

Blockchain Technology in Healthcare

The Revolution Starts Here

Matthias Mettler

M.A. HSG

Boydak Strategy Consulting AG

Freienbach, Switzerland

mettler.matthias@bluewin.ch

Abstract—Blockchain technology has shown its considerable adaptability in recent years as a variety of market sectors sought ways of incorporating its abilities into their operations. While so far most of the focus has been on the financial services industry, several projects in other service related areas such as healthcare show this is beginning to change. Numerous starting points for Blockchain technology in the healthcare industry are the focus of this report. With examples for public healthcare management, user-oriented medical research and drug counterfeiting in the pharmaceutical sector, this report aims to illustrate possible influences, goals and potentials connected to this disruptive technology.

Keywords—Blockchain, new business models, digitalization, healthcare, digital health, health information management, medical treatment, patient data, medical research, counterfeit drugs

I. INTRODUCTION

Blockchain is causing a hype and optimism that has rarely been seen in the history of technology. It is celebrated as a new technological revolution, which will have at least as large an impact on society as the invention of the wheel, the steam engine or the Internet. In a *World Economic Forum* report released in September 2015, 58 percent of all survey respondents said that they expected that by the year 2025, 10 percent of global gross domestic product will be stored using Blockchain technology [1]. It is therefore not surprising that Blockchain is attracting throngs of investors who are extensively investing in Blockchain startups. The investments amounted to almost half a billion dollars in 2015 [2] – the trend increasing. Nevertheless, the approaches, objectives and potentials of Blockchain are still largely unknown throughout society.

II. BITCOINS AS A STARTING POINT FOR THE DEVELOPMENT OF BLOCKCHAIN

Blockchain was originally developed for the cryptocurrency *Bitcoin* and first described in Satoshi Nakamoto's (pseudonym) whitepaper in 2008. In the document, Nakamoto particularly addresses the challenge of ownership related to digital currencies and proposes a solution using a Blockchain prior to the settlement of transactions [3].

The functional principle of the Blockchain can be explained using the concept of such *Bitcoin* transactions. The *Bitcoin*

Blockchain can be considered as a cohesive collection of digital wallets [4]. If a *Bitcoin* transaction, for example, is made from wallet A to wallet B, this information is simultaneously shared with all other wallets in the underlying *Bitcoin* Blockchain. The information on a *Bitcoin* transaction (e.g. transferred sum, ownership, etc.) are combined in an information block, marked with a timestamp and added as a new block to the existing *Bitcoin* Blockchain. At the same time, the transaction is verified and confirmed by all involved wallets. Due to this continuous sequence of blocks of information, the information with respect to all transactions made in the past, at any given time, are completely transparent and literally tamper-proof [4] [5].

Put simply, the solution of ownership associated with *Bitcoins* as published by Satoshi Nakamoto [3], therefore, lies in consolidating all necessary information in a single database, which is then publicly distributed [4] [5]. A database that does not claim any ownership and simultaneously, everyone owns. The content of this decentralized database is available to all parties involved. Furthermore, since all transactions are processed by users via a particular pseudonym, the information contained in the *Bitcoin* Blockchain is completely anonymous [4] [5].

III. BLOCKCHAIN POTENTIAL EXTENDS FAR BEYOND THE FINANCIAL SECTOR

The *Bitcoin* Blockchain example clearly shows that Blockchain technology represents an approach as to how ownership of digital goods can be achieved. The underlying principle of decentralized, transparent and instant access to information represents a starting point for many market sectors [5] [6]. This may also be considered a reason why, in recent years, Blockchain has continued to develop both within and outside of the financial sector. Consequently, there are some interesting examples outside of the financial sector.

Startups like *Ujo* or *Peertraks* offer a new approach, such as how music rights can be administered and enforced using Blockchain. Or at *Stampery*, for example, contracts, emails and documents can be signed digitally and smart contracts can be settled. Also, in the healthcare industry there are various possibilities: for example, in (public) health management, in the pharmaceutical sector, in medical research or in consumer-

oriented healthcare [6]. Below there are certain examples from the healthcare industry which highlight the importance of Blockchain and its functionality.

IV. SMART HEALTHCARE MANAGEMENT FOR THE BENEFIT OF THE PATIENT

A decentralized database which is consistently held up to date presents many advantages to the healthcare industry. These advantages become especially interesting, when many different parties need access to the same information [6] [7] [8]. Medical treatment processes, for example in the area of elderly care or chronic diseases, are predestined fields of application where Blockchain technology can create added value. A variety of involved parties (e.g., general practitioners, medical specialists, hospitals, therapists, etc.) and the amount of media disruptions involved during the treatment of a patient (e.g., change of communication media, various medical health records, incompatible IT interfaces, etc.) can lead to time-consuming and resource-intensive authentication and information processes for all medical stakeholders involved [6].

For example, *Gem*, a US startup, is actively involved in this area and, therefore, launched the *Gem Health Network* based on the *Ethereum Blockchain technology* [7]. Through this shared network infrastructure, different healthcare specialists can access the same information. This will also permit the development of a new class of Blockchain-based applications in healthcare that will unlock wasted resources and solve important operational problems [7].

Therefore, the *Gem Health Network* represents a healthcare ecosystem that combines both businesses, individuals and experts and which, at the same time, improve patient-centered care while address operational efficiency issues. This network is thus an example of a Blockchain approach that provides all relevant medical stakeholders transparent and clear access to the latest treatment information. On the one hand, this can limit medical negligence due to outdated information and thereby prevent health issues in an early stage. This can lead to extensive savings in merit costs. On the other hand, it allows medical experts involved to track the interactions between the patient and all physicians which have taken place in the past. Consequently, the entire treatment of a patient is characterized in a transparent manner, whereby a completely new information and confidence level between all medical stakeholders is created.

The fact that this logic proves itself correct not only for direct patient-physician relationships, can be demonstrated by the example of Estonia's digital health infrastructure. In 2011, Estonia collaborated with *Guardtime* which operates a healthcare platform based on Blockchain technology [9]. Since then, Estonian citizens, healthcare providers or health insurance companies have been able to retrieve all information on medical treatments performed in Estonia by using the

Guardtime Blockchain [9]. Estonia thus has proven that a complete public health infrastructure can be operated using Blockchain.

V. BLOCKCHAIN EMPOWERS END USERS RESPECTIVELY PATIENTS IN HEALTHCARE

Data is the new gold – this also applies to patient-generated health data. The abundance of available worldwide health apps and health wearables leads to a powerful flood of data, which can be used for medical issues related research. Blockchain offers various application possibilities in the field of patient-generated health data [6].

For example, *healthbank*, a global Swiss digital health startup, takes a radically new approach when it comes to the handling of data transactions and sharing of personal health data. This startup offers its users a platform on which they can store and manage their health information in a secure environment [10]. The data sovereignty lies fully in the hands of the user. As a next step, *healthbank* plans to consistently apply and implement Blockchain technology for the underlying business model [10]. Using Blockchain, in the future, personal patient-generated health data (e.g., heart rate, blood pressure, medicines taken, sleep patterns, eating habits etc.) can be retrieved from health apps, wearables or physician visits and be securely stored in the *healthbank* Blockchain.

Already today, *healthbank* users are not only able to save their data on the platform, but can also make it available for medical research. In return, they receive specific financial compensation for their data provided. *Healthbank* thereby becomes a unique data-trading platform, with which new opportunities in patient-oriented research are made available (e.g., in clinical trials for the pharmaceutical industry, in academic research projects at universities, etc.). Using Blockchain, this model could be even further individualized in a way that personal patient-generated health data which is available to researchers can be tracked in the research process with a timestamp (e.g., analogue to the described *Bitcoin* transaction) [6] [8]. *Healthbank* users who have significantly contributed to the success of medical research projects could be identified using Blockchain and rewarded at a higher level than the average.

Healthbank has thereby become a symbol of end user respectively patient empowerment in healthcare which rides alongside digitalization, new digital business models and digital health initiatives. Blockchain technology will further boost this end user and patient empowerment in healthcare.

VI. USING BLOCKCHAIN TO FIGHT COUNTERFEIT DRUGS IN THE PHARMACEUTICAL INDUSTRY

Wherever products are subject to a sensitive production process and where extensive reputational and liability issues are associated with the final product, the benefits of Blockchain are evident. Therefore, the research, development

and production of drugs in the pharmaceutical sector is a further field of application for Blockchain technology. Corresponding to the previously described example referring to *Bitcoin* transactions via Blockchain, this technology can also be used to monitor the production processes for drugs.

In this context, the issue of counterfeit medicine is an urgent and increasingly acute worldwide issue. According to the *World Health Organization*, ten percent of drugs are counterfeit worldwide, in developing countries the number rises up to 30 percent [11]. Such counterfeit drugs often do not only affect so-called lifestyle products (e.g., muscle building supplements, potency stimulants, slimming products, etc.), but also drugs for the treatment of cardiovascular disorders and cancer, antibiotics, painkillers, contraceptives and other prescription drugs [11]. Such counterfeits can contain the correct active ingredient, but in most cases show a dose which is too high or too low or which are produced in an impure manner. It then becomes extremely dangerous for the human organism when there is no trace of the expected active substance in the forged drug [11].

Hyperledger, a research network across industries, recently launched the *Counterfeit Medicines Project* [12]. The project especially focuses on the issue of drug counterfeiting and is one of the current use cases within the research network, in which *Accenture*, *Cisco*, *Intel*, *IBM*, *Block Stream* and *Bloomberg* are involved [12]. As part of this project, each drug produced is marked with a timestamp. Firstly, thanks to this approach, it is possible to determine when and where the drug was produced at any given time. Secondly, such an approach can be specifically used to fight the production of counterfeit drugs. Using Blockchain, the origin of the product and its components are detected, and any transfer of ownership in each case is made clear and available to everyone. Forged, poor quality or stolen goods can be tracked and identified.

In this field of application, Blockchain contributes to ensuring that safety in relation to drugs is increased, and health-related follow-up costs are reduced.

VII. CONCLUSION

The examples described, show that Blockchain offers numerous opportunities for usage in the healthcare sector, e.g. in public health management, user-oriented medical research based on personal patient data as well as drug counterfeiting.

The immense potential of this technology shows up wherever, until now, a *trusted third party* was necessary for

the settlement of market services. With Blockchain, direct transactions suddenly become possible, whereby a central actor, who controlled the data, earned commission or even intervened in a censoring fashion, can be eliminated.

This disruptive character, which underlies Blockchain technology, will strongly affect the balance of power between existing market players in healthcare. It will also promote new digital business models and digital health initiatives. Due to the fact that, in the future, (data) intermediaries can be avoided, this technology opens new doors with respect to how market interactions in healthcare can be conducted. Blockchain thus has an immense potential for the future and will show disruptive changes in the healthcare industry.

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