Chapter

Introductory Chapter: Blockchain Technology and Smart Healthcare

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1. Introduction

Phase 1 of the technology revolution began with the development of the computer and the computer chip. Phase 2 occurred when communication between computers became widely distributed via the Internet. We are now in phase 3 which is the development of artificial intelligence to replace or augment human intelligence. This revolution in technology has and will continue to have profound effects upon healthcare, human health, and longevity.

Blockchain technology has played a major role in the ongoing development of artificial intelligence. In the financial world, it has created a new, Internet-based global monetary system through the development of the Bitcoin protocol [1]. The ethereum blockchain has made the use of Turing complete computer programs available online, enabling the development of smart contracts [2, 3]. To complete the transition to a smart economy, the blockchain-based, self-sovereign smart identities are being developed [4, 5]. Taken together, these blockchain-based developments have created the foundation for a truly decentralized healthcare system in which patients have control of their own medical data by the use of a digital identity, and providers are reimbursed with digital money (bitcoin) immediately after providing documentation of services rendered (via ethereum-based smart contracts).

While promising, blockchain technology remains in its infancy, and there continues to be a need to clarify what exactly blockchain technology involves. To do this, a review of the original Bitcoin white paper is required. This white paper was published under the pseudonym "Satoshi Nakamoto." It is unknown whether this pseudonym represents a single person or group of people, as the author as of 2019 remains unknown. The original Bitcoin codebase and white paper were written in 2008 [1, 6]. The first bitcoin was mined by Satoshi Nakamoto on January 3, 2008, and the first bitcoin transaction occurred shortly thereafter between Satoshi Nakamoto and Hal Finney [7].

The blockchain is simply a distributed database that is populated with transactions. Given the nature of distributed blockchain databases, the transactions are immutable and permanent. Furthermore, advanced computer cryptography has made it possible to fully anonymize transactions using zero-knowledge proofs [8]. The transactions recorded can be many different things, including financial transactions using bitcoin, smart contracts using ethereum, Internet advertisements [9], or any of a number of healthcare-specific transactions. The immutable, permanent nature of blockchains makes healthcare applications particularly useful in maintaining patient records, billing insurances, and conducting medical research [10].

The revolutionary aspect of blockchain technology is that it eliminates the need for a trusted third party to validate transactions and store data. With current electronic medical records, for example, access to medical records is controlled by the clinic or hospital. Individuals must ask the hospital for access to their own medical

records. Medical records are stored by the hospital in a centralized location. This centralization of data storage creates a single point of entry for hackers [11].

Distributed blockchain databases, on the other hand, do not have a single vulnerable point of access, making them extremely resistant to malicious manipulation. For example, although Internet sites managing bitcoin have been hacked, the bitcoin blockchain has not. This is in spite of a $125 billion USD market capitalization. Theoretically, a hacker able to break the bitcoin blockchain would have access to billions of dollars. In spite of this large financial incentive, after more than a decade of existence publicly on the Internet, the bitcoin blockchain remains intact.

Not only does blockchain technology enable storing data in an immutable, permanent way, it also can store contracts in a similar way. Such contracts can be "dumb" and simply record an agreement, or they can be "smart" and take action. For example, a smart contract could automatically release funds from an insurance company, payable directly to the provider, immediately when proper documentation of medical services rendered was uploaded to the blockchain. Such transactions are enabled by having a blockchain-based digital identity for patients, digital assets for insurance company payments, and digital smart contracts. An integrated blockchain including all three of these components is NEO, originally founded in China, which aims to create the essential components of blockchain-based economy [12, 13].

Smart contracts, along with digital identities, enable the implementation of artificial intelligence in remote patient monitoring, hospital wards, and clinics. A smart contract could simply be the instruction to notify a patient's provider and/or possibly emergency medical services when the patient's wearable technology identifies new onset atrial fibrillation. The use of blockchain technology as opposed to a centralized database helps ensure data integrity, patient privacy, and database robustness.

By making artificial intelligence patient centric, blockchain technology is leading the way through the growing wave of technology and artificial intelligence. By creating self-sovereign digital identities, people will have control over their identification instead of relying on government institutions for identification. This is critically important, especially for refugees and the homeless. By creating several methods of transferring assets, blockchain technology allows people to trade directly with each other, without relying on a central bank or credit card company to audit their every transaction. Such monetary systems are essential for the creation of efficient smart contracts that do not rely excessively on a centralized verification process. Finally, blockchain-based smart contracts have the ability to efficiently analyze patient data and act quickly on the results.

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