PARADIGM
BLOCKCHAIN EMR

Version 2.1

Daniel Keller, CSO, Flux and ZelCore

Reliability | Usability | Auditability | Scalability

"If you change the way you look at things, the things you look at change."

-Wayne Dryer

What is Paradigm

Secure, streamlined, interoperable, and patient-centered: Paradigm transforms EMRs (Electronic Medical Records) and insurance/healthcare infrastructures through the use of blockchain technology to create a seamless and scalable framework for healthcare delivery while allowing the end-user to full ownership and control of the experience, while also expanding privacy-based features.

Risk mitigation, playing a significant part in the process, manifests in multiple ways:

1) Risk is mitigated via enhancing the patient experience with an end of consultation "acceptance of records" functionality. This feature may seem like a trivial point, but it removes EMR from being a part of the administrative process and reassigns it to being a part of the patient experience. This shift will personalize the experience for the patient while lowering instances of non-adherence (which is?)
2) Data being available at the scan of a finger will enhance attending physicians' work experience, enabling them to adjust medication and other treatment regimes more accurately without delays.
3) Full data availability has multiple advantages for risk assessments and mitigation in terms of improved efficacy for both healthcare and insurance providers.

To provide the best care for their patients, clinicians, hospitals, and other healthcare entities need timely and pertinent clinical information. The lack of access to such data not only results in costlier, less efficient care but also causes errors that can lead to serious adverse events, including death. Something significantly more likely at 28% of hospitals still has to manually scan and import patient records.[1]

The current siloed health record system often prevents the timely flow of data amongst and between healthcare providers and plans. Some practitioners have dubbed the adoption of health record interoperability instruments as health IT's Holy Grail (colloquial- how about the archetypal system). This machination, while deeply desirable, has not yet been implemented in minimal viable project status. Interoperability has long been an aspiration, as a meaningful use requirement -but heretofore has not been implemented, before Paradigm.

Aside from the technological challenges of implementing interoperability in the health records domain, there are additional obstacles presented by data blocking[2] and the practice of charging patients for copies of their electronic health records. Further, the recent development and active use of data scraping, harvesting, and selling personal health care records are becoming more troublesome and prevalent in the big data arena. Several organizations have partnered with Google, Amazon, and others to create metric-based outcomes for healthcare models. This practice again places users' EMR outside their control, which allows it to be monetized or otherwise subject to changes in regulation or business motivation.

Comprehensive patient information must automatically--and securely--follow the patient across the healthcare continuum. Patients need to have unrestricted access to their complete medical records to best take care of themselves under both proactive and reactive circumstances. Currently, this level of freedom and ownership of personal health data does not exist. The standard advanced EMR buildout models are highly developed, yet completely centralized with little to no access for the patient. This approach represents a massive challenge for a base of users accustomed to "on-demand" access to data that all have the right to possess.

Paradigm, a blockchain solution for healthcare, changes the focus of patient-based healthcare to placing patient outcome and clinician efficiency as paramount above the current focus by a select few centralized entities, whose sole objective is optimal financial gain. Our solution is the antithesis of the siloed, centralized data stores that dominate healthcare data today.

Blockchain was designed as a distributed accounting platform for cryptocurrencies (e.g., Bitcoin). But it's an industry-agnostic tool to keep data in an encrypted, distributed ledger and control access to that ledger. [3] It's decentralized, spread across a synchronized network; with proper authorization all the data becomes visible. As a result, there's no single repository for hackers to target [4], thus reducing the target level for security breaches and allowing the end-users control of their financial data. This control must also apply to other personal data, primarily individual healthcare data.

Beyond Push, Pull, and View

Medical data among institutions is generally shared in three ways: push, pull, or view. But each approach varies by vendor, institution, and state law. Paradigm offers a different model altogether. The Harvard Business Review stated, " Today humans manually attempt to reconcile medical data among clinics, hospitals, labs, pharmacies, and insurance companies. It does not work well because there is no single list of all the places data can be found or the order in which it was entered." Paradigm closes this gap with a decentralized, no third-party infrastructure.

The Paradigm model provides a decentralized control mechanism. Everyone has a stake, but with the patient left in overall control. A clear and transparent audit trail ensures accountability. This approach allows for patient control of record access without the need to create for each vendor custom functionality with expensive and burdensome layers to access.

A patient's data is stored securely on the community-wide ledger, giving clinicians, hospitals, and other relevant organizations access to a patient's complete health (not just medical) history. Because the entire chain is updated in real-time with keys for retrieval from storage, any changes to medication and allergy lists will be immediately available. That also means there's no need to re-enter the same medical data at each encounter with a new provider or institution.

This approach also gives patients control over their data, unlike most, if not all, current practices, while also allowing well-developed systems as a backend connection point via API to the network. In other words, it's not a replacement for standard EMR but rather a bridge for connecting traditional platforms.

Patient-centered

Patients have full access to responsibility and accountability for their data, including control over how it is shared and stored. [5] In accomplishing this primary objective, Paradigm not only achieves the Office of National Coordinator's call for individuals to "have access to longitudinal electronic health information" to which they can add information and "direct ... to any electronic location." It also expands patient accountability by requiring the patient's acceptance of data being added to the record. The overall process is executed on an opt-in basis, thus allowing end-users the possibility to fully control their data.

On the Technical Side

We envision two levels of access using public-private key cryptography, with each different granting level of access. For the record owner, the process will be:

1) Upon signup, each finger is printed.
2) These prints are stored as hex-encoded data strings and processed using a cryptographic algorithm, converting them into a multi-component public key. Using a sufficient number of data points from each scan will make this wholly resistant to attacks by even quantum computing.
3) These components generate the owner's private key and restoration phrase.
4) The restoration phrase is a cryptographically secure method for access control should the owner suffer the loss of seven or more digits (fingers).
5) The private key is what allows data to be written to the owner's record. Preventing deletion in the records facilitates full transparency.
6) Access to the private key is provided by the printing of any three fingers using a unique variation of the cryptographically secure "*some of many*" methodologies. This allows for adding data to the chain.
7) For read-only access, the printing of a single finger is required using the component key to call up the entire public key and its storage.

How this would work with an emergency room:

1) The patient arrives but is entirely incapacitated. On-site staff scan a single digit and now have immediate access to EMR for the patient, facilitating faster, more targeted and risk mitigated treatment. This could also be used to serve the hospital with a "Do Not Revive" order should the patient have such an order standing (hugely offsetting liability issues hospitals may face).
2) The patient recovers sufficiently to participate in the consent process, and grants write access to the medical provider by printing an additional three digits.

How this would work with a general practitioner or specialist clinic:

1) The patient arrives for a checkup post-x-ray and scans/prints in, allowing the available practitioner access to the x-ray data recorded at the radiological center.
2) To complete the check-up and confirm receipt of instructions regarding medication, diet, exercise, etc., the patient "writes" the general practitioner's additions to their record by scanning/printing three fingers adding medication lists, diet, etc. to their record.

What this means for the patient:

1) They can never claim to not have been issued medication/dietary instructions as they sign it onto the chain at the end of each medical practitioner's visit. That will put them in a position to negotiate significantly better rates from insurance/healthcare providers.
2) The chances of them requiring "experimentation/exploration" during an incapacitated ER visit are drastically reduced as things like antibiotic intolerance, or general allergies would readily be available to ER staff following the scan/printing of a finger. Mitigating risks to this level will again empower participants to negotiate better rates from insurance and healthcare providers.
3) Responsibility for understanding instructions and medication prescribed cannot be laid at the feet of the physician since they have "signed" in acceptance and have their access to records if in doubt. This significantly reduces the possibility of malpractice through physicians not hammering home instructions sufficiently (why would you "sign" something you do not understand) and through patient negligence, as they now have copies of dosages, etc. Once again a powerful negotiation tool when dealing with insurance/healthcare providers.
4) The patient is empowered to provide instructions for such steps as organ donation and does not resuscitate/revive orders directly to the hospital in question, bypassing and overriding instructions from "family" or "relatives" who may hold beliefs contrary to those of the patient (hence limiting Power of Attorney controversy). This practice serves to temper any legal "disputes" or issues at the end-of-life situation, again facilitating a stronger negotiation position for rates.

The above four stages go a long way towards achieving the Quadruple Aim and facilitating the changes that would bring with itself to the industry.

What this means for insurance providers:

1) A robust new set of tools for the targeted and fully personalized provision of care plans dependent on the level and frequency of access granted by the client or their designate.
2) Full record access for making evaluations when offering plans. This potentially opens up markets to customers previously deemed too high risk from being in higher percentiles. Full transparent access will enable risk mitigation for high percentile individuals who would otherwise be dismissed as a matter of statistics.
3) Complete and immutable records being available during treatments, particularly ER visits, will significantly mitigate many of the 80k+ annual instances of ER "mal/malpractice" due to a lack of data on patients.
4) A complete bypass of the current pay-for-play system of medical records inflates operational costs and, in many cases, forces the employment of otherwise redundant staff.
5) Development of a DAO (decentralized autonomous organization) that would allow users to submit a payment directly to the DAO, allowing insurance providers to bill directly to a group based on an à la carte structure. Much like the current "Pay for services model" that is becoming increasingly popular in remote work environments.
6) The vast increase in efficiency and accuracy renders the use of Paradigm's leveraging of blockchain (DLT) technology by insurers potentially greater cost-effectiveness, and unwavering least wasteful of integral resources (time, human, financial).
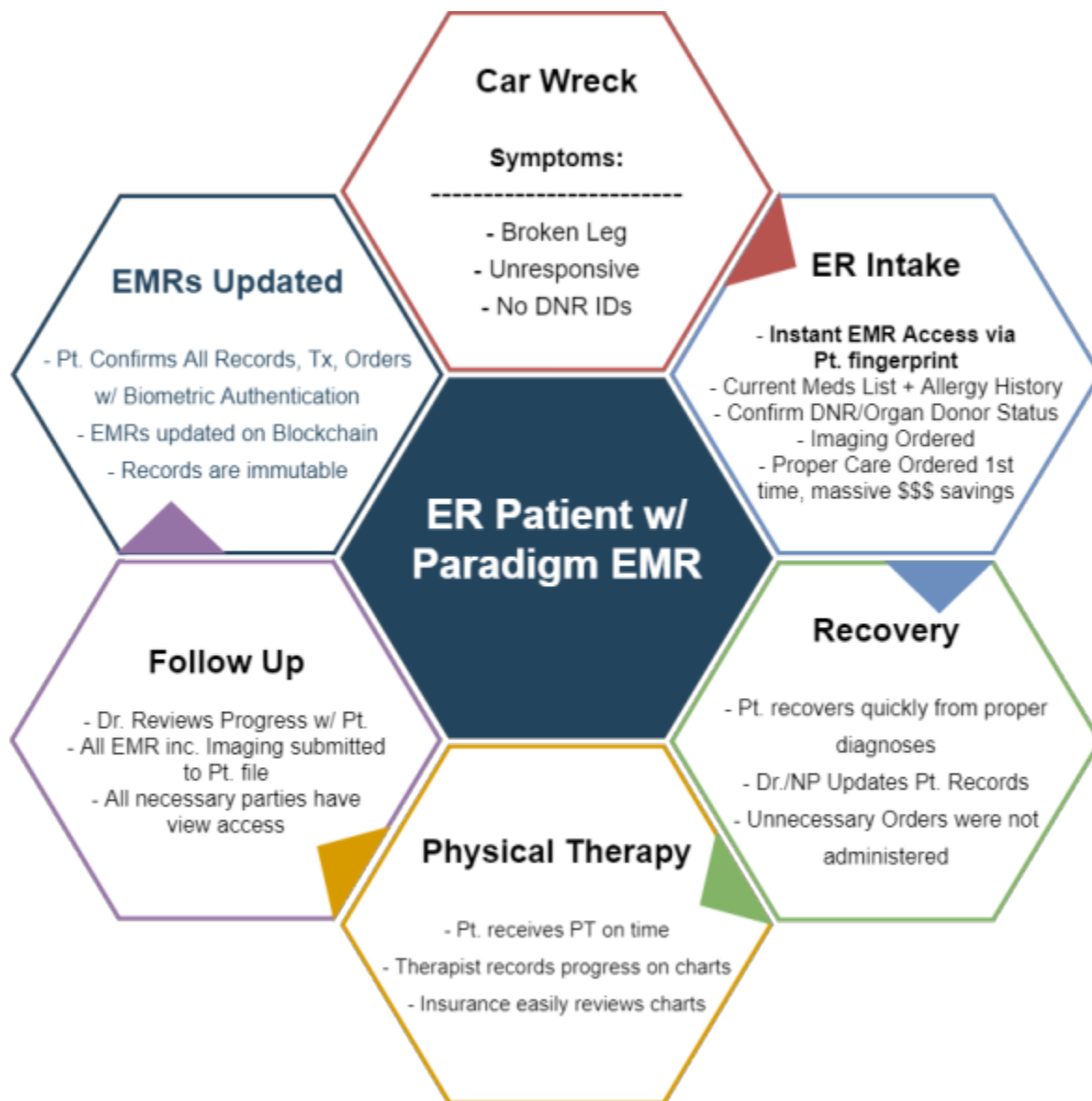
These steps enhance and increase the contribution of insurance providers towards the attainment of the Quadruple Aim by facilitating areas for rationalization, as well as broadening the scope of individualized healthcare plans.

What this means for healthcare providers:

1) A strengthening of patient care through heightened bidirectional accountability enforced through the active signing of data to records.
2) An amended only policy on records will level up compliance on the checking of documents, enhancing audit trails, and facilitating improved performance measurements for care-providing staff.
3) Immediate data access in emergency medical situations drastically mitigates risks and expenses associated with delays from experimental treatments. For example, the primary usage of regularly targeted antibiotics, as opposed to macrolides or aminoglycosides, reduces medication costs by up to 95%

4) This efficiency and accuracy render the opportunity for optimal patient outcomes much greater.
5) No hidden fees or additional compliance work is involved in the transfer of records.
6) Risk mitigation from "non-adherent patients" as they "sign" their records onto their storage hence accepting the instructions simultaneously.

Steps such as these empower hospitals and care providers both in terms of the golden Quadruple Aim and the federal requirement for meaningful use.

Car Wreck

Symptoms:

- Broken Leg
- Unresponsive
- No DNR IDs

EMRs Updated

- Pt. Confirms All Records, Tx, Orders w/ Biometric Authentication
- EMRs updated on Blockchain
- Records are immutable

ER Intake

- **Instant EMR Access via Pt. fingerprint**
- Current Meds List + Allergy History
- Confirm DNR/Organ Donor Status
- Imaging Ordered
- Proper Care Ordered 1st time, massive $$$ savings

ER Patient w/ Paradigm EMR

Follow Up

- Dr. Reviews Progress w/ Pt.
- All EMR inc. Imaging submitted to Pt. file
- All necessary parties have view access

Recovery

- Pt. recovers quickly from proper diagnoses
- Dr./NP Updates Pt. Records
- Unnecessary Orders were not administered

Physical Therapy

- Pt. receives PT on time
- Therapist records progress on charts
- Insurance easily reviews charts

Hospitals and Health Systems

Apart from what we have raised in the preceding section, examining the transformative power of a decentralized patient-centered approach to EMR brings to light many potential improvements.

There is instant access to patient data, facilitating faster and more efficient consultations for clinicians performing surgery follow-ups, or other outpatient treatment. Additionally, the transparent audit trail in the immutable records enables expedited tracking and tracing of either patient non-adherence or medical error.

Furthermore, it offers up the possibility of developing "designated record keeper" services for patients who have no interest in controlling their records. This would not be without compliance issues but would be a new service stream in shifting from a provider-centered to a patient-centered care delivery approach.

Overall, the streamlining and synchronization of workflows across the care spectrum has the potential to offer greater efficiency across the entire care spectrum, as well as significantly mitigate risks associated with emergency medicine, non-adherent patients, and administrative malpractice.

The transformative potential of Paradigm is previously unseen in the industry, altering the decision cycle, not just for practicing physicians, but simultaneously for administrative processes.

Secure and Immutable

Paradigm's decentralization is the key to its security. Once a record is submitted to the chain, it becomes immutable--it can't be updated or changed. The documents are synced and stored on all nodes worldwide. To hack a document, the hacker would have to hack the entire system and change the information on every computer, simultaneously. Not only would that alert everyone, but the sheer computational power required would be too much for even the most sophisticated state-sponsored hacker.

Credentialed users can add to--but not delete or change--the records, addendum workflow. Transactions must be verified by the network. The process involves taking the data being added to the network and processing it using a cryptographic function called a hashing sequence.

The output from the hashing sequence (Aes 2048/4096 a standard higher than what is usually used in military communication protocols) quickly produces a hash (a long string

of numbers and letters) which will have to remain fully unaltered to cryptographically facilitate the retrieval of data. What this means in practice is that once data has been pushed to storage, it is unalterable as any alterations will cause the hash to no longer match the hash of the stored data.

The system also offers protection against inaccurate information being entered. A consensus algorithm, essentially a mathematical proof that every hash entered into the ledger remains unaltered, checks that newly entered information complies with the set parameters, and is entered in sequence. For instance, if a hospital adds data indicating the patient has blood type A, but the existing data block indicates the type is O, then the information will be appended in sequence to his record. This real-time, immutable sequencing enables full and transparent audits at any time.

Such audits could be of use in determining errors in cases of malpractice or non-adherence.

Insurance Claims

Paradigm also provides the potential to automate claim adjudication and payment processing, eliminating the need for intermediaries and reducing the administrative costs and overhead for providers and payers (and thereby reducing cost and frustration for patients). It would also minimize, if not eliminate, the number of claims that are rejected due to incomplete or inaccurate patient information.

The current coding process in healthcare is fractured and daunting. Standard ICD coding is a long process and often up to human interpretation leading to confusion, lost or denied claims, and a massive workforce for ensuring that the process works. Paradigm creates a centralized repository of coding, editing, and record keeping with direct-to-consumer communications. All parties can easily see the coding history and reduce time and human capital.

Building on Success

We are not reinventing the wheel. The financial services and logistics industries have already demonstrated the power of blockchain. The technologies for data storage, security, and encryption exist and are in use today. The Flux family of products creates the ideal incubation and acceleration layer for new technology development. Currently, EMR input models are robust and well built; the massive issue is the centralization of the overall process. Paradigm is input model agnostic; only the storage, decentralization, and security of the hot and cold data matter.

Currently, there are thousands of flux nodes all over the world. This network can scale infinitely as the nodes halve and the growth of the network is developed. Node owners are rewarded with FLUX for the uptime and maintenance of their hardware.

*More information about FluxNodes can be found here: runonflux.io

An Expanded Healthcare Economy

The digital asset--FLUX--is the unit of value to create and manage this closed ecosystem. It can be used for network storage allocation, revenue payment cycles, provider incentives, and resolve inefficiencies that currently plague electronic medical records, while removing the barriers between end-users and care providers. Ultimately, this enhancement lies in Paradigm's decentralized nature, as it facilitates a fully global network irrespective of geographical borders likewise rendering it fully censorship-resistant.

Given that blockchain was developed primarily in the financial sector, it makes sense to apply that concept to the healthcare marketplace. For example, patients will be given an allotted space to store information for free on the Paradigm network. Flux currency or gateway services allow them to purchase extra space from nodes set up on hospital systems, elsewhere across the globe, or on Flux, Flux's decentralized computing network in an overall fully distributed computing network.

Paradigm will be partially facilitated on the Flux distributed operating system, allowing user information to be stored on its distributed computing network. This structure offers a level of redundancy hitherto unseen. There will be several advantages to the current infrastructure process in place.

1. Primary access would be secured by the highest possible levels of cryptography. Users would be assigned a unique id that would follow them through the medical

retention process in several forms. It would also allow access to financial transitions in a symbiotic ecosystem

2. FluxNodes are decentralized services provided by global participants and cryptographically protected by the flux ecosystem, thus allowing scalability and security.
3. Medical records and personal information would be allowed in a trusted key environment. Users would be able to assign key access to their providers, physicians, insurance companies, and others. This data would be bidirectional and resemble a standard EMR we know today.
4. The "Opt-In" process would allow users to create and store their information in the Paradigm framework. Controlling their information would allow end-users the choice of where and when they would like their information accessed or scraped for further review and analytics.

Closing

We have become too comfortable in the world we live in today allowing others to use, exploit, and maintain our most valuable asset, our health records. Much like Bitcoin started a disruptive cycle in the financial industry, Paradigm will create new accountabilities in the healthcare sector.

A special thank you to the Flux Team and Community, without the support of those that believe, we would not be capable of endeavoring to have such a palpable global impact in such a variety of human experiences. The following were used in the production concepts of Paradigm:

- Zel Technologies
- FluxNodes
- Flux
- FluxOS
- ZelCore Inc.

Paradigm is partially powered By Flux and ZelCore, learn more about them online: https://runonflux.io/ Zel Technologies Limited is registered in the U.K, all rights are reserved. Zelcore INC. is registered in the US, DE all rights are reserved.

"A customer is the most important visitor on our premises, he is not dependent on us. We are dependent on him. He is not an interruption in our work. He is the purpose of it. He is not an outsider in our business. He is part of it. We are not doing him a favor by serving him. He is doing us a favor by allowing us to do so."

~Mahatma Gandhi

References

[1] Data from Merocom Capital www.mercomcapital.com/healthcareITreports.php

[2] Report on Health Information Blocking, ONC, April 2015

[3]"Moving Patient Data Is Messy, But Blockchain Is Here to Help," Wired, Feb. 2017 www.wired.com/2017/02/moving-patient-data-messy-blockchain-help/

[4] "What is Blockchain Technology? A Step-by-Step Guide for Beginners" blockgeeks.com/guides/what-is-blockchain-technology/

[5] Linn L, Koo M. Blockchain for Health Data and Its Potential Use in Health IT and HealthCare Related Research. Posted by ONC April 2016

[6] Ekblaw A, Azaria A, Halamka J, Lippman A. "Case Study for Blockchain in Healthcare: 'MedRec' Prototype for Electronic Health Records and Medical Research Data." posted by the ONC April 2016