed in a high number of computers, thus avoiding centralization, censorship, and other aspects of conventional contracts.

2.4 Usage of smart contracts

To explain this subsection let us take an example where we could use this type of smart contracts and blockchain technology. Suppose that you want to sale a house, you can create a smart contract and publish it in an existing blockchain network. The community will be able to see the information about the property that will be stored in a cell of the blockchain. This is the way where you can find a buyer for your house without any third-party organization.

Smart contracts based on the blockchain technology offer the following benefits:

- Speed and real-time updates.
- Verifiability.
- Observability.
- Consistency.
- Accuracy.
- Lower execution risk.
- Fewer intermediaries.
- Lower cost.
- New business models. [5][21]

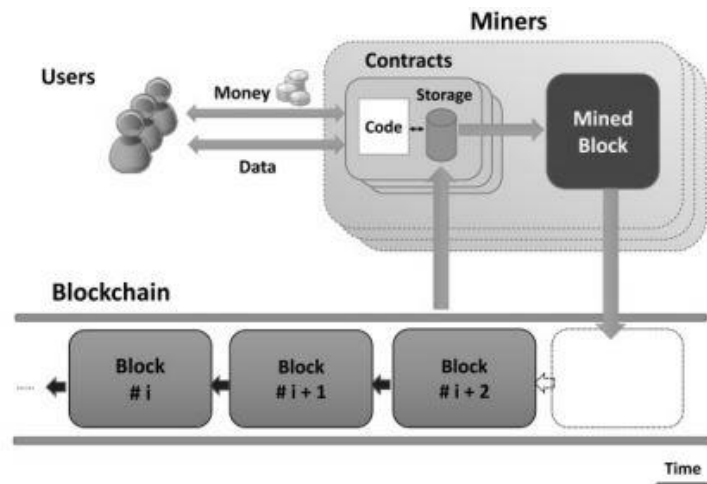


Fig. 1. Smart Contract System [5]

3 Potential uses

In this section we discussed about some potential application of the smart contracts. There are severe opportunity areas where this technology could be use and change the way to manage the transactions and eliminate the third-party organizations. We have identified different potential uses of the smart contracts and blockchain bases application. [19][20]

3.1 Supply chain

Supply chain management is the integration of key business processes, from the original suppliers to the end user. There are some challenges and limitations in this process, such as, demand forecasting and inventory management, risk management, unforeseen delays, search for greater transparency, lack of communication between services and consumers, among others. [19]

With blockchain based smart contracts it is possible to manage these limitations, when a smart contract is placed into the blockchain the number of advantages in the supply chain increase because the system become autonomous as well as secure, the actors will be participating between them without any third party, the transactions will be now verified for the blockchain nodes, the transaction gain trust and transparency, thus, the trades and processes related to this application become more trusted.

3.2 Healthcare System

Within the health area, personal data is usually shared, as well as bank accounts, transactions between insurance, patients and the hospital, medical records, etc. For all the data involved in the processes of the health system, it is important to work on the issue of their security, being able to process data safely is of great importance. The use of blockchain technology allows this information to be treated in a secure way by introducing a block with the corresponding data within the network.

Likewise, the use of smart contracts within the supply chain in the health area is important, since not only in times of high urgency, but also in the day-to-day operations within this area, it is important that the inputs used, as well as their negotiation and distribution, are carried out quickly and safely.[7]

3.3 Financial System

Financial transactions are an example of the type of operations that could be improved with the blockchain technology because of the nature of subject that involves, person-

al data, bank transactions, legal documents, among others, that must be reviewed and execute in a safe and legal way. The financial system could gain trust and transparency from end to end thanks to the benefits of a blockchain and its properties. As mentioned in [14] the allocation of resources in the process for a financial supply chain are compatible with blockchain technology due to the facilities and traceability that it brings to the information flow and helps to construct a more reliable and safe information stream.

As shown in this section, it is possible to remark several fields of action where an improvement could be done by the application and usage of the smart contracts thanks to the fast sharing inbound and outbound information different areas and how this utilization can be applied to the relationship between actors from the healthcare supply chain flow.

4 Smart contract in supply chain

In the supply chain management area, we can find different types of information flows as the inbound or outbound ones that includes different actors in the process. To obtain the goal of deliver a product to a final customer it is essential to follow some steps that will help the industry to accomplish the expected results. The supply chain process integrates two different types of data flows, internal and external. The internal flow is the one in charge of communicate inside the operations of the industry what needs to be taken in count to create the external requirements and handle the information to get the flows as clean as possible in terms of the information.

For the internal processes and operations, it is essential to have a fast and agile communication and avoid every lack of information that could exists. The literature is showing that some fundamental characteristics that are involved in the supply chain that must be considered to achieve a result in the most secure possible way. The information that is treated and shared in a working flow becomes the principal source along with the properties involved with it. As shown in table one we have compared different sources to identify and summarize these elements to have a clear image of what is happening inside and outside the functioning of this solution. There is a lack of study in the performance and traceability as described in [13]. Traceability could be improved with the solution proposed but there the performance remaining that is a priority to create a good channel of communication. Therefore, the use of smart contracts inside a company, could help to improve these parameters with the security of themselves.

4.1 Business Process Model and Notation

BPMN is an important diagram notation that is being used in the industry to provide a notation, as mentioned in [8], for specifying business processes in a business process model that helps to represent the different actions that happen in the full flow of oper-

ations and that is understandable for all the users involved in the processes, such as, the business analysts, the technical developers, and the business actors. One of the usages of BPMN goals is to create simple mechanism for creating business process models and at the same time handle their complexity.

With the purpose of study of this investigation we will be using a BPMN diagram to understand the flows of information that occurs in a supply chain process.

5 Healthcare supply chain management

In this section we will discuss about a proposed flow that aligns with some of the needs of a healthcare supply chain process and the different aspects and data exchanges that may occur during this cycle. As described in the previous section we are going to focus the possible introduction of a smart contract and blockchain technologies with a diagram example in the Figure 2, that will allow us to follow in an easier way the benefits of these changes and improvements.

In this example process we can identify four different actors that are communicating between them, it is not mandatory that they interact with every of the other actors because in a real scenario it is not how it works. We can find in this schema the healthcare professional, the hospital pharmacy, pharmaceutical manufacturer, and the raw material manufacturer as the main actors in the process. These four actors will share information, transactions, personal data, among others and that is why a blockchain implementation could help to keep the safety, transparency, and traceability of the data.

Table 1. Systematic review: Challenges in smart contracts.

Challenges	[9]	[10]	[11]	[12]	[13]
Supply chain operations	✓	✓	✓	✓	✓
Human interaction	✓	✓	✗	✗	✗
Transparency	✓	✗	✓	✓	✓
Price	✗	✓	✓	✓	✗
Inventory management	✓	✗	✗	✓	✗
Use of smart contract	✗	✗	✓	✗	✓
Security	✗	✗	✓	✗	✗
Performance	✗	✗	✓	✗	✓
Traceability	✗	✗	✗	✗	✓

In this workflow we have many parameters described in the Table 1 as challenges that are the ones that we will be focused on for the study to better understand where in the process could be possible to allocate the smart contracts and blockchain technologies. Having a smart contract could be a complex addition but a very beneficial one too because it will allow the flow to automate some conditional parts of it such as the email notifications the in a real-life situation involves the human interaction and this can cause a lack of time and in the information because the human job could be done in a bad way or with some errors because of the human nature.

In the case that will be described, many critical processes need to be saved and shared with the actors involved in order to achieve the main purpose of the healthcare supply chain management, this is why an important part of the challenges mentioned in the Table 1 is the traceability as discussed in [13] because this allows us to keep track of the important exchanges that take part in the actions at an operational level.

5.1 BPMN model description

As discussed, we will focus on the diagram that shows how the flow of a healthcare supply chain works. As described in the figure 2, it is possible to observe in the process that two types of communication occur, inbound and outbound exchanges of information. The inbound communication is the one that will internally describe the actions that need to be accomplished for a single actor and the outbound communication will represent the exchanges between different actors. In the literature there are few actions taken in count for these types of communication and it is at this point where the flow of a transaction can be disrupted by any kind of interruption such as human interaction, failures in the network, bad requests between actors among others. This kind of ruptures in the process are the ones that a smart contract based on the blockchain technology can improve thanks to their nature, if a smart contract is placed once an action finished will trigger the next one that has been defined in the sequence of actions. To better understand the full activity, we propose a description for the actors involved.

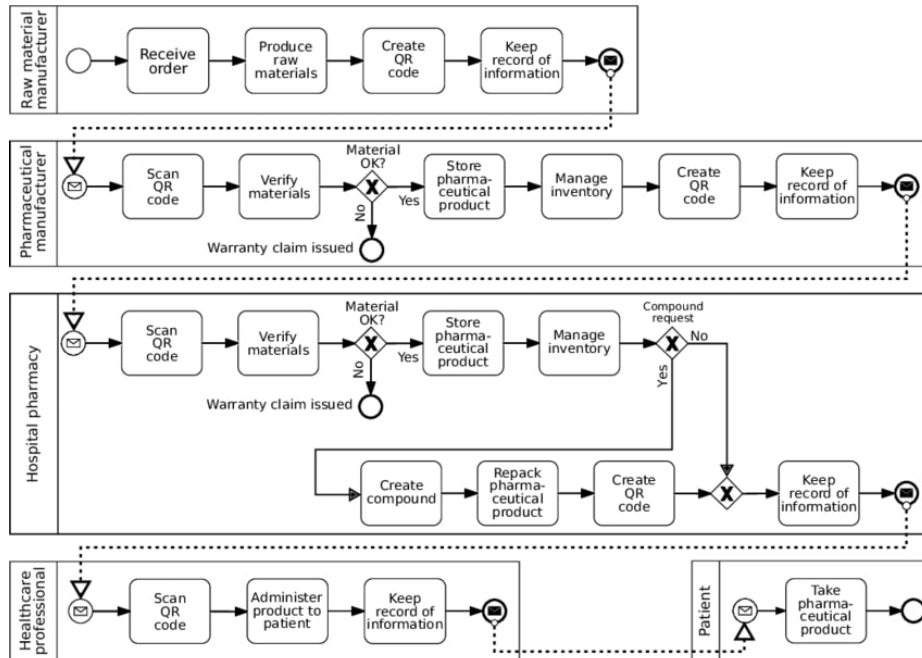


Fig. 2. BPMN diagram for healthcare supply chain [13]

The first actor that will be described is the raw material manufacturer. This pipeline in the Figure 2 describes the external communication and how it starts since the manufacturer receive and order request, after this request the actor will process this information until the end of internal actions that will launch an email to the next actor, that normally in a real-life situation it is a human in charge of the execution. This kind of interactions are the ones that a smart contract could supersede in a more efficient way because the action will be launched once another action finish, thus, the performance in terms of communication and data sharing are being benefited.

As described before, we can find internal communication as well. The hospital pharmacy pipeline is a clear example of how the information interacts with the different steps of the flow. Inside the transactions we can find conditions that will decide the course of the operation. Normally in a real-life situation an operator will be in charge of taking decisions that will affect the next steps to be triggered, thus, mistakes can be added and disrupt the course. Once again, we could spot a lack of fidelity in the process and consequently an area of improvement where the technology discussed in this article could contribute to enhance.

6 Related works

Even though smart contracts are mostly implemented for targets that involve legal transactions, the technology emerging is being used in applications that need to keep a trail of the different actions involved in an exchange of information. In table 2 we aim to present different works that have been done in the health care field. As said in [16] smart contracts present a beneficial solution to rely on the information that is being shared when a smart contract is executed, security, accuracy and efficiency are three important characteristics that are defended to trust in a block chain-based contract. A basic smart contract implementation for an application such as mentioned in [16] could be a good approach for the results expected in this paper thanks to the facility that it provides to keep track of the related transactions.

As mentioned in [18], block chain technology can be adapted to other technologies to get a better approach to the implementation to obtain the results expected. Using a semantic web approach combined with the block chain technology allows the flow to be connected and to keep trail of the transactions that occur in the process thanks to the nature of the relationships that it offers. With this approach smart contracts are more organized and linked and it offers a better traceability of the components that are being used and shared in the chain. As discussed in [17], with a smart contract, the information that is being generated could be preserved in a secure way thanks to the main characteristics of the technology that allow the information to be shared also in a secure way. This approach allows to reduce the time execution of the operations that involves a transaction that is going to be added to the chain and shared to be authorized depending on the user that is being sharing the information.

As shown in Table 2, there are different characteristics involved in the application of a smart contract that will be helpful to achieve the final objective depending on the nature of the problem, in the case of this paper we find that these characteristic are necessary to implement a smart contract for it to can be used in a supply chain and more specific in the health care area because of the information sensitivity and the time of execution that can be improved thanks to this applications.

Table 2. Smart contracts implementation in health care.

Characteristics	[15]	[16]	[17]	[18]
Accuracy	✓	✓	✗	✗
Efficiency	✓	✓	✗	✗
Security	✓	✓	✓	✓
Integrity	✗	✓	✓	✓
Privacy	✗	✓	✓	✓
Performance	✗	✓	✗	✗

Traceability	x	✓	✓	✓
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As described in Figure 2 there is a complete flow to determine the operations and activities that could be included in a supply chain process. To identify the use case for a smart contract and the way it could improve in a better way in Figure 3 we describe a simple flow between two entities that are interacting inside the full flow. As we described in Figure 3, the smart contract can be included when an actor finishes his operations inside the flow that must share with another actor of the process, then the smart contract will be executed to share the end or the fulfilment of his actions to then start to execute the actions for another actor of the deal.

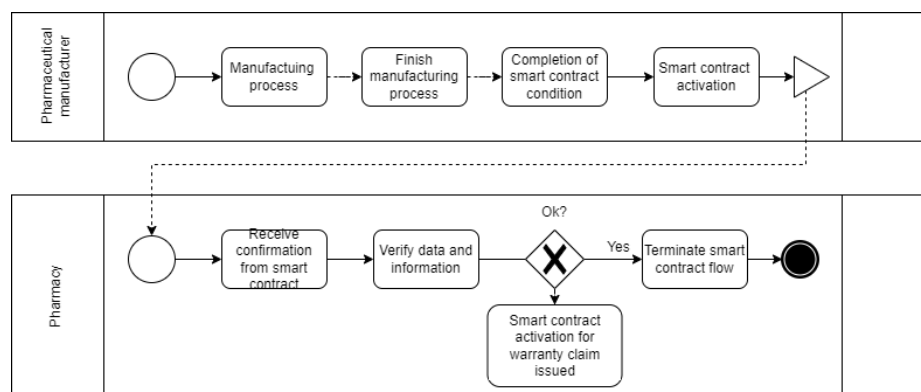


Fig. 3. Smart contracts use case for a simple flow

7 Conclusions

This article analyzes the possible implementation of the smart contracts inside a healthcare supply chain operation. The study case that is described in this paper is a possible flow of transactions in a healthcare example. We found that inside the real-life operations there is a lack of performance in the information sharing and in the communication actions due to different actors that manipulate the course of execution of the flow. Time execution is an important characteristic to be improved because of the nature of the operations involved in the health care area. With this work we were able to remark different flows and operations that could be directly enhanced and impacted with the block chain and smart contracts technology. Our future work to continue improving the process is the investigation and implementation of a smart contract based in a test blockchain technology such as Ethereum, taking in count the main actors that are involved in the process and the characteristics that must be taken

in count to achieve an optimal result. Finally, we aim to present results based in the solution to be implemented.

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Chapter 2

Presentation

This chapter contains the slides of the paper presented at the conference in English format to accord the paper with the information provided in the presentation. Some of the slides were modified as discussed in the previous examen to improve the quality of the work done



Master in Computer Engineering

Final exam, to obtain the degree of:

Master in Computer Engineering

Through the article entitled:

“Blockchain technology applied to health care supply chain”

Academic advisor: PhD. Alejandra Guadalupe Silva Trujillo

Student: Diego Alejandro Ochoa González

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Main objective

Analyze the state of the art on smart contracts within the supply chain healthcare area.

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Particular objectives

1. Identify potential flows that can be improved by blockchain technology
2. Identify the characteristics where supply chain can be improved by smart contracts

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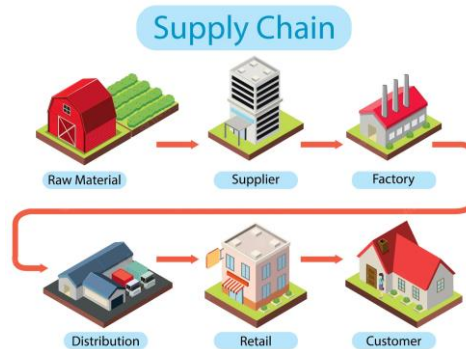
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- The supply chain is the management of the flow of goods and services and includes all the processes that transform raw materials into final products.



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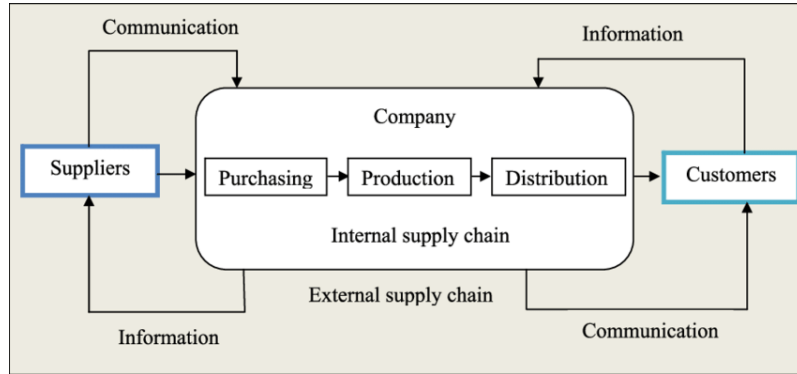
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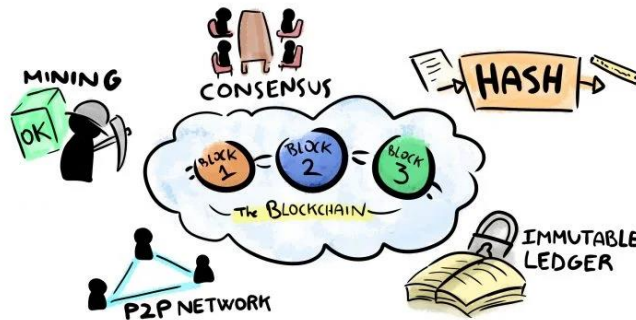
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Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets in a business network.



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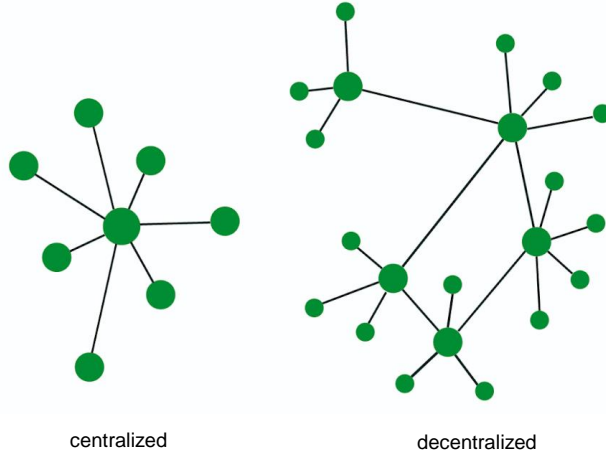
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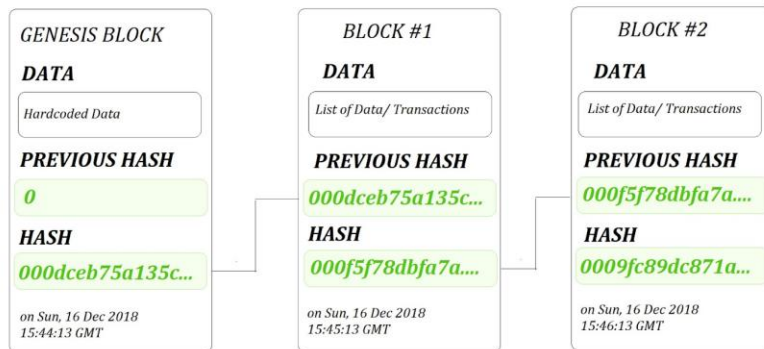


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1. Agreement between two or more parties
2. It is governed by law
3. Third parties involved



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1. Decentralized contracts
2. Based on blockchain technology
3. Autonomous



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1. Real-time speed and tracking.
2. Security.
3. Consistency.
4. Precision.
5. Low risk in execution.
6. Without intermediaries.
7. Low cost.
8. New business models.



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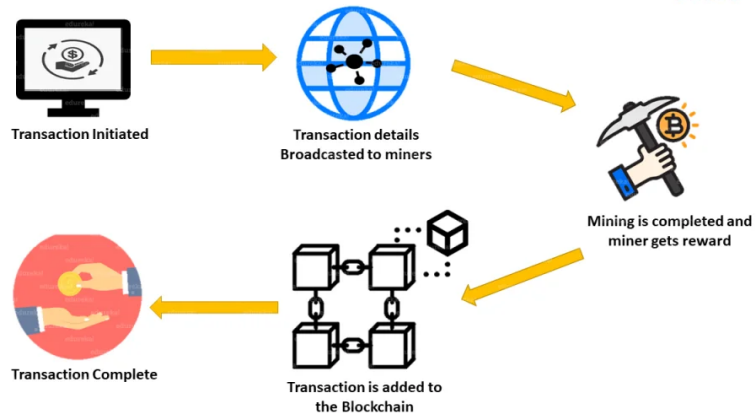
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Smart contract operation

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1. Immediate and automated execution
2. Low cost
3. Virtual presence
4. No need of third parties

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Table 1. Systematic review: Challenges in smart contracts.

Challenges	[9]	[10]	[11]	[12]	[13]
Supply chain operations	✓	✓	✓	✓	✓
Human interaction	✓	✓	✗	✗	✗
Transparency	✓	✗	✓	✓	✓
Price	✗	✓	✓	✓	✗
Inventory management	✓	✗	✗	✓	✗
Use of smart contract	✗	✗	✓	✗	✓
Security	✗	✗	✓	✗	✗
Performance	✗	✗	✓	✗	✓
Traceability	✗	✗	✗	✗	✓

- [9] Srikanta Routroy, Anuj Dixit, Sunil Kumar Dubey, "A systematic literature review of healthcare supply chain and implications of future research" 27 June, 2019.
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Table 1. Systematic review: Challenges in smart contracts.

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Price	✗	✓	✓	✓	✗
Inventory management	✓	✗	✗	✓	✗
Use of smart contract	✗	✗	✓	✗	✓
Security	✗	✗	✓	✗	✗
Performance	✗	✗	✓	✗	✓
Traceability	✗	✗	✗	✗	✓

- [9] Srikanta Routroy, Anuj Dixit, Sunil Kumar Dubey, "A systematic literature review of healthcare supply chain and implications of future research" 27 June, 2019.
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1. BPMN is a model that allows us to create diagrams, from the perspective of a business flow, including the actions and actors involved in it.
2. Objective: To help create and visualize a flow and at the same time manage its complexity.

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BPMN example

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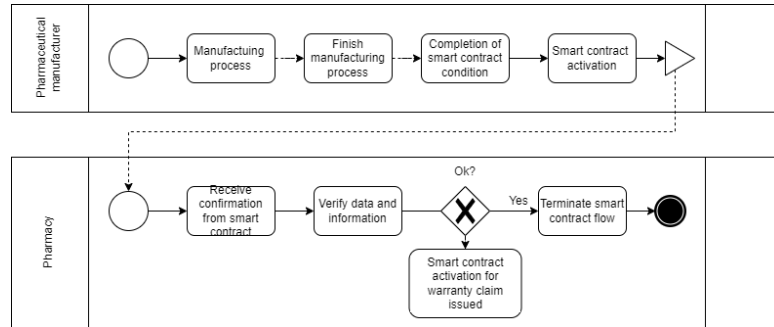


Fig. 3. Smart contracts use case for a simple flow

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Blockchain – Smart contract – Supply chain

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1. The cost of manufacturing items as part of a specific order
2. Deadlines for the manufacture of items between receipt of that order and shipment
3. Penalty and bonus clauses



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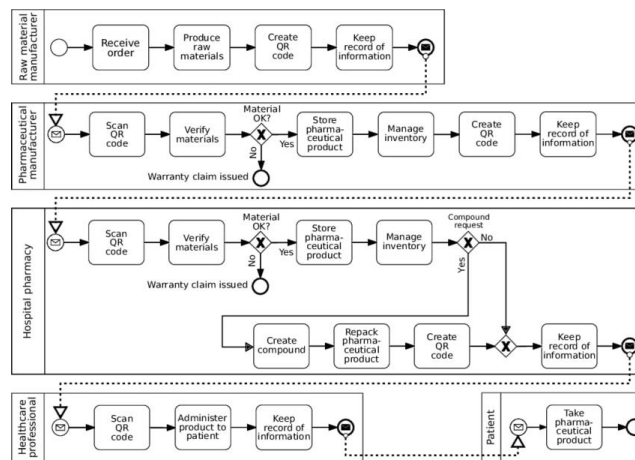


Fig. 2. BPMN diagram for healthcare supply chain [13]

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Table 2. Smart contracts implementation in health care.

Characteristics	[15]	[16]	[17]	[18]
Accuracy	✓	✓	✗	✗
Efficiency	✓	✓	✗	✗
Security	✓	✓	✓	✓
Integrity	✗	✓	✓	✓
Privacy	✗	✓	✓	✓
Performance	✗	✓	✗	✗

[15] M. Sookhak, M. R. Jabbarpour, N. S. Sata, y F. R. Yu, "Blockchain and smart contract for access control in healthcare: A survey, issues and challenges, and open issues", *Journal of Network and Computer Applications*, vol. 178, p. 102950, mar. 2021, doi: 10.1016/j.jnca.2020.102950.

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1. Adopting blockchain technology to the supply chain may increase the efficiency within the flows
2. Proposes better security, efficiency, speed in transactions thanks to this technology
3. No third-party entity required

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Smart contract implementation on a hypothetical and a real scenario



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1. Exchange year in “Université de Pau et pays de l’Adour”, campus Anglet, France.
2. Industry 4.0 specialization

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Blockchain technology applied to health care supply chain

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² Department of Computer Engineering, Universidad Autónoma de San Luis Potosí, San Luis Potosí, S.L.P., México. email: dago@uadl.mx

Abstract. Supply Chain Management (SCM) has grown in the last years due to the changing and evolutionary environment. The SCM has become fundamental for getting financial and social, among others, benefits. Currently, the traditional SCM mechanisms have some areas of improvement, such as the transparency and lack of information, long waiting times for information retrieval and data fidelity. The past months our daily lives have been changing in a drastic way due to COVID-19 and some industries were affected but with this change there has been some opportunities to improve. In this article, we describe the main concepts about the blockchain technology, the smart contracts, and their uses.

We talk about different areas that these technologies could help to improve in different types of their internal and external processes. Our main discussion is the description and improvement in the performance inside a supply chain, how it could be possible to spread up the information sharing, how a smart contract could be applied to a customer-supplier relationship in the healthcare supply chain and the benefits that it would bring to it due to the quick times that this area demands because of the nature of these transactions and operations that are critical to maintain the needs of the industry.

Keywords: Supply chain, blockchain, health care, smart contracts, management systems.

1 Introduction

Blockchain technology has become an important field of study and growth in the last years, this study aims to give an overview of the way we make transactions in our daily professional or personal life and the security of this transactions that becomes important for the use of this technology.

In the industry or in the business operation the transactions rely mostly on a conventional process or need the authorization from third parties, some of them are an extra step in the chain that they are used to follow. In the healthcare Supply Chain Management some actors are involved and take part in the decisions made to achieve a

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1. Student congress of the “Université de Pau et des Pays de l’Adour”, in the city of Anglet, France.
2. “The 11th International Congress in Telematics and Computing” (<https://www.witcom.upiita.ipn.mx/>).

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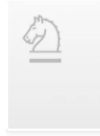
Telematics and Computing

11th International Congress, WITCOM 2022, Cancun, Mexico, November 7–11, 2022, Proceedings

Editors: Miguel Félix Mata-Rivera, Roberto Zagal-Flores & Cristian Barria-Huidobro

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Bibliographic Information

Book Title Telematics and Computing	Book Subtitle 11th International Congress, WITCOM 2022, Cancún, México, November 7–11, 2022, Proceedings	Editors Miguel Félix Mata-Rivera, Roberto Zagal-Flores, Cristian Barria-Huidobro
Series Title Communications in Computer and Information Science	Publisher Springer Cham	eBook Packages Computer Science , Computer Science (R0)
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Edition Number 1	Number of Pages XII, 484	Topics Artificial Intelligence

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1. This book constitutes the proceedings of the XI International Conference on Telematics and Computing, WITCOM 2022, held in Cancun, Mexico, in November 2022.
2. The 30 full-length articles presented in this volume were carefully reviewed and selected from 73 submissions. The articles are focused on the topics of artificial intelligence techniques, data science, blockchain, environmental monitoring, cybersecurity, education, and software for communication protocols.

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Appendix A

Blockchain Technology

This appendix introduces Blockchain Technology its processes and actors.

A.1 Introduction

The Internet has revolutionized many aspects of life, society, and business. Blockchain is believed to be the component that completes the Internet puzzle and makes it more open, more accessible, and more reliable. To understand blockchain, you have to understand it from both a business perspective and technical perspective. Let us first understand it in a business transaction context to get the “what” of it, and then look into the technicality to understand the “how” of it in the following chapters. Blockchain is a system of records to transact value (not just money!) in a peer-to-peer fashion. What it means is that there is no need for a trusted intermediary such as banks, brokers, or other escrow services to serve as a trusted third party. An example is shown in Figure 1-1 [1]

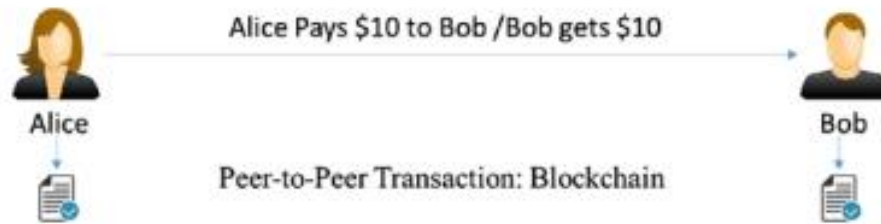


Figure 1-1. Transaction through an intermediary vs. peer-to-peer transaction

A.2 Characteristics

- Blockchain is a peer-to-peer system of transacting values with no trusted third parties in between.
- It is a shared, decentralized, and open ledger of transactions. This ledger database is replicated across a large number of nodes.
- This ledger database is an append-only database and cannot be changed or altered. It means that every entry is a permanent entry. Any new entry on it gets reflected on all copies of the databases hosted on different nodes.
- There is no need for trusted third parties to serve as intermediaries to verify, secure, and settle the transactions.
- It is another layer on top of the Internet and can coexist with other Internet technologies.
- Just the way TCP/IP was designed to achieve an open system, blockchain technology was designed to enable true decentralization. In an effort to do so, the creators of Bitcoin open-sourced it so it could inspire many decentralized applications.

Typical blockchain is shown in Figure 1-4.

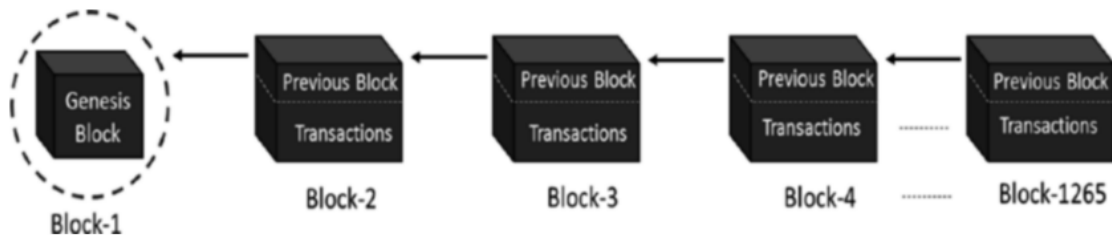


Figure 1-4. *The blockchain data structure*

A.3 Mining

Mining is the process of adding blocks to a blockchain. In a blockchain network, such as the Bitcoin or Ethereum network, there are different types of computers known as nodes. Computers on a blockchain that add blocks to the blockchain are known as miner nodes (or mining nodes, or more simply miners). We will talk about the different types of nodes later on in this course, but for now, we want to talk about a particular type of node, known as the miner node. The role of the miner node is to add blocks to the blockchain. [2]

A.4 Mining process

In order to successfully add a block to the blockchain, a miner would hash the content of a block and check that the hash meets the criteria set by the difficulty target. For example, the resultant hash must start with five zeros and so on. As more miners join the network, the difficulty level increases, for example, the hash must now start with six zeros and so on. This allows the blocks to be added to the blockchain at a consistent rate.

The first miner who meets the target gets to claim the rewards and adds the block to the blockchain. It will broadcast the block to other nodes so that they can verify the claim and stop working on their current work of mining their own blocks. The miners would drop their current work, and the process of mining a new block starts all over again. The transactions that were not included in the block that was successfully mined will be added to the next block to be mined. [2]

The process in which blocks are mined and added to the blockchain is known as the Proof of Work (PoW). It is difficult to produce the proof but very easy to validate. A good example of Proof of Work is cracking a combination lock – it takes a lot of time to find the right combination, but it is easy to verify once the combination is found. Proof of Work uses tremendous computing resources – GPUs are required, while CPU speed is not important. It also uses a lot of electricity, because miners are doing the same work repeatedly – find the nonce to meet the network difficulty for the block. A common question is why you need to use a powerful GPU instead of CPU for mining? Well, as a simple comparison, a CPU core can execute 4 32-bit instructions per clock, whereas a GPU like the Radeon HD 5970 can execute

3200 32-bit instructions per clock. In short, the CPU excels at doing complex manipulations to a small set of data, whereas the GPU excels at doing simple manipulations to a large set of data. And since mining is all about performing hashin. [3]

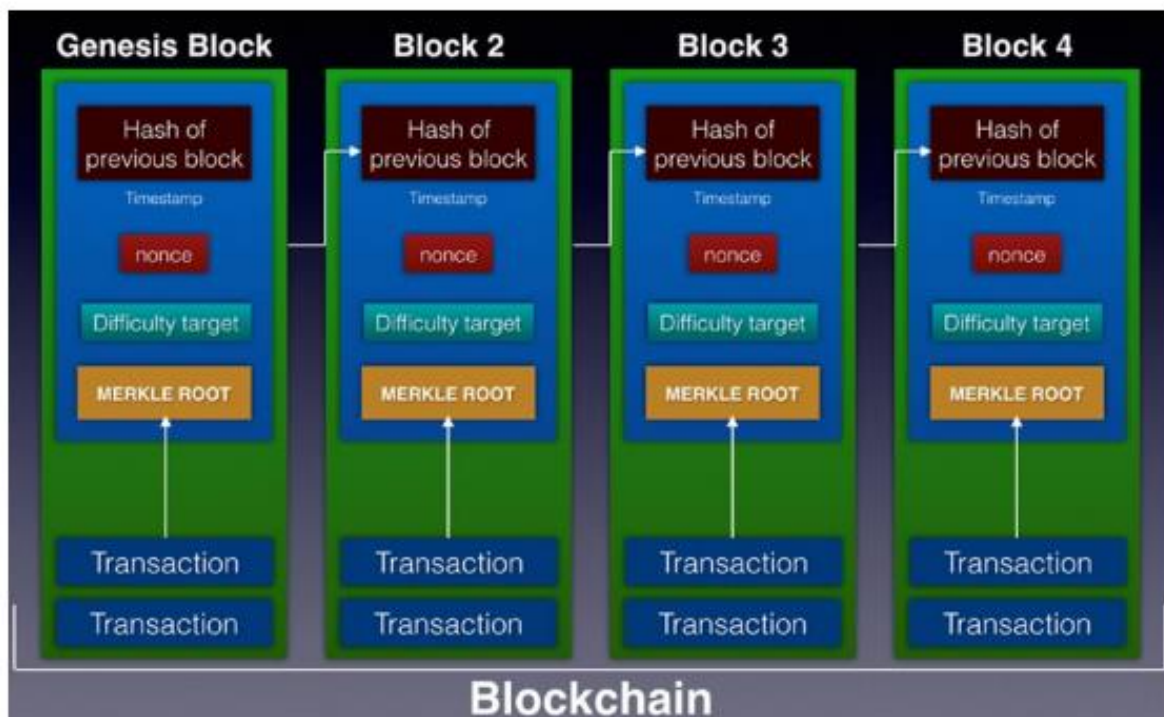
A.5 Blockchain in More Detail

In real implementation, a block consists of

- A block header
- The list of transactions

The block header in turn consists of the following:

- The hash of the previous block
- Timestamp
- Merkle root
- Nonce
- Network difficulty target



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