Blockchain and its applications

07/10/2022

Pablo Escribano Ruiz

Lab1

ACM classification

ACM offers a tool for the visual display format that makes it easier to apply CCS categories to upcoming papers.

According to the ACM classification tree, which we can see on the following website:

https://dl.acm.org/ccs

I've categorized my project using the following branches:

Networks ->> Network algorithms ->> Network economics

AMS classification

The fundamental goal of classifying items in mathematical literature using the Mathematics Subject Classification method is to make it as easy as possible for users to locate articles that are currently or potentially of interest to them.

The MSC2010, which MR and Zbl have been using since 2010, has been updated into the MSC2020, which is currently in use. The editors of MR and Zbl worked together to update their joint classification, which led to MSC2020. Over the course of the review process, which lasted more than two years, these editors acknowledge the many beneficial recommendations provided by the mathematical community.

My project fits the following description:

68P25	Data encryption

Lab2

Related scientific articles

The topic I have chosen is "Blockchain and its applications" so I have searched for five scientific articles related to that topic. Specifically, because blockchain has various applications, I have chosen an article that talks in general about the different applications it has, and another four focused on a specific application of blockchain.

To search for scientific articles I have used the web:

Google scholar - https://scholar.google.ro/

Some of these articles are in English and others in Spanish (my native language). The articles that are in Spanish have seemed good enough and related to my topic to choose them over other articles in English, so I hope that it will not be a problem.

1.

https://link.springer.com/article/10.1007/s42979-020-00366-x

This scientific article begins with a detailed explanation of how Blockchain works, the various variants of Blockchain that are in use, and the overall architecture of this decentralized system before discussing the advantages it offers over competing systems.

Last but not least, and the section that most interests me, it discusses Blockchain applications in the financial sector, concentrating on the cryptocurrency known as "Bitcoin" that is developed utilizing this kind of technology.

Additionally, it discusses various uses for blockchain that are different from the ones mentioned above, such as in the fields of education, cloud storage, and medicine. It also has several benefits when setting up an election system.

This is how the scientific article is organized:

- ### Introduction

  Brief introduction with the general characteristics and the birth of Blockchain.

- ## Types of Blockchain

  Explains and compares the 3 types of Blockchain that exist, also includes photos to make understanding easier.

- ## Centralization and Decentralization

  This chapter talks about centralized and decentralized systems, and focuses on discussing the advantages and disadvantages that a decentralized system like Blockchain has over traditional centralized systems.

- ## Architecture and Working

  In this section, it explains the architecture of the blocks in the Blockchain, and its operation when verifying a new block.

- ## Consensus Algorithm

  Here we can see an explanation of the security that Blockchain has and how difficult it is to corrupt a network: "The threshold for gaining control over the network is 51 percent of hash power".

- ## Applications

  This section, as I previously mentioned, demonstrates many use scenarios in which we may implement a decentralized network like Blockchain.

- ## Future Enhancements

  Like the section before it, this one discusses several Blockchain use cases, but it is more future-oriented.

- ## Conclusion

  The article's conclusion discusses the promising prospects for the Blockchain network and the extensive research being done in this area. In addition to mentioning the Bitcoin network, he also briefly mentions the "Ethereum" network, which in my opinion has the most promising prospects for the future.

- ## References

  It has a total of 22 references, which you can download at the end of the article.

2.

https://www.researchgate.net/profile/Jorge-Perdomo-4/publication/343541340_El_blockchain_y_sus_posibles_aplicaciones_para_la_educacion/links/5f302e29a6fdcccc43b9e375/El-blockchain-y-sus-posibles-aplicaciones-para-la-educacion.pdf

The creation of this document was driven by the exploration of blockchain technology's potential educational applications (which were already covered in the preceding article). The following section of this article explores some of the current Blockchain applications for education before introducing the features and advantages of the technology. The merits and difficulties of utilizing Blockchain technology for education are also highlighted, along with some cutting-edge implementations of this technology.

This article is written in Spanish.

This is how the scientific article is organized:

- ## Introduction

  Like the previous document, it makes a brief introduction with the general characteristics and the birth of Blockchain. It also comments on the different pioneering companies in the use of this type of network.

- ## Literary review

  This section focuses on explaining the architecture, operation, and security of the Blockchain network, as in the previous scientific article, but also tells us about some of the main networks such as "Bitcoin", "Ethereum", "ZCash " , or "Dogecoin".

- ## Educational applications with technology blockchain

  There are some educational platforms that already employ Blockchain network technology, and in this section they discuss a few of them. For example, "MOOC" (Massive Open Online Course) uses Blockchain to manage certificates, and "Kudos" implements a system of rewards for learning that is paid for with cryptocurrency.

- ## Future innovative educational applications using blockchain technology

  In this section he talks about the future of Blockchain in this field. According to the smart contract, the students would receive a specific quantity of digital currency as rewards. This kind of money can be used as tuition, kept in the student wallet, and even swapped for actual currencies.

  In addition, in the aspect of collaborative work, it can have many advantages when evaluating, since Blockchain guarantees the fairness of the evaluation.

- ## Possible problems with the application Blockchain technology in education

  If this system were to be used at educational facilities, there are various issues that would arise, as discussed in this section: high energy usage or the inability to change records like a student's grades due to the immutability of this technology.

- ## Conclusion

  The article's conclusion informs us that blockchain has a great deal of potential to be widely used in education, according to researchers. But there hasn't been much study done.

- ## References

  It has a total of 20 references which we can find in this last section.

3.

https://deliverypdf.ssrn.com/delivery.php?ID=552114115001088023012111125020090027046082018033091033077096118073112082107112081005034102023059043112038105084003104081092082053021092039027007087012011113116025078083088092124017084098087071098000080064018006010010089125113099084123072017068084&EXT=pdf&INDEX=TRUE

This article is related to the application of Blockchain technology in the marketing sector. The majority of blockchain uses have taken place in the financial sector, therefore

marketing has mostly ignored the technology. We contend that the practice of marketing will be significantly impacted by blockchain. Early adopters in marketing could reap significant benefits, but those who are left behind will pay a price.

This is how the scientific article is organized:

- ## Introduction

  The introduction discusses the benefits of Blockchain technology for the field of marketing in the opening to this post. In addition to its transmission architecture, properties like transparency, immutability, security, lower transaction costs, enable efficient property exchange through verification, and pave the way for real-time micropayments.

  Here, we can see how disruptive blockchain technology can be for marketing.

- ## The Marketing Impact of Near-Zero Transaction Costs

  Nowadays, financial transactions have considerable costs. Retailers routinely pay credit card companies a 3% payment processing fee, while gas stations pay even more. Blockchain technology allows almost zero transaction costs, even in microtransactions.

  This has implications for sellers and advertisers, in addition to the advantage of being able to use "smart contracts", which, for example, allow tasks to be carried out automatically such as: "Micropayments are deposited directly to the users' wallets whenever they interact with commercial emails ".

- ## Ending the Google-Facebook Advertising Duopoly

  With the use of blockchain technology, marketers might be able to recoup part of that money using a novel business model that eliminates the Google-Facebook barrier and instead pays customers directly for their attention.

  Additionally, blockchain technology may confirm ad delivery and consumer engagement, eliminate overserving of advertising or emails, which irritates customers and discourages them from making purchases, and stop follow-me ads that are no longer relevant.

- ## Ending Marketing Fraud and Spam

Blockchain fraud verification will also aid in confirming the source and marketing strategy of marketers.

The existing idea of mass phishing spam, which reduces the efficiency of marketing for everyone, will likewise be successfully destroyed by micropayments.

By making spamming more expensive, a very little blockchain-enabled payment to the email recipient will deter spammers.

By making spamming more expensive, a very little blockchain-enabled payment to the email recipient will repel spammers.

- ## Remonetizing Media Consumption

Blockchain fraud verification will also aid in confirming the source and marketing strategy of marketers.

The existing idea of mass phishing spam, which reduces the efficiency of marketing for everyone, will likewise be successfully destroyed by micropayments.

By making spamming more expensive, a very little blockchain-enabled payment to the email recipient will deter spammers.

A new web browser called Brave is one instance of this. A blockchain-based system that Brave is allowing aims to change the dynamic between users, advertising, and content producers. Publishers will be able to monetize value-added services and take a portion of the rise in advertising, which currently accounts for 73% of revenue and is controlled by Facebook and Google.

- ## Adapt or Risk Becoming Obsolete

All mediators will need to change their business models as blockchain becomes more widely used.

By improving visibility, linking parties, and paying individuals for their contributions to transactions, blockchain technology has the ability to empower societies and make them more trustworthy.

These modifications have an important impact on marketing and advertising.

Blockchain has the ability to help marketing and technology leaders redefine their consumer connections.

- ## References

It has only a total of 3 references which we can find in this last section.

4.

https://link.springer.com/chapter/10.1007/978-3-319-50011-9_20

This article is related to the application of Blockchain technology in the medical sector. The main facets of big data, blockchain, and medical records will be covered in this paper. It will then go into the benefits and disadvantages of using blockchain for the storage and retrieval of medical records. The alternatives to employing blockchain and big data methods will also be explored.

This is how the scientific article is organized:

- ## Introduction

  In the introduction to this document, it talks about the importance and benefits of a shared system of medical records that meet the condition of being easily accessible by an authorized person, properly stored, properly protected, and traceable.

  All this could be achieved with the use of "Big Data" and the technology of a Blockchain network.

- ## Development Approaches

  The issues that Blockchain is proposed to address in the field of medicine are described in the introduction, and they are all thoroughly examined in this portion of the paper.

  For current and past works by others that focus on the integrity of medical reports without caring about many other issues, Blockchain is a very good choice. However, as medical data records and files increase in amount over time, Blockchain-related application development may soon reach a brick wall. Many of the issues identified in the previous section will need to be resolved. It is much preferable to be ready for the worst-case scenarios. The integrity can be protected through Blockchain. It cannot, however, guarantee the veracity or accuracy of the reports. It is unable to regulate the right to view. It is unable to address the problems caused by outdated formats. It is unable to manage constantly growing storage sizes. Neither delete nor purge will work.

  Not everything is on the blockchain. Other technologies are required to support any design.

- ## Conclusion

  This article came to the conclusion that the use of blockchain is crucial after weighing the advantages and disadvantages of doing so in this line of work. To support the original plan, new technologies like big data analytics and tokenization are crucially needed.

- ## References

  It has a total of 10 references, which you can download at the end of the article.

5.

http://sedici.unlp.edu.ar/bitstream/handle/10915/104030/Documento_completo.pdf-PDFA.pdf?sequence=1&isAllowed=y

This article is related to the application of Blockchain technology in the security of the IoT sector. The main issues with IoT security are analyzed in this research project, and some of the issues can be resolved by using Blockchain, one of the most tearing technologies of our time, whose use has been gaining interest ever since it was first introduced for its decentralized ability to guarantee the authenticity of transactions and the integrity of any entity connected to the Internet.

This article is written in Spanish.

This is how the scientific article is organized:

- ## Introduction

  In the introduction to this document, he talks about the characteristics that make Blockchain a secure, transparent, and immutable network technology, as I have already mentioned in previous articles. He also briefly explains the differences between the "Ethereum" and "Bitcoin" networks, as well as smart contracts, which are very interesting for the "Internet of Things" field.

  Blockchain can be a key technology in providing viable security solutions to challenging IoT security problems. With the development of the Ethereum blockchain, which implements smart contracts, the potential use space of the Blockchain has become very important.

- ### Research And Development Lines

  The use of smart contracts, which define access rules, conditions, and times to permit certain individuals or groups of users or machines to own, control, or have access to data at rest or in transit, can help secure data privacy.

  In addition, smart contracts can specify who is authorized to reset an IoT device, create new key pairs, start a service or repair request, and change ownership of a device. They can also specify who is authorized to update and patch IoT software or hardware, and provide a device reset.

- ### Results Obtained/Expected

  The results obtained so far were presented in an article approved for publication in the digital magazine ReDDI (Digital Magazine of the Department of Engineering).

  This study examines the potential for fusing blockchain technology with the Internet of Things, showing both its advantages and disadvantages.

- ### Training Of Human Resources

  He discusses the project's future, the people involved, and their intended areas of focus in this final portion.

- ### References

  It has a total of 19 references which we can find in this last section.

Lab3_4

Content of the work

Next I am going to write the index of my research project.

1. **Introduction**
2. **Blockchain operation and architecture**

   a. Decentralized networks
   b. Architecture of a Blockchain network
   c. Types of Blockchain networks
   d. Smart Contracts
3. **Blockchain applications today**
   a. Data management and digital identity
   b. Financial sector
   c. IoT sector
   d. Educational sector
   e. Marketing sector
   f. Other sector's
4. **Future Blockchain applications**
   a. Medical sector
   b. Security sector
   c. Legal sector
   d. Logistics sector
   e. Other sector's
5. **Advantages of the decentralized network: Blockchain**
6. **Blockchain disadvantages and their possible solutions**
7. **Conclusion**
8. **Bibliography**

Bibliographic elements

The 15 bibliographical items listed below are relevant to my research (The first five have already been mentioned in this article):

1. A Detailed Review on Blockchain and Its Applications - https://link.springer.com/article/10.1007/s42979-020-00366-x
2. El blockchain y sus posibles aplicaciones para la educación - https://www.researchgate.net/profile/Jorge-Perdomo-4/publication/343541340_El_bl

ockchain_y_sus_posibles_aplicaciones_para_la_educacion/links/5f302e29a6fdcccc43b9e375/El-blockchain-y-sus-posibles-aplicaciones-para-la-educacion.pdf

3. How Blockchain Will Change Marketing as We Know It - https://deliverypdf.ssrn.com/delivery.php?ID=552114115001088023012111125020090027046082018033091033077096118073112082107112081005034102023059043112038105084003104081092082053021092039027007087012011113116025078083088092124017084098087071098000080064018006010010089125113099084123072017068084&EXT=pdf&INDEX=TRUE
4. Medical Record System Using Blockchain, Big Data and Tokenization - https://link.springer.com/chapter/10.1007/978-3-319-50011-9_20
5. Seguridad en Internet de las Cosas usando soluciones Blockchain - http://sedici.unlp.edu.ar/bitstream/handle/10915/104030/Documento_completo.pdf-PDFA.pdf?sequence=1&isAllowed=y
6. BLOCKCHAIN AND THE APPLICATION OF BLOCKCHAIN TECHNOLOGY - https://www.researchgate.net/publication/362023529_BLOCKCHAIN_AND_THE_APPLICATION_OF_BLOCKCHAIN_TECHNOLOGY
7. A Survey of Blockchain Applications in the FinTech Sector - https://www.researchgate.net/publication/364324844_A_Survey_of_Blockchain_Applications_in_the_FinTech_Sector
8. Machine Intelligence and Blockchain for Smart City applications - https://www.researchgate.net/publication/364380448_Machine_Intelligence_and_Blockchain_for_Smart_City_applications
9. BLOCKCHAIN APPLICATIONS FOR COVID-19–A SURVEY - https://www.researchgate.net/publication/363519773_BLOCKCHAIN_APPLICATIONS_FOR_COVID-19-A_SURVEY
10. Blockchain Applications in Agriculture: A Scoping Review - https://www.researchgate.net/publication/362649451_Blockchain_Applications_in_Agriculture_A_Scoping_Review
11. Analysis of Blockchain in the Healthcare Sector: Application and Issues - https://www.researchgate.net/publication/362885986_Analysis_of_Blockchain_in_the_Healthcare_Sector_Application_and_Issues?_iepl%5BgeneralViewId%5D=g5T4xZ4DFoJOqVmgZeCLfPvQYFE3OOSbezz3&_iepl%5Bcontexts%5D%5B0%5D=searchReact&_iepl%5BviewId%5D=BuQzyK9QmK9oHIhU9l7jnFc8Jlz6eUJfGDHj&_iepl%5BsearchType%5D=publication&_iepl%5Bdata%5D%5BcountLessEqual20%5D=1&_iepl%5Bdata%5D%5BinteractedWithPosition20plus%5D=1&_iepl%5Bdata%5D%5BwithoutEnrichment%5D=1&_iepl%5Bposition%5D=21&_iepl%5BrgKey%5D=PB%3A362885986&_iepl%

5BtargetEntityId%5D=PB%3A362885986&_iepl%5BinteractionType%5D=publicationTitle

12. Investigating the Requirements for Building a Blockchain Simulator for IoT Applications - https://www.researchgate.net/publication/362908902_Investigating_the_Requirements_for_Building_a_Blockchain_Simulator_for_IoT_Applications
13. Blockchain: Current Problems and Applications - https://www.researchgate.net/publication/364916567_Blockchain_Current_Problems_and_Applications
14. Blockchain Enabled Applications Understand the Blockchain Ecosystem and How to Make it Work for You - https://www.researchgate.net/publication/362689200_Blockchain_Enabled_Applications_Understand_the_Blockchain_Ecosystem_and_How_to_Make_it_Work_for_You
15. Application of Blockchain Technology in Intellectual Property Protection - https://www.researchgate.net/publication/361180238_Application_of_Blockchain_Technology_in_Intellectual_Property_Protection

Plan for the application part of the work

Because this type of decentralized networks is a relatively new field that is being thoroughly investigated to improve it and find some new applications, my project is about a research in the field of Blockchain networks, specifically in the variety of applications that it currently has, and will have in the future.

My work consists in finding and listing the different existing and developing applications on Blockchain networks, but I also develop my own idea about an application that could be very useful thanks to the use of this technology:

My hypothesis is that we may use this kind of decentralized network for the "appellation of origin" of wine bottles by utilizing it.

When we look at a bottle of wine in any supermarket or winery in Spain (I'm not sure if this occurs in other countries), we can see a brief description of the grape and its manufacturing process on the label, which for the majority of products doesn't change for years. Manufacturers are required by law to include this information on the bottle so that the consumer can understand the steps taken to produce that particular wine.

Let's now imagine that, in addition to all of those seals and their brief descriptions, there was a little code that, when scanned, would show us in full the entire history of that wine up until the moment it reached our hands:

- Its clarification.

- Any treatments the plant has had during the course of its life.

- Storage type, duration, and temperature.

- Transport that is specialized.

- The length of exposure in the store, etc.

It could be used not only for wine, but also for any product in a supermarket (such as meat and all its information from the livestock farm to the supermarket).

I have focused only on wine, since it is regulated by law (in Spain all wineries are obliged to have it), it is a sector in which a Blockchain network would have a lot of potential because all wines must have it. My experiment would consist of testing whether it would be viable and useful to develop something like this.

Identify the possible original contribution

My original idea in this research, apart from the task of collecting the different applications of Blockchain technology, is the use of the Blockchain network in the labels of "denomination of origin" of wine bottles which (at least in Spain) must carry them by law and offer information of all kinds about the process of obtaining, transport, etc. of that bottle of wine.

Because of that, we can realize that if we offer advantages to both the buyer and the producer, it could be a revolution for the wine sector (and it could be for any other type of product sold in a supermarket). Below I will expose different advantages of using a Blockchain network in these labels.

From the consumer's point of view, it is not the same to take a bottle from a supermarket for a special occasion, and read a small description on the back, than to see next to that description a small code that you can scan with your mobile phone and know what kind of product you have in your hand, from its origin to its destination with what or how it has been treated and whether or not it is environmentally friendly.

Additionally, these seals would be "ecologically sustainable".

With them, the buyer could confirm, for instance, that the product he purchases does not use pesticides or fertilizers that are harmful to the environment:

- Does not use pesticides or fertilizers that are damaging to the environment.

- Does not produce enough garbage in the area to have a detrimental ecological impact.

- Does not impact the environment's habitat (as was previously the case with factories that dumped directly into rivers and so on).

It is not only interesting for the buyer, an entrepreneur wine producer who cares about the reputation of his product could be afraid that a poor shipment could ruin the name of the wine he has been meticulously crafting and growing for years.

The following parameters can be recorded using the blockchain system:

- Transportation (knowing how long our product is in circulation before being delivered to the point of sale).

- Refrigeration circumstances, if applicable.

- The length of time it takes a buyer to buy our product.

- Keep track of consumer comments and product-related questions in order to implement marketing and customer engagement strategies, etc.

My experiment would consist in answering the following questions:

- Is my proposal technologically viable nowadays?

- Could it actually be interesting for the consumer as well as for the suppliers, carriers, merchants, and other distributors?

- In order to use this technology, would it be required to modify the law regulating the "denomination of origin" label (in countries that demand it)?

- Would it be interesting to use this same concept for other supermarket product categories?

Lab5_8

Modeling the experimental part

Next, I will model some small experiment or way to test the answers to the questions I posed at the end of the previous lab:

- Is my proposal technologically viable nowadays?

- Could it actually be interesting for the consumer as well as for the suppliers, carriers, merchants, and other distributors?

- In order to use this technology, would it be required to modify the law regulating the "denomination of origin" label (in countries that demand it)?

- Would it be interesting to use this same concept for other supermarket product categories?

To do so, I will go through them one by one.

First question:

- Is my proposal technologically viable nowadays?

Well, to check if today it would be technologically possible to develop my idea about smart labels on wine bottles with Blockchain technology, I thought that the best way is to learn how to program in Blockchain (in the Solidity language, to be more exact) to check it myself, with a small program that performs something similar, although obviously on a very very small scale.

Second question:

- Could it actually be interesting for the consumer as well as for the suppliers, carriers, merchants, and other distributors?

Well, as I analyzed in the previous lab (I quote myself):

"From the consumer's point of view, it is not the same to take a bottle from a supermarket for a special occasion, and read a small description on the back, than to see next to that description a small code that you can scan with your mobile phone and know what kind of product you have in your hand, from its

origin to its destination with what or how it has been treated and whether or not it is environmentally friendly.

Additionally, these seals would be "ecologically sustainable".

With them, the buyer could confirm, for instance, that the product he purchases does not use pesticides or fertilizers that are harmful to the environment"

"*It is not only interesting for the buyer, an entrepreneur wine producer who cares about the reputation of his product could be afraid that a poor shipment could ruin the name of the wine he has been meticulously crafting and growing for years.*"

Therefore, I believe that with this small analysis it is not necessary to carry out any further study, since it is clear that it is of interest to all parties. A survey of both consumers and producers could be carried out, but it is beyond my scope.

Third question:

- In order to use this technology, would it be required to modify the law regulating the "denomination of origin" label (in countries that demand it)?

To check whether it is necessary to modify any regulation, we must obviously study the current regulation. But each country has its own regulation, so in my case we will focus on studying the Spanish regulation regarding the "denomination of origin".

Fourth question:

- Would it be interesting to use this same concept for other supermarket product categories?

In this case we should make a small analysis, as in the second question, to reach some conclusion on whether it would be interesting to carry out this also in other supermarket products. In this case it would also be interesting to carry out a survey to confirm the study, but again it is beyond my scope.

Initial case study

Now, we must answer the questions I pose in the way I have decided in each case, and we are going to do it one by one.

First question:

- Is my proposal technologically viable nowadays?

I have learned how to program in the Blockchain and I have made a small program in Solidity in order to check if it is really feasible to do this:

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.13;

library IterableMapping {
    // Iterable mapping from address to uint;
    struct Map {
        address[] keys;
        mapping(address => uint256) values;
        mapping(address => uint256) indexOf;
        mapping(address => bool) inserted;
    }

    function get(Map storage map, address key) public view returns
(uint256) {
        return map.values[key];
    }

    function getKeyAtIndex(Map storage map, uint256 index)
```

```
        public
        view
        returns (address)
    {
        return map.keys[index];
    }

    function size(Map storage map) public view returns (uint256) {
        return map.keys.length;
    }

    function set(
        Map storage map,
        address key,
        uint256 val
    ) public {
        if (map.inserted[key]) {
            map.values[key] = val;
        } else {
            map.inserted[key] = true;
            map.values[key] = val;
            map.indexOf[key] = map.keys.length;
            map.keys.push(key);
        }
    }

    function remove(Map storage map, address key) public {
```

```
        if (!map.inserted[key]) {
            return;
        }

        delete map.inserted[key];
        delete map.values[key];

        uint256 index = map.indexOf[key];
        uint256 lastIndex = map.keys.length - 1;
        address lastKey = map.keys[lastIndex];

        map.indexOf[lastKey] = index;
        delete map.indexOf[key];

        map.keys[index] = lastKey;
        map.keys.pop();
    }
}

contract TestIterableMap {
    using IterableMapping for IterableMapping.Map;

    IterableMapping.Map private map;
```

```
    /*
        The map positions could be the information that the "denomination
of origin" label contains,
        for example in this example it would be:

            [grapeType, wineWarehouse, transportCompany, supplier]

        And it would contain the following codes (which can be the
identifying code for each attribute):

            [13,125467,232466,336246]

    */
    function testIterableMap() public {
        map.set(address(0), 13);
        map.set(address(1), 125467);
        map.set(address(2), 232465); // bad insert (it would be 232466)
        map.set(address(2), 232466); // update
        map.set(address(3), 336246);

        //  Iteration
        for (uint256 i = 0; i < map.size(); i++) {
            address key = map.getKeyAtIndex(i);

            assert(map.get(key) != 0);
        }

        //  You can remove one field (wineWarehouse "address(1)")
```

```
        map.remove(address(1));


        // keys = [grapeType "address(0)", transportCompany "address(2)",
supplier "address(3)"]
        assert(map.size() == 3);
        assert(map.getKeyAtIndex(0) == address(0));
        assert(map.getKeyAtIndex(1) == address(3));
        assert(map.getKeyAtIndex(2) == address(2));
    }
}
```

As we can see, the code contains some explanatory comments, and in it I created a map where I can save all the information that interests me (in this case would be the information contained in the label of the bottle of wine), so I can conclude that it is technologically possible to carry out.

Second question:

- Could it actually be interesting for the consumer as well as for the suppliers, carriers, merchants, and other distributors?

For this second question, as I mentioned in the previous section, I have already reached a conclusion with the small analysis I did in the last laboratory, so I consider that I should not perform any other experiment. I can only think of contrasting the data with a survey, which I cannot do at the moment.

Third question:

- In order to use this technology, would it be required to modify the law regulating the "denomination of origin" label (in countries that demand it)?

To check if it would be necessary to modify the Spanish regulation, I have gone to the BOE (Official State Bulletin) and after reading it, at least to the best of my knowledge of the law, I believe that there would be no problem to carry this out in Spain.

The official bulletin I have read is this one (referring to the "denomination of origin"):

https://www.boe.es/diario_boe/txt.php?id=BOE-A-2015-5288

Fourth question:

- Would it be interesting to use this same concept for other supermarket product categories?

To analyze whether this same technology would also be interesting for other supermarket products, we should ask ourselves the following question: have we concluded that it is interesting for both producers and consumers, and is it technologically and regulatory feasible? We have already concluded that the answer to both of those questions is yes, so that trying to cover this idea with other types of products should be at least technologically feasible.

Now, although the law does not require in Spain to put these labels on other types of products, that does not mean that producers cannot do it to benefit from the advantages mentioned above, and of course, if a consumer finds it an interesting idea for bottles of wine, it will also seem a good idea for any other product such as meat, vegetables, etc...

So my conclusion is that of course it would be interesting for other types of supermarket products. In fact I would say that we will probably end up seeing something similar in all supermarkets in the future.

Preparing validation

In order to perform the validation I will look for a related article, with which I can contrast my conclusions.

Related work

- To begin with, I have found this article that talks about the same concept I am dealing with, but instead of focusing on Spain with the Spanish regulation, it focuses on Venezuela, where there are other types of different regulations:

https://forum.cardano.org/t/usando-la-blockchain-cardano-para-emitir-certificados-de-denominacion-de-origen-en-venezuela/63309

- In this other article, for example, I found a project called DOPCHAIN, which aims to develop a traceability solution based on Blockchain technologies to improve consumer confidence in protected quality agri-food products:

https://www.fundacionctic.org/es/proyectos/dopchain-solucion-basada-en-tecnologias-blockchain-para-la-trazabilidad-de-productos-de

As we can see, the articles I have found have carried out their own studies and experiments, but they reach a conclusion in line with mine, so I can understand that my analysis has been correct.

Source code

To answer my first question posed, I had to make a little code written in Solidity, which I have uploaded to github at the following link:

https://github.com/pabloubb/Denomination-of-origin

As I have made the code locally, I had not uploaded the code to github until today that I am making the delivery, so there is no repo history where you can see my progress over time.

Lab9_12

Research project structure

Summary:

In this article, I have researched about blockchain technology: its different applications and current uses, the future of this technology, the advantages of this network over other types of networks, the way it works... But also, as an original contribution, I have carried out the research of an experiment on the usefulness, viability, and advantages (among other things) of the use of blockchain in the labels of denomination of origin such as those of wine bottles, obtaining results and conclusions that agree with my hypothesis.

Classification:

As I discussed at the beginning of this article, the AMS and ACM classification is as follows:

- ACM:

Networks ->> Network algorithms ->> Network economics

- AMS:

68P25	*Data encryption*

Introduction:

The problem addressed is to solve a series of questions formulated by myself, in order to validate my hypothesis:

- Is my proposal technologically viable nowadays?

- Could it actually be interesting for the consumer as well as for the suppliers, carriers, merchants, and other distributors?

- In order to use this technology, would it be required to modify the law regulating the "denomination of origin" label (in countries that demand it)?

- Would it be interesting to use this same concept for other supermarket product categories?

Once the research was done, I was able to answer all the questions, and prove that my hypothesis was correct.

In order to have such a hypothesis in my mind, I have done another previous research work about the functioning of blockchain and the different applications of this type of network, both present and future. Different related bibliographic sources can be found throughout the document.

Description of the original approach:

In order to solve the problem posed in the 4 questions mentioned above, I have needed to read many related articles, research on the internet about blockchain technology, about the Spanish legislation regarding appellation of origin labels, and I have also had to learn how to program in Solidity to be able to make a small test program and check that my idea is technologically feasible today.

Experimental validation:

After learning about blockchain technology, the Spanish legislation on the appellation of origin label, Solidity, and having read many other related research projects; I already had all the necessary data to be able to solve the questions posed about the problem. All the data was collected by myself, although really everything was on the internet, so other people had previously researched to obtain many of those data that I used.

The result was that thanks to these data, I was able to validate my hypothesis correctly, since they were in agreement with each other.

Results and conclusions:

In my case, for this research, I only had to answer some questions that I posed myself, and for this I looked for the necessary data to be able to carry out a study and answer them.

Thanks to my research, I have concluded that a blockchain-based system focused on appellation of origin labels could be beneficial, useful, and feasible to carry out today, so other lines of research could appear focused, for example, on carrying out a real implementation of this innovative idea.

Bibliography:

Throughout this document, there are several bibliographic elements, which I have used to help me, both in the first laboratory deliverable and in the second one, there are many of

them, and also on page 23, there are others which I used to solve the questions posed in my experiment.

Research project structure

This document and the source code used in the previous lab, is uploaded in github to be able to study them together, in the following link:

https://github.com/pabloubb/Denomination-of-origin