Health Data Chain White paper

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Abstract

Health Data Chain is a blockchain technology based ecosystem for healthcare industry. As blockchain brought about powerful solutions for many technical and social problems, we believe that it's perfectly fit for the health care industry. It not only provides a new information management solution for the health care industry, but also brings in new mechanisms to solve the long standing problems in the health care industry.

As we know, the business models in health care industry are very complicated. There are many entities involved in this market, including patients or customers, service providers or organizations, government agencies etc. The relationships between them are very complex. Because of these, there are many long standing problems in the health care industry, such as rising costs, information islanding, scarcity of medical resources, etc.

The complexity of these problems generally comes from the externality of the market, which happens when the decisions and behaviors of the participants of the market lead to costs or benefits of others who are not involved in this market. For example, a man with infectious disease may influence the health condition of people around him, so if he tried his best to cure himself, people around him would be benefited, otherwise, they might suffer. Because of the externality, many government agencies and third-party organizations are introduced into this market, aiming to represent the benefits of external people. This makes the health care market a semi-free market, and the decisions and behaviors of entities in this market are entangled with each other.

However, the externality isn't effectively removed by the introduction of government agencies and third-party organizations. There are still a lot of behaviors of externality in this market. For example, people lack incentives to pay for fitness services, although it's good for their long-term health so it can reduce medical care burdens of the whole society; Some doctors provide over treatments to their patients, which add to the medical care burdens of the whole society.

The development of blockchain technology provides us a new tool to solve the externality problems of the health care industry. In fact, blockchain technology builds consensus by incentivizing nodes in the network to honestly package the transaction records generated in the network, so removes the role of central organization. This consensus scheme can also be used to incentivize people to make their decisions considering the total benefits of the whole society but not only his current personal benefit. Generally speaking, people can get cryptocurrency rewards when they make efforts to contribute to their own health and thus the total society's welfare. By providing such an incentive, we could make the market work properly considering its external influences.

For short, we build an ecosystem on blockchain technology which can bring about following changes to the health care industry:

- People will be incentivized to pay more attention about their own health conditions, which would reduce the burdens of the medical expenditure of the whole society, improve the adherence of the patients to the treatments, lower the number of claims of insurance companies. At the same time, this provides good opportunities to many innovative companies, such as companies provide fitness services and intelligent healthcare devices. In a word, this is a win-win solution to all parties in the health care industry.
- The transaction processes between entities would be automated and accelerated, and the cost during these processes would be greatly reduced. Meanwhile, the security would be enhanced.
- The information generated during service processes, including the medical records and transaction records would be securely stored and easily shared to entities who are authorized. This greatly improve the interoperability of the entities in the health care industry. Patients could hold their health data and profit from sharing data to research organizations, and organizations could get data they wanted easily from patients all around the world.
- There would be more innovative businesses built based on the new ecosystem, breaking the territory restrictions and information barriers.

Overview of current health care industry

We are facing severe challenges in health care industry around the world. A recent study by Deloitte revealed that by 2020 global health care expenditure is estimated to reach $8.7 trillion, compared with $7 trillion in 2015, and increase to 10.5% as a percentage of GDP. Contributing factors include an aging pollution, chronic diseases such as obesity and diabetes, and a rise in the number of cases of dementia and HIV-AIDs. The study found that life expectancy is expected to increase by one year by 2020, but the natural progression of aging brings with it challenges. A staggering $4 trillion is estimated to be spent on cancer, cardiovascular and respiratory diseases with obesity on the rise due to poor eating habits and sedentary lifestyles. India and China will be among the highest sufferers of diabetes globally where 69 million and 110 million cases are projected. The most overwhelming discovery is the growing rate of dementia, which is anticipated to double every 20 years resulting in 74.7 million cases by 2030.

These challenges leaves us the choice of promoting efficiency of health care industry or lowering the quality of our future life. However, we are making slow progress in developing and reforming the health care industry because of the relatively closed and semi-market-oriented feature of this field. Health care is such a strictly regulated business by government agencies, along with the employers and insurance companies who are only working in their own interest and not that of the individual patients or health service providers, there exists no free market economics in healthcare. Additionally, there are little to no financial motivations for individuals to take personal responsibility or “buy-in” to manage their own health. Why is health care industry a semi-market and why are behaviors in this field so complex?

Externality

Externality is an important concept in economics. In economics, an externality is the cost or benefit that affects a party who did not choose to incur that cost or benefit.For example, manufacturing activities that cause air pollution impose

health and clean-up costs on the whole society, whereas the neighbors of an individual who chooses to fire-proof his home may benefit from a reduced risk of a fire spreading to their own houses. If external costs exist, such as pollution, the producer may choose to produce more of the product than would be produced if the producer were required to pay all associated environmental costs. If there are external benefits, such as in public safety, less of the good may be produced than would be the case if the producer were to receive payment for the external benefits to others. For the purpose of these statements, overall cost and benefit to society is defined as the sum of the imputed monetary value of benefits and costs to all parties involved. Thus, unregulated markets in goods or services with significant externalities generate prices that do not reflect the full social cost or benefit of their transactions; such markets are therefore inefficient.

There are significant externalities in the health care market, effecting both the behaviors of consumers and service providers:

For consumers, individual health behaviors not only effect the quality of one's own life, but also effect the hygienic conditions of his circumstance and the occupation of social medical resources. For example, in epidemic period, the neighbors of an individual who buys sanitary disinfection products and takes vaccinations may benefit from a reduced risk of epidemic spreading; people who spend time and money on keeping their bodies healthy save the expenditure of social medical insurance. Otherwise, if individuals don't pay attention to their personal health conditions, the society would pay much more for the treatments of patients and occupy the benefits of those who devote a lot of energy to keeping healthy.

For service providers, it's hard to make balance between keeping profitable and shouldering social responsibilities. For example, the abuse of antibiotic is causing severe results for human beings, although antibiotic may cure the patients rapidly and bring profits for hospital; Over-treatment is another widespread problem in health care industry. A lot of social resources are consumed by over-treatment only to bring some hospitals profits and relieve the fear and anxiety of some patients.

Problems

Just because of the externality wide-spreading in the health care industry, many government agencies and third-party organizations are introduced into this market, aiming to represent the external benefits and regulate the behaviors of entities in this market. However, this bring about complexity which hinders the developments and innovations in this field. Generally speaking, the following problems are long standing in the health care industries:

- Lack of reasonable incentives： on one hand, there are little or no financial motivations for individuals to take personal responsibility or "buy-in" to manage their own health; on the other hand, hospitals and other service providers have no motivations to improve their services.
- Scarcity and misallocation of medical resources： the strict regulation and complex authentication made the industry develop slowly, and new innovative companies are difficult to enter this business. Consequently, medical resources can't be provided appropriately according to the market's demand. Because of the scarcity and misallocation of medical resources, the costs of medical services are more and more unaffordable for many families. In addition, healthcare providers are also concerned with patients having access to the appropriate treatments, which would bring them more profits.
- Lack of interoperability： There are seldom or no motivation for hospitals and service providers to interoperate to provide better services. This pose additional barriers to effective data sharing. This lack of coordinated data management and exchange means health records are fragmented, rather than cohesive. Patients and providers may face significant hurdles in initiating data retrieval and sharing due to economic incentives that encourage "health information blocking."
- Complex transaction processes: transactions are complex and slow because of third-party payments, especially the process of claim settlement. Because of the information asymmetry, it takes much time to audit the claim settlements and commit the payments. Healthcare insurance payers have complicated billing requirements and often deny and delay claim payment. Additionally, many healthcare providers experience significant cash flow difficulties due to claim denials.

- Information Opacity: patients rarely have specialized knowledges and are easy to be deceived. Fraud is an ever-increasing problem in healthcare. Meanwhile, information transparency is also important in liability assessment.

Challenges to all parties

Problems above make great challenges to all parties of the market.

1. For patients

Generally, patients have difficulty finding trusted and affordable care providers when prices are increasing rapidly.

- High medical costs.
- Shortage of medical resources.
- Risk of privacy data leak.
- Lack of guidances and incentives to adhere to good healthy habits.
- Medical information is not transparent, and easy to be deceived

2. For hospitals

Hospitals are supposed to shoulder social responsibility while make profits to maintain operation.

- The payment process is complex and the cash flow cycle period is long.
- Medical records and data aren't shared.
- Difficulties in the monitoring the patients' behaviors outside the hospital.
- Difficulties in liability assessments of medical disputes.
- Difficulties in catching up with technology development.
- Over-treatment problem.

3. For pharmaceutical enterprises

Reaching patients and care providers globally is expensive, serving niche markets fragmented by physical borders is economically impossible.

- Difficulties in supply chain management.
- High marketing costs.

4. For insurance companies

Insurance companies must make their efforts to help customers reduce health risks so they could save their compensation.

- High audit costs and marketing costs.
- Difficulties in risk management

5. For fitness service providers

Many people are not willing to pay for fitness services or fitness devices which are out of the coverage of medical insurance. This make it difficult for fitness companies to run their business.

6. For governments

Governments all around the world face the common challenges of high rising medical expenditure and low efficiency of medical system.

- Medical expenditure is high.
- Low efficiency of current medical system.
- Difficulties in regulation.
- Difficulties in monitoring population health status.

Solution

Charlie Munger says that getting incentives right is the most fundamental thing to build a sustainable business. As we analyzed above, externality distorted the incentives of different parties in health care industry, so our target is to try to remove the externality and revitalize the health care market.

How to remove Externality

In fact, There are several general types of solutions to the problem of externality, among which direct government regulation is not the best one. A main idea is to recovery the reasonable incentives by making a price for the externality.

For example, concerning environmental problems, emission trading, or cap and trade(CAT), is an effective approach to controlling pollution by providing economic incentives for achieving reductions in the emissions of pollutants. In contrast to command-and-control environmental regulations, cap and trade (CAT) schemes are a type of flexible environmental regulation that allows organizations to decide how best to meet policy targets. Various countries, states and groups of companies have adopted such trading systems, notably for mitigating climate change. A central authority (usually a governmental body) allocates or sells a limited number of permits to discharge specific quantities of a specific pollutant per time period. Polluters are required to hold permits in amount equal to their emissions. Polluters that want to increase their emissions must buy permits from others willing to sell them. Financial derivatives of permits can also be traded on secondary markets. In theory, polluters who can reduce emissions most cheaply will do so, achieving the emission reduction at the lowest cost to society. Cap and trade is meant to provide the private sector with the flexibility required to reduce emissions while stimulating technological innovation and economic growth.

We can build similar schemes to solve the externality problems in health care industry. However, entities involved in health care industry are numerous and scattered, which makes the CAT like schemes difficult to apply in this filed.

Fortunately, the development of blockchain technology brings possibility to build such a scheme in health care industry.

What the blockchain technology has brought us

At its core, blockchain is a distributed system for recording and storing transaction records. More specifically, blockchain is a shared, immutable record of peer-to-peer transactions built from linked transaction blocks and stored in a digital ledger. Blockchain relies on established cryptographic techniques to allow each participant in a network to interact (e.g. store, exchange, and view information), without preexisting trust between the parties. In a blockchain system, there is no central authority; instead, transaction records are stored and distributed across all network participants. Interactions with the blockchain become known to all participants and require verification by the network before information is added, enabling trustless collaboration between network participants while recording an immutable audit trail of all interactions.

Blockchain technology has several innovative characters that can be used to build a better ecosystem.

1. Incentivization

Blockchain technology builds consensus by incentivizing nodes in the network to honestly package the transaction records generated in the network, so removes the role of central organization. This consensus scheme can also be used to incentivize entities in the health care industry to consider the total benefits of the whole society. A definite amount of cryptocurrency will be issued through the progress of mining, which can be designed to use a proof of work protocol measuring people's meaningful efforts to incentivize them.

Cryptocurrency and smart contracts make it possible to create very efficient incentive systems and token economies, which can quickly surpass traditional players. For example, as a blockchain social media platform, Steemit solves the incentivization of content creation and curation with a specialized blockchain by rewarding users, who contribute great quality

content. Steemit has quickly risen from 2.9M to 16.9M monthly visits from March to August 2017, while in comparison, the well-established New York Magazine has 20M monthly visits.

2. Security

From a security perspective, cryptography protects the data via a number of different mechanisms. Users can address privacy and transparency needs using different consensus mechanisms specified by the protocol and public and private key pairs. A blockchain environment protects information at the data element level, rather than in aggregate, and appropriate parties can only access data using appropriate permissions as defined by the protocol.

3. Automation

With smart contracts, a lot of procedures can be automized. In traditional settings we would need a massive legal and accounting team to make it possible for anyone, anywhere on the globe to conclude a transaction. With smart contracts and blockchain, transaction processes are greatly simplified.

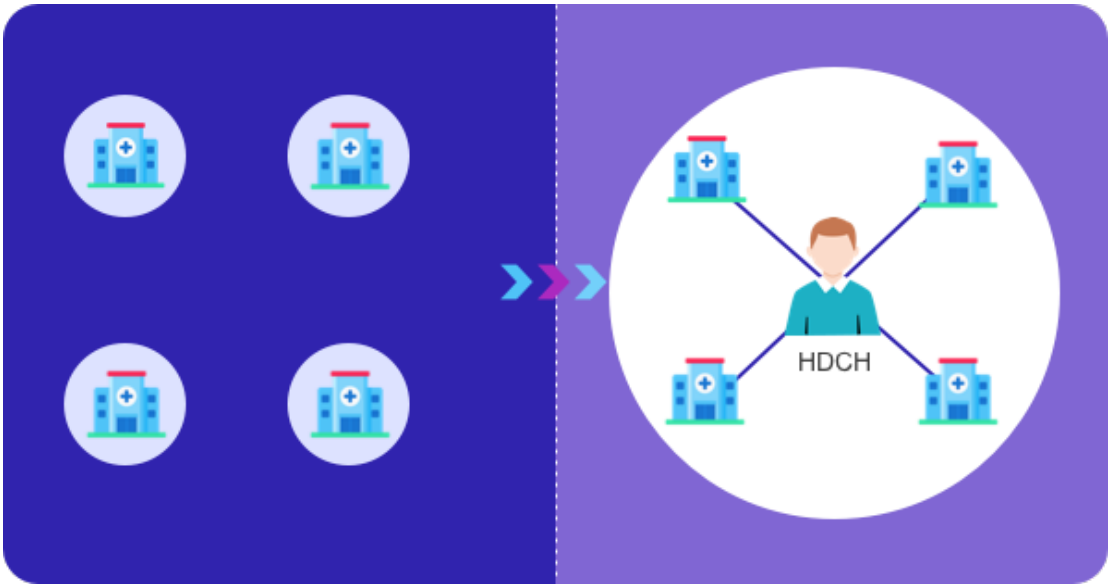
These characters are exactly the missing ingredients to a killer solution of long standing problems in health care industry. As Deloitte explains that blockchain truly shines when four conditions have been met:

(1) multiple parties generate transactions that change information in a shared repository,
(2) parties need to trust that the transactions are valid,
(3) intermediaries are inefficient or not trusted as arbiters of truth,
(4) enhanced security is needed to ensure integrity of the system.

We can see that the health care industry is exactly suitable to apply blockchain technology.

Introduction to Health Data Chain

Health Data Chain is a solution that uses the innovative technology of blockchain and cryptocurrency to create a ecosystem in which entities have incentives to act and cooperate responsibly regarding individual and population health. It includes a blockchain to secure and share personal health data and transaction data, a cryptocurrency to incentivize and finance health behaviors, and smart contracts running on it to help automize transactions and design new business models.



Health Data Chain

(1) User Data

Health Data Chain will enable users to consolidate all their data, whether personal, fitness, medical or emergency, stored in a single platform which is secured with encrypted codes, keeping all their information private, safe and all in one place. The goal is to create a system that does not rely on trust, and facilitates information storage, sharing and collaboration to improve efficiency in the management of healthcare and population health.

Users' personal data are securely encrypted through differential privacy technology to integrate IPFS (interplanetary file storage) system, which protects users' privacy while providing a big-data analyzing use for research organizations.

All data is stored on the blockchain in chronological order and cannot be tampered with or mismanaged. The cryptographic nature will mitigate the risk of hacking or illegal sharing of your data. People can access their data and medical history at their fingertips, making it easy to share with doctors. Give access to view or add additional data to one's records, enabling hospitals and service providers to access and update data in real time.

Blockchain-enabled electronic health records(EHR) will bring value to the industry by significantly reducing the resources, time, errors, updates, and reconciliations required, which will directly correlate to more efficient healthcare provision, higher patient satisfaction and benefits to the bottom line.

(2) Provider data

Provider data is a cornerstone of the health information system. Provider demographic information, such as office addresses, provider hours, phone numbers, specialties, and certifications, is used to populate provider directories, which are in turn used by members to find relevant and in-network physicians in their area. Provider data is also critical for claims adjudication. A payer must verify that a reimbursement request came from a credentialed, in-network doctor and that the care delivered is reimbursable under the policy. Maintaining and disseminating accurate and up-to-date provider data is paramount for the industry. Furthermore, there is opportunity for under qualified practitioners to gain access to patients in desperate need. With no time or knowledge of how to validate their qualification, patients can end up in dire situations after botched surgeries and unregulated procedures.

Health Data Chain would enable patients to verify the authenticity of a health professional including where they are allowed to practice, licenses and affiliations. Capturing data such as medical schools, residency programs, certifying boards and hospital affiliations, accurately recording practitioner data

over the course of their careers. This builds confidence with employers, patients and regulatory bodies while mitigating the risk of fraud.

(3) Transaction data

All transaction data would be stored on the Health Data Chain in chronological order and cannot be deleted or tampered. Combined with smart contracts technology, it would made the claim adjudication rather easy and quick.

Cryptocurrency

The Health Data Chain healthcare finance system uses blockchain to secure and facilitate transactions, designs a scheme of the creation of additional coin units as an incentivization; Health Data Chain uses decentralized control as opposed to centralized electronic money and central banking systems. As there is no interference by third parties, it is automated, and has the cost of administration and security built into the value of the coin. Health Data Chain incentivizes individual behavior and facilitates a trusted relationship between entities in the health care market.

As with any other cryptocurrency, there is an opportunity to mine the HDCH. The standard is Bitcoin mining as the process of verifying transactions and adding them to the blockchain which then releases new Bitcoin for the miner to exchange, called Proof-of-Work(POW). In addition to POW, mining the HDCH goes beyond just the processing power in the network.

Proof of Performance

Both individuals and health service providers could mine more HDCH by executing Proof of Performance. The Proof of performance is a incentivization scheme to reward those behaviors that are beneficial to the health of the whole society.

Individuals could mine for HDCH by living a healthy life, including taking workouts, eating healthy food, recording body data, reading health related articles, taking health examinations regularly etc.

Service providers could mine through providing superior quality services, including attaining quality outcomes, maintaining a good reputation, and managing healthy patient populations etc.

This will revolutionize the model of incentivizing health service providers and members with respect to payment rewards through cryptocurrencies.

Proof of Authorization

Health Data Chain hands over the retroactive rights, knowing rights and the access and control rights of medical data to users, so users can authorize the data to service providers for researching use, thereby improving the free trade of medical data.

Health Data chain allow data holders to mine under the scheme of Proof of Authorization, which rewards data holders when they authorize other institutions to use their data. It can benefit the contributors and holders of data, and users and institutions would be motivated to share data and other resources on the premise of safety, equality and trust, and build an open platform of data storage and sharing.

Smart Contracts

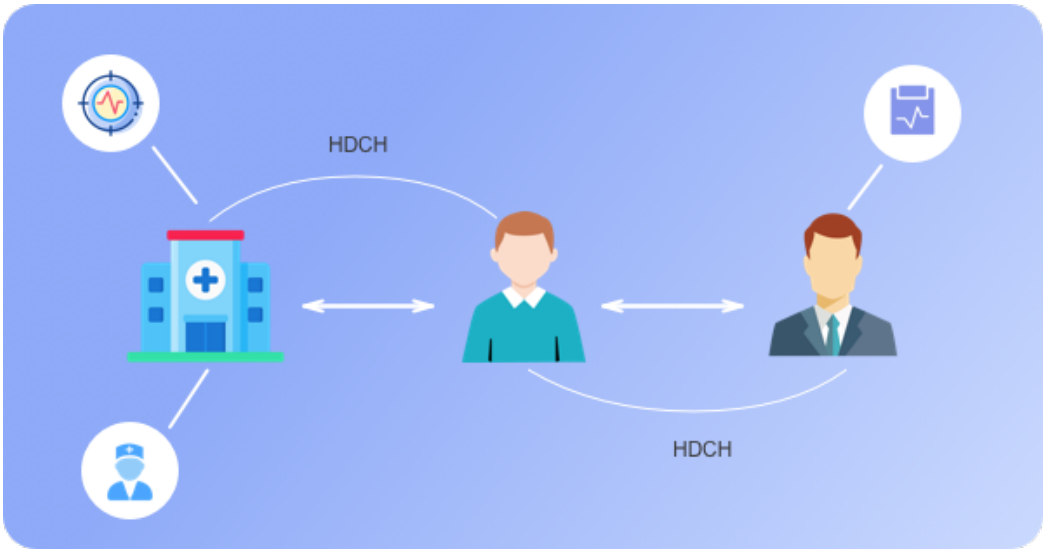
Smart Contracts are autonomous computer programs that execute automatically and mandatorily the conditions defined beforehand, such as the facilitation, verification or enforcement of the negotiation or performance of a contract. The main advantage of putting Smart Contracts in a blockchain is the guarantee provided by the blockchain that the contract terms cannot be modified. The blockchain makes it impossible to tamper or hack the contract terms. This ensures correct completion of claims and supports compliance audits using business rules. Smart Contracts enable to reduce the costs of verification, execution, arbitration and fraud prevention. They enable to overcome the moral hazard problem.

Health Data Chain smart contracts allow users and service providers to publish and deploy custom smart contracts based on their own requirements. With the

powerful data system and many other user-friendly features, it would be rather easy for users to develop reliable and efficient smart contracts.

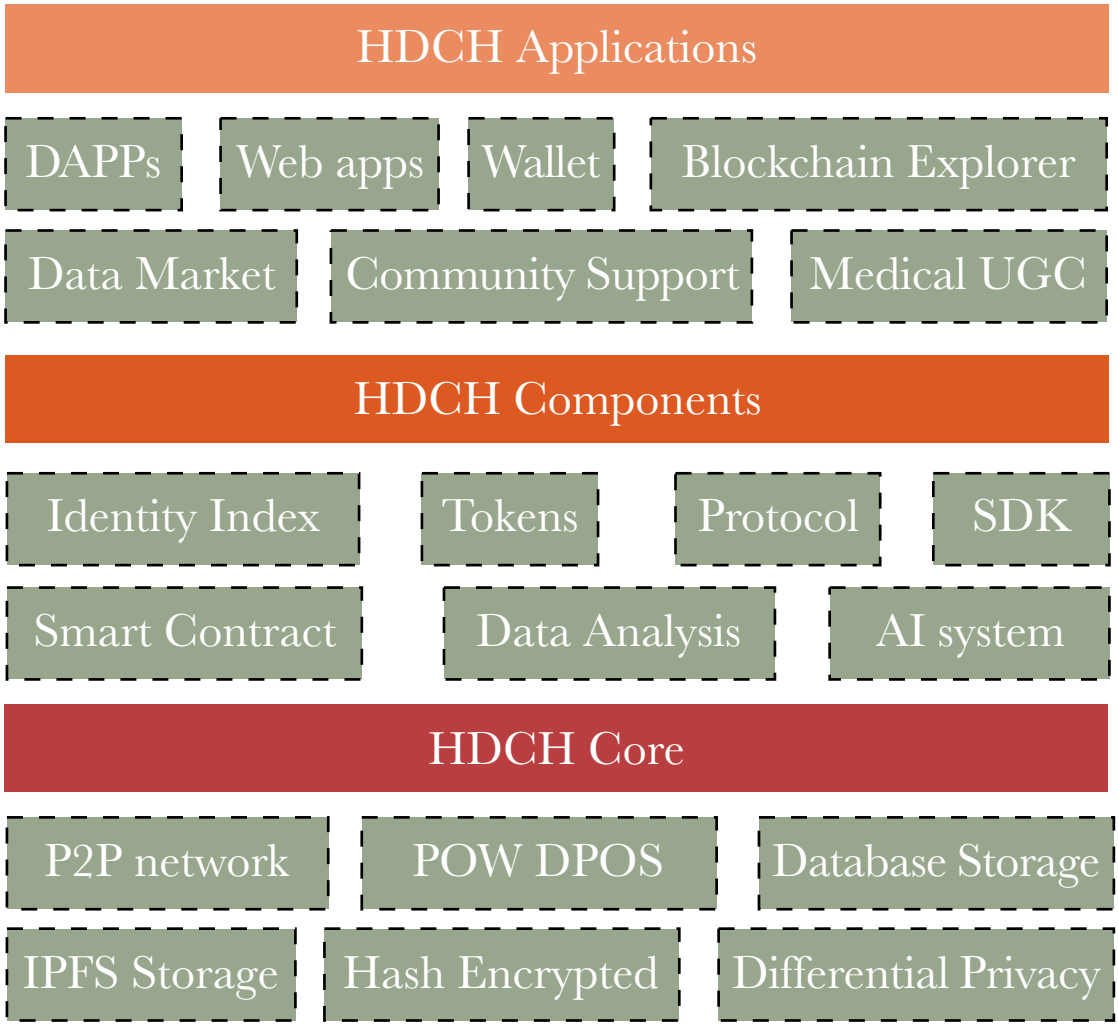
Smart contracts provide digitized lawful agreement that parties in a transaction validate upon acceptance of definite terms, which brings about information transparency and mutual trust among parties involved in health care services. Patients could find high quality services easily, many procedures of treatment and payment would also be automated and simplified.

Furthermore, along with intelligent devices and Internet of things technology, smart contracts can help users and service providers build an reliable and efficient interaction scheme any time any where as needed. For example, a doctor could manage health-related behavior of his patient through the monitoring of intelligent devices and incentivization of smart contracts:
The doctor may inform his patient that he must exercise moderately every day for 30 minutes or more, and the patient acknowledges the doctor's recommendation and agrees to the goal. Then their agreement are placed into a smart contract in the block. The patient's activity is collected via data entry or wearables & IoT, and validated. When the patient complies with doctor's orders and achieves the goals set, the reward is transferred to the patient's and the doctor's Wallets. If the patient does not comply with doctor's orders, a penalty is assessed to the patient's and the doctor's Wallets; in either case, the block is updated and validated.



Technology Architecture

Health Data Chain adopts a modular architecture of loose coupling, which made the platform open and easy to use. Developers could participate in the development of the system on all stages. Based on a main chain providing the basic operating environment and a storage chain securing the data storage, HDCH build a set of application module by which developers and service providers could develop customized services for users. Furthermore, HDCH will make all efforts to build an open community which could help the developers get feedback from users, promote their services and applications, and get other supports. Meanwhile, the community will also help users get useful medical information and guidance, address their requests to developers and service providers, and solve other problems.



The architecture of HDCH is shown as in following figure:

HDCH Core

The core layer of HDCH is the basic operating environment of the whole ecosystem, including a token blockchain and a data side chain, along with database storage systems which used to store large medical files such as photos. All parts are modular designed, so as the system will have flexible configuration capabilities for different data sizes and TPS response requirements.

HDCH adopts multi consensus mechanisms, including POW and DPOS, which could support the needs of large data volume and high TPS requests while providing reasonable mining schemes for users.

HDCH Components

The components of HDCH provides developers abundant tools to develop various applications. HDCH components include user identity index system, HDCH token for transaction, protocols for inter-blockchain communication, data analysis and AI system etc.

HDCH would support most programming languages， such as JS, python etc. It would support all app platforms.

HDCH Applications

The applications for users includes the wallet, user service APP, data exchange market, user generated contents platform, and other functions. Users can create their own private key via the wallet so as to conduct token transactions and call and execute intelligent contract, and the whole network can be maintained by the consensus mechanism.

Providing the authorization for access of their data, users could use the DAPPs to fulfill various demands.

Ecosystem

Health Data Chain would revolutionize the businesses of healthcare industry as it builds an appropriate scheme of incentivization and clarify the rights of entities involved in the market.

Data exchange

Once the health data is securely stored and its ownership is handed over to users, the data trading market would develop rapidly to meet the demand of exchanging healthcare data. The decentralized data marketplace provides a unique solution for businesses. Comparing to traditional solutions, such as centralized data center or underground data trading market, decentralized data marketplace allows P2P data transmission without precipitating data. This effectively protects data privacy and copyright, as well as prevents fraudulent activities.
The free trade of health data would provide great driving power to the development of healthcare technology.

Global healthcare

The markets previously fragmented by physical borders could be united by a universal blockchain system, so providing and purchasing healthcare services around the world would become possible. Convenient data sharing and automated transaction processes would make global healthcare service rather easy.

Users could find trusted and affordable healthcare services in time, which would be rather difficult only depending on local healthcare markets. On the other hand, service providers could reach relevant patients and building trust easily. They could earn their reputation over the world by providing excellent services, and improve their service technology by enhancing interoperability.

In summary, healthcare resources could be properly allocated over the world market and the efficiency of healthcare service could be dramatically improved.

Preventive medicine market

As the old Chinese saying goes: the great doctor treats people before they get ill. Preventive medicine is always important in keeping people healthy. As the incentivization is rectified, people would pay more attention on preventive medicine, so the preventive medicine market would flourish.
We would provide timely and valuable healthcare data for preventive medicine analysis and actions macroscopically. While microscopically, the incentivization scheme could improve the popularization of medicine science among people.

IoT in healthcare

The flourish of healthcare data market would facilitate the application of intelligent devices or wearables as data collectors, and accelerate the development of IoT. Meanwhile, the application of IoT technology in healthcare industry would help build an continuous and omni healthcare monitor system, which would greatly improve the quality of healthcare outcomes.

Roadmap

- 2018 Q2, white paper 1.0 release.
- 2018 Q4, release DApp,
- 2018 Q4, token list on exchange.
- 2019 Q2, main chain public test.
- 2019 Q3, release SDK for third-party app.
- 2019 Q4, main chain launch online.
- 2020 Q1, side chain public test.
- 2020 Q2, side chain launch online.

Token Distribution

HDCH is the ERC-20 token of Health Data Chain. It should be the only token that used by apps on the chain. The total amount of HDCH is 10 billion, and it will never increase issue.

The distribution plan of HDCH is as follows:
- Token name: HDCH
- Total supply: 10,000,000,000
- Mining pool for Dapp and SDK: 70%
- PoW on main chain: 10%
- Rewards for super nodes: 10%
- Community support: 10%

There is no public offering, private offering, crowd funding, or ICO for HDCH. HDCH will only issued by mining. Users could mine HDCH through measuring health data or exercising with HDCH Dapp or third-party app integrated with SDK.

HDCH is held separately by all users. HDCH represents all the rights and interests of the health data chain and is the cornerstone of HDCH community governance. HDCH community is an open, transparent, tokenized organization. The major decision of the health data chain will be made by the votes of HDCH holders.

Conclusion

Health Data Chain plans to revolutionize the healthcare market by offering healthcare data access to stakeholders and to patients seeking better medical treatment. Meanwhile we provide an proper incentivization for all entities involved in the healthcare market. In doing so we could open the door to a new kind of healthcare befitting our modern civilization.

The application uses multiple approaches to fill the gap between all healthcare providers. Health Data Chain will cut the cost and time patients, and physicians need to access healthcare products and services, while ensuring the consumer enjoys a newly competitive market that puts service first. The platform's transparency, accuracy and efficiency will dominate the healthcare sector in the near future. With blockchain technology the healthcare industry could be dramatically improved!