

# Blockchain in Healthcare

How distributed ledger technology could help mitigate some of the sector's biggest challenges.



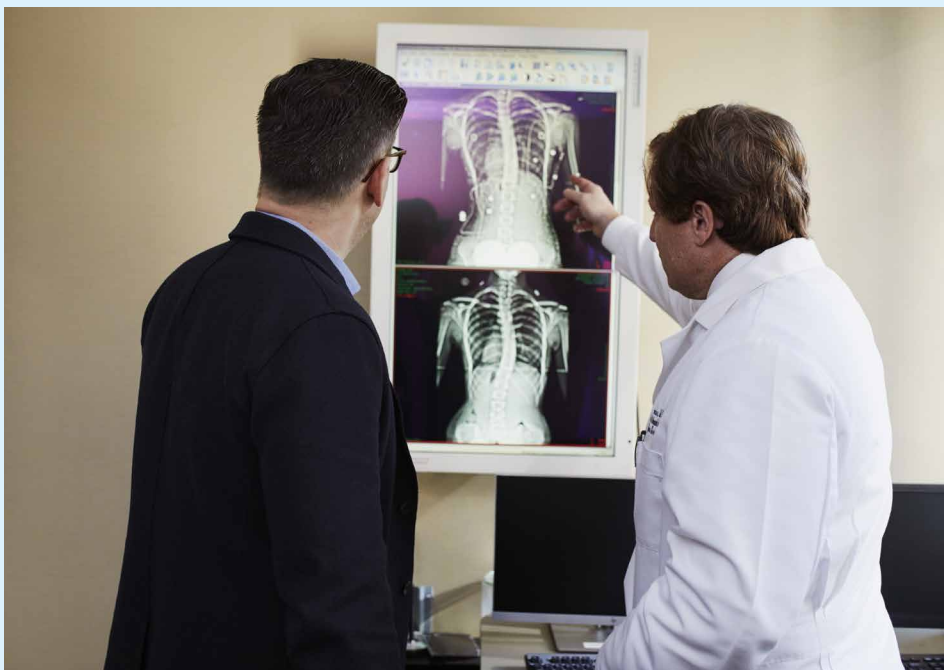
# — About this report

This IET Insight discusses the evolution of blockchain, a form of distributed ledger technology, and how its application can produce a breakthrough in the healthcare industry; more specifically, the benefits it can bring. It examines the 'art of the possible' with blockchain and how it may impact health provisioning, accelerate innovation and enable new data-driven intelligence facilitating stratified care and seamless integrated care. The paper considers how this might, alongside other emerging technologies such as the Internet of Things (IoT) and artificial intelligence (AI), bring about new services and new business models in the private healthcare sector as well.

It is written by Ilesh Dattani, founder of Assentian Limited, and published by the Institution of Engineering and Technology with input from the IET's Healthcare Panel as a piece of opinion-based thought leadership, but does not represent overall IET policy.

## About IET Healthcare

IET Healthcare was established to promote innovation and creativity amongst future leaders in healthcare, social care and wellbeing. Its mission statement is **"because we believe that technology can drive better health, we exist to harness all sector vices to build a healthier future for all."** By bringing together stakeholders from groups including clinicians, patients, technologists and entrepreneurs it ultimately aims to bring about more effective solutions to the health and care needs of international populations.





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# 1. Introduction



The healthcare industry – both public and private – is under extreme pressure to both regulate costs and provide high quality to patients. As it evolves alongside emergent market-disruptive technologies, it becomes increasingly difficult to keep costs down while providing the levels of service expected by patients.

This has required healthcare providers to continuously look for opportunities to reduce costs while enhancing the quality of care that patients receive. Keeping up with these market changes would not be possible without the technological advancements that support the healthcare industry.

Distributed Ledger Technology (DLT), of which blockchain is now the best known example, has the potential to alleviate one of the major challenges of the industry: the transmission of patient data without compromising its privacy and security. This application of blockchain can have a major, positive impact on health management.

## What is blockchain?

Blockchain is one of the most hyped technologies of the present day with use cases and start-ups appearing at pace. It is a decentralised ledger that uses algorithms and strong encryption to record digital

transactions or data in a transparent, secure and anonymous way.

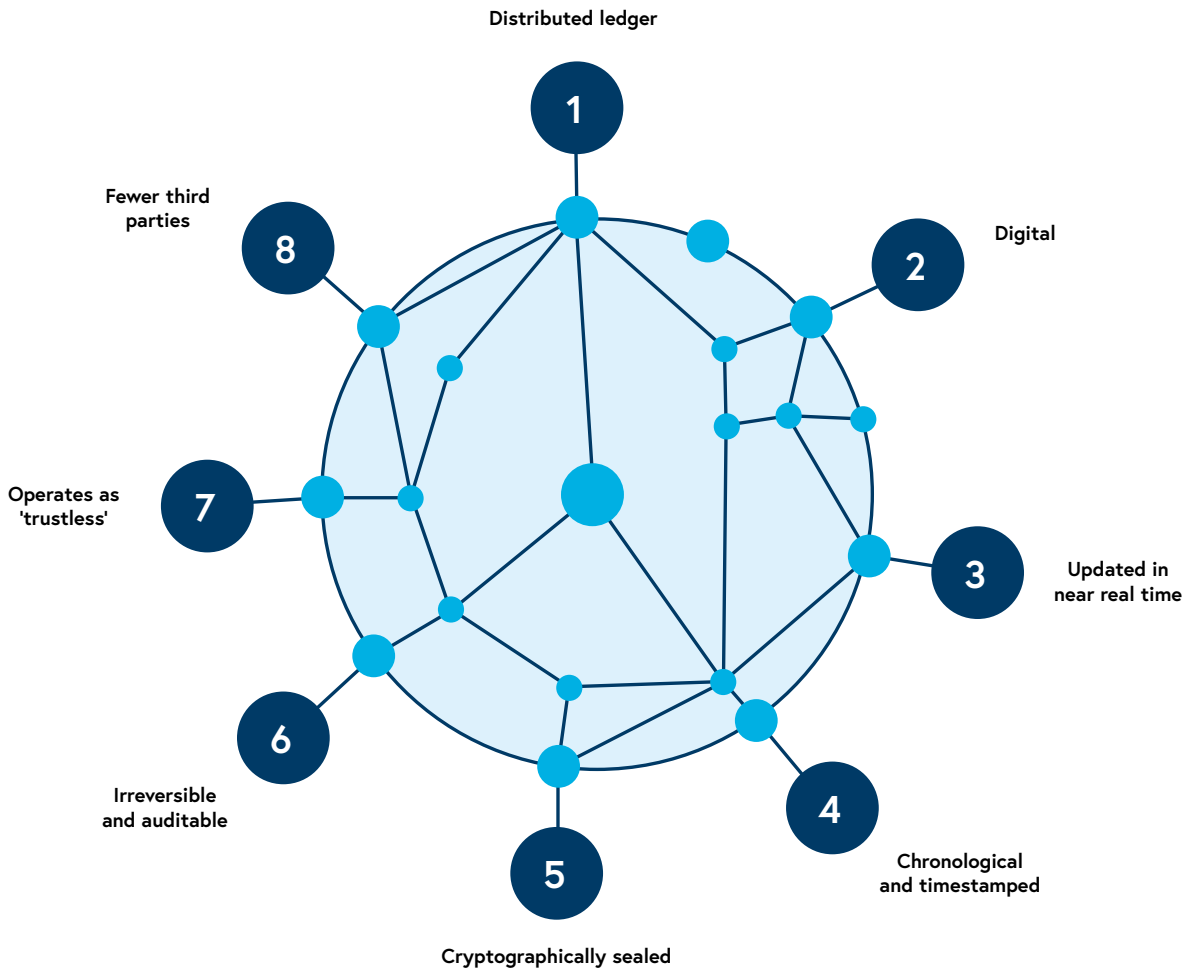
By allowing digital information to be distributed but not copied, this technology has created the support for a new breed of internet. The blockchain network exists in a state of consensus, automatically checking itself periodically – for instance every ten minutes – creating intervals known as 'blocks'. Each block typically contains a hash pointer as a link to a previous block, a timestamp and transaction data. It is typically managed by a peer-to-peer network (architecture) collectively adhering to a protocol for validating new blocks. By design, blockchains are inherently resistant to modification of the data.

The invention of the blockchain for Bitcoin made it the first digital currency to solve the double spending problem – the potential risk of a digital currency being spent twice – without the use of a trusted authority or central server.

### The key technical characteristics of the technology

- Data integrity and provenance from cradle to grave
- While many of the features such as secure, resilient, unalterable evidence are available through traditional architectures, blockchain is unique in providing them 'out of the box'
- In blockchain there is no single point of failure – if a node fails then other participants are able to continue accessing their data. This decentralised approach provides added resilience
- A blockchain solution serves as the 'single source of truth'
- Immutability – Data can only be appended and cannot subsequently be changed or deleted. An in-built, tamper-proof, timestamped audit trail is available for all transactions along with full transaction history/traceability
- Privacy – Data is encrypted such that only authorised participants can access the data against which they have permissions
- Synchronised – All participants are accessing exactly the same data (and associated state)
- Dynamic consent – The possibility for individuals to provide different types of consent according to distinct potential data uses, taking control over who will access his/her data and for what purpose; hence providing the ability to change consent and revoke consent in line with GDPR at any given point in time
- Personal data storage clouds enable individual access from any personal device through the blockchain in a probative, secure, open and decentralised manner
- Self-executing contractual states, based on the formalisation of contractual relations in digital form, which are stored on the blockchain and automate the execution of peer-to-peer transactions under user-defined conditions
- Multilevel de-identification and encryption technologies – Advanced techniques for encoding and de-associating sensitive data from the owners' identity (i.e. multi-party secure computation, homomorphic encryptions), while allowing analytics applications to leverage the information.

Figure 1 – The distributed nature of blockchain with the individual nodes represented by the blue dots. Numbers 1 through to 8 indicate all the key technical features that form part of any blockchain.



The disruptive nature of blockchain technology is easy for people to conceptualise in the field of finance. T+3 (where investors are required to settle their security transactions in three business days) interferes in traders being able to maximise earnings – payments shouldn't take days to process while an email can be sent in seconds. As the first use case ahead of many to come, finance is a perfect area of application for the blockchain.

But a trend toward new use cases is emerging, and one industry that is ripe for optimisation and increased efficiency through this technology is healthcare. Consider all the sensitive information that is associated with health: identity, diseases, treatments, payment, etc. An individual's health is one of the most private things they have, yet time and again, data breaches release considerable amounts of information about an individual's health onto the web.

## 2. The problems with healthcare

Healthcare is a huge market worldwide. In the USA alone, total healthcare expenditures were estimated to be approximately \$3.55 trillion in 2017, and are predicted to reach more than \$5.5 trillion in 2025. However, this important sphere of our life is considered extremely inefficient. The Institute of Medicine estimates that between 20–30% of total healthcare spending is either wasteful or a consequence of poor outcomes.

The main source of these excessive costs are high administrative fees, overpriced medical tests, useless treatments, medical fraud and missed prevention opportunities. According to some estimates, around \$875 billion is spent on duplicating services due to poor communications between doctors and hospitals. More than \$500 billion is allocated for administration of healthcare, and substantial budgets are needed to provide protection of health data.

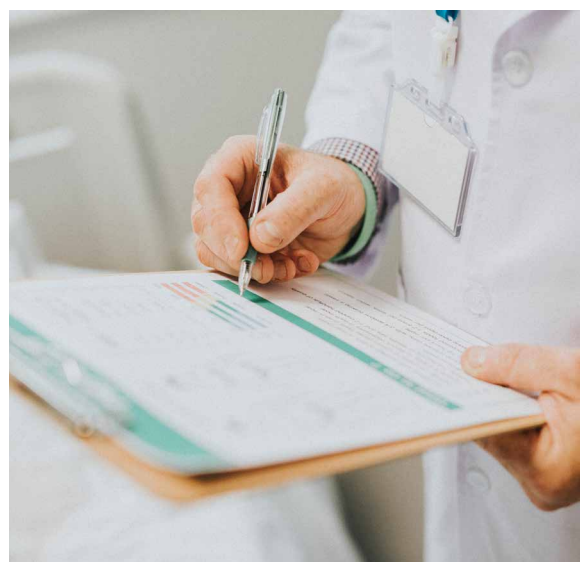
In the UK, the NHS is facing a £30 billion funding shortfall by 2020 if it fails to make savings ([www.fullfact.org](http://www.fullfact.org)) yet it has underutilised data assets that could easily exceed this value.

The use of blockchain could potentially deliver increased healthcare delivery efficiency while unlocking the research potential of NHS data assets, delivering social benefits. Patient data in healthcare remains in silos within NHS Trusts and private healthcare providers for example, and there is little integration or sharing of this data at scale that could bring about improved care, accelerated access, higher productivity, cost savings and innovation in new medical breakthroughs.

However, medical informatics and analytics communities have experienced growth and there is now a move towards data-driven medical research. But consent is complex – a healthcare practitioner has to gain consent every time they wish to utilise the patient's healthcare data and going through this repetitive process is currently impractical.

The motivation is to unlock data value and social benefits by building blockchain consent/permissioning infrastructure with implicit trust between the individual and the organisations who serve them. The current state-of-the-art includes paper consent forms, IT systems in Trusts, GP Practice systems, health and wellbeing technologies. Data is held within these systems with little integration or cross-sharing.

The health data in the main is inaccessible to individuals maintaining transparency, immutability and integrity complying with GDPR and the Declaration of Helsinki<sup>2</sup>, a statement of ethical principles developed by the World Medical Association (WMA) for medical research involving human subjects, including research on identifiable human material and data.



<sup>1</sup> <https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/>

## 3. The blockchain solution

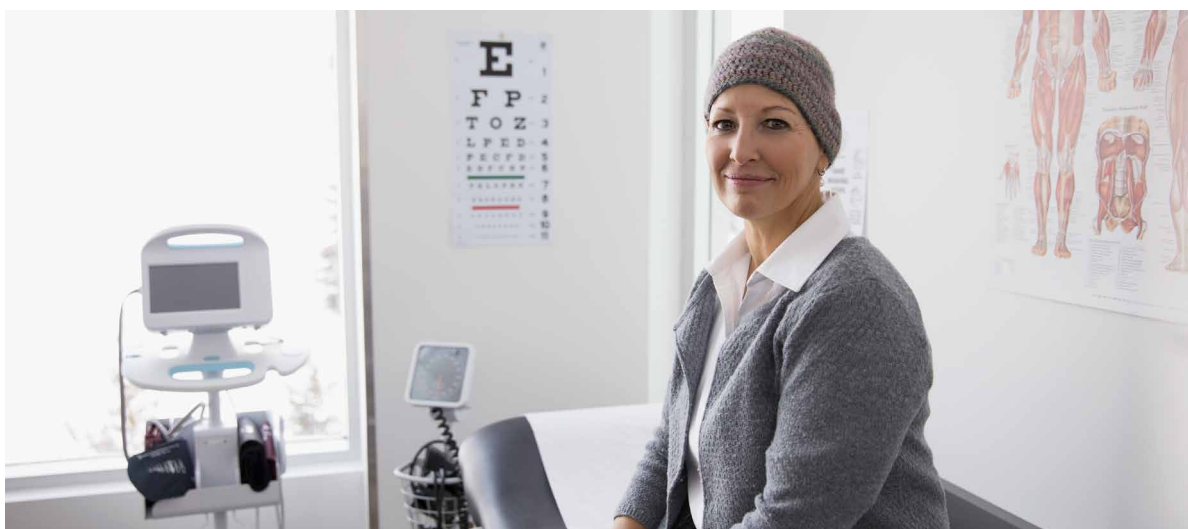
The innovation beyond the state-of-the-art as it relates to healthcare is through giving effective ownership back to individual data subjects (on each of the 'who', 'why' and 'for what purpose' dimensions) allowing them to give consent for its use and also revoke that consent in full or in part – these rights being seamlessly migrated with the data between the custodians as it passes across organisational boundaries.

This is in line with the 1997 Caldicott Committee report on patient confidentiality<sup>2</sup>, which came after concerns started to emerge about patient information and security. It is also in line with the job of Caldicott Guardians who have responsibilities to safeguard and govern the use of patient information. The Guardian is usually a board-level health professional or their deputy. They should develop local protocols for information disclosure, restrict access to patient information by enforcing strict need-to-know principles, and regularly review and justify the uses of patient information.

Blockchain provides a means by which data can be transacted as a commodity (where appropriate) and facilitates the opportunity for new services and offerings to emerge as a result. It also presents a 'secure by design' approach and provides a solution where security is an integral part of the framework and architecture as opposed to a number of supporting solutions providing the required security and their integration, in turn opening up other system complexities.

### Understanding the architecture

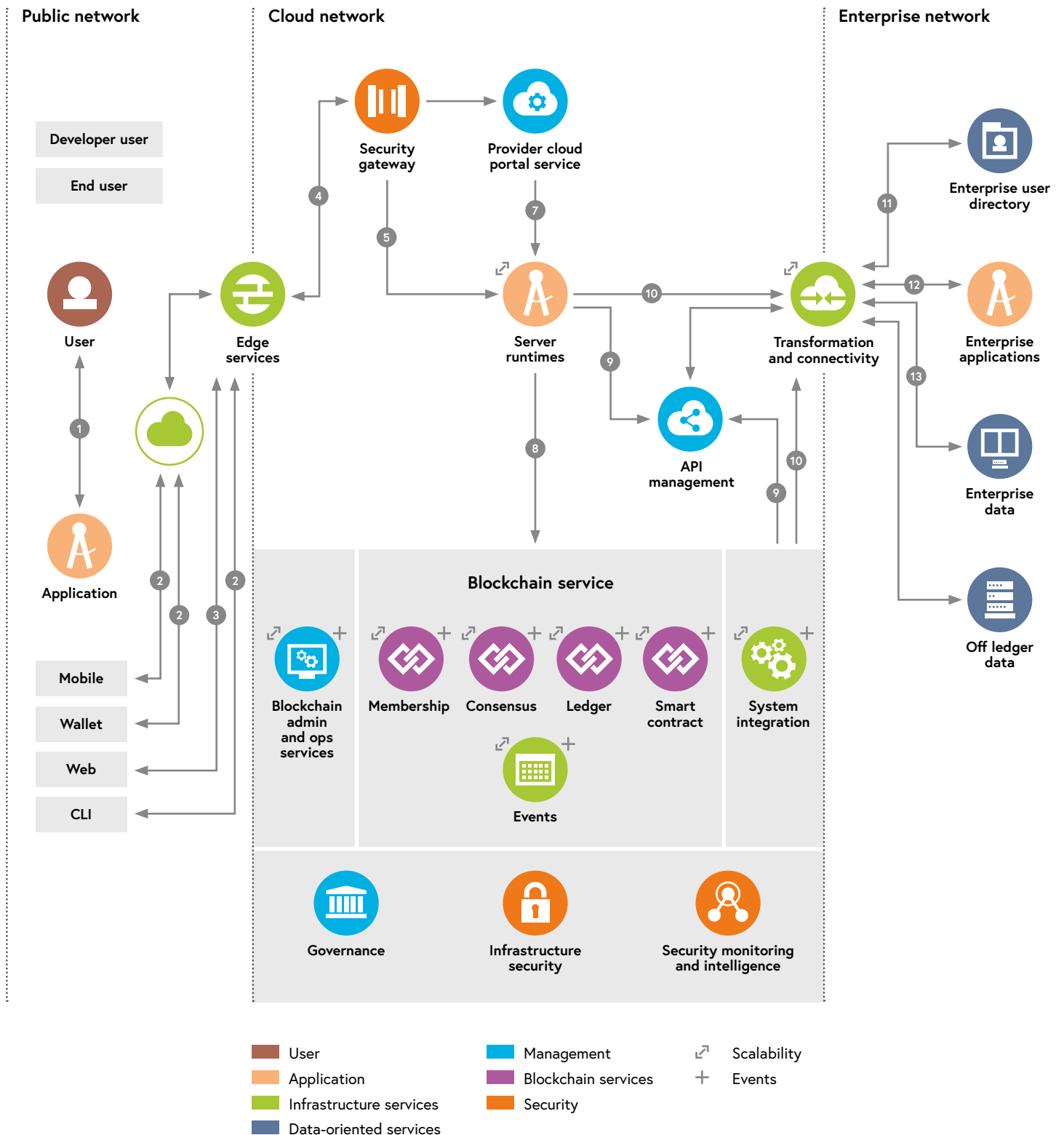
The full blockchain client syncs up with other nodes in the network. From then onwards the particular server maintains all and any transaction records conducted using the framework. The integrity and chronological order of the transactions are enforced by strong cryptographic rules. The blockchain software operates at such a massive scale that it makes it virtually impossible (and cost prohibitive) to hack or otherwise break into the framework or any other application running on it. Thus, there is no need for a central third party to issue, authenticate and validate ownership of the data. The nodes in the overall network use the peer-to-peer IP network to process and verify transactions. When several nodes all have the same blocks in their individual databases, they are considered to be in consensus.



<sup>2</sup> The Caldicott Committee (1997). 'Report on the Review of Patient-Identifiable Information'



Figure 2 – A blockchain reference architecture.



**Figure 2 shows all the following functional requirements of the architecture:**

- A shared ledger records all validated transactions and is replicated among permissioned participants. It is the shared system of record
- Privacy is assured by a shared ledger holding authenticated, validated, private transactions. Transactions are not linked to identity of participant
- Consensus is achieved by validating and committing the transactions. Known and trusted participants results in low cost
- There is support for multiple pluggable consensus including proof of work, proof of stake, multi-signature and more
- User data privacy and identity is managed by giving users control of data sharing with third parties and mapping user rights to system resources for identified users
- There is hosted business logic and data to work between vendor cloud platforms without undue customer effort

The use of blockchain supports elements of the accelerated access policy and would aid its realisation:

"Many innovations come to market with incomplete evidence of impact on patients, clinical pathways and efficiency. The NHS, as a single system where cost and outcomes data can be collected, can offer innovators significant value in building their evidence base. Combined with the scale and strength of its early translational and clinical research through the National Institute for Health Research (NIHR), this provides a compelling opportunity to create global value for strategically important innovations<sup>3</sup>."

A blockchain-based framework could help to build up that evidence base, aggregate data from disparate sources and maintain its integrity – helping the NHS realise its objective. Societies' wellbeing and outcomes could be influenced as data sharing could aid preventative care and medicine and could as a result improve life outcomes, improve children's learning capacity in socially deprived areas and deliver long-term productivity gains to the UK economy. Patients, being an intrinsic part of the value chain, could be able to choose other charitable causes and community

projects where 5% of the revenues to the NHS can be invested. The solution could capture, aggregate and analyse data to better highlight drivers of regional inequalities in health and social care outcomes, empowering policymakers to more efficiently address these regional disparities.

Blockchain technology and encryption could drive innovation in preventative care and community-based healthcare models. This technology is the missing link that could enable a synergy between rising trends in healthcare that could be vital in helping the world improve the health of communities. Some of the foreseen trends that could enable this innovation are as follows:

- **Innovative healthcare models:** The rise of experiments in healthcare such as Accountable Care Organisations (ACO) and community-based healthcare indicate an increased focus on preventative vs. reactionary healthcare
- **New technology and data:** The increased utility and prevalence of Electronic Health Records (EHR) and mobile health applications (for example Apple Health) foreshadow a future where individual and aggregate population data has greater utility
- **The blockchain and cryptography:** A new method pseudonymously collecting, storing, protecting and sharing health data may be possible without violating the requirements of the Health Insurance Portability and Accountability Act (HIPAA) that have traditionally limited the utility of health data and delayed its use in real-time

In a time where we are only beginning to harness the utility of health-related data and technology the emergence of these three factors may make the following scenarios possible in the near future.

<sup>3</sup> CapGemini (2017) Blockchain: A Healthcare Industry View



## More data

Through the use of mobile health applications/ services and the refinement of electronic health records/systems/databases we will be collecting more individual and population-based health measures than ever before. The sample size for population data will increase exponentially.

## Encryption and comprehensive population health data

By properly securing the identity of patients through cryptography and storing individual health records to a blockchain we will make available an aggregate database of community health records that can be used in community-focused preventative care programmes, driving population health without violating the critical rules of HIPAA. This would make it possible to use all data from all medical records for populations rather than relying on voluntary release.

## Pseudonymous patient-focused health recommendations

The most exciting possibility of this scenario is that of encrypted health advisories and warnings. In a situation where the identity of an individual remains secure but their health information can be contributed to an aggregate of data on a blockchain it would be possible to blindly relay encrypted patient-specific health recommendations securely back to the patient based on their data in real-time. The recommendation, though delivered to an anonymous patient, would be based on their own information, risk factors, etc.

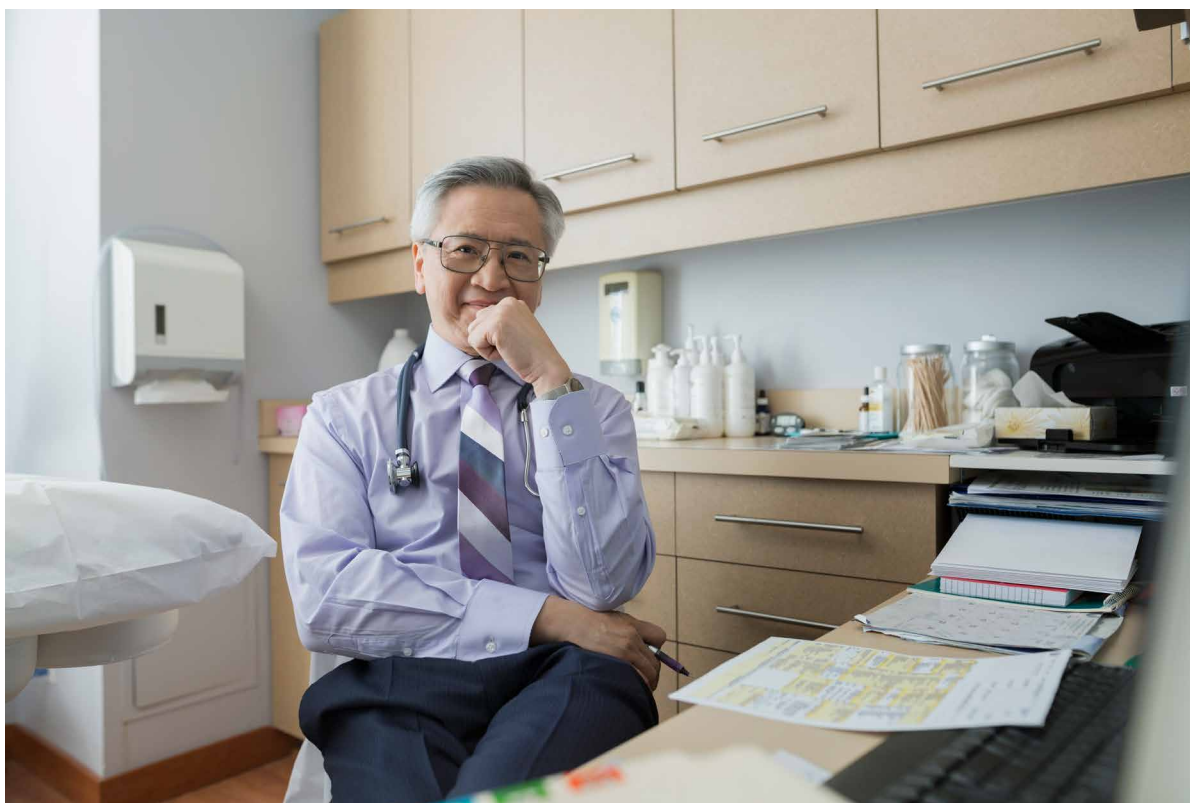
The overwhelming trend in healthcare to drive towards more proactive and community-focused preventative care models (preventing disease or injury before they occur or metastasise) make this potential scenario all the more relevant. A future where medical records can be fully shared but also secured and encrypted could usher in a new era of understanding for population health and care.

One of the unique properties about blockchains is that they're not centralised systems. If you think about the current healthcare system, it's based around a collection of centralised systems – whether it's EHR companies that are managing medical records on behalf of the industry or medical processors that are acting as go-betweens in the middle of providers or insurers – these intermediaries are essentially becoming giant centralised warehouses of patient data.

## Specific value in healthcare can be derived for a number of purposes:

1. **Privacy** – Consider all the sensitive information that is associated with health: identity, diseases, treatments, payment, etc. A blockchain can help prevent this with multi-signatures and cryptography. The data is hashed onto the blockchain and then, using multi-signatures, people can gain access only if there is approval from the appropriate number of people.
2. The ability to have insurance companies, hospital billing departments, lenders and patients using one blockchain to manage payments could **reduce redundancies** across the entire industry,
3. Blockchain technology and encryption will potentially **drive innovation** in preventative care and community-based healthcare models. This technology is the missing link that will enable a synergy between rising trends in healthcare that will be vital in helping the world improve the health of communities.
4. With smart contracts the healthcare insurance, life assurance, etc. markets are enabled with the data sharing in blockchain; they can **mitigate risk** more and the individual has less risk of compliance breaches.

## 4. Creating monetary value



Technology has created new business opportunities for healthcare entities – covered entities, business associates and others – to use health data for financial purposes. This is true not only where the financial remuneration is for cash (e.g. the sale or marketing of a product using health systems), as big data will play a critical role in the move from volume-based care to value-based, accountable care. The ability to integrate, synthesise and share complex health information can lead to enhanced coordination of care, potentially resulting in better health outcomes and lower costs.

There is growing interest in monetising health data by data custodians. The business drivers are varied. In all cases, it is seen as a valuable asset that can generate revenue for the organisation. In fact, PwC estimated in 2009 that the market value for health data (mainly claims-based data) purchased by life science companies and others was over \$6 billion, while the market for data supporting outcomes studies was more than \$900 million.

Many entities could profit from a more thorough understanding of the ways in which healthcare data can be transformed into revenue.

## The range of possibilities

### Internal use

Perhaps the easiest way to capitalise on healthcare data is internally. For example, hospitals facing the increasing fiscal pressures of accountable and value-based care may use big data to identify deviations from operational or care delivery standards. Institutions no longer have to rely upon the unpredictable presence of whistleblowers; variance from outcome norms can be the smoke that identifies the fires of best practice deviations, which can in turn identify actionable intervention strategies. By turning big data into fast data, healthcare institutions can profit from Lean Six Sigma (the business process improvement methodology) like never before.

### Collaborative use

Similarly, many providers and payors seek to monetise data collaboratively as they explore new models of integrated care delivery. Perhaps the most obvious model of collaborative monetisation is that of the risk-bearing, multi-provider alliance sharing once-siloed patient records in an effort to reduce hospital admissions and keep patients in the less costly home setting.

### Transactional use

Others seek to monetise data transactionally, either through direct sale or exchange for something else of value. Payors or SaaS (software as a service) vendors who aggregate large amounts of patient data from many sources can aggregate and benchmark that data in very useful and profitable ways.

Like everything else in our market economy, data's value is a function of its marginal utility. The true value of data lies less in what it is than in what it can become. As a rule, data, whether aggregated or integrated, is less valuable than analytics, which in turn is less valuable than prediction. As a simple example, a program that can identify the commonalities among high-cost patients in a covered population is less valuable than one that can analyse the range of treatment regimens that might be effective.

## 5. Conclusion

Whilst we present here a hugely ambitious vision of what the potential of blockchain might be there are initiatives under way in Europe and North America that are beginning to explore the potential of clinical service offerings by exploiting the data sharing capability offered by blockchain.



The healthcare industry, in most countries, is a complex system of interconnected entities. Each of these entities has separate, siloed information systems that a) contain plan member/patient data and records, and b) support the (regulated) processes specific to the entity's contribution to the healthcare delivery value chain. The cost of healthcare delivery continues to increase rapidly, and administrative costs are a major contributor. Taking into consideration all the capabilities of the technology, blockchain has a huge potential to become the next big technology innovation engine. Blockchain applications for patient data portability, interoperability, care delivery management and administration can provide the answers to many challenges facing this industry.

The potential of blockchain for healthcare highly depends on the acceptance of the new technology within the healthcare ecosystem in order to create technical infrastructure. Though there are certain concerns and speculations regarding blockchain's integration with current healthcare systems and its cultural adoption, the technology is beginning to prove popular in the sector.

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