"Connected Health"

Take charge of your health using Blockchain

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Abstract.
Development of fundamental design changes for Electronic Health Records (EHRs) and Patient Health Records (PHRs) has been constrained traditionally through a long-standing focus on compliance. We now face a critical need for such innovation, as personalization and data science prompt patients to engage in the details of their healthcare and restore agency over their medical data. Connected Health is an Internet based electronic application built using Blockchain Technology through which individuals can access, manage and share their health information. It allows people to access and coordinate their lifelong health information and make appropriate parts of it available to those who need it in an authorized, private, secure and confidential environment. People can use their heath records as a communications hub: to send email to doctors, transfer information to specialists, receive test results and access online self-help tools.
The individual person is the primary user of the Connected Health platform. Other potential users are "stakeholders" who – when then primary user of the platform gives his/her permission – can make valuable use of the information being kept in the personal health record.
The purpose of this paper is to expose, in preparation for field tests, a working prototype through which we analyze and discuss our approach and the potential for blockchain in health IT and research.

Keywords: ConnectedHealth, EMR, PHR, HER, EMRonBlockchain.

1 Introduction

EHRs were never designed to manage multi-institutional, life time medical records. Patients leave data scattered across various organizations as life events take them away from one provider's data silo and into another. Through the HIPAA Privacy Rule, providers can take up to 60 days to respond (not necessarily to comply) to a request for updating or removing a record that was erroneously added [1]. Beyond the time delay, record maintenance can prove quite challenging to initiate as patients are rarely encour-

aged and seldom enabled to review their full record [1], [2]. Patients thus interact with records in a fractured manner that reflects the nature of how these records are managed. Interoperability challenges between different provider and hospital systems pose additional barriers to effective data sharing. When designing new systems to overcome these barriers, we must prioritize patient agency. Patients benefit from a holistic, transparent picture of their medical history [3]. This proves crucial in establishing trust and continued participation in the medical system, as patients that doubt the confidentiality of their records may abstain from full, honest disclosures or even avoid treatment.

Personal Health Record (PHR) offer an integrated and comprehensive view of health information, including information people generate themselves such as symptoms and medication use, information from doctors such as diagnoses and test results, and information from their pharmacies and insurance companies. Individuals access their PHRs via the Internet, using state-of-the-art security and privacy controls, at any time and from any location. Family members, doctors or school nurses can see portions of a PHR when necessary and emergency room staff can retrieve vital information from it in a crisis. PHR connects each of us to the incredible potential of modern health care and gives us control over our own information.

Information is the currency of modern health care. Knowing one's family background, history of diagnoses and procedures, test results and medications and diet and exercise habits is essential to managing health, assessing problems, and preventing medical error.

1.1   Preamble

Healthcare records are increasingly becoming digitized. As patients move around the healthcare ecosystem, their electronic health records must be available, discoverable, and understandable. Further, to support automated clinical decision support and other machine-based processing, the data must also be structured and standardized [9].

FHIR aims to simplify implementation without sacrificing information integrity. It leverages existing logical and theoretical models to provide a consistent, easy to implement, and rigorous mechanism for exchanging data between healthcare applications. FHIR has built-in mechanisms for traceability to the HL7 RIM and other important content models [9].

Information is the currency of modern health care. Knowing one's family background, history of diagnoses and procedures, test results and medications and diet and exercise habits is essential to managing health, assessing problems, and preventing medical error. Today medical information is scattered among the many health care providers people see throughout their lives. It is stored in individual memories, on scraps of paper and in spreadsheets on personal computers. Some doctors and hospitals keep computerized medical records, but most personal health information is stored in thick paper files that line office walls. These paper-based systems are often disorganized, illegible, prone to error, difficult to transfer from provider to patient or specialist and they usually do not include information contributed by patients. In the paper-based world of medical records, there is no coordinated system, no standardized, private and secure way to integrate anyone's health information in one place. A visit to a new doctor means new forms to complete, new tests to run and new conversations reviewing personal medical history -- conversations that depend almost entirely on memory alone. People need effective tools to help them manage their health and Health care.

1.2   Existing Complexities

Emergency room personal need to be able access a patient's health records when necessary. Caregivers can be more effective in helping a loved one manage their care if they have access to a heath record. With worldwide electronic access to one's personal health information, it raises both privacy and security concerns.

The person-centric nature of health records poses some issues for data integrity. The sources of data in the health records must be identified and the system must include mechanisms for correcting errors or inconsistencies. It's a maze, having the perfect solution to all the above problems may not necessary be useful. When you lose your conscious or barely able to move or speak, you can't expect history to be recited by you or your care taker to the life saver. Moreover, the health records may initially be available to more affluent patients and those affiliated with advanced integrated health systems.

1.3   Blockchain Background

Originally designed for keeping a financial ledger, the blockchain paradigm can be extended to provide a generalized framework for implementing decentralized compute resources [7]. Each compute resource can be thought of as a singleton state-machine that can transition between states via cryptographically-secured transactions. When generating a new state-machine, the nodes encode logic which defines valid state transitions and upload it onto the blockchain. From there on, the blocks journal a series of valid transactions that, when incrementally executed with the state from the previous block, morph the state-machine into its current state. NEM's primary contribution to the crypto currency landscape is a new consensus mechanism called Proof of Importance (PoI). Unlike Proof of Work (PoW), it is environmentally sustainable and does not require large scale computing resources in perpetuity. PoI is like Proof of Stake (PoS) except that it is not solely derived from the size of an account's balance. It incorporates other behaviors that are believed to be positive for the holistic economy. In this way, it attempts to reward active economy participants at the expense of inactive ones and dampens the rich getting richer effect that is inherent to PoS

We utilize NEMs features to create intelligent representations of existing medical records that are stored within individual nodes on the network. Blocks are constructed to contain metadata. The blockchain transactions in our system carry cryptographically signed instructions to manage these properties. The contract's state transition functions carry out policies, enforcing data alternation only by legitimate transactions. Such policies can be designed to implement any set of rules which govern a particular medical record, as long as it can be represented computationally. For example, a policy may enforce that separate transactions representing consent are sent from both patients and care providers, before granting viewing permissions to a third party.

1.4   Health Record System using Blockchain [4]

With FHIR, Connected Health follows the following points

- A common way to define and represent them, building them from data types that define common reusable patterns of elements
- A common set of metadata
- A human readable part

For Connected Health, the block content represents data ownership and viewership permissions shared by members of a private, peer-to-peer network. Blockchain technology supports the use of "cryptographically signed data," which allow us to automate and track certain state transitions (such as a change in viewership rights, or the birth of a new record in the system). Via NEM we can hash the data cryptographically and log the patient-provider relationships that associate a medical record with viewing permissions and data retrieval instructions (essentially data pointers) for execution on external databases. We include on the blockchain a cryptographic hash of the record to ensure against tampering, thus guaranteeing data integrity.

A syncing algorithm handles data exchange "off-chain" between a patient database and a provider database, after referencing the blockchain to confirm permissions via our database authentication server.

1.4.1 Health organization direct information to the blockchain

- Health organizations provide services to patients
- Clinical data is tracked in existing health IT systems
- Standard data fields and a patient's public ID are redirected to the blockchain via APIs

1.4.2 Transactions are completed and uniquely identified

- Smart contract processes incoming transactions
- Each transaction is stored onto the blockchain containing the patient's public (non-identifiable) ID

1.4.3 Health Organizations and Institutions can directly query the blockchain

- Health organizations and institutions submit their queries via APIs
- Non-identifiable patient information (ex. age, gender, illness) is viewable
- Data can be analyzed to uncover new insights

1.4.4 Patients can share their identity with health organization

- The patient's private key links their identity to blockchain data
- The private key can be shared with new health organizations
- With the key organizations can then uncover the patient's data

- Data remains non-identifiable to those without the key

2 Solution Architecture

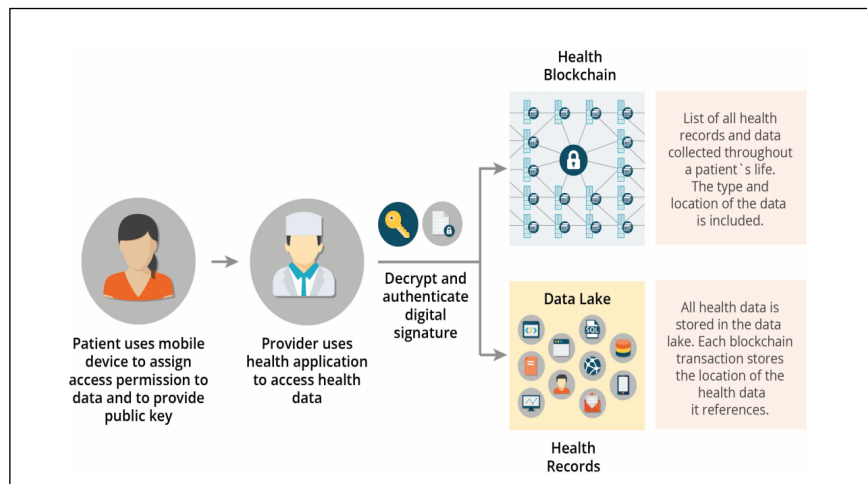## 2.1 Blockchain Model for Health Care

Fig. 1. The user has singular control over his data and the power to grant access to specific health care providers and/or health care entities for communication and collaboration in disease treatment and prevention. The decentralized nature of the blockchain combined with digitally signed transactions ensure that an adversary cannot pose as the user or corrupt the network as that would imply the adversary forged a digital signature or gained control over most of the network's resources.
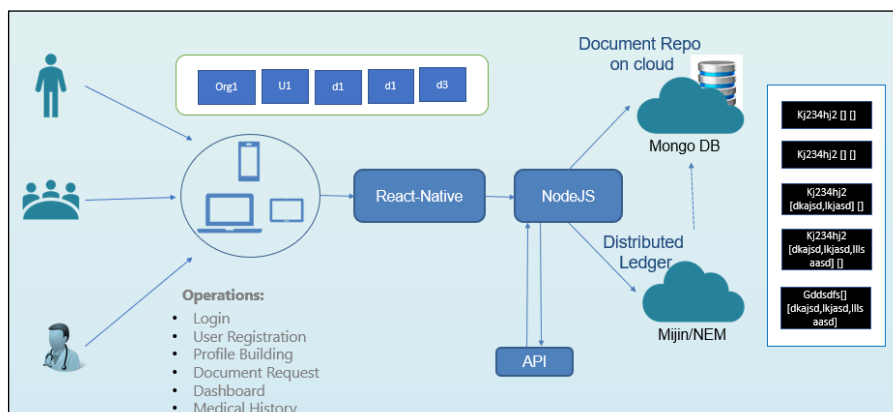
2.2 Architecture or Flow Diagram

Fig. 2. UI is built on a hybrid technology to bring out the omni-channel experience. APIs are built using NodeJS and NEM is being used for storing transactions on the Blockchain Platform.

2.3 Benefits of using Blockchain for Health Care

Following points lists out the benefits of using a blockchain based solution for our personal health records.

- Improved privacy protection and greater control over personal data
- Increased efficiency in compliance control, quality and monitoring
- Rapid onboarding and improved customer experience
- Privacy by design – immutable chain of evidences
- Zero knowledge proof algorithms to protect data
- Distributed system to avoid central point of failure and recovery
- Blockchain strengthens data integrity and patient digital identities
- Blockchain supports frictionless connectivity, supported by smart contracts and consistent authorization to access electronic health information
- The blockchain transaction layer could enable access to a rich set of standardized, non-patient identifiable information

References

1. U.S. Department of Health and Human Services, Office of Civil Rights. (2013). 45 CFR Parts 160, 162, and 164. "HIPAA Administrative Simplification." [Online] Available: http://www.hhs.gov/sites/default/files/hipaa-simplification-201303.pdf
2. "Who Owns Medical Records: 50 State Comparison." Health Information and the Law. George Washington University Hirsh Health Law and Policy Program. Aug. 20, 2015. [Online] Available: http://www.healthinfolaw.org/comparative-analysis/who-owns-medical-records-50-state-comparison
3. Mandl, Kenneth D., David Markwell, Rhona MacDonald, Peter Szolovits, and Isaac S. Kohane. "Public Standards and Patients' Control: how to keep electronic medical records accessible but private." Bmj 322, no. 7281 (2001): 283-287.
4. http://www.rjkrawiec.com/blog/2016/9/15/blockchain-opportunities-for-healthcare
5. https://www.slideshare.net/naveenbtlit/scalable-and-secure-sharing-of-personal-health-records-in-cloud-computing-using-attribute-based-encryption-21661227?next_slideshow=1
6. NEM Technical Reference: https://blog.nem.io/nem-technical-report/
7. Wood, Gavin. "Ethereum: A secure decentralised generalised transaction ledger." Ethereum Project Yellow Paper (2014)
8. MedRec: Prototype for electronic health records and medical research data https://pdfs.semanticscholar.org/56e6/5b469cad2f3ebd560b3a10e7346780f4ab0a.pdf?_ga=2.15444598.1743165385.1513328645-1885603011.1513328645
9. FHIR Overview: https://www.hl7.org/fhir/overview.html