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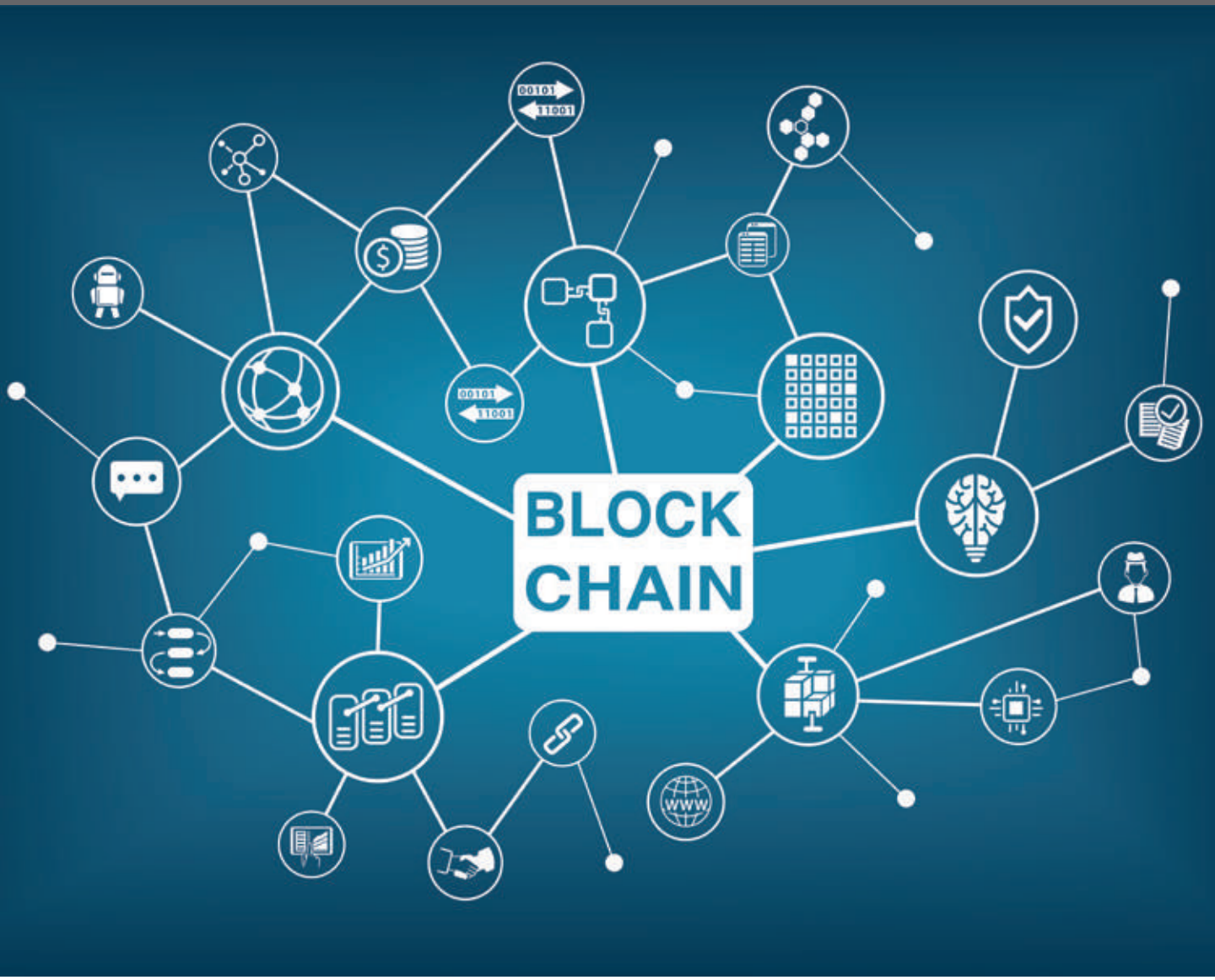
Blockchain-based patient-centric healthcare



A Harbinger Group White Paper

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Harbinger Group (www.harbingergroup.com) is a leading provider of software engineering services to some of the world's best product companies.

This white paper is part of Harbinger's Human Capital Management services. Harbinger, with an experience of more than 15+ years in the HCM (HR) space, Harbinger has helped leading HCM software companies to build next generation service offerings and deliver some of the greatest success stories touching more than two million lives. Visit our HCM Solutions page to learn more.

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Exec Summary

The paper illustrates some of the complicated issues that permeate healthcare in advanced societies, especially the speedy sharing of health data. As blockchain has certain characteristics of immutability and trustworthiness, a solution was implemented based on that. In addition to describing the solution, the paper indicates some of the challenges faced in making a successful implementation.

Some Crucial Problems in Healthcare

Healthcare in advanced societies today is a complex ecosystem of interconnected entities that involves patients, care providers, healthcare organizations and payers. It is one of the highest growth industries in the entire world. But the existing systems and solutions create barriers and challenges that impede the efficient delivery of healthcare.

Among the problems in healthcare is the issue of sharing of medical records. Whereas hospitals and clinics maintain electronic medical records [1], the systems are not interoperable across care centers and data sharing is extremely time consuming and inefficient. For example, care for a patient after hospital discharge often requires re-tests and repeat x-rays because the data does not reach the primary caregiver in time. This distribution failure results in poor health outcomes. As an example, a U.S. study in colon cancer treatment found that better sharing of medical data could lead to cost savings of approximately 30% [2].

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1 JaWanna Henry, MPH; Yuriy Pylypchuk, PhD; Talisha Searcy, MPA, MA; Vaishali Patel, PhD, “Adoption of Electronic Health Record Systems among U.S. Non-Federal Acute Care Hospitals: 2008-2015,” ONC Data Brief, No. 35, The Office of the National Coordinator for Health Information Technology: May 2016,

www.healthit.gov/sites/default/files/briefs/2015_hospital_adoption_db_v17.pdf

2 Hoverman Jr., Cartwright TH, Patt DA: Pathways, Outcomes and Costs in Colon Cancer, 2011.

Patients, though central to the healthcare ecosystem, do not have control over their own health data. Neither do they get easy access to the data nor do they get the visibility of who accessed their health data.

Because data is in a few centralized systems and the data is valuable, Healthcare suffers from frequent data breaches. U.S. Department of Health and Human Services reported that more than 15.5 million Electronic Medical Records were breached in the U.S. in 2016 [3].

3 Research And Markets.com January 2018: Cybersecurity in Healthcare Market, 2018-2030.

www.researchandmarkets.com/research/3kvk6t/global?w=5)

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The blockchain solution - multiple benefits

As Harbinger had experience in blockchain, it was able to help the customer address these problems with a blockchain based solution.

As blockchain maintains blocks of data and connects one block with its previous block with encryption, the data in a block is immutable, that is, it cannot be altered. The access to data is controlled by public key - private key pairs, so it is possible to restrict access and to identify access. This enables the blockchain system to be trusted and this in turns enables sharing of data with known parties.

In the healthcare situation, a blockchain can enable the patient to store their data, control the data and then provide access as needed to caregivers. The data is tamper-proof because of the immutability of the blockchain. The data can be provided to caregivers instantaneously on demand as the patient and caregiver are known to and trusted by each other. Caregivers need only get data from the patients and need not interface with multiple systems.

The patient can give access to the data to caregivers as well as to other parties who may be interested in the data. In all cases, the patient knows who has access to the data. No other party can access the data.

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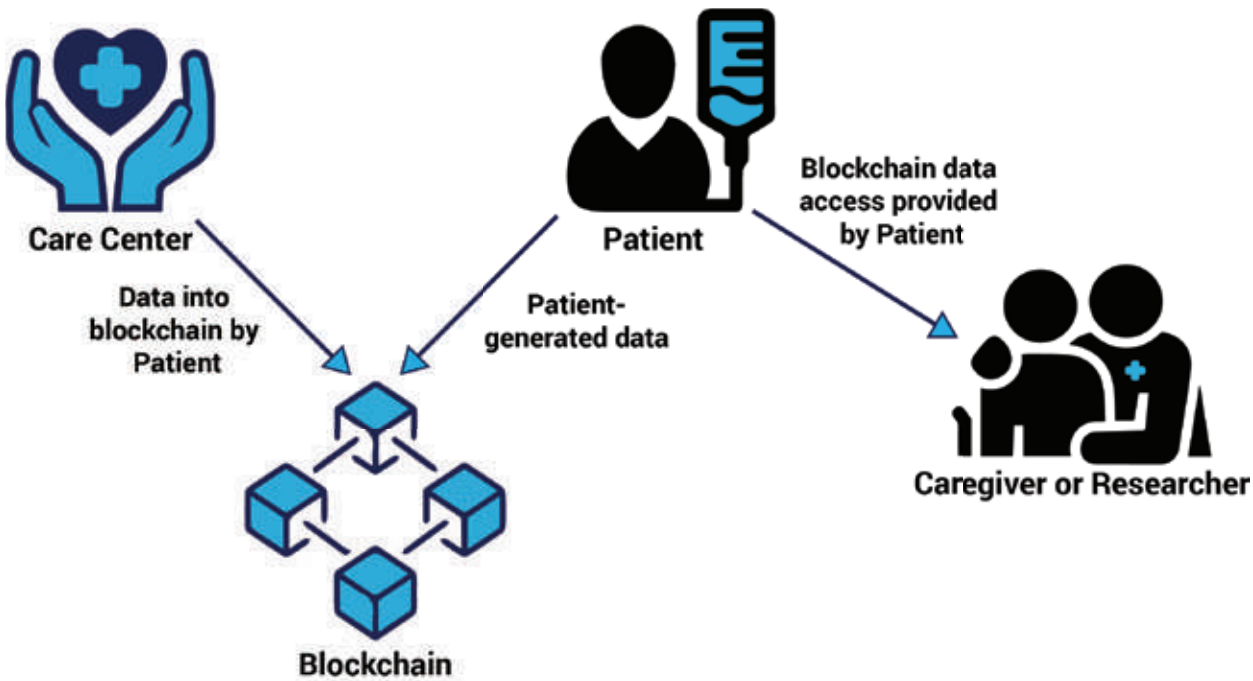
Thus, blockchain provides an elegant solution to the problems identified above. Not only that, because the blockchain solution devised here also keeps a record of every access of the data, so an audit trail can be built in, thus increasing the confidence in the system. Because the patient owns the data, the patient can monetize the data by selling it directly to those who are willing to purchase the data and obviate the intermediaries who currently give the patient a paltry sum if at all.

Implementation

Harbinger implemented the above solution using a private blockchain. A private blockchain can enforce verified access, that is, KYC (Know Your Customer) checks are carried out.

Workflow diagram



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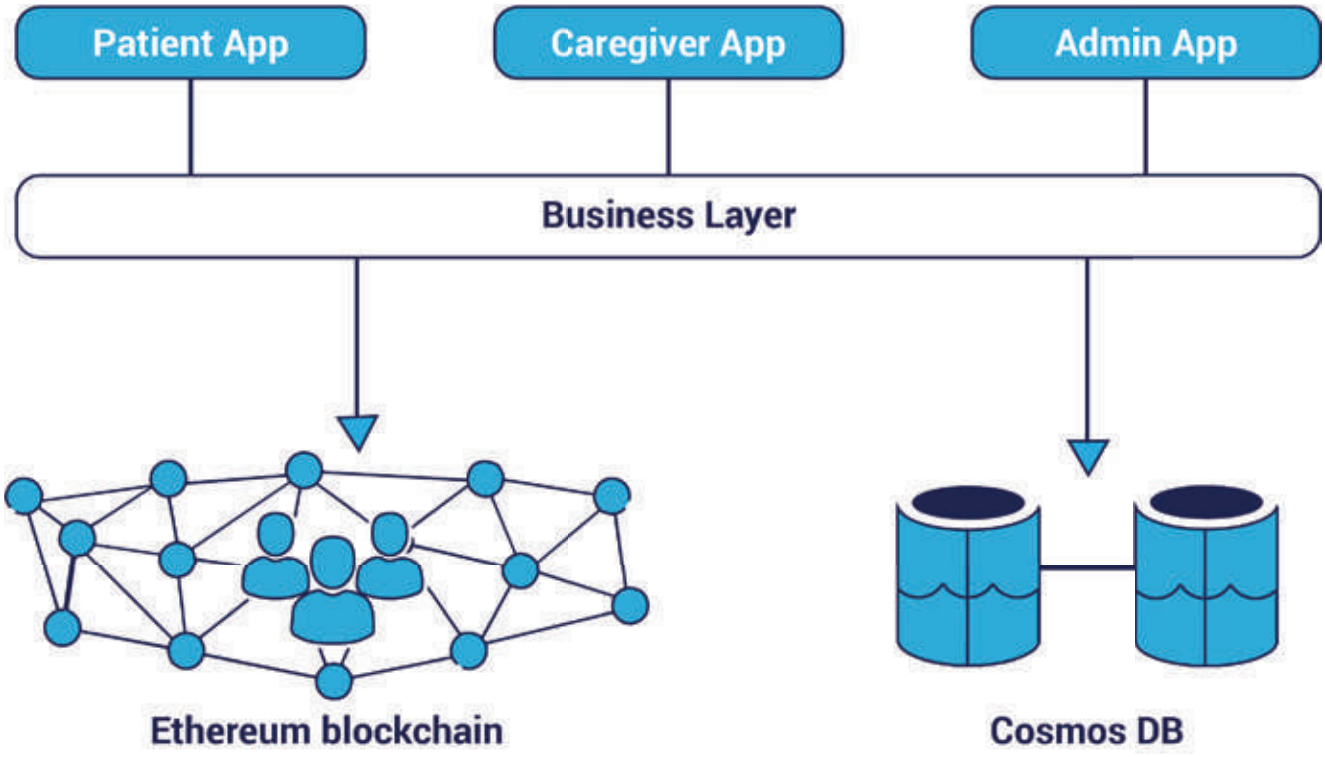
As the Workflow diagram indicates, a patient gets data from hospitals and clinics; this data is HL7 standard CCD (Continuity of Care Document) data. The patient uploads the data into the blockchain. The patient can also upload health and wellness data (PGHD or patient generated health data), for example, Fitbit data. The patient can provide access to caregivers on a need basis. The patient can also sell data to researchers.

Architecture Overview



The heart of the system is the private Ethereum blockchain. Ethereum was chosen for the following:

- Has a flexible coding language -- Solidity.
- Is straightforward to create a private blockchain.
- Has an active developer community and continues to evolve in innovative ways.

Comparatively, Hyperledger was still nascent and somewhat opaque in its working. Due to these reasons, Ethereum is the most widely used blockchain platform today.

Identical copies of the blockchain (which are called “nodes”) exist on servers belonging to multiple organizations that are part of the consortium. They are not centralized under the aegis of just one organization. The current servers are Microsoft Azure, but they can be on any other Cloud.

Solidity code runs on Ethereum and handles the following:

- The de-identified health records
- The identities of the participant entities - patients, caregivers, system administrators
- The permission to access for each data record and the removal of such permission
- An audit trail of health data access

Whereas there is a bit of System Administration such as the letting participants create accounts and verifying their credentials, and, determining whether all the nodes of the blockchain are functioning properly, the Administrator has no access to the health data.

The Solidity code connects via JavaScript API to the business layer. The business layer is mostly written in Node.JS. There is also Java in the business layer – it handles parsing of CCD via REST APIs. The layer also supports patient generated data. API integration for Fitbit data import makes it easy for patients to get their wellness data in the system. The front-end achieves smooth user interaction via responsive web design.

Use is made of Cosmos DB as an off-chain database. The blockchain stores de-identified health data with minimal information such as code numbers, whereas Cosmos DB stores de-identified health data suitable for data analytics. The patient profile information is also separately stored in Cosmos DB. So is publicly available information about caregivers. This split data model smoothly handles data analytics opportunities while ensuring data privacy and security.
The Harbinger team also created the ERC-20 standard crypto-tokens; ERC-20 is a standard within Ethereum that defines the rules for the creation of tokens and the transfer of tokens between participants.
Tokens are used in this system for availing services such as subscribing to the system, uploading health records, maintaining those records over a period of time, and, for compensating patients for their health data. Tokens can also be used for incentivization drives.

Challenges

Some of the peculiarities of health data and those of Ethereum created some challenges. These entailed some effort to solve.

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A single CCD can have several sections and subsections, so it can be 20,000 characters or longer. Ethereum mainly supports a string data type for such long objects. Also, this size is more than the size of a single Ethereum block hence the string had to be split into multiple parts. A series of tests indicated that a good limit for timely performance is around 3,500 characters. Hence the original CCD string is broken up into chunks of 3,000 characters with the chunks (along with the patient identifier, date of event, etc.) being posted as separate blockchain transactions. During retrieval all the chunks are fetched and re-assembled into a logical CCD.

The implementation initially utilized Ethereum's Proof of Work (POW) consensus algorithm. In this, the nodes compete for the right to create ("to mine") a block. As the blockchain height (that is, the number of blocks in the chain) increases the time for insertion of records shoots up. This behavior is detected only when the blockchain is used in a sustained manner over many weeks.

To handle the performance degradation, the system was switched from using server-class CPUs to GPUs (Graphical Processing Units). This provided up to 50% performance gain but with increased cost of operation. This was not a very satisfactory solution. Ethereum had recently released the Proof of Authority (POA) consensus algorithm. Upon evaluation via a series of tests, this turned out to be a suitable choice for the system to have good performance and reasonable infrastructure cost.

The CCD architecture is quite complicated with various code numbers being used by caregivers for various conditions and treatments. Identifying whether the code numbers are correct or whether the source data has errors takes a significant amount of time. Also, a blockchain takes time to determine the validity of the blocks being added, so this increases the response time seen by the patient while uploading the data. The solution was to keep the patient continuously informed of the multiple stages through which the data is progressing.

Road ahead

Some of the activities for the near future are:

- To increase number of organizations (non-profits) that host the nodes of the blockchain
- To optimize the rewards paid to the patients, from research organizations, for their data
- To extend support for the recent Fast Healthcare Interoperability Resources (FHIR) protocol which is the successor of HL7.
- To extend support for more PGHD such as Glucometer, sleep meters, etc.

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Concluding remarks

The system, in a true sense, empowers patients to control their own health data. Patients can import their health records in the system, store those in secure way, access those seamlessly, share selected health records with caregivers of their choice and remove such access, at any time.

Caregivers get easy access to a patient's health data across various care centers. This helps in providing better care to patients avoiding issues due to health data silos.

The data can be used for analytics in an anonymized manner. Anonymized health data management offers the benefits of improving patient engagement with predictive modelling, better care coordination, and, improving population health outcomes by tracking current health trends.

Or, can use the following points.

- Patient driven, secure sharing of heath data
- Effective use of health data avoiding silos
- Data security and privacy
- Audit trail traceability of health data access

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About Harbinger Systems

Harbinger Systems is a global company providing software technology services for independent software vendors and enterprises, with a specialization in product engineering. Since 1990, Harbinger has developed a strong customer base worldwide. Harbinger Systems builds software solutions leveraging social, mobile, analytics, and cloud (SMAC) technologies and IoT (Internet of Things) for domains such as human capital management (HCM), healthcare, eLearning, and publishing. International Association of Outsourcing Professionals (IAOP) ranks Harbinger Systems in The Global Outsourcing 100 listing consecutively for last five years. Recently, Harbinger is recognized in 2015 Global R&D Service Providers Rating – Product Engineering Services, by leading management consulting firm Zinnov. Harbinger Systems is a part of Harbinger Group, a leading global provider of innovative software products and services to companies in over 60 countries.

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