

HEALTH INFORMATION CHALLENGE

NEED FOR PATIENT CONTROL AND ACCESSIBILITY

One of the most dominant problems in healthcare information is the lack of a universal patient identity that can be used to quickly and efficiently bind patient identities across diverse electronic health record (EHR) systems.

WHO CAN SOLVE THE PROBLEM?



Hospitals can't.

Hospitals are only interested in patients during episodes of care.



Doctors can't.

Doctors are only interested in patients while treating them.



Insurers can't.

Health insurers are only interested in patients during enrollment periods.



The only party with a lifelong interest in patient health is the patients themselves.

The Universal Patient Index solves the biggest problem in patient health information by creating a universal patient identity that can be used by healthcare enterprises to efficiently bind patient identities across healthcare transactions while granting patients sovereign control over their own private health information. Blockchain provides an immutable, secure, and private space for individuals to maintain information about their health throughout their lifetimes.

WHAT IS THE CHALLENGE?



Solutions to the worldwide challenges facing healthcare today—lowering costs, improving quality, and increasing access to healthcare—are all dependent on one missing ingredient: access to health information! Without extensive information, the fantastic innovations of the 21st century are impotent; without sufficient information, modern technology cannot be fully employed to solve the challenges facing healthcare today. The entire healthcare industry is crying out for access to patient health information. Further, there is an enduring need for individuals to have the ability to maintain, control, and readily access their own health information over the course of their lifetimes. KalibrateBlockchain overcomes this challenge.

WHY HAVE OTHER SOLUTIONS FAILED?

It is not difficult to identify projects over the past couple decades seeking to solve the problem of effectively exchanging health information across enterprise boundaries, most of which have failed to achieve success, and some spectacularly. None have succeeded. This remains an unsolved problem chronically plaguing healthcare that, if solved, would be transformational. The dearth of success is not for lack of trying. Big technology companies like Google, Intel, and Microsoft have all attempted to solve this problem with less than remarkable results.

Solutions to the worldwide challenges facing healthcare today—lowering costs, improving quality, and increasing access to healthcare—all are waiting for this one secret ingredient: *access to health information*. Without *extensive information*, the fantastic innovations of the 21st century are impotent. Without *sufficient data*, modern technology cannot be fully employed to solve the challenges facing healthcare today. The entire healthcare industry is crying out for access to health information.

ENTER KALIBRATE BLOCKCHAIN

CREATING PATIENT IDENTITY AND HEALTH INFORMATION SOLUTIONS

WHAT IS KALIBRATE BLOCKCHAIN?

Kalibrate Blockchain is a company driving the development of a commonly-curated, fully-autonomous Universal Patient Index (UPI) built on distributed trust blockchain technology. This Universal Patient Index facilitates efficient binding of patient identities and tracking of patient health information across enterprise boundaries.

Ultimately, the Universal Patient Index allows Kalibrate patients to manage their personal health information, authorizing access by healthcare providers whenever and wherever needed. It establishes an autonomous health information indexing and transmission protocol, secured by blockchain technology.

Patients can finally know and control where and by whom all of their health information is being stored. Even better, they can privately share and control data across platforms and databases so all of their healthcare providers have ongoing access to essential information.

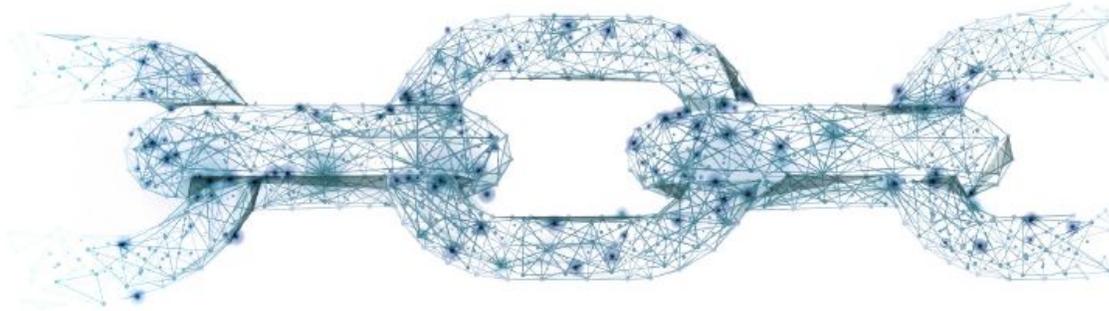
The Universal Patient Index is a universal, distributed, immutable log of every patient medical record.

It is the “Google” of patient health information—the universal health information log. For each medical record, immutable logged entries include:

- a) content addressing hash, similarly used by InterPlanetary File System, that secures authenticity and resolves its transfer pathway,
- b) provenance,

c) type, and

d) timestamps.



Kalibrate Blockchain encompasses three information components:

- 1. Distributed databases existing in every healthcare enterprise that store the actual information,**
- 2. Public, immutable, distributed blockchain that store the health information log in the distributed databases, and**
- 3. Cryptographic wallets that store the keys that correlate the information to patients.**

Importantly, the logged entries do not include private patient Protected Health Information (PHI). Each logged entry is protected by keys jointly controlled by the medical record creator and the patient. To access the health information, the transfer protocol requires a key that resolves to the logged entry. The transfer protocol uses the key to locate the logged entry, which in turn grants access to the logged medical record. Access is denied if the key does not resolve to the logged entry. The creator and the patient may issue multiple keys on the Kalibrate Blockchain for any of their logged entries. Keys may be revoked by the patient, rendering them useless so that they no longer resolve to the logged entry. Keys to logged entries are granted to users who store them off-chain in wallets that keep them safe and secure.

WHY THE UNIVERSAL PATIENT INDEX WILL SUCCEED WHERE OTHERS HAVE FAILED

New Solution Space

Blockchains deployed in distributed autonomous systems and incentivized by cryptocurrency occupy a new solution space where problems that have defied solution in the past may succeed where others have failed. This is particularly true with regard to 1) trust problems, and 2) network problems. Bitcoin, which pioneered this new solution space, is known for solving the unsolved double-spend problem that had prevented digital currency from achieving wide adoption.

While too many blockchain projects are merely adapting blockchain technology to implement old solutions, Kalibrate Blockchain robustly exploits this new solution space. This problem fits this new solution space where 1) trust in protection of privacy is paramount, and 2) it is a classical network problem. Kalibrate Blockchain harnesses both of these strengths in its novel solution to this unsolved problem.

Private Exchange of Health Information

Privacy protection requires the establishment of trust between the parties involved in the exchange. While trusting relationships naturally arise between physicians and patients engaged in the exchange of health information, most exchange solutions also require trust in an intermediating third party to facilitate the exchange between the physician sending the health information and the physician receiving it. Establishing trust between such intermediating parties has been cumbersome and difficult and is a significant barrier to success.

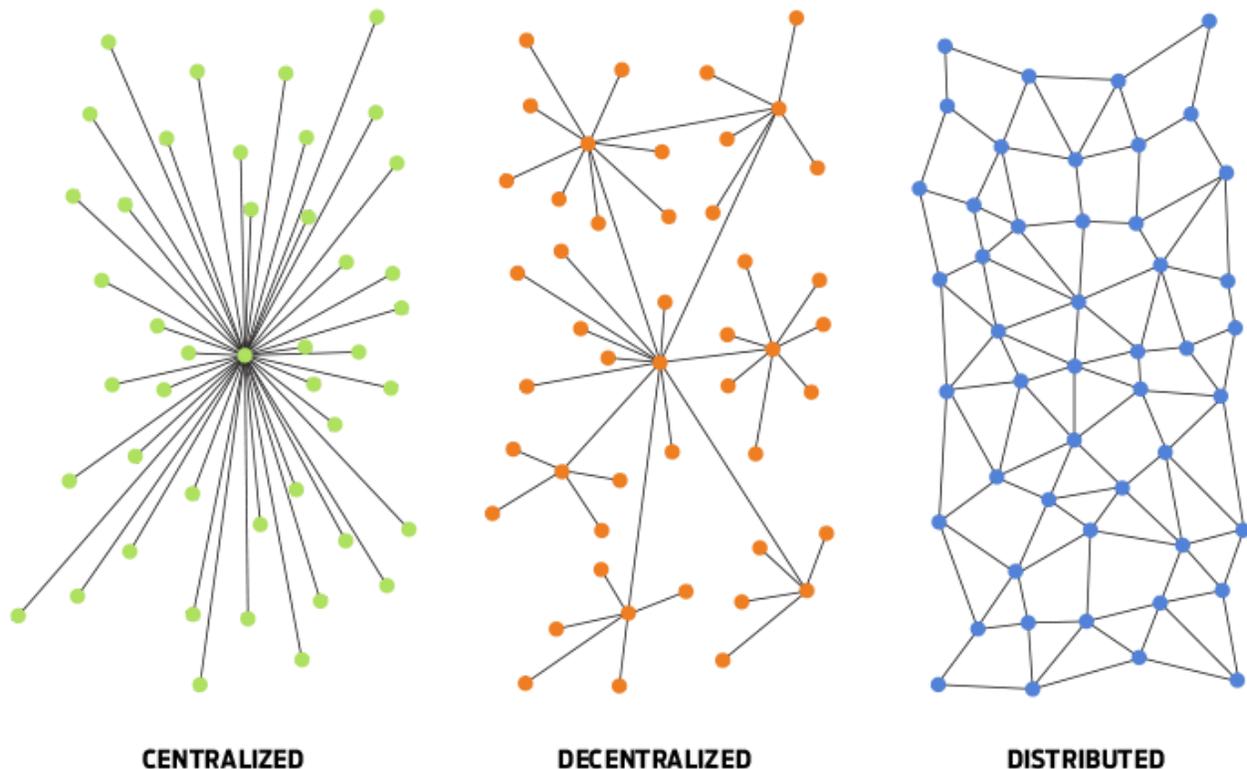
Kalibrate Blockchain harnesses this new solution space by implementing distributed trust privacy—privacy that does not require trust in any third party. Just as Bitcoin avoids the need to trust a bank with its “trustless” solution to the double-spend problem, Kalibrate Blockchain eliminates the need to trust a third party to protect privacy. As with Bitcoin, Kalibrate Blockchain does this by achieving consensus among distributed anonymous agents that are incentivized by Kalibrate Coin.

Network Problem Solved

In 1962, Paul Barron’s “On Distributed Communication Networks” classically described an ontology of network topologies (see figures below). This ontology reveals the distinctions between major approaches for exchanging health information. Centralized networks have failed to succeed when implemented by mighty technology companies such as Google, Microsoft, and Intel. Apple Health is the latest player seeking to centralize exchange of health

information. Regional information exchanges in recent decades seek success by implementing decentralized networks. The ONC (Office of the National Coordinator for Health Information Technology) leads the US federal government’s initiative to coordinate these decentralized networks.

Centralized and decentralized networks are characterized by the creation and maintenance of trust relationships through trusted third parties—for centralized networks, a single trusted third party, and for decentralized networks, multiple trusted third parties. Trust relationships for these topologies are primarily instantiated through legal contracts structured to conform with the HIPAA privacy regime. These contracts are necessarily rigid and brittle.



For example, in response to the ONC’s proposal to restructure the health exchange decentralized topology, an executive of one of the regional exchanges said, “I would characterize participation agreement revisions in the short-term pain for long-term gain category, but if the market moves in the direction that ONC is intending and only a small number of qualified HINs come into existence, there will be a lot of work that has to occur to update these agreements across the entire community.” This statement reflects the brittleness and rigidity of these contracts in establishing trust.

Control Regained

Under the HIPAA privacy regime, patients lose effective control of their Private Health Information (PHI) by granting providers unprecedented rights to disclose their private health information. Along with these rights, however, come high penalties for violations: up to \$1 million in civil penalties. As such, providers cannot tolerate any breach—hence the need for brittle and rigid trust agreements.

Every participant in these decentralized health information exchange networks must sign these legal contracts with some trusted third party. The decentralized network can't be used for the cases when one of the parties has not established the requisite relationship. Too many times that is the case, and the parties have to find some other way to exchange the needed health information.

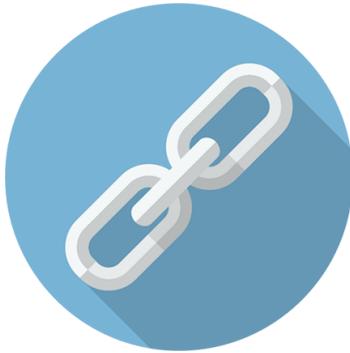
Inherent in these decentralized networks is the inevitability of healthcare competitors needing to collaborate because the health information travels down the same network. Generally, even the best collaboration among competitors is not great.

For these and a host of other reasons that have been studied to death and reported in peer reviewed journals, both centralized and decentralized networks have failed to achieve the effective exchange of health information across enterprise boundaries. Much effort, influence, money, and resources continue to be spent in the quest to achieve this virtuous but unattained outcome.

Possibly, with enough effort, influence, and money, some form of decentralized network might superficially solve this pressing problem, but it is clear that decentralized networks do not naturally fit the problem; rather, they are forced to fit like a wrong-sized shoe.

How much better, then, to cultivate the new solution space to see if it might yield a solution with emergent properties; a solution that would naturally emerge to solve this unsolved problem.

DISTRIBUTED NETWORK TOPOLOGY



The Kalibrate Blockchain Solution

Enter distributed network topology—the Distributed Trust Protocol (DTP). DTP is Kalibrate Blockchain’s solution to this unsolved problem. With it, health information is exchanged, peer-to-peer, on a distributed network where the patient is always one of the peers.

Health information is sent to patients, and patients send their own health information. No health information is exchanged without the patient’s intermediation. This solution harnesses the naturally occurring trust relationship between patients and physicians.

Instead of seeking to establish artificial, brittle, rigid trust between third parties, it positions the patient at the center of all health information exchange. Rather than patients losing control of their health information every time they sign the HIPAA release, patients decide who to trust with their health information.

Solution to the HIPAA Compromise

The HIPAA regime compromises patient privacy for clinical efficiency. This compromise requires patients to give up control of their health information in order to obtain treatment; every patient consents to this, but that consent is coerced and rarely fully informed; this should not be the case.

The technology landscape has dramatically shifted since 1996 when HIPAA was codified. It is now common for patients to hold mobile devices with significant computing resources available to them at all times. The emergence of blockchains, along with their anonymous distributed agents, enable trustless, immutable record keeping.

Combined, these powerful technologies shift the landscape on patient privacy. DTP makes it possible to achieve clinical efficiency while finally solving the problem of effective exchange of health information without patients losing control of their health information privacy. With DTP, no trusted third-party participation is necessary, nor is there a legal need for brittle and rigid participation contracts or collaboration among competitors. With DTP, no parties are excluded from participating due to lack of enrollment. Any party authorized by the patient can participate, easily and seamlessly.

Since many of the benefits of connecting to a health information exchange inure subsequent to other parties adopting the blockchain, prior solutions have fatally suffered from the classical problem of how to motivate early adopters to jump on board. Critical mass adoption

has proven elusive. There are plenty of projects on the dump heap, despite great technology, because they never attained the necessary critical mass adoption.

Benefits Early Adopters

In contrast to prior failed solutions, Kalibrate Blockchain provides useful benefits to early adopters prior to critical mass adoption. Blockchain My Medical Record, the Minimal Viable Product of Kalibrate Blockchain, supports smooth, easy, full peer-to-peer medical data exchange with any party the patient decides to trust—without a priori adoption.

Kalibrate Blockchain employs its cryptocurrency to further solve the network problem by incentivizing early adopters through grants of Kalibrate Coin. Consequently, there are benefits associated with early adoption in addition to the benefits that come later with critical mass adoption.

Nurtures Demand for Medical Data

Of equal importance is the fact Kalibrate Blockchain nurtures orthogonal demand for the logging of health information to further drive adoption. This demand is created by a diverse portfolio of products, services, and projects that log health information onto the Kalibrate Blockchain as a byproduct of their use or implementation.

These projects have orthogonal demand distributions such that they harness a diverse set of market vectors independent of demand for Kalibrate Blockchain's UPI. As these projects drive ongoing logging of medical data on Kalibrate Blockchain, demand for UPI by doctors and hospitals will grow, driving increased adoption.

Accordingly, Kalibrate Blockchain will nurture and invest in the development of a wide and diverse portfolio of projects associated with the Kalibrate Blockchain.

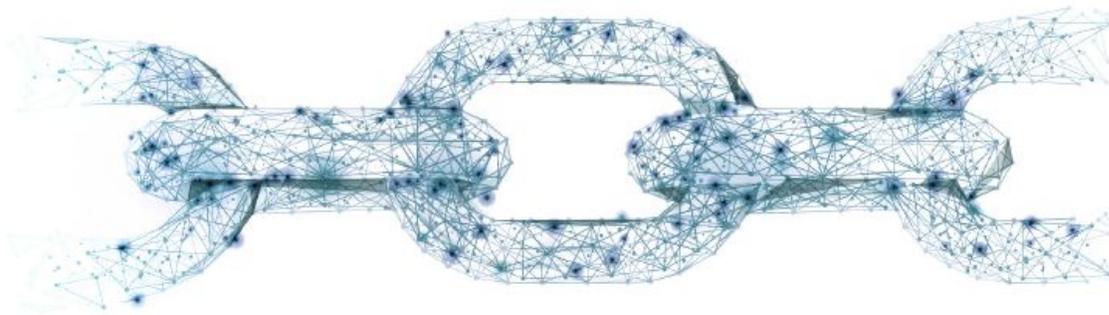
LOCKS OF CHAIN

PRIVACY AND SECURITY REQUIREMENTS FOR STORING SENSITIVE HEALTH INFORMATION

Privacy and security requirements for storing sensitive medical data on a public immutable blockchain necessarily are stringent. These requirements include:

- No correlations stored on the public, immutable blockchain
- Correlations of data stored on the public, immutable blockchain made by hierarchical deterministic key sequences held off blockchain
- Privacy breaches can only be made by misappropriation of the key
- Key can always be recovered without the need to trust a third party
- Can be revoked and new key can be issued in the event of misappropriation
- Key is provably bound to one person
- One person can only have a single key

Prevalent forms of cryptology do not obviously meet these requirements. In order to meet them, novel, alternative methods have been conceived and are being instantiated.



Novel Protocol

Locks of Chain are used by the Distributed Trust Protocol and the Eukerium Keys to meet these requirements. Locks of Chain is a novel protocol for associating values such that the associations are undiscoverable. Instead, only the utility of the associations is realizable. Values are associated by chains of numbers. Each link is represented as a triple; the first element corresponds to the last element of the prior link, the last element corresponds to the first element of the subsequent link, and the middle element is used to store values in certain situations—when not used to store values, it is simply filled with a random number.

DISTRIBUTED TRUST PROTOCOL

METHOD FOR TRANSFERRING DATA BETWEEN PEERS ON A NETWORK



The immutability of blockchain makes any vulnerability from hacking especially perilous, because when immutable data is hacked, the hack is immutable. It is not possible to recover the privacy; the data is immutably transparent.

Accordingly, encryption is not suited for the privacy protection of highly sensitive data on immutable blockchains. This is particularly the case for medical data that can define the essence of a person such that, if it is hacked, the essence of the person can be forever changed.

DTP raises the bar on privacy. While typical medical data stores are layered with privacy protection mechanisms, DTP instantiates correlations that are not discoverable. Through the interactions between the blockchain and the swarm of distributed anonymous agents, it sets the gold standard for medical privacy that will be demanded by privacy conscious medical consumers.

Because we can't exclude the possibility of loss, theft, or other forms of adversarial discovery, cryptographic encryption is not a primary form of managing privacy on the DTP. Patient-controlled privacy is only achievable when the immutable data on the Kalibrate Blockchain is non-correlated (not related to any personal identity).

Thus, the medical record log entries immutably stored on Kalibrate Blockchain do not include patient identifiers—that is, no Protected Health Information (PHI) is ever stored on Kalibrate Blockchain. This way, privacy can be achieved on a public, immutable blockchain. Logged entries on the Kalibrate Blockchain correlate to patient identities through off-the-blockchain keys held by the patients in wallets, much like Bitcoin wallets.

EUKERIUM KEYS

A BLOCKCHAIN-BASED CRYPTOKEY THAT BINDS TO A PERSON'S DNA

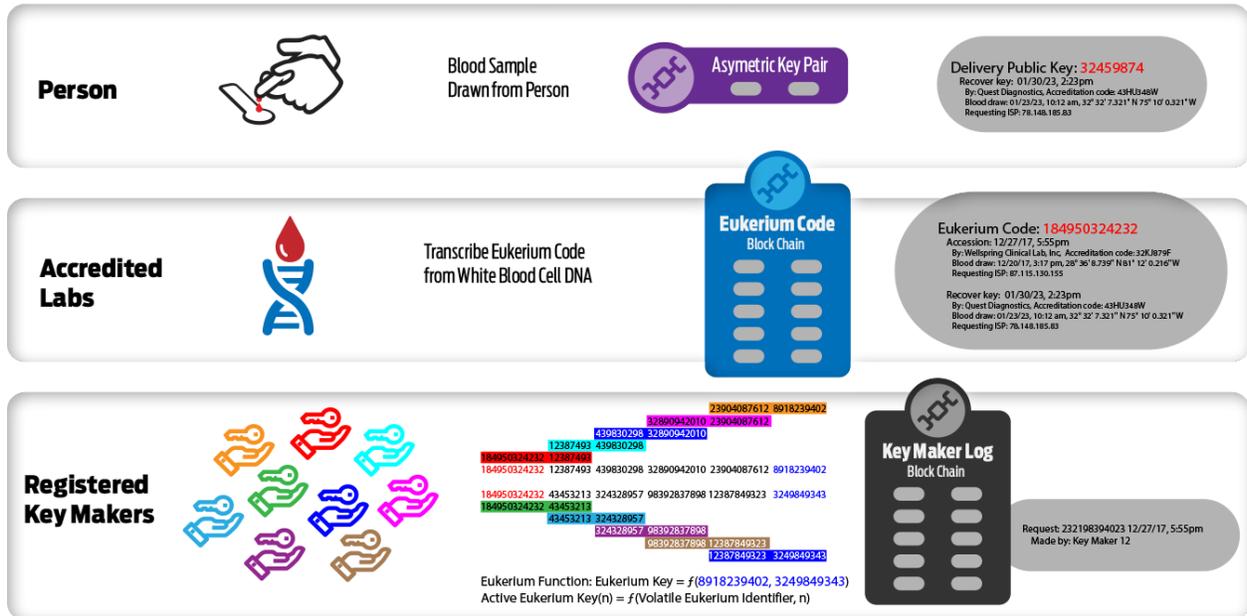
Kalibrate Blockchain employs off-blockchain correlations using Eukerium-derived key chains held by patients in wallets. Eukerium is a blockchain-based cryptokey that immutably binds hierarchical deterministic cryptographic key chains to a person's DNA transcribed from white blood cells obtained from blood test samples.

These DNA-based keys are:

- Unique to each person so that no two persons hold the same key, with no possibility of duplicates
- Associated only with human persons; provable human personhood; “meat-bags” only, no “sock puppets”
- Immutable throughout the person's lifetime always recoverable upon request
- Revocable if compromised, they can be replaced
- Secret, provable, not discoverable

With Eukerium keys, the medical record log entries immutably written on the Kalibrate Blockchain are correlated off-blockchain. As such, privacy cannot be breached. Correlations are made only by Eukerium's hierarchical deterministic chains of keys held by the individual that fit into the locks of chains that resolve to the logged entries on the Kalibrate Blockchain. This is person-controlled privacy; only the person with the keys can correlate any of their immutable medical record log entries on the Kalibrate Blockchain.

Eukerium Key



PATIENT-SOVEREIGN PRIVACY

ULTIMATE PATIENT CONTROL OVER HEALTH INFORMATION

The Kalibrate Blockchain Universal Patient Index tracks private health information, including medical records, images, and lab results. It tracks where those records are located and who has access to share or access them.

Patients empowered to share health information

Essentially, the Kalibrate Blockchain Universal Patient Index empowers patients to control where all of their health information is being stored and by whom. This level of control also enables patients and healthcare providers to securely share data across platforms and databases so

doctors can have ongoing access to all the data they need in making well-informed decisions with regard to treatment and care.

PATIENT ENGAGEMENT:

Kalibrate Blockchain
is an effective way for
doctors and hospitals
to achieve patient
engagement for
Medicare's Meaningful
Use Incentive Programs.

Private, patient-controlled health identity

Most importantly, the Universal Patient Index gives patients—and patients alone—sovereign privacy and control over their private health information. Patient identities corresponding to the private health information indexed on the Universal Patient Index are themselves undiscoverable and are not stored anywhere or in any form on the blockchain index. Rather, the Universal Patient Index correlates patient identity with deterministic hierarchical keys which are owned and stored solely by the patient in an off-blockchain wallet.

Comprehensive provider access

Limited access to patient health information is a serious problem in healthcare today. Healthcare providers need access to longitudinal lifelong health information to reduce costs, increase access to healthcare, and improve outcomes. Massive amounts of information exists, with more being created everyday, but most of it is siloed within disparate healthcare organizations. Interoperability between these organizations is currently hindered by legacy information systems that cannot communicate with each other, as well as by cumbersome, enterprise-facing, health information exchange strategies that compete with each other for dominance—to the point of stalemate.

Universal health information exchange protocol

The Kalibrate Blockchain Universal Patient Index puts patients at the center of the health information world, giving them full access to and

control over their own personal health information. This transformative, patient-mediated health information exchange platform creates the foundation for a truly universal health information exchange protocol that will make health information accessible across enterprise and international boundaries. Access and control will follow patients wherever they seek care, emulating naturally occurring patient-physician channels of communication.

Applications for this new platform will include patient portals, personal health records, health identity services, and longitudinal research efforts that will finally engage patients on their own terms. Access and exchange will be available to any patient and provider, regardless of their provider network.