Block Chain

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About Me

Om.lalchandani

- B.Tech (CS) – 1990 *Gold Medallist* LLB (1997), PMP, PhD (robotics)
- Currently working as Director Operations
- Development of Covid-19 Robots
- Worked for brands like IBM, Mphasis, StanChart, InfoSys, Symbiosis
- Undertake Regular Corporate as well as Academic Trainings for Top brands
- Regular Live sessions at National TV Channels and Radio
- Patent: 202121044919

Course Objectives

- To understand the basics of Block chain & Crypto currencies
- how they can be used as a tool to increase the speed, security, efficiency and transparency in financial and nonfinancial world.

Course Process

- Interactive classes – brief exciting activities
- Assignments
- Presentations
- Design Examples
- Class Test
- Quizzes & Examination
- Project Work
- Case Studies

Recommended Books

1. Blockchain Basics (A non-technical introduction in 25 steps) by Daniel Drescher
2. The Internet of Money (Vol 1 &2): Talks by Andreas M. Antonopoulos
3. Bitcoin: A Peer-to-Peer Electronic Cash System (White paper by Satoshi Nakamoto)

Introduction

A **blockchain** is a growing list of records, called *blocks*, that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data.

Block Chain Video and answer simple question

- https://www.youtube.com/watch?v=SSo_EIwHSd4&ab_channel=SimplyExplained

- Hash Calculator
- https://www.tools4noobs.com/online_tools/hash/

Types of Blockchain

- Public BlockChain
- Consortium Blockchain
- Private Blockchain
- Hybrid Blockchain

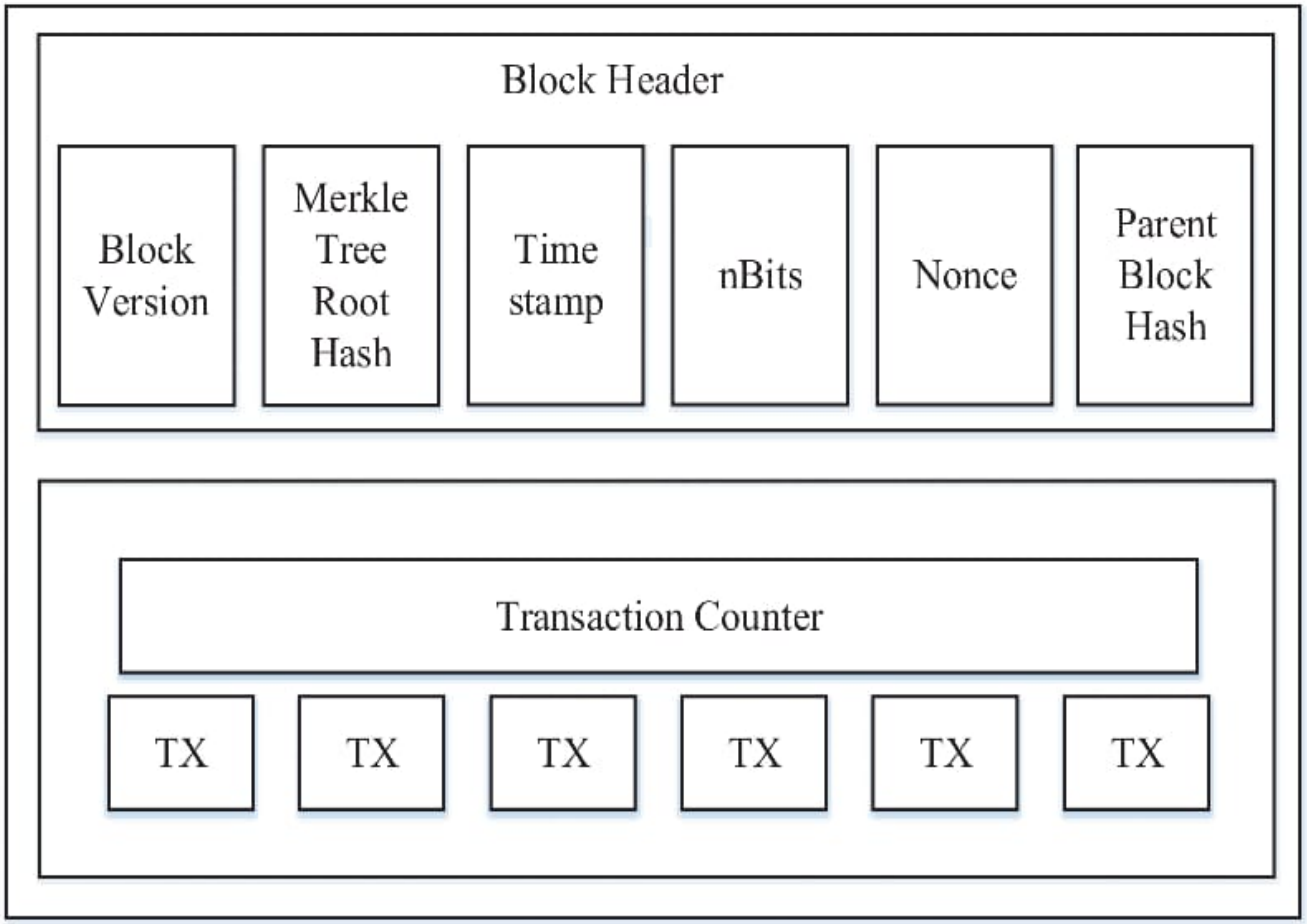
Architecture of Blockchain

- **Node** — user or computer within the blockchain
- **Transaction** — smallest building block of a blockchain system
- **Block** — a data structure used for keeping a set of transactions which is distributed to all nodes in the network
- **Chain** — a sequence of blocks in a specific order
- **Miners** — specific nodes which perform the block verification process
- **Consensus**— a set of rules and arrangements to carry out blockchain operations

The inside of a Block

https://www.researchgate.net/figure/Example-of-a-bitcoin-block-data-from-blockexplorercom_fig2_281773799

https://developer.bitcoin.org/reference/block_chain.html



BLOCKCHAIN

Blockchain is a growing immutable list of records, (immutable ledger) called blocks, that are linked together using cryptography. Each block contains **cryptographic hash values** of the previous block, a timestamp, and transaction data.

A blockchain is essentially a digital ledger of **transactions** that is duplicated and distributed across the entire network of computer systems on the blockchain. Each block in the chain contains a number of transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's ledger.

Blockchain Concepts:

- **Transactions**:

Transactions are data structures that encode the transfer of value between participants in a blockchain system. Each transaction is a public entry in the blockchain.

Transactions are a good way to describe any transfer of ownership, and the complete history of transactions is the key to identifying the current owners.

- **Cryptography**:

This is using the techniques of encryption and decryption to send and receive messages.

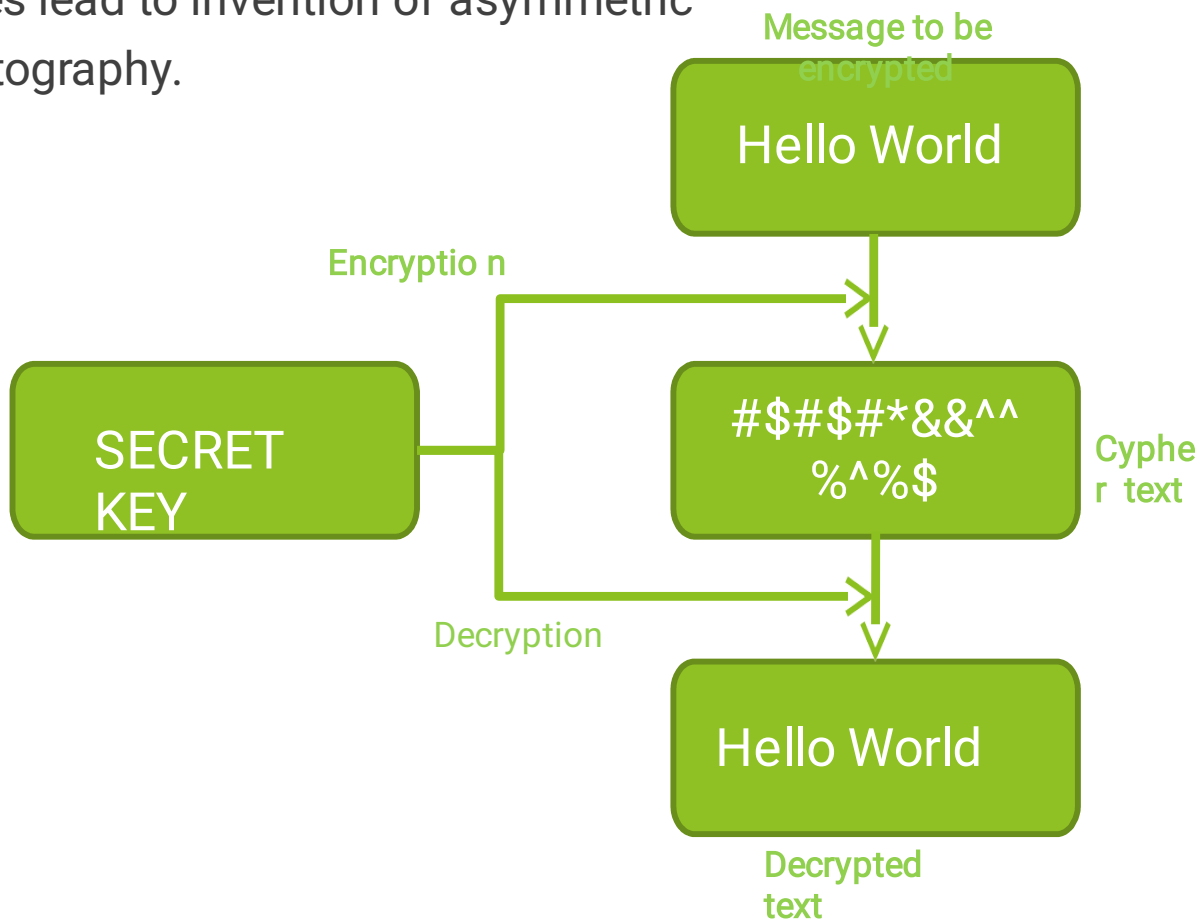
The major idea of cryptography is to protect data from being accessed by unauthorized people. Cryptography uses the concept of keys to protect data similar to the idea of locks and keys in physical world.

In blockchain, cryptography is attained in two ways; **Symmetric Cryptography**
and **Asymmetric Cryptography.**

Symmetric Cryptography and Asymmetric Cryptography

Symmetric Cryptography:

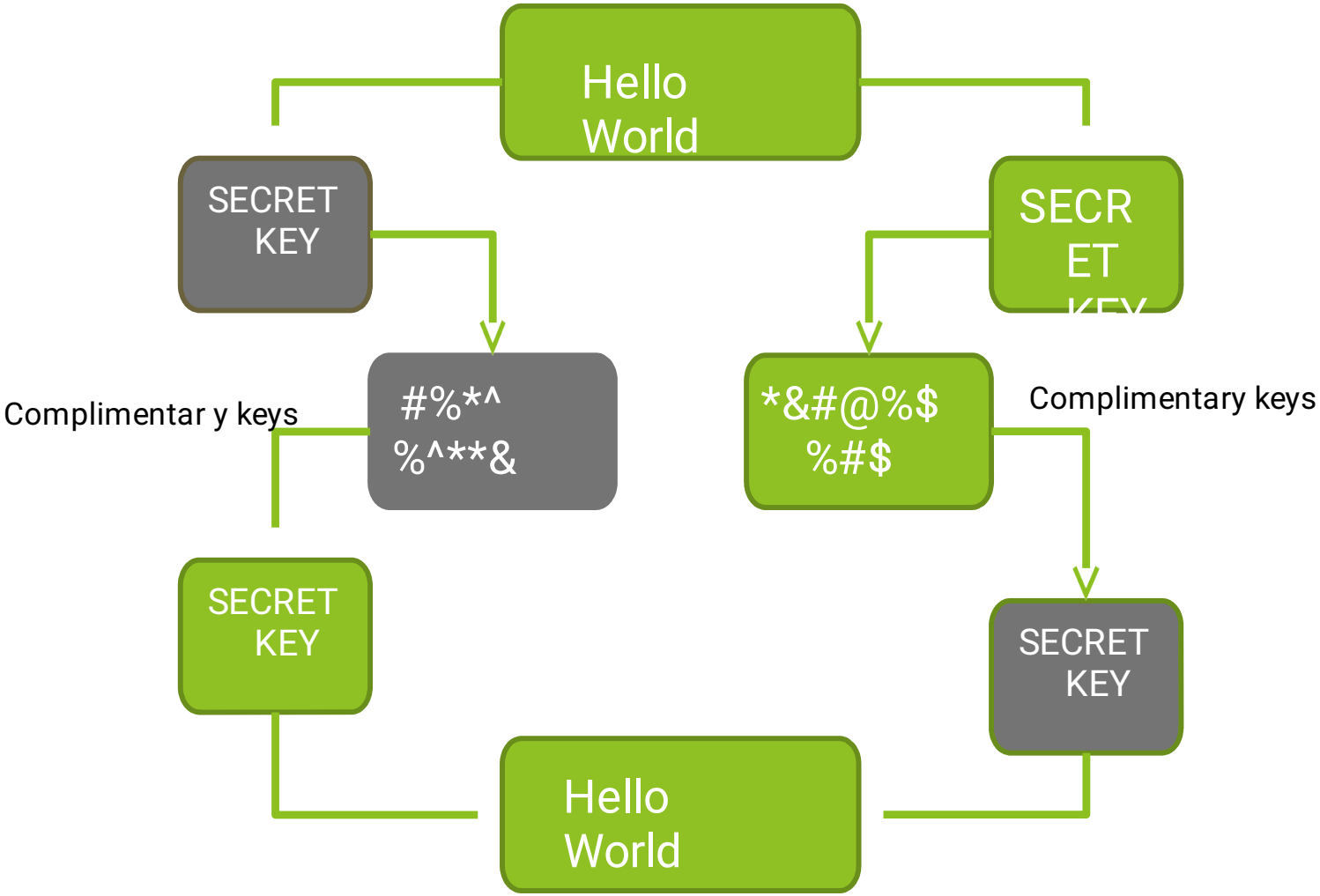
This is whereby a single secret key is leveraged for both encryption and decryption functions. The fact that only one key was used for both encryption and decryption which can create some security issues lead to invention of asymmetric cryptography.



Symmetric Cryptography and Asymmetric Cryptography

- Asymmetric Cryptography /public-private-key cryptography.

In asymmetric cryptography, two complimentary keys are used during the encryption and decryption process. cypher text created with one of these keys can only be decrypted with the other key and vice versa.



There are two keys, together they form the pair of corresponding keys. One key is used for encryption and the other for decryption.

The trick to asymmetric cryptography is that you can never decrypt cypher text with the key that was used to encrypt it.

The two keys are called Private and public key.

Hashing, Hash pointer & Hash Value:

Hashing refers to the transformation and generation of input data of any length into a string of a fixed size.

In blockchain, every block is cryptographically tied to the next block.
A **hash pointer** is similar to a pointer, but instead of just containing the address of the previous block it also contains the hash of the data inside the previous block. Hashing is used in blockchain to compare and validate data authenticity.

Hash value is equivalent to a digital fingerprint .

Blockchain Data Structure:

A block is considered to be the prime blockchain data structure. The different blocks in a blockchain are identified with the help of a hash in the block header.

Data structures help in the organization and storage of data in a way that they can be easily accessed and modified.

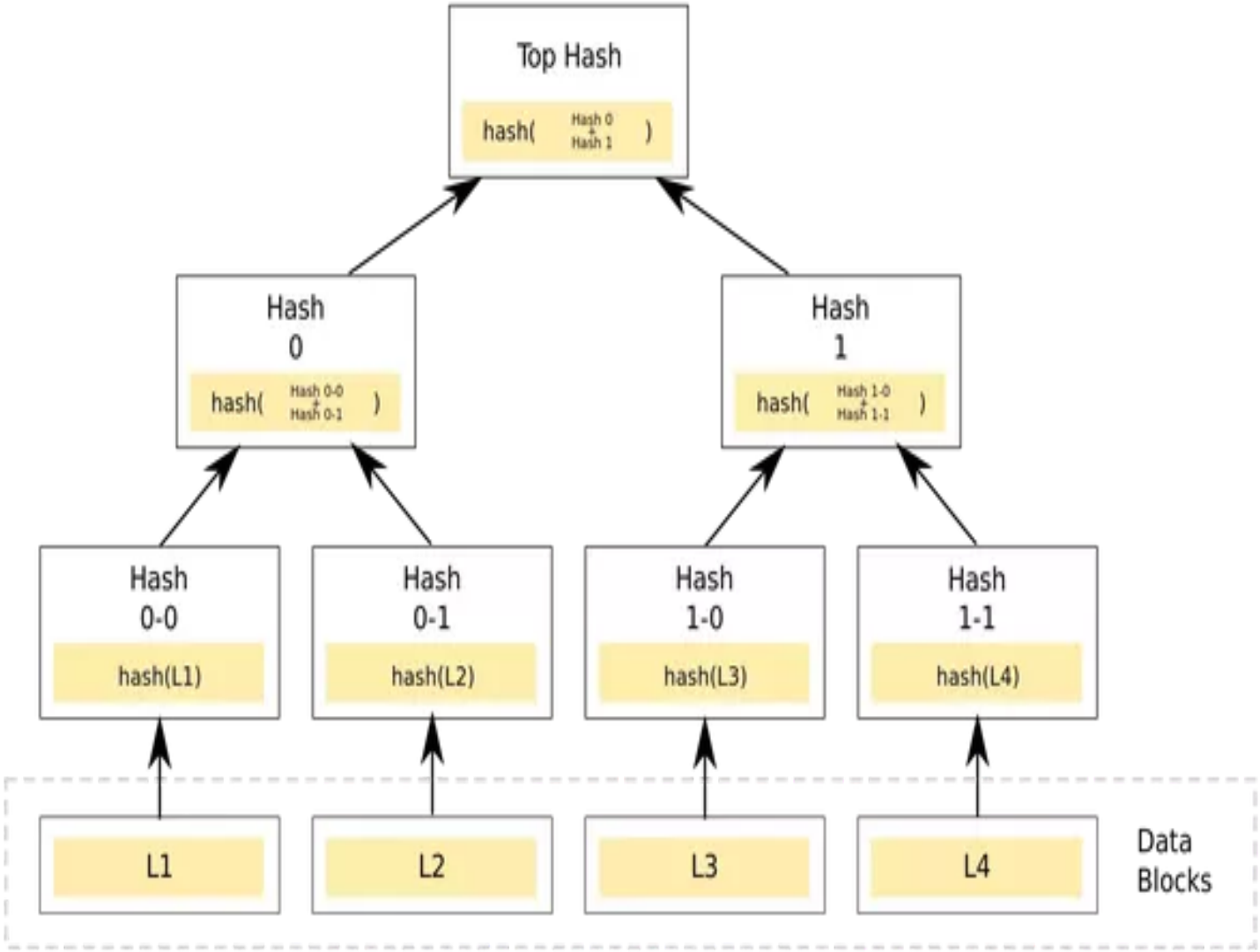
Peer to peer network

- Peer to peer network, commonly known as P2P is a decentralized network communications model that consists of a group of devices (nodes) that collectively store and share files where each node acts as an individual peer. In this network, P2P communication is done without any central administration or server, which means all nodes have equal power and perform the same tasks.

The P2P technology is based on a very simple principle, and that is the concept of decentralization. The peer-to-peer architecture of blockchain allows all cryptocurrencies to be transferred worldwide, without the need of any middle-man or intermediaries or central server

Distributed System

- Distributed systems are a computing paradigm whereby two or more nodes work with each other in a coordinated fashion in order to achieve a common outcome and it's modeled in such a way that end users see it as a single logical platform. Conversely, a blockchain can be described as a continuously growing distributed ledger jointly maintained by multiple parties. Blockchain therefore heavily uses the concepts and elements of Distributed Systems.


Top Hash
hash(Hash 0 + Hash 1)
Hash 0
hash(Hash 0-0 + Hash 0-1)
Hash 1
hash(Hash 1-0 + Hash 1-1)
Hash 0-0
hash(L1)
Hash 0-1
hash(L2)
Hash 1-0
hash(L3)
Hash 1-1
hash(L4)
L1
L2
L3
L4
Data Blocks

- Here there are 4 transactions L1, L2, L3 and L4 in the block. All the transactions, as can be seen, are individually hashed. Eg L1 is hashed to hash 0–0. Then the combination of hash 0–0 and hash 0–1 is hashed and stored into a parent node, hash 0. Same goes for the other three transactions.

• Data Integrity

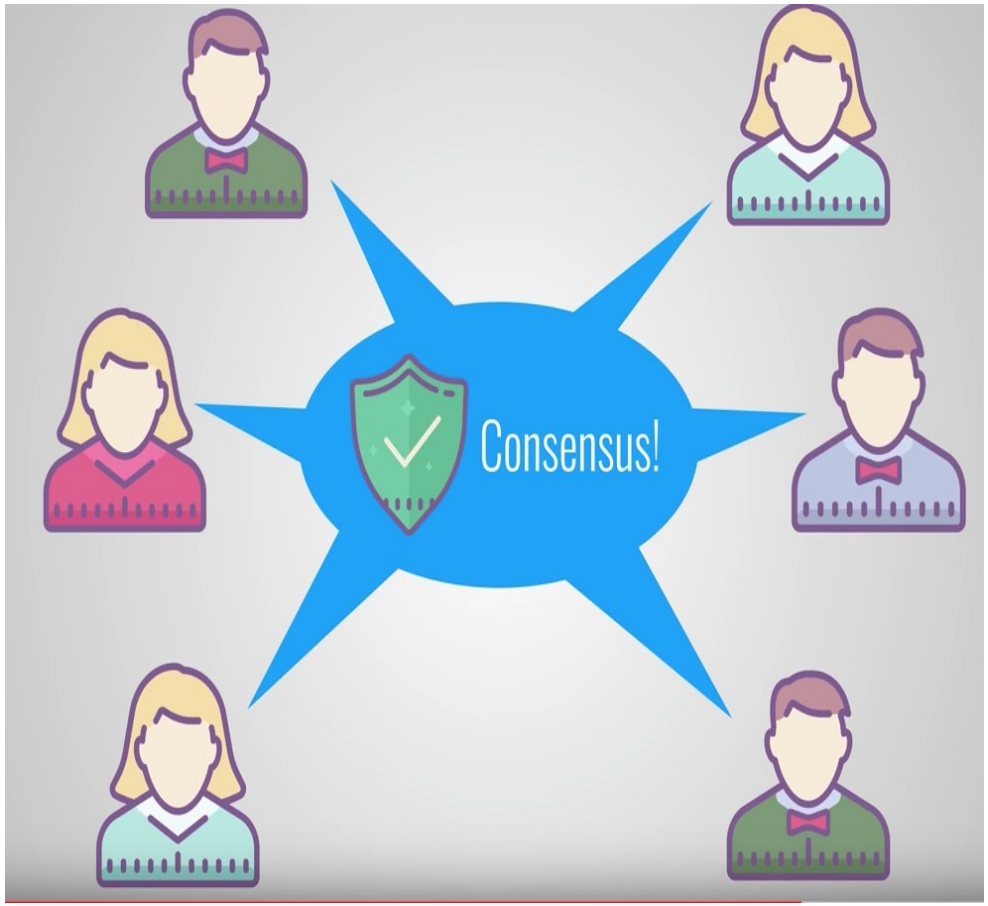
Proof-of-work

- a function to deter denial of service attacks and other potential spam on a network by requiring some level of work that is usually costly and timeconsuming. In the Bitcoin network, miners must complete a proof-of-work in order to regulate the rate at which new blocks are generated.

Distributed consensus

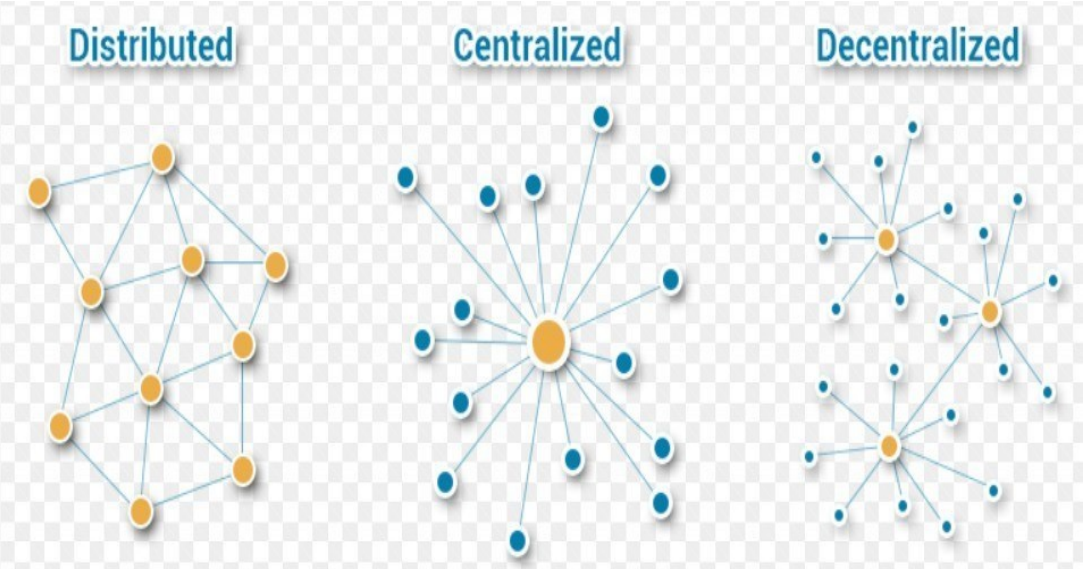
- A distributed consensus ensures a consensus of data among nodes in a distributed system or reaches an agreement on a proposal. A consensus algorithm may be defined as the mechanism through which a blockchain network reach consensus. Public (decentralized) blockchains are built as distributed systems and, since they do not rely on a central authority, the distributed nodes need to agree on the validity of transactions. This is where consensus algorithms come into play. They assure that the protocol rules are being followed and guarantee that all transactions occur in a trustless way, so the coins are only able to be spent once.

Distributed consensus



Software architecture and it’s relation to the Blockchain

- Centralized Systems
- Distributed Systems (Advantages and Disadvantages)
- Distributed Peer-to-Peer Systems



Decentralized Systems

- A blockchain can be either centralized or decentralized. It is important, however, that decentralized not be confused with distributed. While a blockchain is inherently distributed (meaning that many parties hold copies of the ledger), it is not inherently decentralized.
- Whether a blockchain is centralized or decentralized simply refers to the rights of participants on the ledger, and is therefore a question of design.
- In a decentralized network, anyone can participate and transact on the ledger. As a result, mechanisms must exist in order to combat the vulnerabilities that arise from this design and to ensure that transactions are correct

Distributed Ledger Technology (DLT)

https://www.bosch.com/stories/distributed-ledger-technology/

Centralized Network

- A centralized network, on the other hand, is made up of parties whose identities are known. Thus, the system is valid because only credible and reputable participants can post to the ledger. Because participants' identities are known, their transactions can therefore be audited.
- Ultimately, a centralized distributed ledger should be used in any highly regulated industry - such as financial services – to minimize vulnerability.
- While both decentralized and centralized blockchains have respective risks, a centralized network is much preferred for our purposes in that the identity of participants is known and, as a result, an audit trail exists should an actor attempt to corrupt the system.

Use-cases: Centralized vs Decentralized

- Payment Systems: All the currencies in the world that are operated by banks work on top of centralized servers. By doing so, they have full control over all the operations and also know about all your entire financial activities.

  However, one of the worst things about using a centralized currency is that if someone gets hold of your bank credentials, they can easily access all your money and use it for their own benefit. Another disadvantage of centralized payment systems is that there can be a disruption or failure and you will not be able to access your funds when you need it.

  In decentralized systems, as there is no central authority or point of failure, your funds are always available. It also removes the chance of your funds getting hacked or accessed by a malicious actor. Another benefit of the payment system is the removal of intermediate fees. The only fees that are associated with the process are either small or non-existent. They are also borderless and secure.

Use-cases Centralized vs Decentralized

- Government Voting: The whole voting scenario is dealing with one most important issue, transparency. The current way of carrying out the vote doesn't take transparency into account. That's where a decentralized voting platform can come into rescue. Governments can use it to run the votes and provide transparent voting. By using a transparent voting system or a voting system running on a decentralized network, the voters can easily verify the votes. This also means that no party can do frauds when it comes to counting of votes.

  Another benefit of using this approach is that results can be declared as soon as voting is finished.
- Energy: Centralized entities mainly control and distribute the energy who decide where they want to provide their services and at what price. To solve this, decentralization can come up with a unique solution. It can use a decentralized power grid, which you can use to cut the middleman. It also provides equal opportunity to everyone who wants to get energy or generate energy and then sell it to others.

Hands-on Exercise

- Install Go
- https://go.dev/doc/tutorial/getting-started
- Run Hello World Program

Why Blockchain is Needed

Trust and Integrity in Peer-to-Peer Systems.

- In the context of software systems, integrity is a nonfunctional aspect of a system to be safe, complete, consistent, correct, and free of corruption and errors
- Trust is the firm belief of humans in the reliability, truth, or ability of someone or something without evidence, proof, or investigation.
- People will join and continue to contribute to a peer-to-peer system if they trust it and if the results of interacting with the system on an ongoing basis confirm and reinforce their trust. In order to fulfill the expectations of the users and reinforce their trust in any system, integrity of the system is required.
- As soon as people lose trust in a peer-to-peer system, they will abandon it, which in turn will cause the system to terminate eventually.

Why Blockchain is Needed

Integrity in a purely distributed system depends on a variety of factors, some of the most important factors include:

- Knowledge about the number of peers.
- Knowledge about the trustworthiness of the peers.

- If the number of peers as well as their trustworthiness is known, the chances of achieving integrity in a distributed system are higher. However, if the number of peers and their trustworthiness is unknown, the chances of achieving integrity are lower. This is the case when running a purely distributed peer-to-peer system on the Internet that is open to everyone.

Integrity Threats in Peer-to-Peer Systems

- For simplicity purposes, we will consider two major integrity threats in the peer-to- peer systems. These are:

- Technical
- failure.

Malicious

peers.

Why Blockchain is Needed

Technical Failures.

All hardware and software components of a computer system as well as any component of the computer network have the risk of failing and creating errors. Hence, any distributed system has to face the problem that its components may fail or produce wrong results by chance.

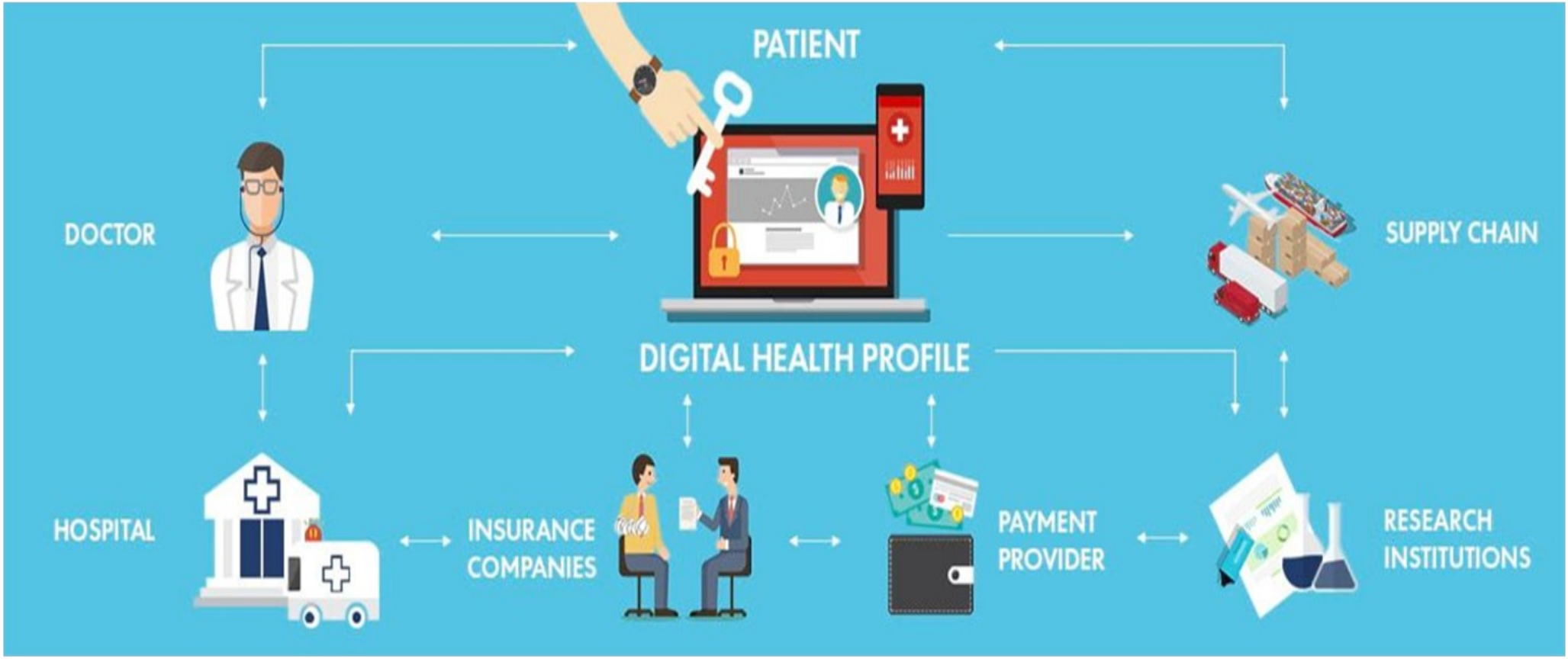
Malicious Peers.

This source of untrustworthiness is caused by the goal of individuals who decide to exploit the system for their own purposes. Malicious peers comprise the most severe threat as they attack the foundation on which any peer-to-peer system is built: trust.

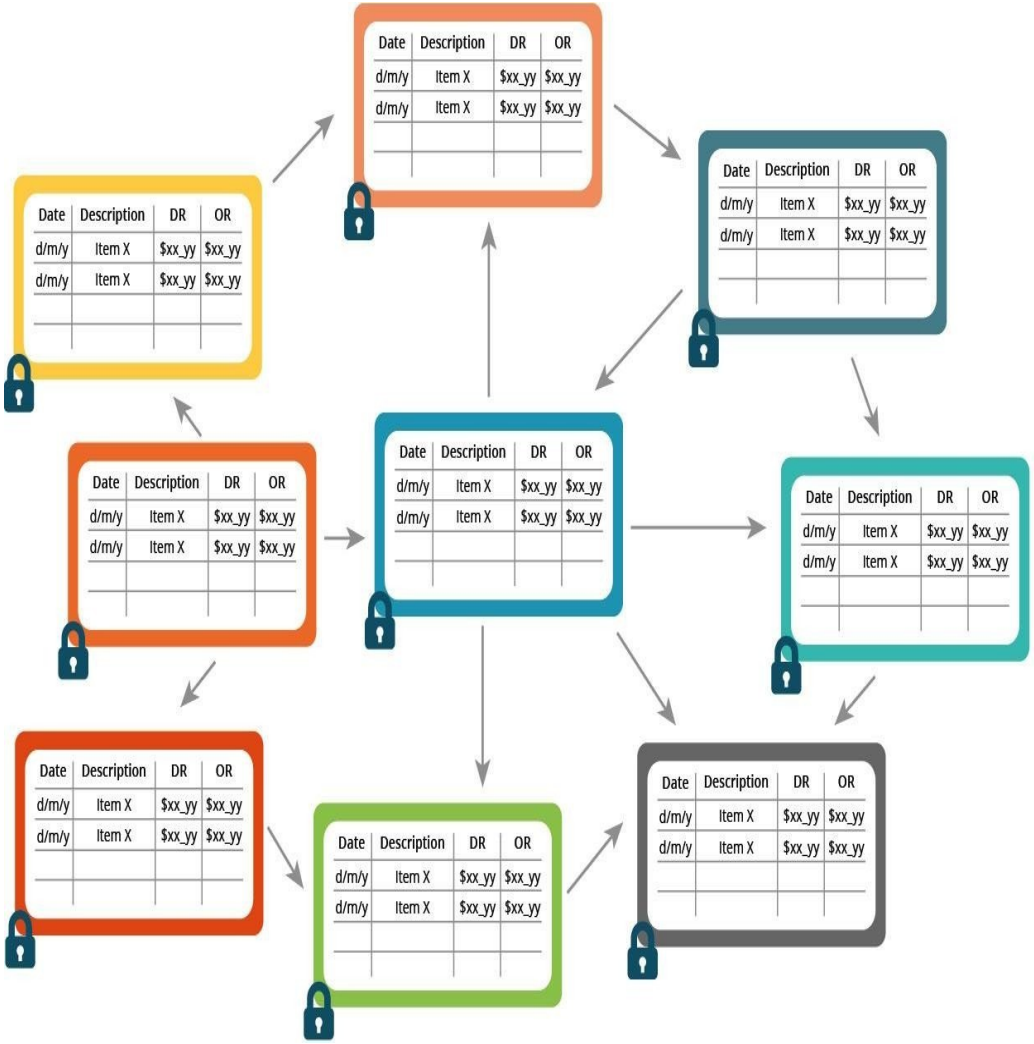
The Core Problem to Be Solved by the Blockchain.

The core problem to be solved by the blockchain is achieving and maintaining integrity in a purely distributed peer-to-peer system that is comprised of an unknown number of peers with unknown reliability and trustworthiness.

Blockchain in Healthcare



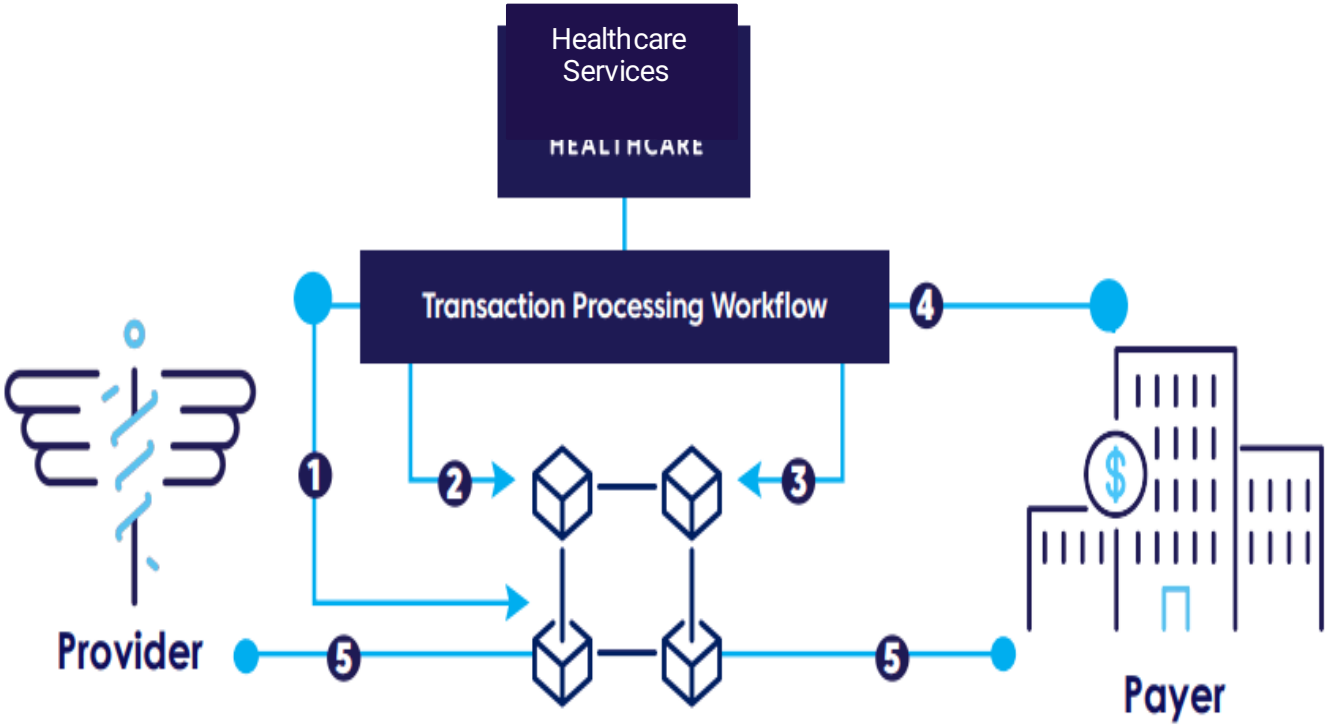
Blockchain Technology



Blockchain is a decentralized P2P architecture. Members in the distributed network record digital transactions into a shared ledger. Each member stores an identical copy of the shared ledger and changes to the shared ledger are reflected in all copies.

Source: Laura A Linn and Marta B. Koo, Blockchain For Health Data and Its Potential Use in Health IT and Health Care Related Research

How The Change Healthcare Intelligent Healthcare Network Gets Even Smarter With Blockchain



Blockchain Distributed Ledger:
Using Hyperledger Fabric 1.0, an open source blockchain framework hosted by The Linux Foundation

Blockchain Workflow

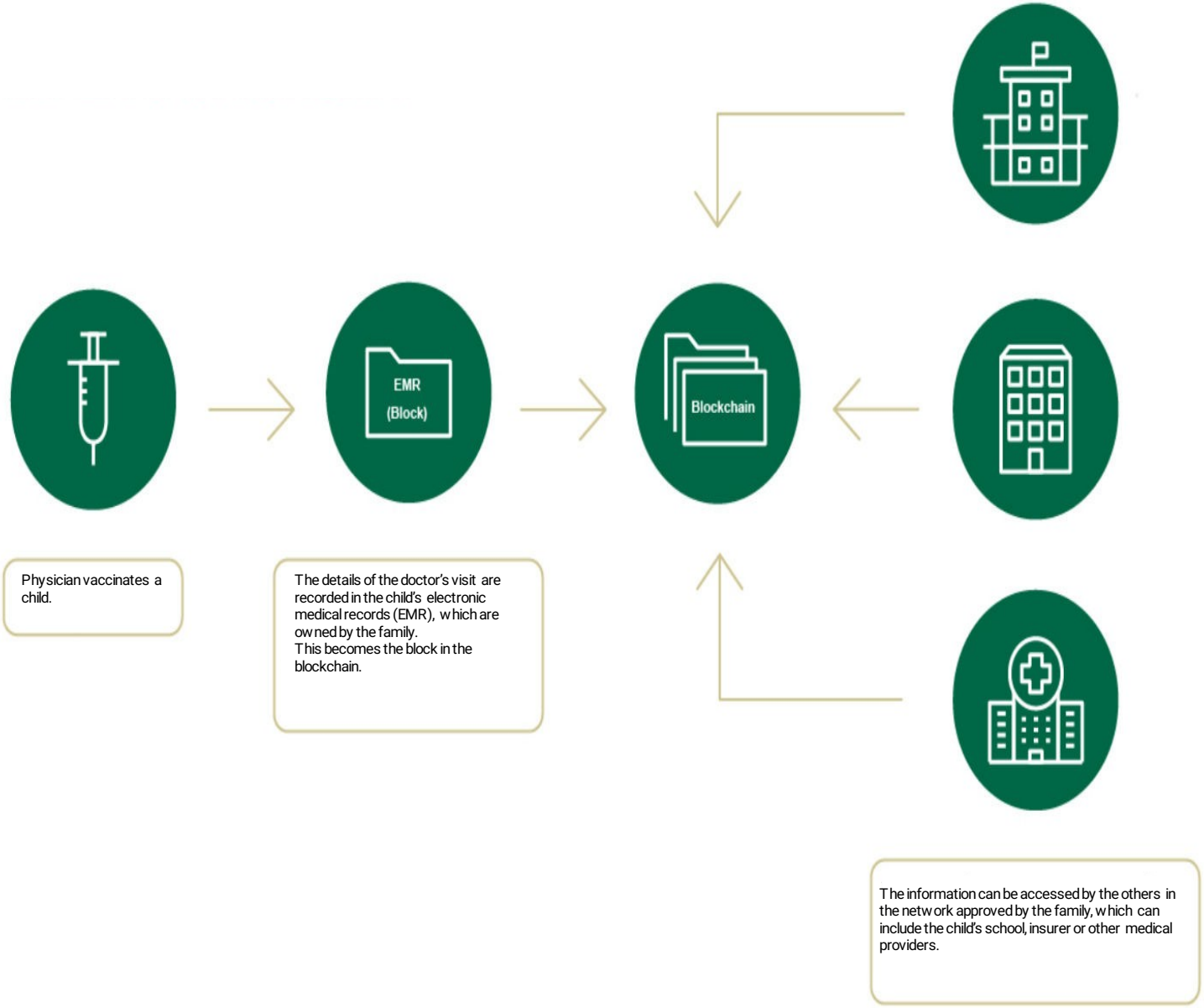
1) Claim event logged to blockchain
2) Claim workflow writes events to blockchain
3) Blockchain events trigger workflow activity
4) Workflow mediated through blockchain
5) Blockchain events trigger calls to customer/partner APIs

Benefits of Blockchain

A new, distributed healthcare data ledger applied to revenue cycle and payment process enables:

- Decentralized data available to all stakeholders
- Faster transaction processing speed
- Lower overhead and cost
- Immutable historical healthcare data record
- Transparency of transactions
- Higher payment accuracy and visibility

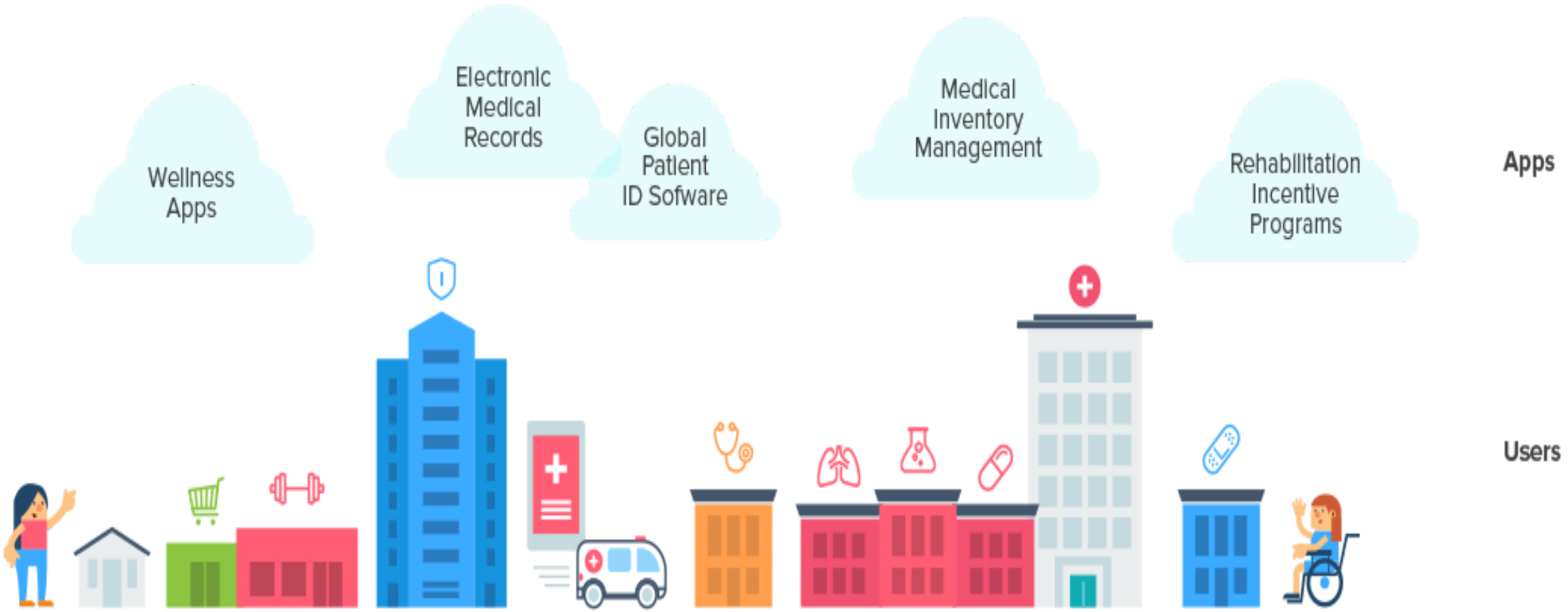
A Healthcare Transaction in Blockchain



Benefits of Blockchain in Healthcare

With blockchain healthcare applications, the quality of healthcare is predicted to rise, and the risks and costs are likely to go down. Following are the benefits of blockchain in Healthcare:

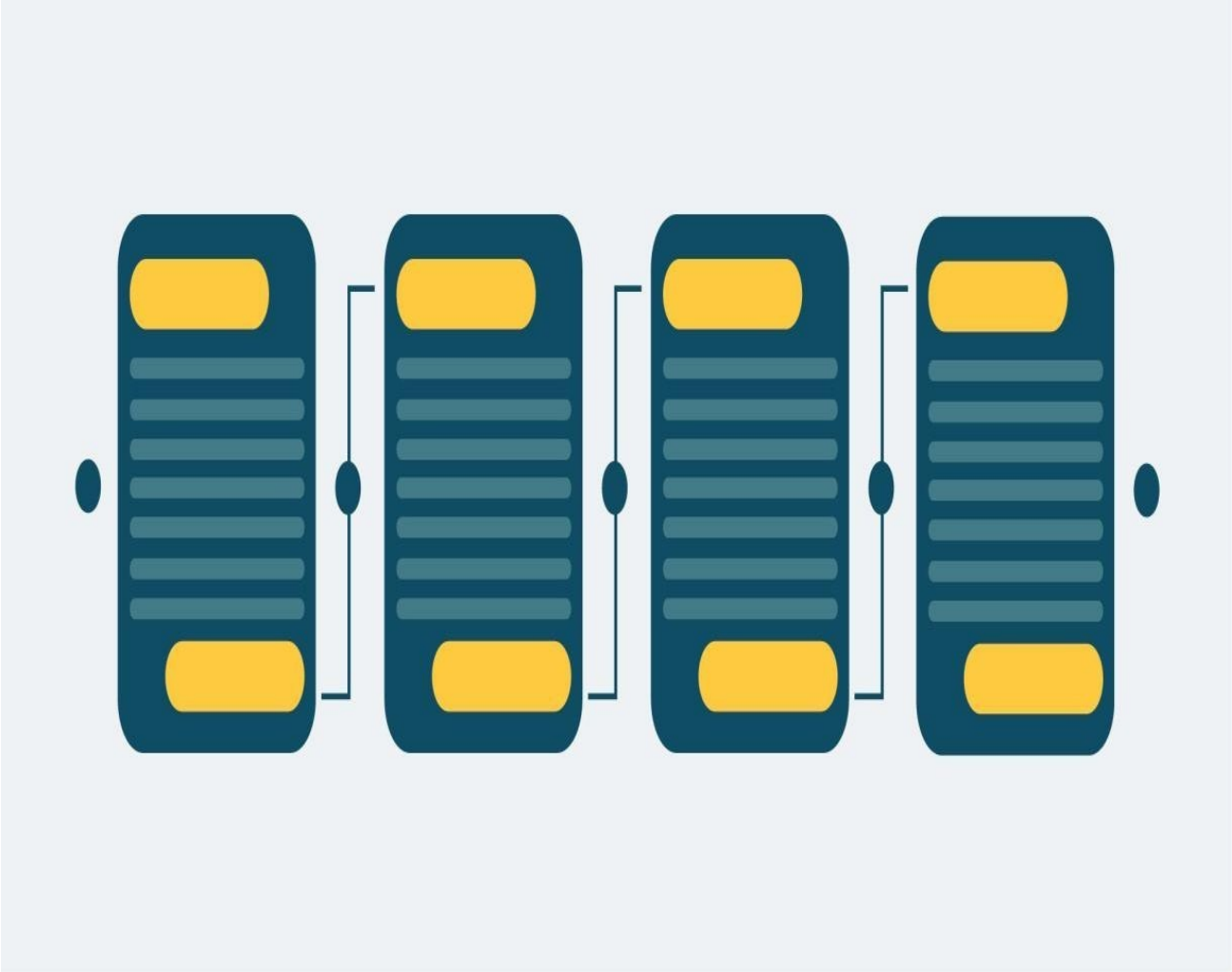
- Effective and cost efficient
- Powerful monitoring
- Better Collaboration
- Cleared and organised process
- Easy access and budget control
- Protection of crucial data
- Extracting the best benefits



Drawbacks of Blockchain in Healthcare

- New technology – It's still in its nascent stage and even large corporations are struggling to integrate it into their core systems.
- High initial cost - The high buy-in for the technology coupled with the huge amount of processing power required to keep it up is proving to be a deterrent.
- Not able to handle large data sets – Although it can handle personal data like IDs and certificates, large data like CT scans will be difficult to store in blockchains

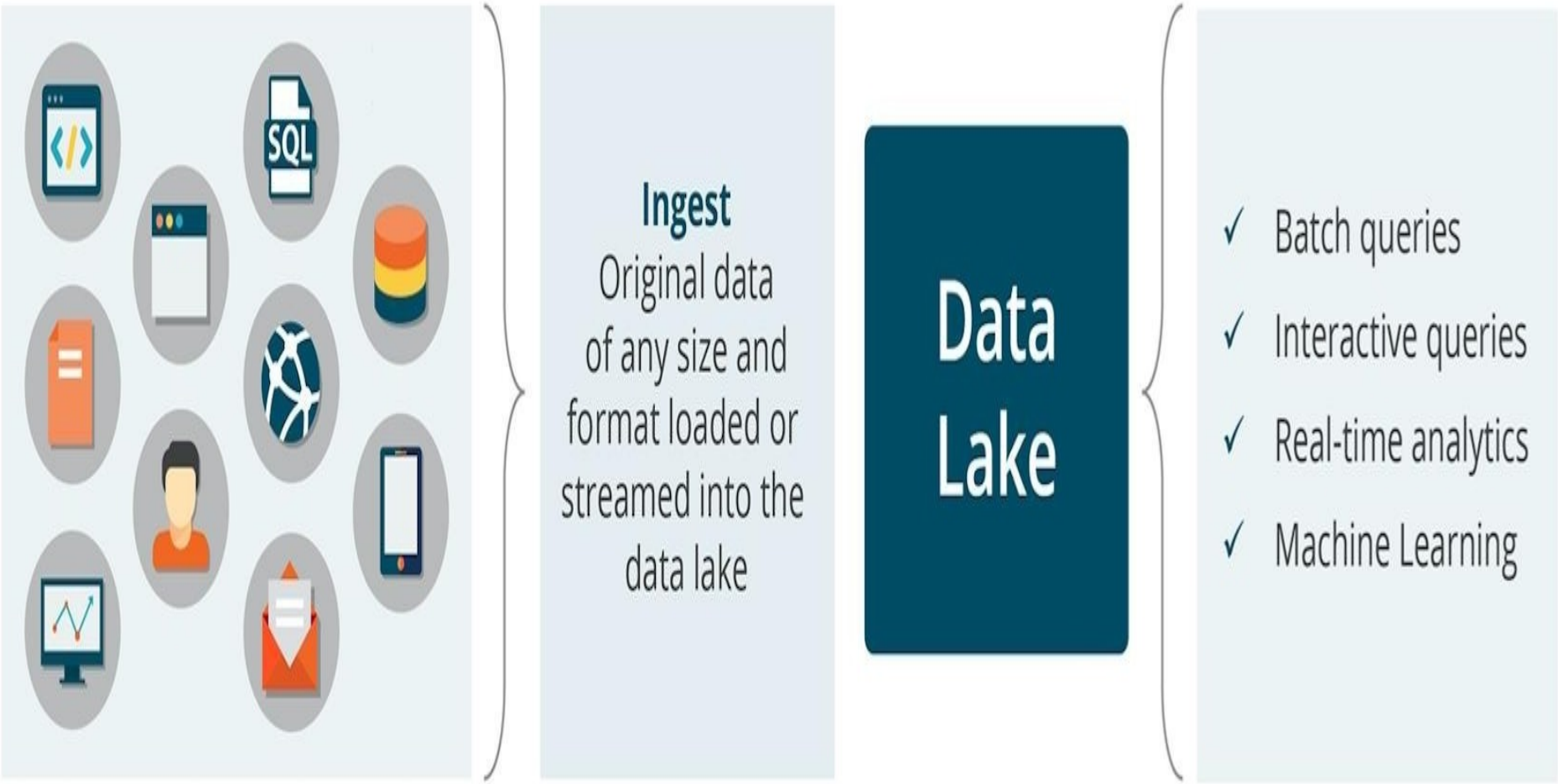
Encryption



Transactons contain encrypted and digitally signed data along with an index that points to the prior block in the blockchain. Transactions are structured into blocks and recorded in chronological order.

Source: Laura A Linn and Marta B. Koo, Blockchain For Health Data and Its Potential Use in Health IT and Health Care Related Research

Data Lake



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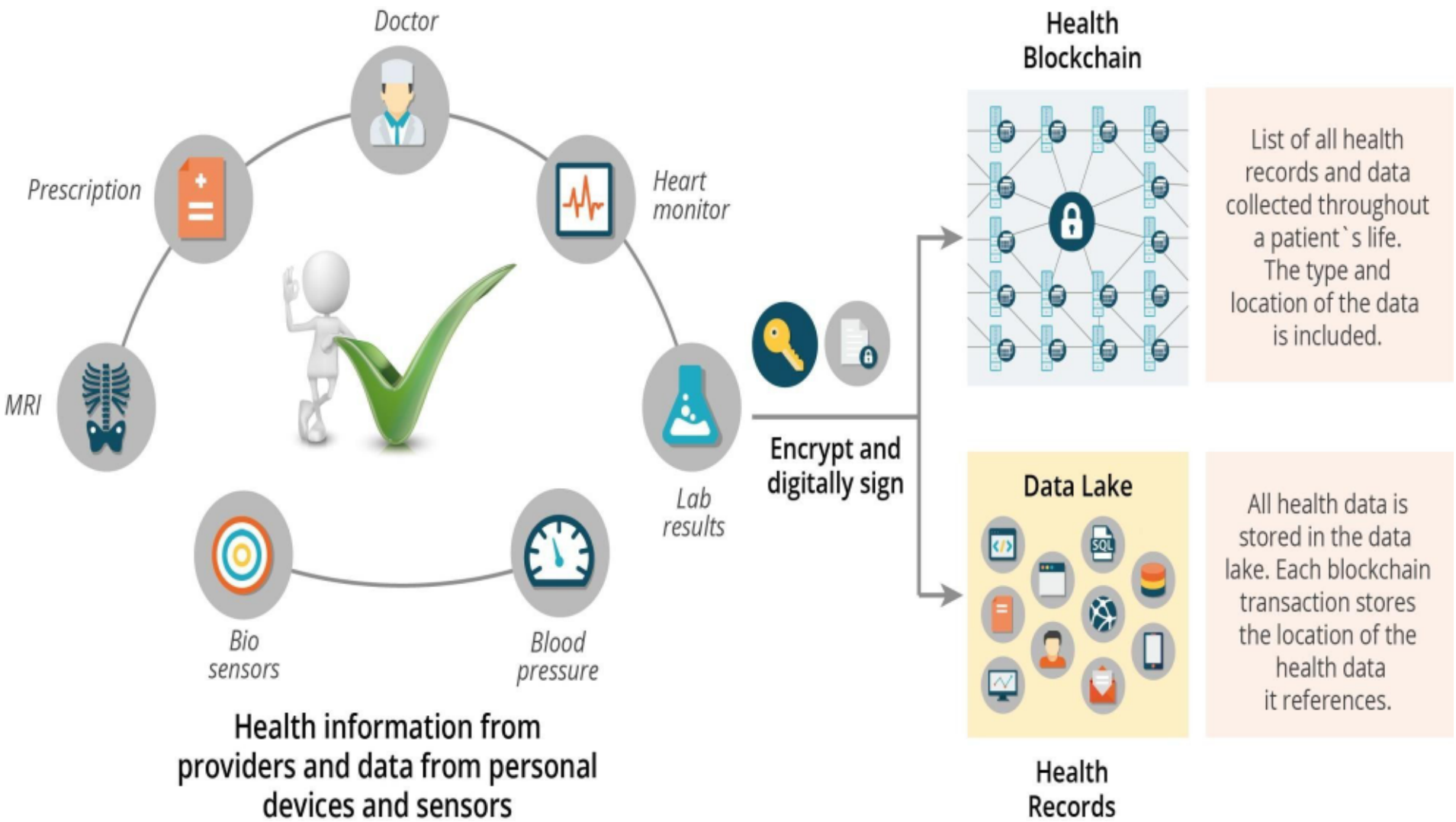
Health Care Blockchain



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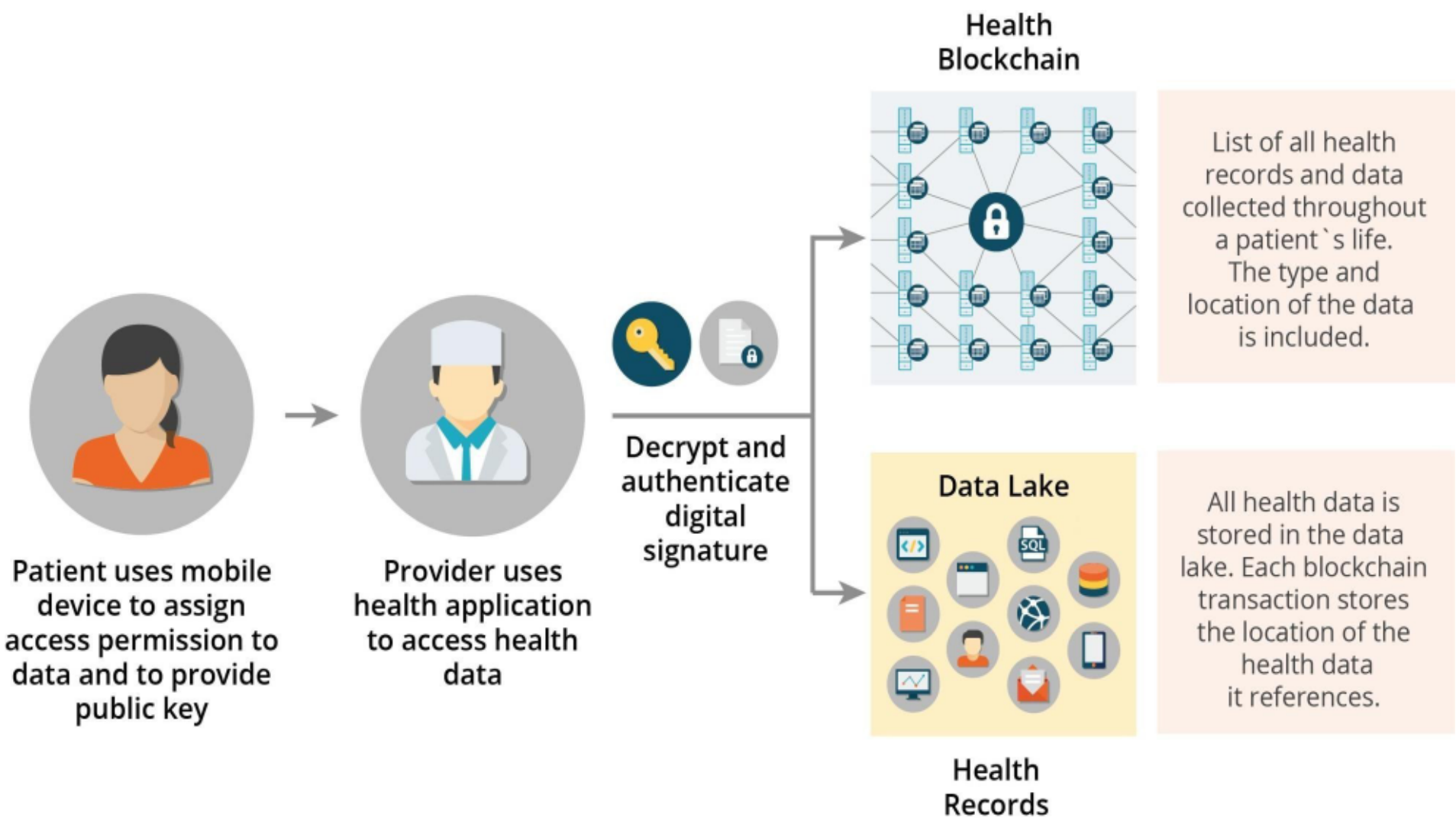

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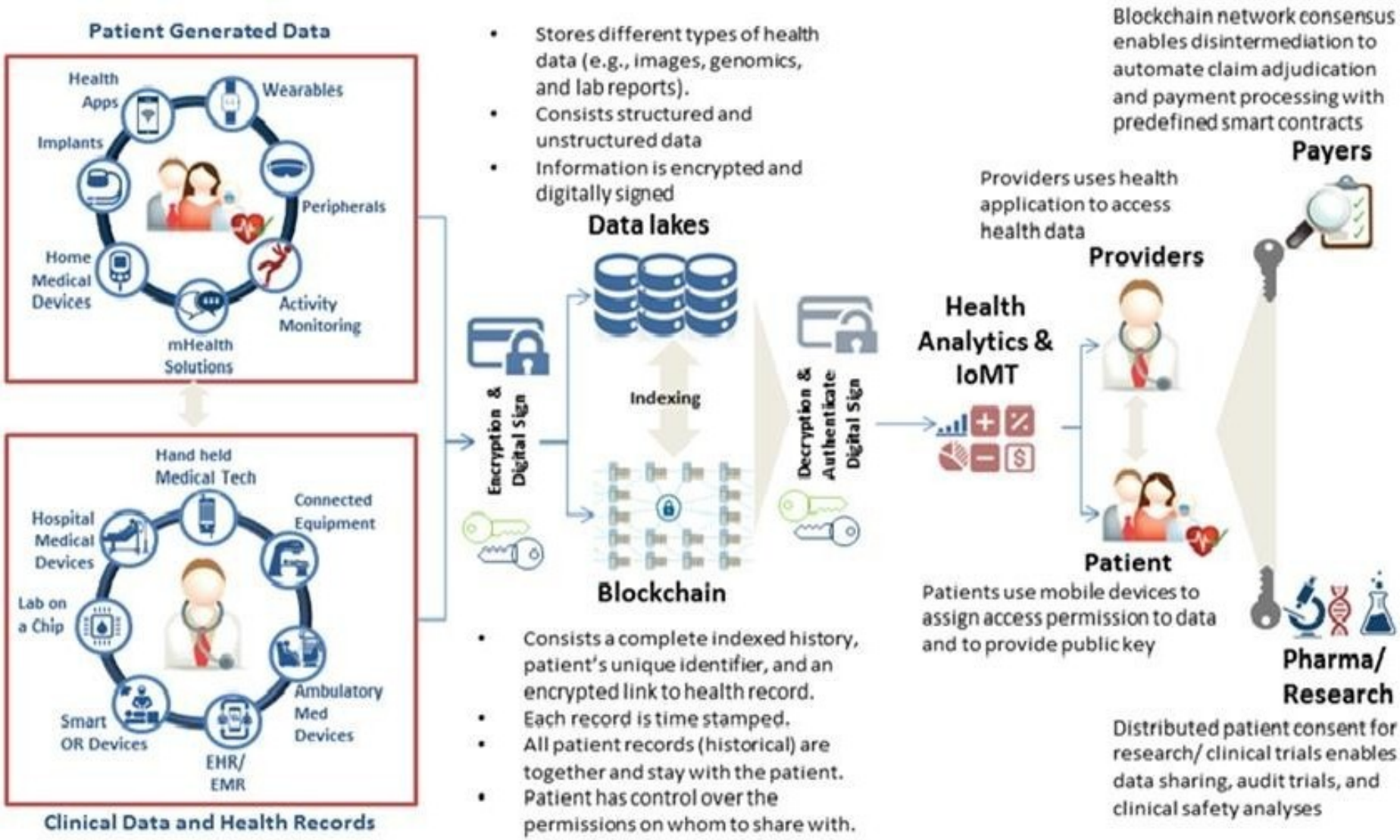

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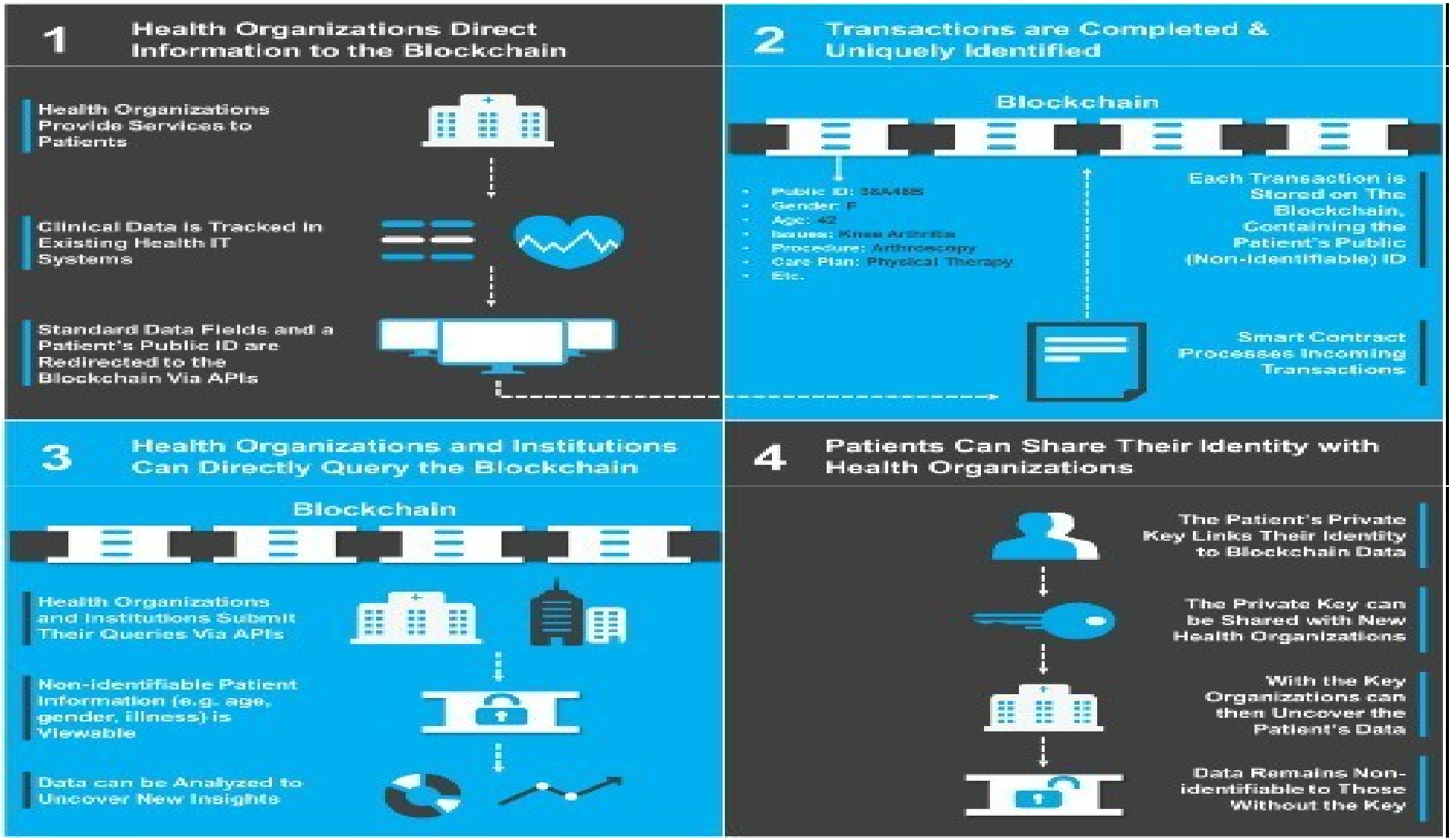


Source: Deloitte, Blockchain: Opportunities for Health Care (Aug. 2016).

Advantages

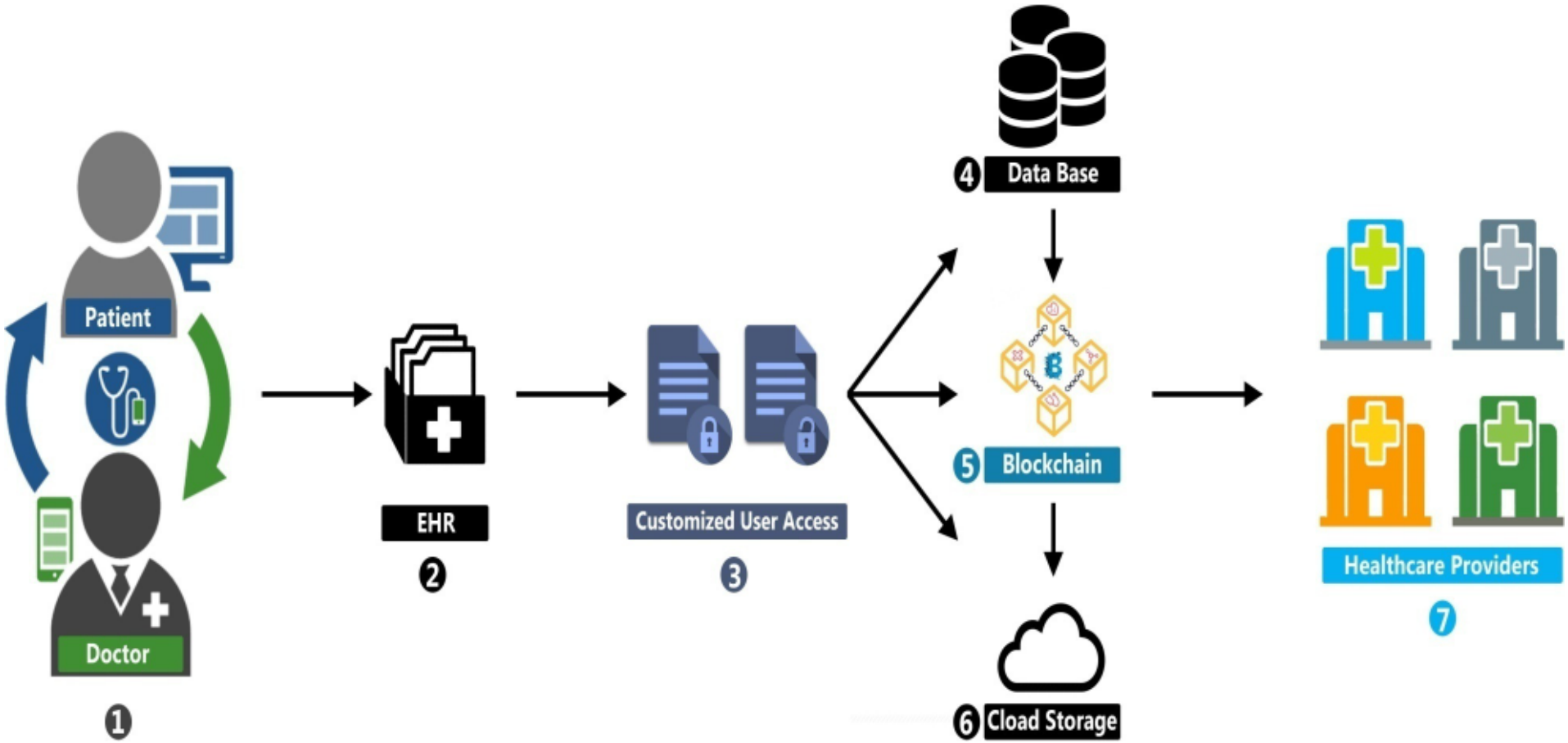
- Blockchain technology offers many advantages for health care IT.
- Blockchain is based on opens source software, commodity hardware, and Open API's.
- These components facilitate faster and easier interoperability between systems and can efficiently scale to handle larger volumes of data and more blockchain users.
- The architecture has built-in fault tolerance and disaster recovery, and the data encryption and cryptography technologies are widely used and accepted as industry standards.
- The health blockchain would be developed as open-source software.

Advantages

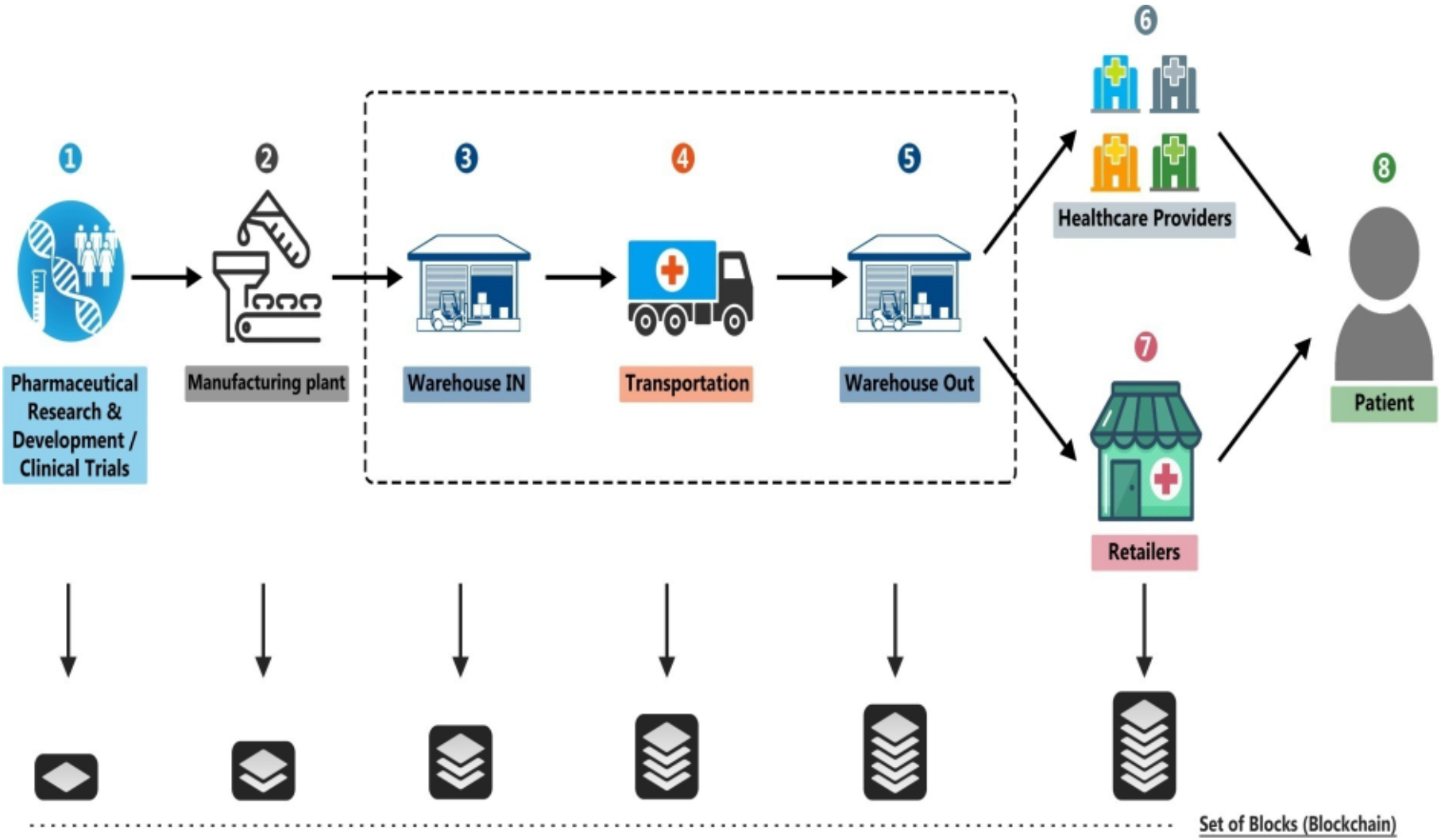
Open-source software is peer-reviewed software developed by experts

- It is reliable and robust under fast changing conditions that cannot be matched by closed, proprietary software.
- Open-source solutions also drive innovations in the applications market. Health providers and individuals would benefit from the wide range of application choices and could select options that matched their specific requirements and needs.
- Blockchain technology offers many advantages to medical researchers,

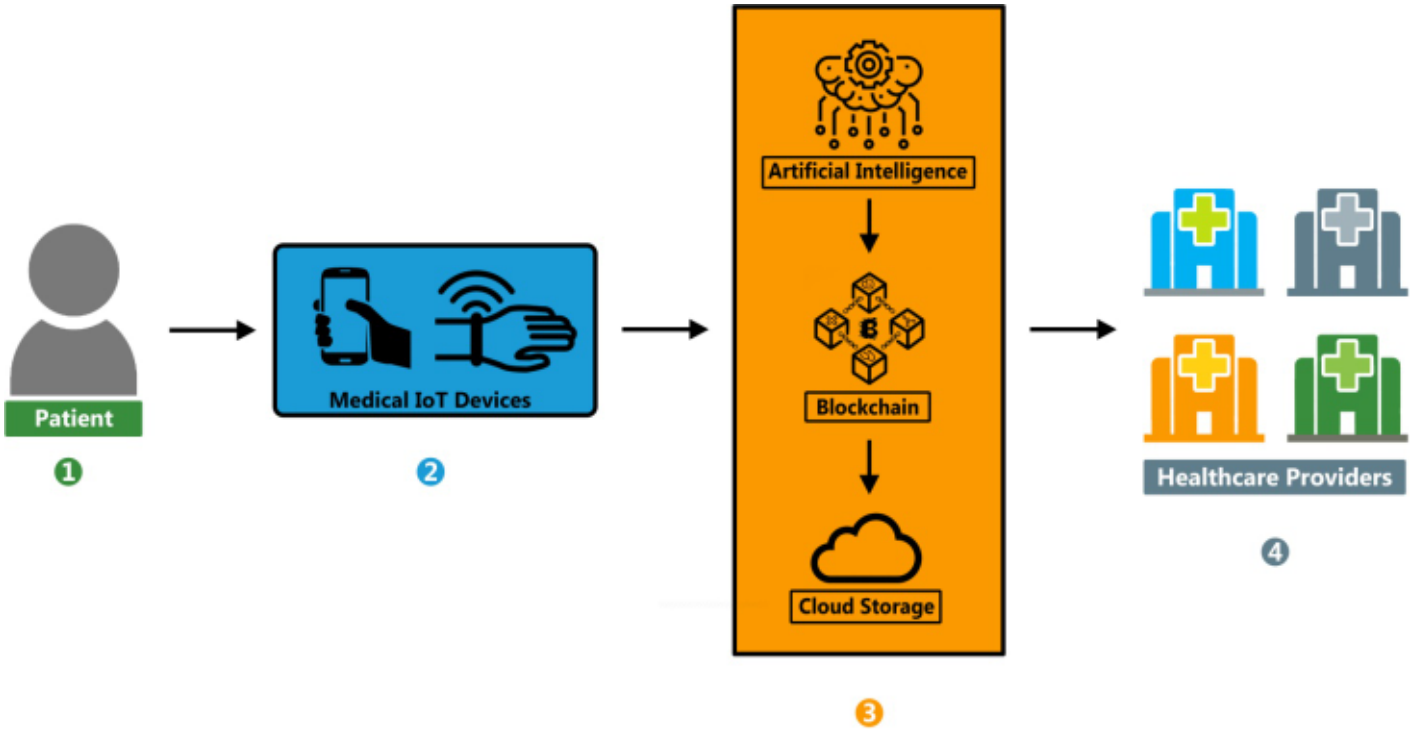
Block Chain and Health Care Management



Block Chain in Supply Chain Mangament



Block Chain and IoMT



Uses of Blockchain in Health Care

Blockchain has thepotential to substantially impact the health care industry as a whole and payers, providers and patients with respect to drug traceability, clinical trials andresearch, and data management.

Drug Traceability

- Blockchain provides security in the process Manufacturer marks
- with a unique code
- # is produced for the drug (contains all relevant information) The
- drug information is stored on the blockchain
- Each time the drug is moved in the process, that information is stored on the blockchain – wholesaler verifies and sends to pharmacist, pharmacist delivers to the patent

Clinical Trials

- Mistakes or fraud may occur
- Considerable amounts of data are produced from the trials themselves including safety, efficiency and quality data
  - Many people will “touch” this data
  - Data collection may not be standardized
- Outcome switching, data dredging and selective publication of results may occur and may also affect protocol development

Clinical Trials

Blockchain can provide authentication and prevent modification:

•Provides proof of existence for and verification of trial data and transparency
•Would include the trial protocol, results, site information, required consents, etc.
•Allows reproducibility and secure data sharing among research communities
•Trial protocol may have a unique signature recorded on the blockchain

Clinical Trials

- Allows the creation of a system to record and verify clinical trials as specified by the parties conducting the trials and prevents modifications

  - Uses an entry from study protocol on clinicaltrials.gov and a text file with pre-specified end points and planned analysis
  - Then converted into SHA-256 hash calculator which was then used as a private key for a Bitcoin wallet, followed by a public key to enable transactions

Patient Data Management

Managing patient data requires complete access the individual medical records to be shared among various clinicians and other professionals and to and from various locations.

- No standards for collection, storage or disclosure of such information
- Social networks and physician portals are not always secure
- Patients do not control their data

Patient Date Management

Blockchain can provide a secure structure:

- Users share information
- Information can be stored in smart contracts containing permissions and conditions for release
- Patients control access – private keys unlock access or third parties authorized by the patients can do so
- Can pull in other information from wearables and registries
- Companies are building personal health records (PHR) to align all stakeholders through patient engagement platforms and utilizing blockchains to implement

Patient Data Management

- **Blockchain can:**
- Address patient consent for data sharing not addressed by HIEs Provide more tailored consents and update as desired
- Create a system of “smart contracts” for a rule-based method for access

Patient Data Management

Store certain data on the blockchain but still allow certain data to be accessed by secure links:

- On blockchain data could include age, gender and other personally identifiable information; be of the size and type to be stored and be immediately viewable
- Off blockchain data could include images and medical notes of any size or format that may have different requirements for the need to view.

Patient Data Management

- Blockchain could also collect information from web-based and mobile applications or other devices and becomes very important for digital health

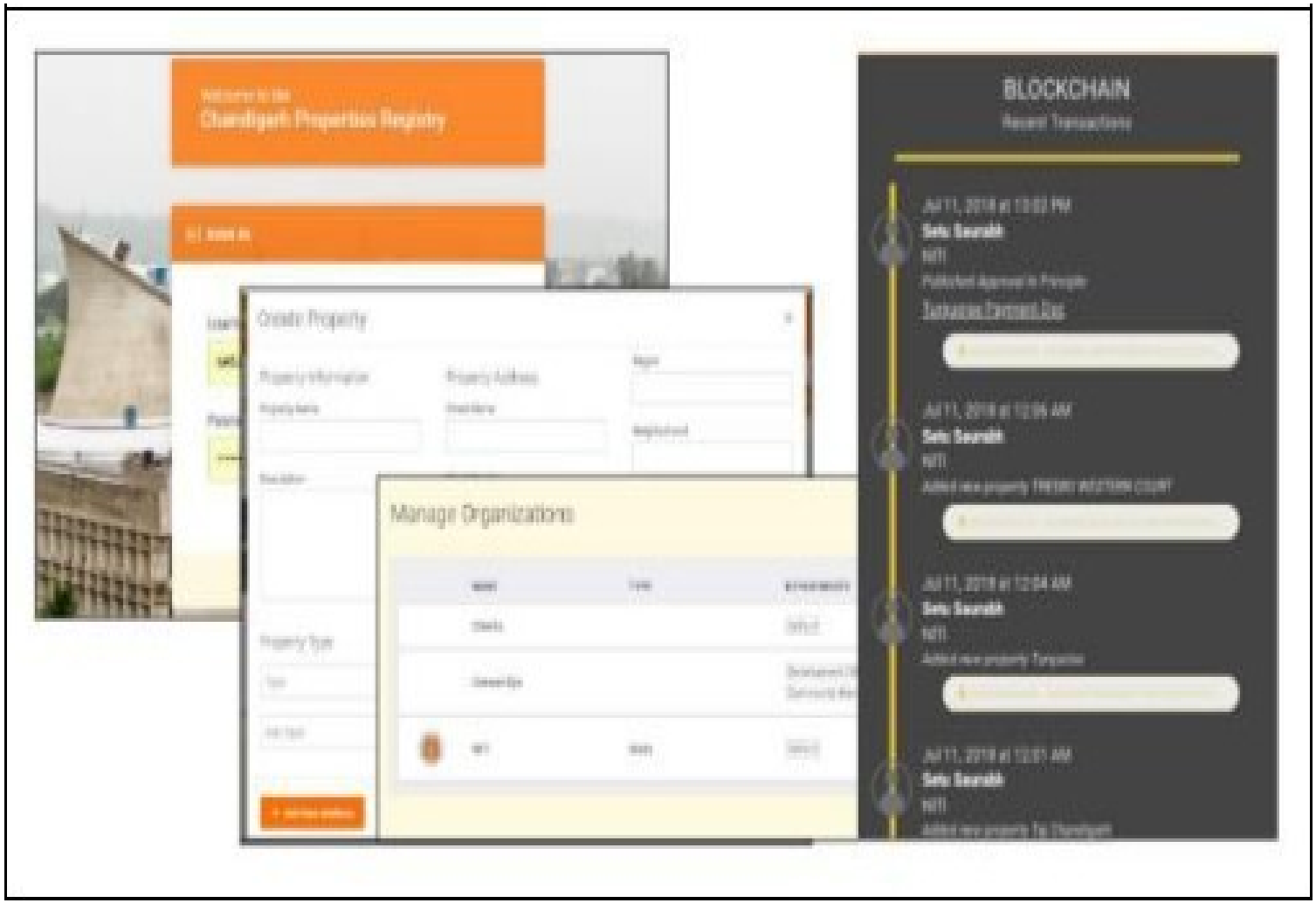
•Development and other costs, concern of patients, scability, storage limits and capacity are obstacles to be addressed

Blockchain Other Uses

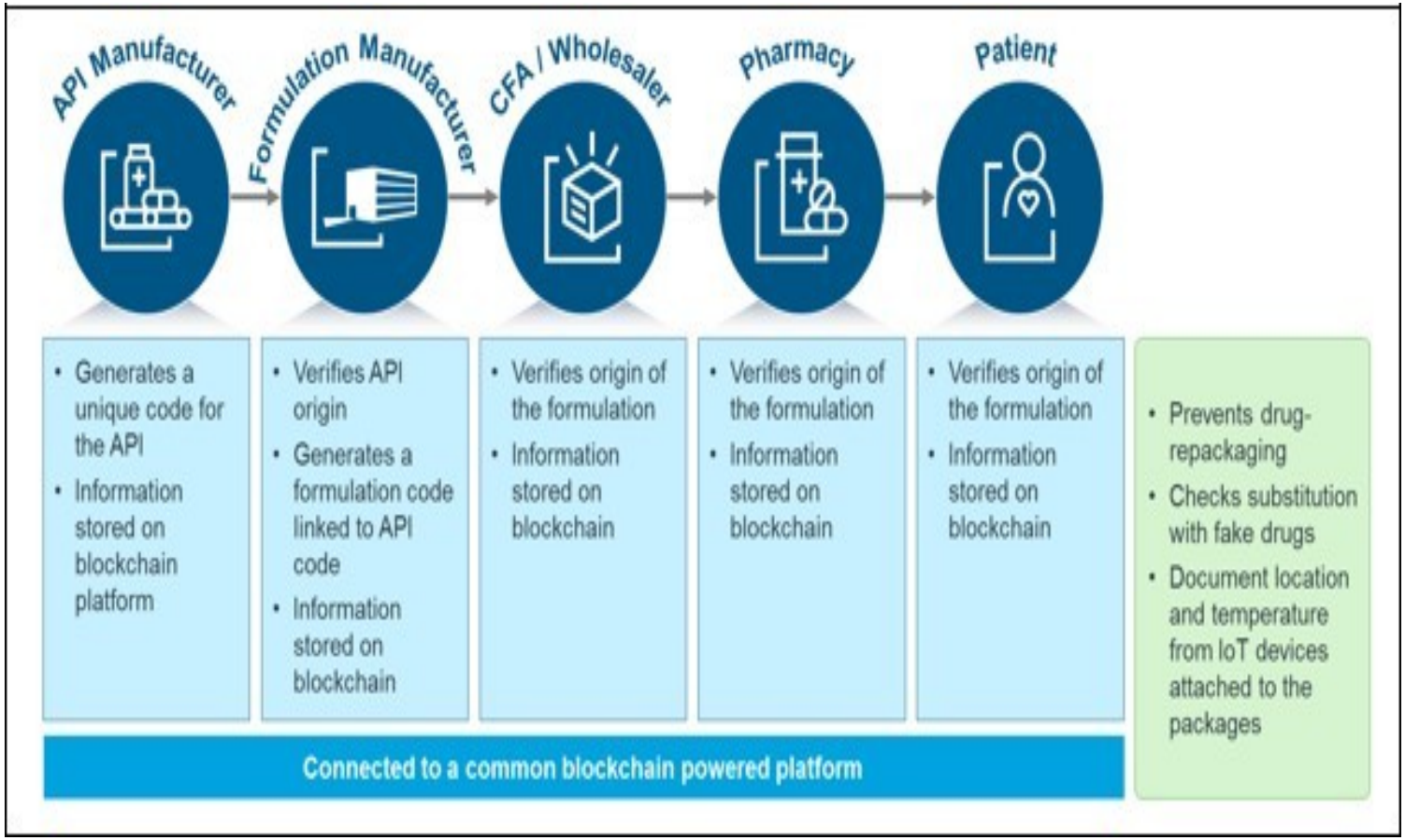
Blockchain may also be used for:
provider licensing and credentialing;
payer administration and data exchange for value- based care;
supply chain management and medication monitoring;
public health surveillance and population health management;
Revenue cycle management and fraud prevention.

Block Chain in Social Sector

1. Land Records:



2. Pharmaceutical drugs supply chain: 'self-regulation' of the sector through blockchain enabled trust



3. SuperCert: anti-fraud identity intelligence blockchain solution for educational certificates

- Creation of student identity – Superidentity. A unique blockchain representation of the identity is provided, along with a set of public and private keys.

- Issuance of certificate by university, together with Superidentity of the student.

- SuperCert i.e. creation of a block of student certificate – hashed version of the certificate on the blockchain

- Verification of the certificate using the public key of the student and the public key of the university. The solutions have features for both online and offline verification.

More applications of the Block chain in social sector

- Immunization Supply Chain: Building A New Immunization Infrastructure for India - Unified and Enhanced by Blockchain
- Chit Funds: A blockchain based model to enhance trust and unlock value creation
- Insurance (Medical, Automotive, etc.)
- Organic Farming
- EV Battery Swapping Energy Trading
- Crytocurrencies for NGO
- donation

References

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- www.deollite.com

Blockchain P2P Network

- Digital signatures(public and private keys) securely ensure a party's identity is kept private and digital asset is securely stored. This is still not enough.
- We need to understand how blockckain uses the peer to peer network to solve perhaps the biggest problem when it comes to digital assets, the double-spending problem.
- When using fiat money, the paper is convertible i.e once you give the paper away, you cannot spend it again.
- In cryptocurrency, what happens if you prove ownership and send digital assets twice at the same exact time?
- Hackers can try to reproduce digital assets as well as double them.
- Cryptocurrency had to solve this issue before being accepted officially as currency.

Blockchain P2P Network

- Double Spending Problem – Fowarding information to elements in a distributed peer to peer system requires time. Because not all peers have the updated information at a given time, they are prone to be exploited by anyone who already has the latest information. Hence one can transfer ownership of a digital asset more than once.

Blockchain P2P Network

- To understand this network, we look at how the cryptocurrency P2P network works. We will explore different blockchains policies specifically and the P2P network in general by breaking the P2P network into five layers: Consensus Layer, Miner Layer, Propagation Layer, Semantic Layer and the Application Layer.

1. <u>Consensus Mechanism</u>

- A consensus mechanism is an agreement needed for the network to operate properly even in the event of a failure. It needs to be able to achieve agreement on the data of the network within the distributed P2P network.
- In cryptocurrencies, the consensus/agreement is on whether the blocks are valid or not. If a block is valid, the block will be added to the blockchain. If a block is invalid, it will be rejected from being added to the blockchain.

Blockchain P2P Network

- That's where a consensus policy comes into play. Most of the peers in the network hold the same blocks in their validated best blockchain and follow the same rules (consensus rules); that's how blockchain ensures security.
- The P2P network enables a ledger. To achieve this goal in a secure way, the P2P network stores the digital ledger rules and security. The consensus mechanism provides not only the rules but also the incentives to do the work of storing the data and creating transactions by giving the reward to miners.

Proof of work(A concensus mechanism)

- PoW is achieved by having a network of miners and presenting the miners with a mathematical problem.

Blockchain P2P Network

- When miners solve a problem, they are rewarded with a cryptocurrency
- A reward is given to the first miner who solves the problem. Then the verified transactions are stored in the public ledger.

2. Mining Layer

- What miners are doing behind the scenes is the network bookkeeping.
- For bitcoin and most coins out there that utilize PoW, each peer needs to hold the entire public ledger, which holds a record of all the transactions that were ever conducted.
- For bitcoin, transactions must be validated by the miners who check the ledger, ensure the sender is not transferring funds it doesn't have, only then add the transaction to the ledger

Blockchain P2P Networks

- Finally, to ensure protection from hackers, the miners seal these transactions behind multiple layers of computational work, requiring too much work for a hacker to possibly achieve. This service is rewarded by providing bitcoins as a fee to the miner.

3. <u>Propagation Layer</u>

- The propagation layer is responsible for deciding how the shared ledger and the blocks are transmitted on the P2P network.
- Each of the peers can transmit a new transaction to other nodes on the network. This architecture allows nodes to communicate indirectly. For instance, you can send a transaction affecting two wallets without each wallet being connected directly to each other.
- Any node that receives a valid transaction it has not seen before will immediately forward it to all other nodes to which it is connected.

Blockchain P2P Networks

4. Semantic Layer

- The semantic layer takes care of how new blocks relate to previous blocks and provides the protocol for verifying the consensus rules.
- In this layer, transactions happen where coins/tokens are transferred between accounts.
- The consensus in the blockchain holds the same blocks in their validated best block chain and follows the same rules (consensus rules).

Blockchain P2P Networks

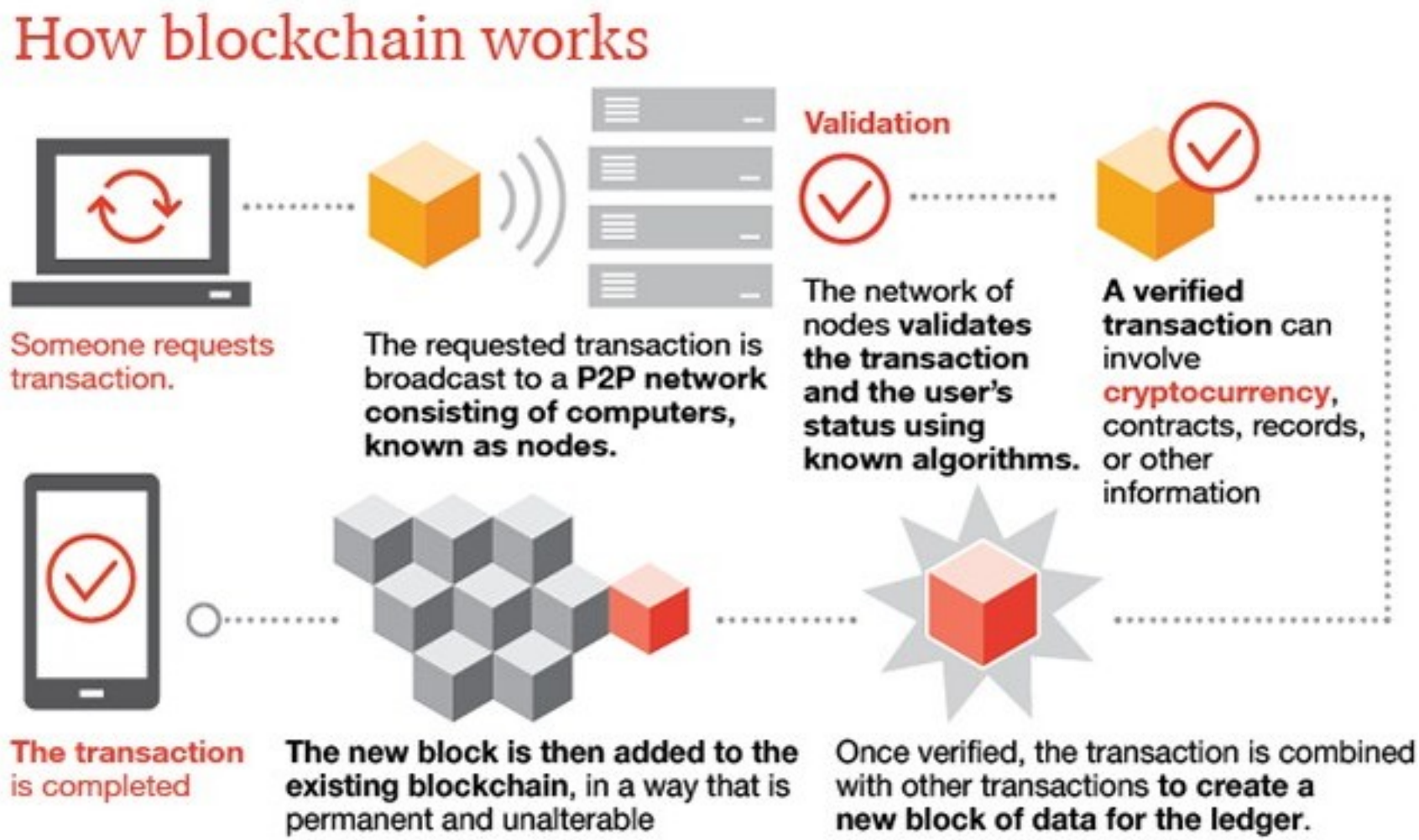
5. Application Layer

- This layer takes care of deploying applications on top of the blockchain.
- For instance, dapps, smart contracts, exchanges, and sites that provide information about a blockchain are applications built on top of blockchains.
- For the application layer, the blockchain needs to expose APIs.
- Bitcoin offers a full node, which is currently about 27 GB and includes a fully enforced node and all the rules of the blockchain. That is needed for mining as well as ensuring the peer you run that gets connected to the application layer is synced with the latest blocks.
- These full nodes contribute to the functionality of the P2P network and help support the network and its security.

History Of Blockchain

- The first work on a cryptographically secured chain of blocks was described in 1991 by Stuart Haber and W. Scott Stornetta
- In 1992, Bayer, Haber and Stornetta incorporated Merkle trees to the design, which improved its efficiency by allowing several document certificates to be collected into one block.
- The first blockchain was conceptualized by a person (or group of people) known as Satoshi Nakamoto in 2008.
- In August 2014, the bitcoin blockchain file size, containing records of all transactions that have occurred on the network, reached 20 GB (gigabytes).
- In January 2015, the size had grown to almost 30 GB, and from January 2016 to January 2017, the bitcoin blockchain grew from 50 GB to
100 GB in size.

Working of Blockchain

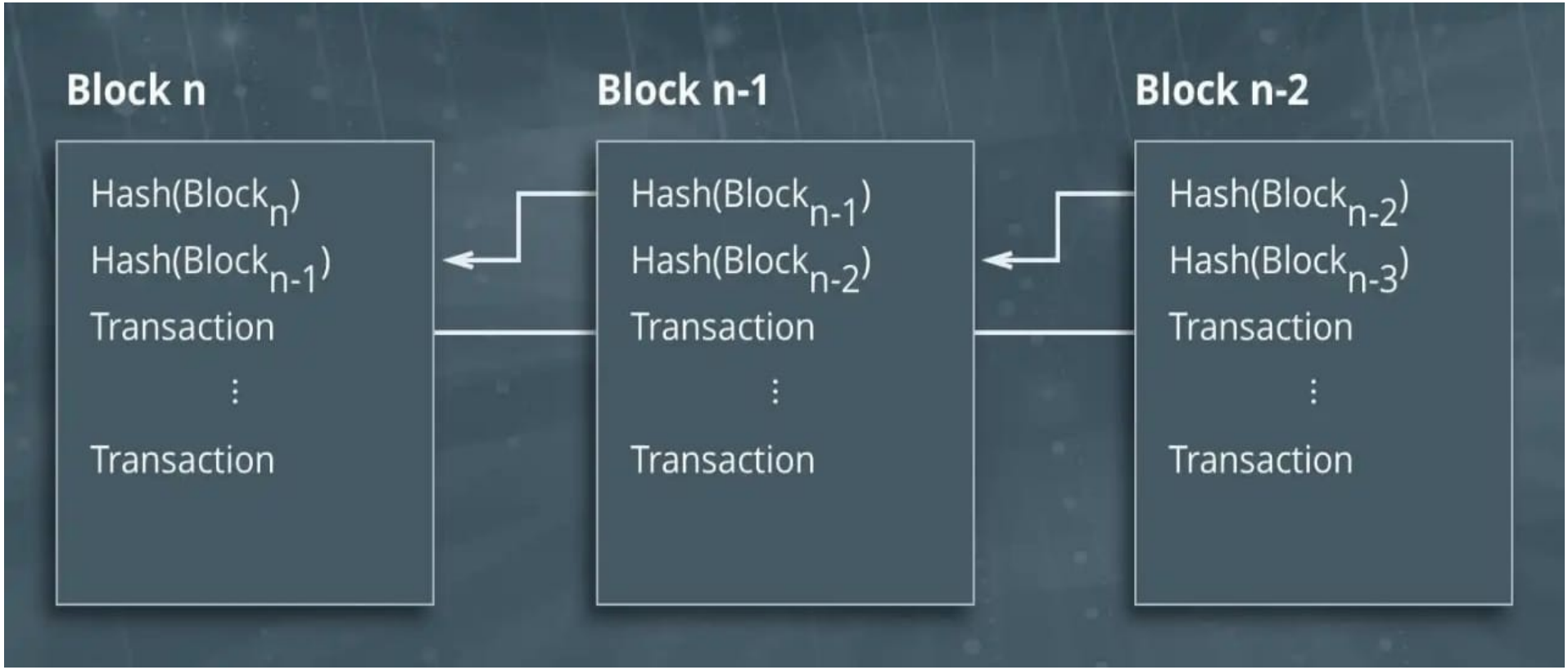


Types of Consensus Algorithms

- Proof-of-Work (PoW) used by BitCoins
- Proof-of-Stack (PoS) used by Ethereum
- Delegated Proof-of-Stack
- Byzantine Fault Tolerance (BFT)
- Practical Byzantine Fault Tolerance (PBFT)
- SIEVE
- Proof-of-Burn (PoB) and a few more

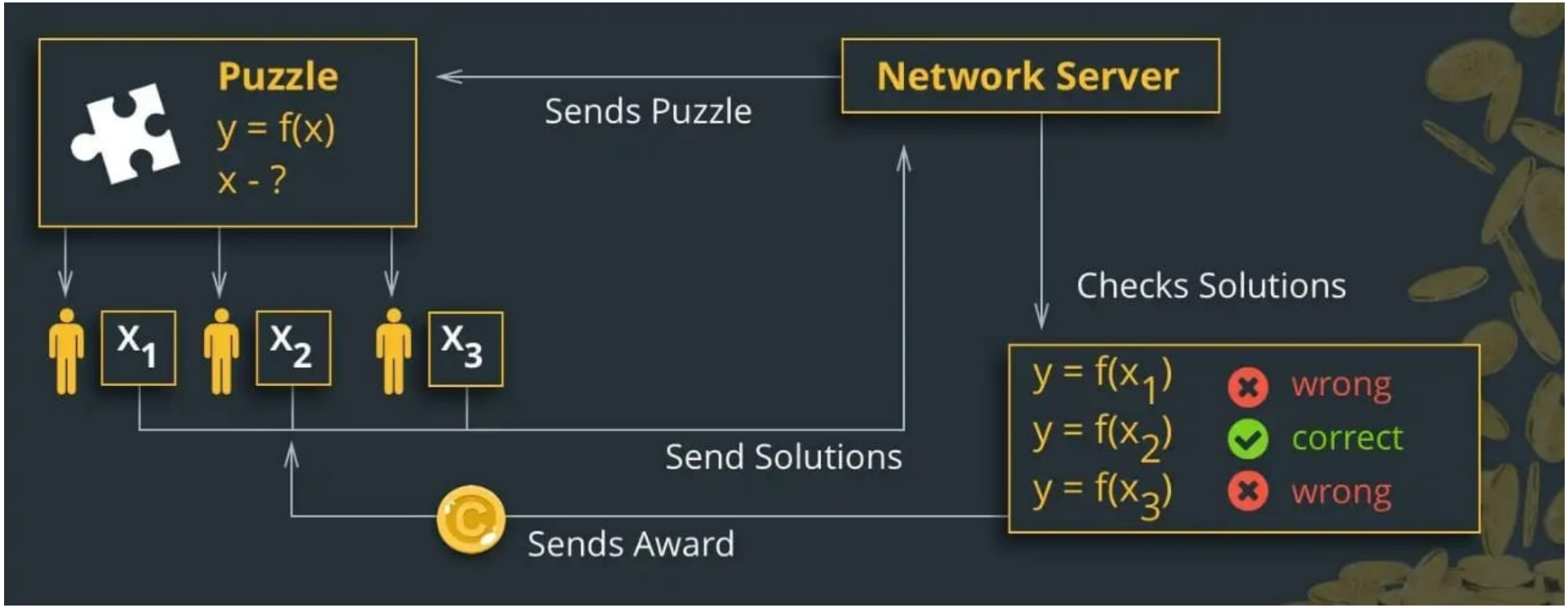
What is PoW Algorithm?

Proof-of-Work algorithm is used to confirm transactions and produce new blocks to the chain. Here miners compete against each otherto complete transactions on the network and get rewarded.



Working Of PoW

Miners solve the Puzzle, form the new Block and Confirm the Transaction in the following way



Applications Of Blockchain

Blockchain's potential applications

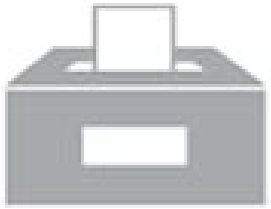
Potential applications

Automotive

Consumers could use the blockchain to manage fractional ownership in autonomous cars.

Financial services

Faster, cheaper settlements could shave billions of dollars from transaction costs while improving transparency.



Voting

Using a blockchain code, constituents could cast votes via smartphone, tablet or computer, **resulting in immediately verifiable results.**

Healthcare

Patients' encrypted health information could be shared with multiple providers without the risk of privacy breaches.

Advantages

- Decentralized system
- Transparent
- Secure
- Faster and cost
- effective Store
- timeline data
- No downtown User empower

Disadvantages

- Complexity
- Size of Blockchain
- Need more
- resources Human errors

Conclusion

Blockchain is a new name in the world of technologies but it is definitely the one to last. Even in the early stages, the technology has gained huge popularity starting with their very first application of cryptocurrencies. More areas of applications are being discovered and tested with each passing day. Once the technology is adopted and accepted on a global level, it'll transform the way we live today.