

B-Health a digitized healthbook

Atos project on Blockchain

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TABLE OF CONTENTS

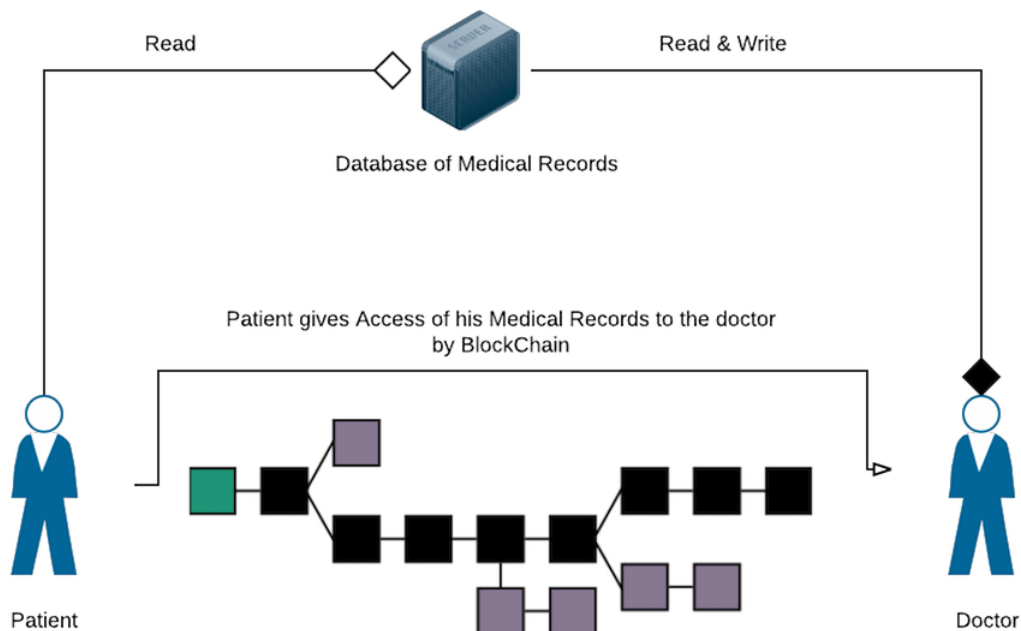
I. Introduction	3
1. B-Health: a online healthbook.....	3
2. Pain point of today's process.....	4
3. Necessity to use Block Chain	5
II - French healthcare system	6
1. Personal data	6
2. Member access.....	6
3. New functionalities for the professionals.....	6
III . System architecture and Implementation with Ethereum	7
1. Technical choices	7
2. Techinal details and different roles	9
IV. Conclusion.....	10
References	11

I. Introduction

With the development of Internet, today's medical system is already way much better than years ago. You can make an appointment online, get information about the medicines but there is no digital innovation on medical record.

In France the Vital Card enable to digitalize and transfer administrative information about a patient. Our idea is to provide a secured system to store and transfer not only administrative data but also medical records. Thus, a patient can decide to show some parts of its medical record (and enable write access) to any medical professional.

1. B-Health: a online healthbook



The healthbook should contain 3 kinds of information. First of all, personal informations about the patient : their single social security number, references to insurance and other administrative information. In France you can find these data on the vital card.

Secondly, the healthbook contains medical records groups by field (podology, psychiatric, etc). This kind of information is less organized because it contains unstructured data like radiography, schema or only notes.

Finally, financial information like prescription and bill are stored in the healthbook separately.

The patient, is considered as the owner of the healthbook. However, they don't have write rights. The patient can only do two things : read the data (full read access) and enable a medical professional to have access.

For example:

A doctor, with its job privilege and the agreement of the patient can read and write only in its specialty field.

A drug seller can only have access to prescriptions.

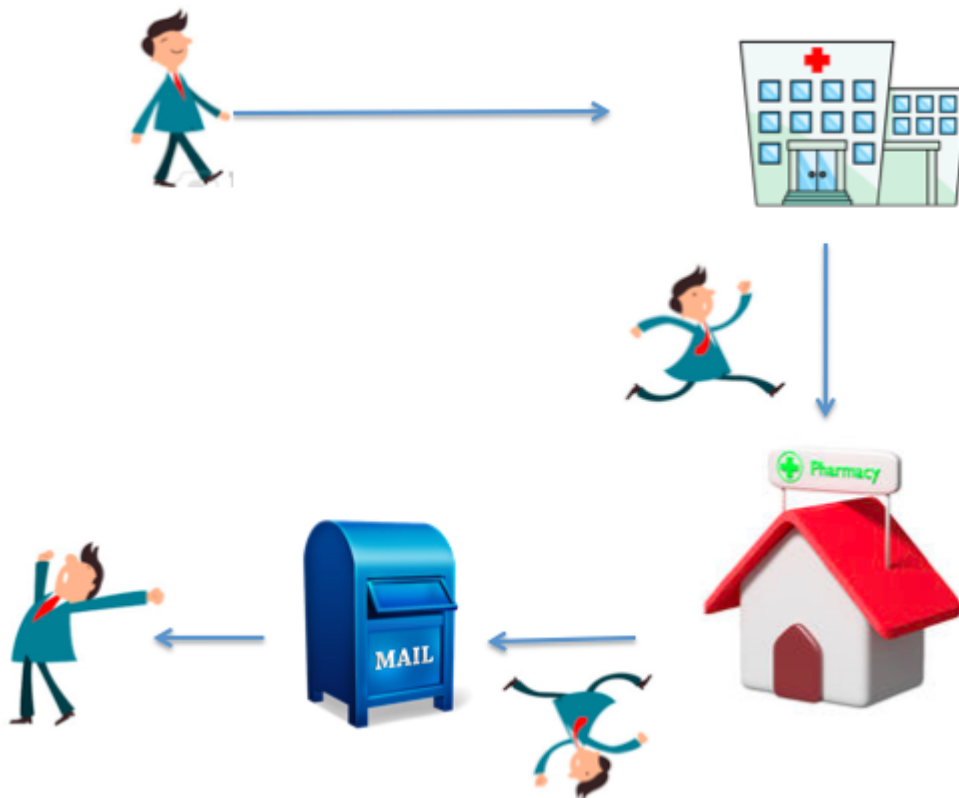
The insurance can only have access to medical bills.

To summarize, there are three kinds of user, patient, doctor and other medical professional that can access to only some parts of the healthbook. Information in this system can be divided in three categories: administrative, financial and medical record. The access and rights are parameterized by the patient and the job of the second user.

The main advantages of this system are:

- Having a full dematerialized medical history of a person
- Preserving personal information by showing to medical professional only some information according to their job
- Connecting several medical agents to reduce administrative tasks

2. Pain point of today's process



With the development of Internet, today's medical system is already way much better than years ago. You can make an appointment online, get information about the medicines and have more choices etc.

However, even so, it can still be better. John is a student who lives in France. Imagine John is getting ill one day. He needs to see a doctor and take some medicines. First he has to make an appointment with a doctor and go to see the doctor, then he has to take the prescription given by the doctor and go to a pharmacy to buy the drugs he needs. After all these it is still not finished, he has to organize these invoices and send them to the insurance company by letter. What worse could happen is: what if John lost his medical records of the past that is requested by the doctor? What if he lost the prescription? What if he cannot find the invoice anymore?

How about a block-chain based platform that facilitates this pain point? The data of John is transferred directly through block-chain to the doctor with security and it is never lost. Then he no longer needs to go to pharmacy and post office, because the data are directly transferred to the pharmacy and assurance. He can go home right after seeing the doctor, and the rest is done for him. The doctor can click a button and send the prescription to the pharmacy, click another button to send the invoice to insurance company. Once pharmacy receives the prescription, it will also transfer it to the insurance company. And all John only needs to wait at home for his medicines (or he can go to a nearby pharmacy to take them).

3. Necessity to use Block Chain

A block chain is a transaction database shared by all nodes participating in a system based on the Bitcoin protocol[1]. It is at first built for the purpose of financial ledger, while it can also be applied to other applications online. Basically a block chain is a long chain of information that contains lots of different blocks, and a transaction needs to be done with all these blocks. Each block contains timestamp and hash of the previous block. The timestamp is important because it ensures the transaction is made in an order and it can be tracked by time. And the hash of the previous block enables the chain to be continuous and synchronized. The feature of the block chain makes it a very secure way to transfer the information and without needing the middle man. If one block has been hacked, all the blocks on the block chain needs to be changed to make that hack happens.

People also see block chain as smart contracts: it contains a transmitter, a recipient and lots of nodes that transfer the information. The encrypted content and is travelling and validated by all the blocks. We are planning to build our application on the Ethereum platform. Ethereum is an open blockchain platform that lets anyone build and use decentralized applications that run on blockchain technology[2]. We can use the smart contract of Ethereum to keep the medical records, the bill records, the prescription records and also make transactions between these different organizations.

For our project, the complexity is to have an good management of all the different level of access. Blockchain can help us to solve this issue by its smart contract.

II - French healthcare system

1. Personal data

In France, all the medical data storage has to be certified by an organism to prove the strong security. Not only the storage but also, the maintenance has to be approved to host medical record (in french we talk about *Environnement hébergeur de santé*). Every access recorded and has to be strong authentication.

There already exists some models of database certified for medical purpose. For this project we will store all the information in an already existing database and only the access part will go through blockchain. In the blockchain model ours transaction will actually be “access demand”.

2. Member access

As it is described before, in medical system every access has to be a strong authentication. For the patient, the french system used vital card ID. And for the doctor there is an identification given to every member of the Order of the Doctors (*membre de l'ordre des médecins*). Thus they have an equivalent to the vital card for professional called CPS (*Carte de Professionnel de la Santé*).

Therefore, in our project the secured key that enable to have access to a file, by another person than its owner, will be a correlation between the vital ID of the patient and the CPS ID of the professional.

3. New functionalities for the professionals

If this system is generalized we can go further following two directives:

- More services for the patient and the doctor
- Enable advances protocols with insurance

Here are some ideas of how to add features to B-Health with simple connected objects:

- Physical authenticator for emergency doctor:

A chronic patient can wear RFID wristband that can deliver a access-key to its medical record for the emergency doctor.

For example, if a patient is unconscious. The doctor, who will also have a RFID wristband, can have access to its medical record by connecting the devices.

- Medical observance for insurance contract:

Some treatments have instructions for the patient like taking regularly some drugs or doing some exercises. We can imagine that some insurance contract will soon refund the fees only if the patient actually follows the recommendations.

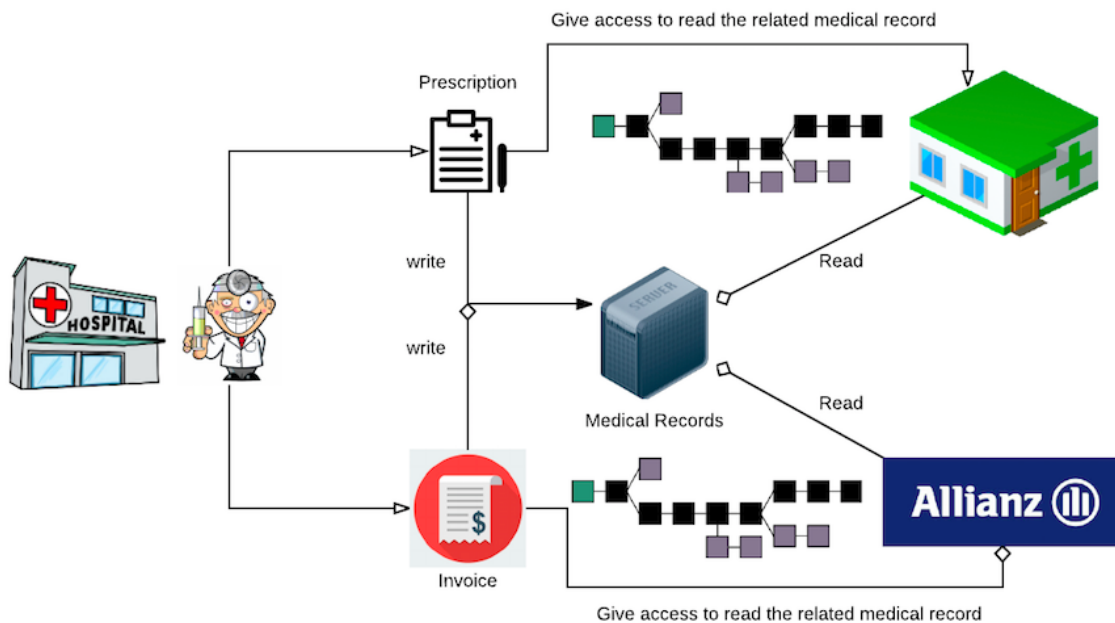
In this case, block chain and the smart contract notion can automate the repayment.

There exist a lot of connected objects that can prove that someone took a medicine or practiced sport. These devices, once connected to the block chain can trigger the repayment if they detect that the instruction is respected.

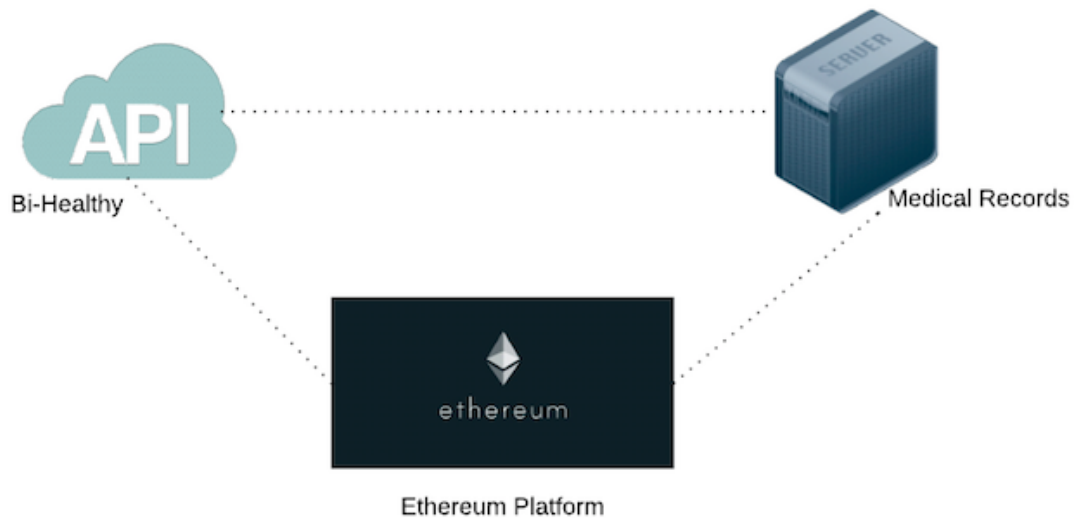
III . System architecture and Implementation with Ethereum

1. Technical choices

a) System architecture:



Once the process of seeing a doctor is done, the prescription written by the doctor is generated and saved in the medical Records database. Then the invoices are also generated automatically. At the same time, access are sent to pharmacy and insurance company for this medical record, so that they can do the following processes.



To solve the important issues which are the conservation of the medical historic and it's confidentiality we plan to base our project on the platform Ethereum and it's system of messages and transactions.

Let's take the example of a drugs prescription, in this case we will have to insure that :

- 1/ Government can provide a list of allowed Doctors & Drugs
- 2/ Any one can check whether or not a Doctor or a Drugs were allowed by the Government
- 3/ Patient and only him can allow her/his Doctor to write in her/his medical record
- 4/ Doctor (allowed by the patient) can write a message in the medical record
- 5/ Pharmacist can see some of the messages (drugs prescription) of the Doctor

b) Solidity language

To actually create the Contracts described in this section III we will use the language Solidity which a language provided by the Platform Ethereum.

The purpose of this language is to let intermediate developers make Blockchain related application without having a deep knowledge of cryptography of the internal behaviour of the Blockchain.

Though we think it's important to understand the issues related to the Blockchain and how it works internally.

We think it's even more important to deliver a proof of concept of our ideas related to medical records and to have.

This language will allow us to build something that we can actually use and test, show and improve while we are learning about how the guts of Ethereum are made.

c) Blockchain constraint

Even though the blockchain provides us with the convenience of safe transaction, however it is also limited. On each block we need to transfer the most basic meta-data, if not, the blockchain will be really loaded and the servers will not be able to calculate large amount of datas.

That's why we still need a database for the detailed medical records. BlockChain helps us to give/take back access of certain records.

2. Technical details and different roles

a) Government can provide a list of allowed Doctors & Drugs

To allow the Government to create a list of allowed Doctors we will define a Contract (A) in Ethereum.

A Contract can be use like a program that a real User (External Account) can call to get a particular result.

This Contract (A) will contain the following state properties to store data :

- (P1) : Address of the creator of the Contract (a Special Government Account)
- (P2) : List of allowed Doctors
- (P3) : List of allowed Government Accounts

The Contract (A) will also contain the following functions :

- (F1) : Check whether or not a Doctor is in the allowed list, this function will be accessible by anyone
- (F2) : Let the creator of the Contract (A) add an allowed Government Account
- (F3) : Let a Government Account add an allowed Doctor in the list
- (F4) : Let the creator of the Contract (A) remove an allow Government Account
- (F5) : Let a Government Account remove an allowed Doctor from the list

N.B. : sometimes in this section we are using the terme Account instead of Account address (Government Account <=> Government Account address)

When a Government Agency needs to be able to add Doctor, the Account which was used to create the Contract (A) can be used to add a Government Account in the allowed list (P3) through the function (F2).

When a new Doctor is available, the special Government Account whom address is stored in (P1) will be used to add this Doctor in the list of allowed Doctor (P2) in the Contract (A) through the function (F3).

If the Doctor is retired or dead or is no longer authorized to practice the special Government Account will be able to remove this Doctor from the allowed list using the function (F5).

b) Any one can check if a Doctor was allowed by the Government

Using the Contract (A) everyone which as access to an External Account (regular Ethereum Account) will be able to check whether or not a Doctor is allowed to practice using the function (F1).

c) Patient and only him can allow her/his Doctor to write in her/his medical record

The medical record of a Patient can be represented by a Contract (B) in Ethereum which will be created directly by the Patient.

This Contract (B) will have the following state properties :

- (P11) : List of Drugs with their expiration date
- (P12) : List of allowed Doctors
- (P13) : List of allowed Pharmacists
- (P14) : Address of the creator (the Patient)

N.B. : an allowed Drugs list can be defined by the Government in a Contract similar to the Contract (A) so the addresses of these Drugs can be stored in the Contract (B)

This Contract (B) will have the following functions :

- (F11) : Let the allowed Doctors to add a Drug address in the list of Drugs with the expiration date
- (F12) : Let the allowed Doctor / Pharmacists read the Drugs added by the Doctor
- (F13) : Add an allowed Doctor in the list, only the creator of the Contract (the Patient) will be able to do this
- (F14) : Add an allowed Pharmacist in the list, only the Patient will be able to do this
- (F15) : Remove an allowed Pharmacist/Doctor, only the Patient will be able to do this

This Contract (B) will have the following event :

- (E11) Notify : let the allowed Pharmacists now when a Drug was added in the list of the Patient

When a Patient has to change her/his Doctor/Pharmacists, he or she will be able to remove her/his previous Doctor/Pharmacists from the allowed list using the function (F15).

The Patient can allow a new Doctor to add Drugs in her/his medical Contract (B) using the function (F13).

The Patient will also be able to allow a Pharmacists to read in his list of Drugs using the function (F14).

d) Doctor (allowed by the patient) can write a message in the medical record

Once a Doctor was allowed by a Patient this Doctor will be able to use the function (F11) to add Drugs with expiration date in the Patient's Contract (B).

e) Pharmacist can see some of the messages (drugs prescription) of the Doctor

We hope we will be able to use the event system of Ethereum to notify the Pharmacists when a Drug prescription is written by a Doctor so this Pharmacists will be able to directly deliver the Drugs to the Patient.

IV. Conclusion

We provide an innovative idea for digital medical records management which improves the process patients, the doctors, the insurance company. This system conform very strict law

on privacy of medical information thanks to the block chain model that guaranty a strong security and a certified medical database.

Our first development will focus on a private grid between patients and doctors. Once this part is validated we will add insurance, drug store and other features.

References

[1] https://en.bitcoin.it/wiki/Block_chain

[2] <http://ethdocs.org/en/latest/introduction/what-is-ethereum.html>