Blockchain & Public Health

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HIMSS GEORGIA Chapter

What is a blockchain?

- A distributed immutable ledger of transactions
- The underlying technology behind the cryptocurrency known as Bitcoin
- What TCP/IP (internet protocol) has been for the exchange of information, blockchain can be for the exchange of value

What is a blockchain?

- A set of tools for cryptographic assurance of data integrity, standardized auditing, and formalized contracts for data access

- A technology which empowers participating members to exchange items of value through a distributed ledger - that each member owns - and who's content is always in sync

video

No really, what's is a blockchain: 5 Principles*

- Distributed Database
- Peer-to-Peer Transmission
- Irreversibility of Records
- Computational Logic (automated)
- Transparency with a degree of anonymity (pseudonymity)

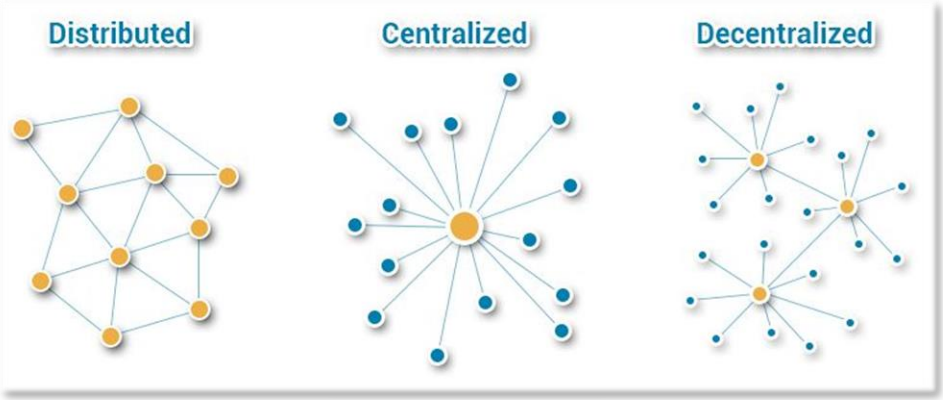
* Harvard Business Review – Halamka et al., 2017

Blockchain: Is it of value to me?

“It is most useful when multiple loosely coupled distinct organizations or entities want to confidently share and audit information and automate mutually beneficial processes”

What is a blockchain? One more time…it is…

- **Distributed**
  - Decentralized, shared, etc.
  - Affording high availability
- **Immutable**
  - Write only
  - Extremely “hacker resistant”
  - Affording high Integrity
- **Ledger**
  - Transaction record (e.g., of financial data, contractual data, physical assets)
  - Uses a validation process (consensus protocol)

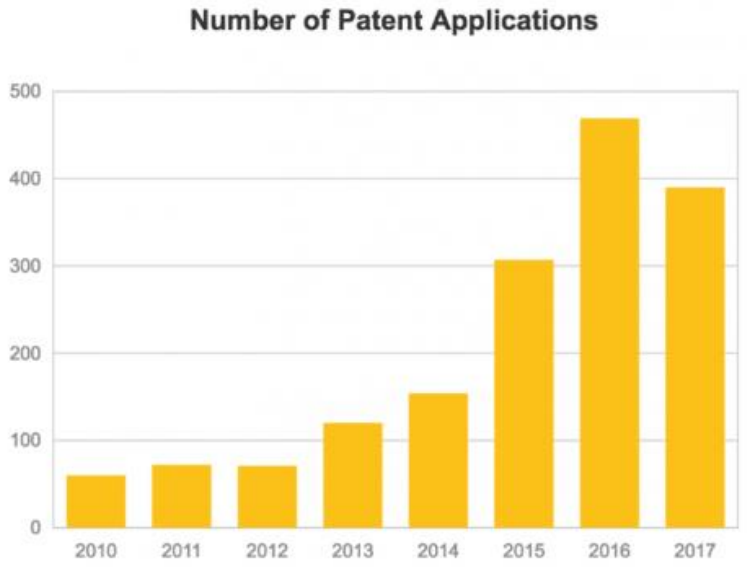


LEDGER

Transactions	Value
Mary → John	10.000
John → Lisa	0.345
Sandra → David	18.4332
Lisa → Sandra	7.156
David → Mary	12.3402
Brian → Lisa	3.029381
…	…

Is Blockchain new?

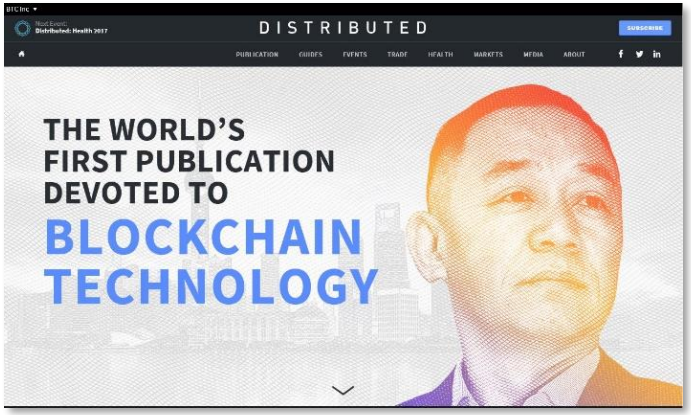
- No…but it is now gaining rapid popularity
- Over $4.5 Billion in private funding for Blockchain-related projects in 2017 (Forbes)
- Dramatic increase in number of Blockchain patents filed (coindesk.com)
- Still in its early stages of development and implementation – similar to the internet itself in the late 1990s



Blockchain development activity

- Significant activity in the Corporate, Academic and Federal spaces:
  - IBM, Microsoft, MIT, GA Tech, GSA, FDA, DHS, DOD, ONC, OMB, NIST, OPM, Postal Service, State Dept., Treasury Dept., Federal Reserve, and hundreds of blockchain startups.
  - https://emerging.digital.gov/blockchain-programs

- New Magazines / Journals:
  - Traditional (e.g., Wired): DISTRIBUTED (2017)
  - Peer-reviewed: Blockchain in Healthcare Today (2018)



BLOCKCHAIN™ IN HEALTHCARE TODAY

Digging a bit deeper into Blockchain: All hype? No.

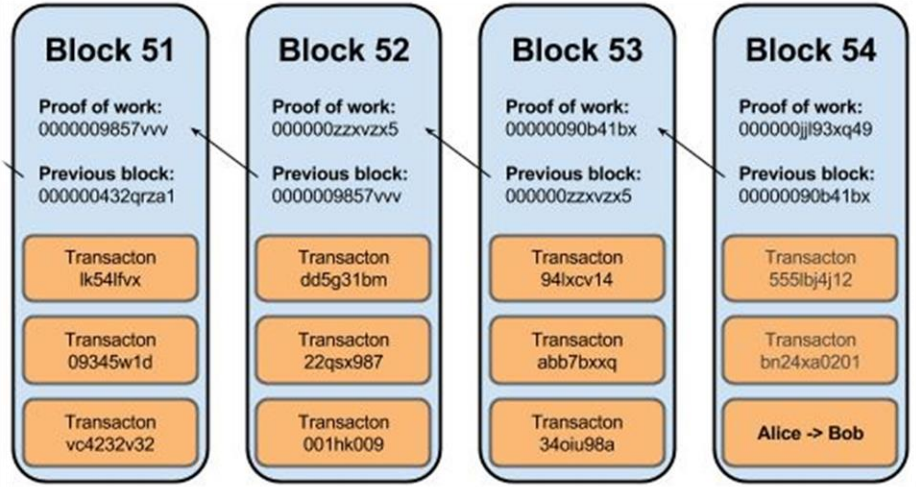
- Leverages and expands existing capability of the internet
- Based on mathematics and cryptography (not magic):
  - (Tech speak: merkle trees, cryptographic hashes, public and private keys, etc.)
- Can be used for many different purposes
- When used in finance – it finally solves the very challenging “double spend” problem

Why is it called Blockchain?

- The power of the technology to be a “trusted source of truth” - is based on its ability to permanently connect groups of validated transactions…

  [connection = called a chain]

  [group = called a block]



Remember: the blockchain data continues to grow and is automatically replicated to every connected node… to potentially thousands of nodes. Sound inefficient? It’s the cost of being a “trusted source of truth”

Why does an internet-based “trusted source of truth” matter?

- You don’t need a trusted 3rd party with a blockchain infrastructure
- Critical ledgers / databases are ubiquitous in our society – and most always require a trusted 3rd party
- Examples:
  - For financial transactions: Bank
  - For drivers license, auto tags, etc.: DMV

Why does an internet-based “trusted source of truth” matter?

Blockchain technology can enhance the internet - from an internet of knowledge and information sharing - to an internet of value and value exchange – where trust and security are “baked in”

Blockchain: There isn't just one

- There are 3 general categories of blockchains:
- Similar to the idea of internet vs. intranet web sites

- Public (full access by anyone)
- Permissioned (consortium)
- Private (i.e., within an organization)

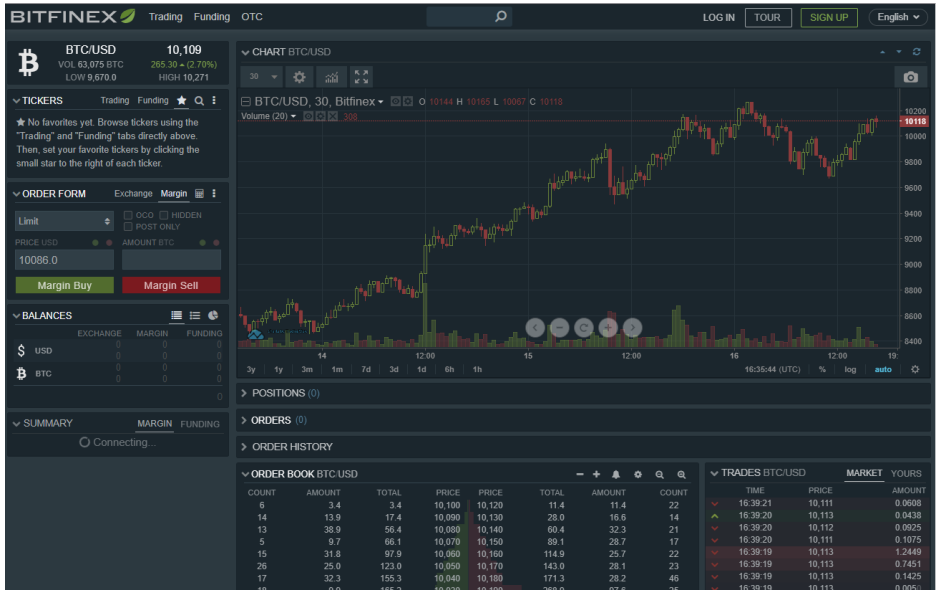
Blockchain: There isn't just one

- There are many different types / configurations of blockchains – with more being created every day
- Similar to the idea of using different operating systems (iOS, Android, Windows, Linux, etc.)
- Examples:
  - Bitcoin Blockchain
  - Ethereum Blockchain
  - Hyperledger Fabric
  - IOTA "Tangle"

Blockchain: A foundation for new ecosystems

- Blockchain technology can support a wide variety of unique use cases
  - Decentralized file sharing, Digital asset exchange, Real estate transactions, Proof of authorship, Laboratory / pharmaceutical asset tracking, etc.
- Examples:
  - Bitcoin - single purpose - exchange and store value
  - Ethereum - distributed application platform
    - i.e., an app store for blockchain-based apps (dApps)
      - Offers custom tokens, smart contracts, etc.

Blockchain: A foundation for new ecosystems



#	Name	Market Cap	Price	Volume (24h)	Circulating Supply
1	Bitcoin	$170,881,820,826	$10,130.30	$8,246,650,000	16,868,387 BTC
2	Ethereum	$91,748,367,603	$939.53	$2,655,990,000	97,653,577 ETH
3	Ripple	$44,311,348,455	$1.14	$720,047,000	39,009,215,838 XRP *
4	Bitcoin Cash	$25,685,740,372	$1,513.51	$887,929,000	16,970,975 BCH
5	Litecoin	$12,903,974,027	$233.58	$1,456,610,000	55,244,108 LTC
6	Cardano	$10,514,178,988	$0.405529	$206,724,000	25,927,070,538 ADA *
7	Stellar	$8,320,551,289	$0.451283	$67,302,500	18,437,546,483 XLM *
8	NEO	$8,268,325,000	$127.21	$193,756,000	65,000,000 NEO *
9	EOS	$6,749,271,805	$10.02	$283,330,000	673,418,723 EOS *
10	IOTA	$5,836,040,759	$2.10	$51,454,100	2,779,530,283 MIOTA *

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The Blockchain Token: Unit of value exchange

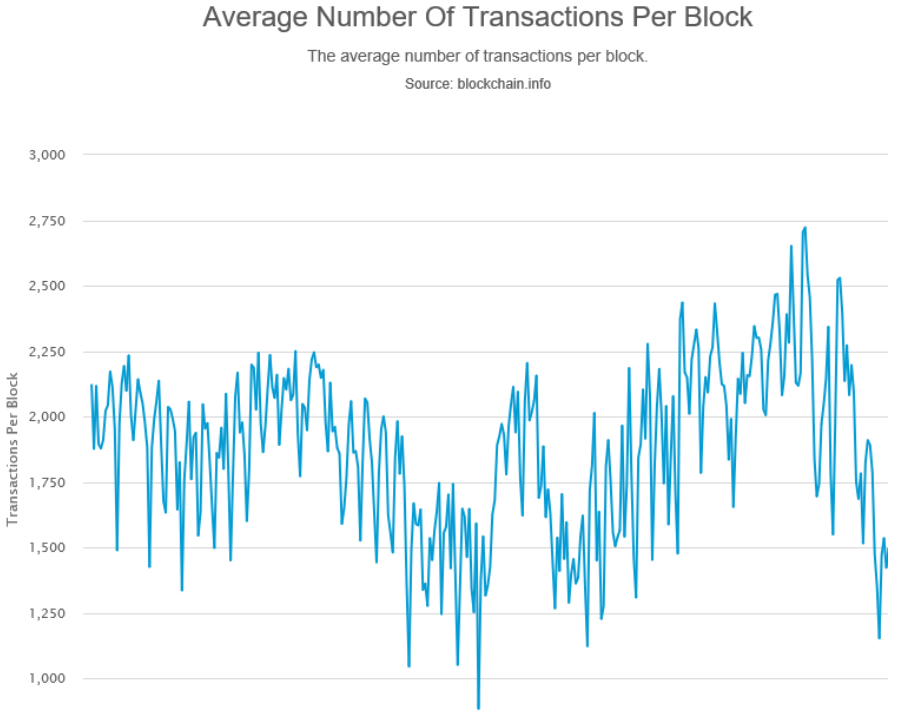
- Public blockchains (almost always) leverage a token
  - (not required with private/permissioned blockchains)
- A token (i.e., digital asset) can be many things…and have different purposes:
  - Digital Currency
  - To support the creation of a “marketplace”
    - A unit of value – to be exchanged within distributed app ecosystem
  - Initial Coin Offering (ICOs) – to be exchanged for fiat currency (e.g., USD)
  - Proxy for physical asset
  - Exchangeable for other digital assets / fiat currencies
    - Coinbase, Kraken, Bitfinex, Bittrex, Binance, etc.

Using the Blockchain: making a transaction

- What is involved in a transaction event recorded on blockchain?
  - Unique Sender
    - Wallet (can be explicit or hidden from the user)
      - Contains Public Key – to receive & Private Key – send
  - Transaction Data (i.e., the data packet / metadata)
    - Financial asset, activating a change in rights to view or access a digital or real world asset
  - Receiver
    - Unique (most often) or multiple (i.e., automated by a “smart contract”)
    - Wallet (can explicit or hidden….same as sender)

Using the Blockchain: the transaction – a deeper look

- Inherent to a standard blockchain- every transaction is stored…every one…forever.
- With, for example, the public (Bitcoin) blockchain – transactions are grouped and processed in blocks (thousands of transactions)
- Blocks are then tied together with 1-way digital fingerprints (cryptographic hashes)



Using the Blockchain: the transaction – a deeper look

- Transactions take time (which varies based on the blockchain type/platform)
  - Huge area of development / activity to improve transaction efficiency
  - There are significant challenges which need to be rapidly overcome (e.g., projects: plasma, lightning network)
- Transactions can have fees (for public blockchains)
  - to prevent spam, misuse of resources
  - e.g., Ethereum requires “Gas”
- All transactions require validation (consensus protocol)
  - Many types
  - Also, a very rapidly evolving area

Blockchain: Validation (have you heard of mining?)

- Blockchain technology elegantly leverages computer science, mathematics, cryptography, & game theory
- For a public blockchain – the goal is to incentivize unknown, untrusting participants to work with the system and not try to break it

Blockchain: Validation (have you heard of mining?)

- There are many types of consensus protocols
  - Proof of Work – classic but incredibly costly (electricity, etc.)
    - Mining – Competing to solve a computationally intensive problem to validate transaction
      - GPU, ASIC (Application Specific Integrated Circuit),etc.
    - With the winner of the competition receiving a financial reward
  - Proof of Stake – Ownership
  - Proof of Authority
  - Proof of Space-Time
  - Proof of Capacity
  - Proof of Elapsed Time (e.g., Intel)
  - With more being studied and tested every day

Blockchain: Quick recap and breather….

- Blockchain doesn't solve every problem
- Most useful "***when loosely coupled distinct organizations / entities want to confidently share and audit information and automate mutually beneficial processes***"
- Removes the need for intermediaries – and thus gives control back to the users / original data / asset owners
- Provides a source of truth / trust between untrusting participants

Blockchain: Where is it ideal?

- It excels in 3 general types of activities in a non-centralized / distributed environment:
  - Tracking and Tracing of Assets / Value
    - i.e., chain of custody (provenance)
  - Data Exchange
  - Automation of operational processes

Blockchain: Once last piece – “the data”

- Important issue:
  - Can / should I put all my data on the blockchain?
    - No, no and no…
  - You will hear the terms “on chain” and “off chain”
    - Remember- what you put on the chain is replicated to all the nodes
      - It’s important to keep the blockchain light…

Blockchain: Once last piece – “the data”

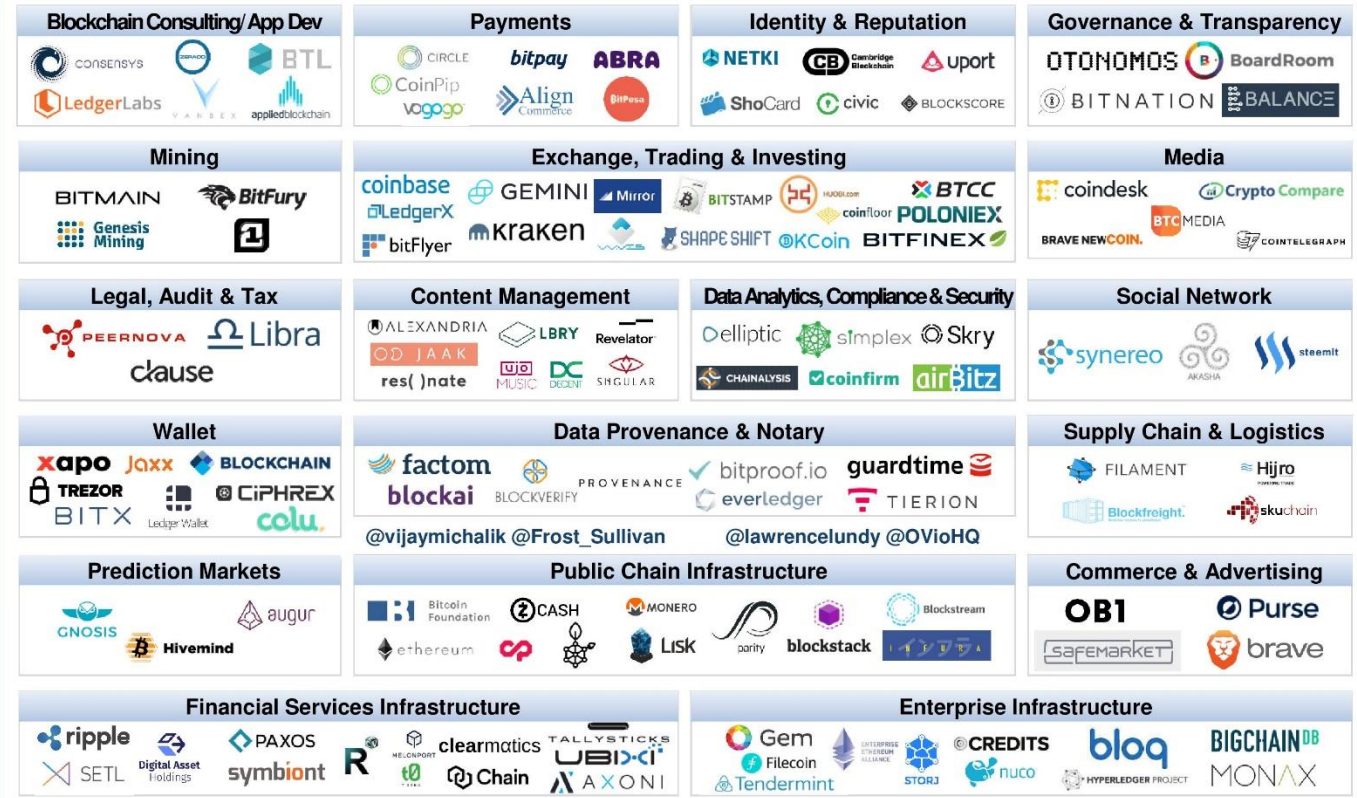
- There are other “on chain/off chain” issues to consider:
  - Privacy / Transparency
    - PII, etc.
  - Storage Capacity Issues (IPFS, Minio, etc.)
    - Large files: e.g., chest x-rays, etc.
- This issue must be carefully evaluated for each unique blockchain implementation

Important Note: It is possible to link off-chain data (encrypted PII, large files, etc.) to the blockchain – and ensure data integrity (via digital fingerprint / cryptographic hashing)

Blockchain: Its impact on the digital global economy

- Accounting
- Digital Identity
- Smart Contracts
- Data Provenance
- eGov
- Supply Chain Management
- Internet of Things (IoT)
- Trade Finance
- Clearing And Settlement

Blockchain Startup Landscape



FROST & SULLIVAN

OUTLIER•VENTURES

Blockchain: Its impact to Healthcare

- Identity Management – Patients, Providers
- Medical Record Management
- Medicaid Management Information Systems
- Benefits Administration
- Data Security
- Reimbursement
- Clinical Trial Management
- Pharmaceutical Supply

Healthcare Data Infrastructure
(e.g., Blockchain-as-a-Service)

DeepMind Health
burstIQ
HYPERLEDGER
pokitdok
BITMARK
HASHED HEALTH
HEALTHCOMBIX
BLOCKCYPHER
LUNA
BlockchainHealth
factom
ENCRYPGEN
SHIVOM
HIT Foundation
Gem
bloq
TIERION
HealthLinkages
Microsoft Azure Blockchain as a Service
Curisium

Electronic and Patient Health Records

guardtime
MEDREC
hearthy
YouBase
IRYO
mint health
HEALTH WIZZ
MEDICALCHAIN
BLOCK M.D.
MEDIBLOC

Healthcare Analytics

doc.ai
OpenMined
enigma
ASTRI

Med Device & IoT Security

NEUROMESH Managed Security & Intelligence
Spiritus

Identity

HASHED HEALTH
NETKI
CHRONICLED
BRON.TECH
accenture

Supply Chain
(e.g., Pharma)

BLOCKPHARMA
TheLinkLab
CHRONICLED

Digital Medicine & Care Delivery

PointNurse
healthcoin
patientory
BOWHEAD
ScalaMed
simplyvital health

Advisory, Dev Shop & More

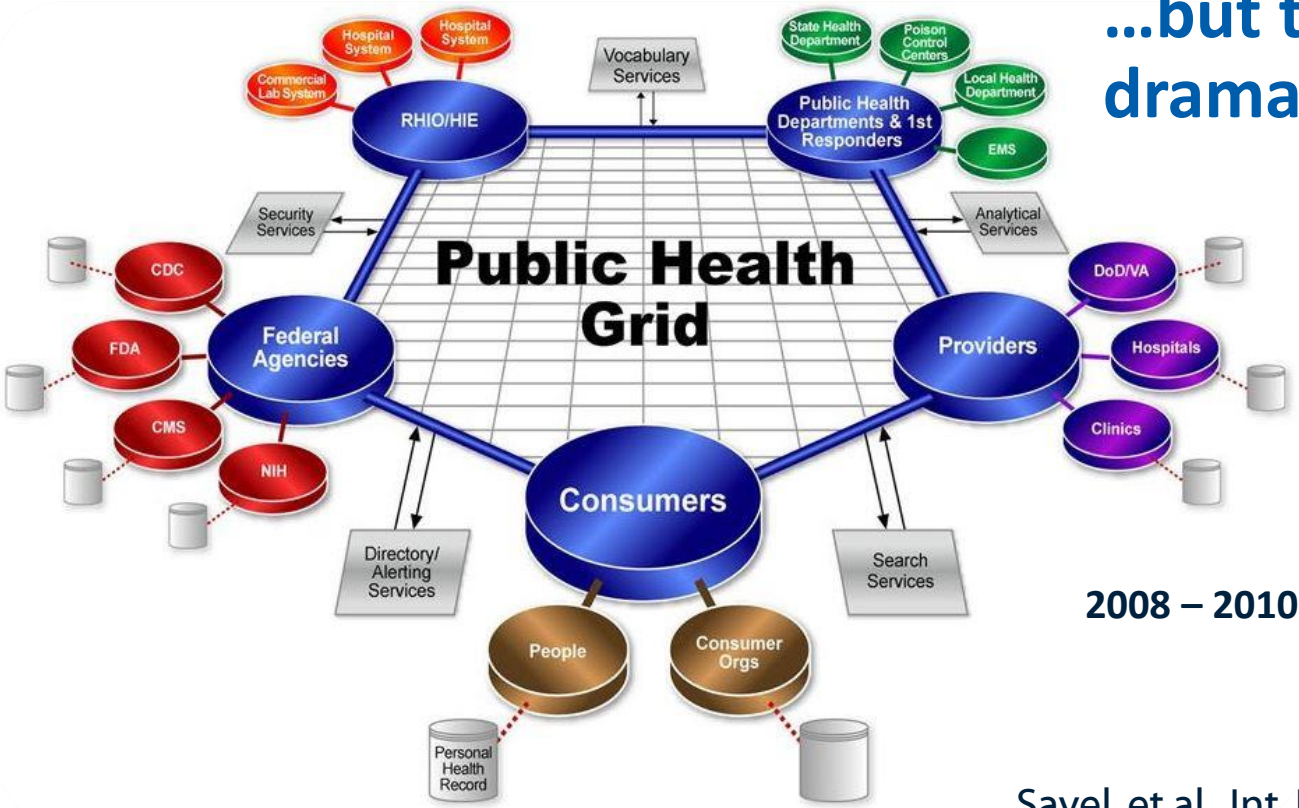
CONSENSYS
HASHED HEALTH
CHRONICLED
TheLinkLab
Chemonics

Blockchain: What about public health?

- Blockchain technology can impact public health at many levels:
  - CDC
    - Within & between programs
      - Examples: laboratory, countermeasure tracking, surveillance and other data…
      - Prototypes…
    - Between programs and partners
  - The entire Public Health Community (as a consortium)
    - Federal, State, Local, etc.

Blockchain & Public health: The vision hasn't changed…

…but the technology has dramatically matured



2008 – 2010: PHGrid

Savel, et al. Int J Med Inform. 2010 Jul;79(7):523-9

Blockchain: What about public health?

- Blockchain technology can impact public health at even more levels (in time):
  - Public Health / Clinical Healthcare Exchange
  - Health research data
  - Connections to other health and non-health related blockchains:
    - Financial, pharmaceutical, food supply blockchains

Blockchain: What about public health?

- Many use cases to consider (with varying levels of effort & numbers of stakeholders)
  - Surveillance / Monitoring
    - Event detection, situational awareness, notifiable condition reporting, surveillance / vital statistics, specimen tracking / results reporting, outbreak management
  - Interventions
    - Response management, inventory allocation and distro., resource utilization (hosp. beds, etc.)

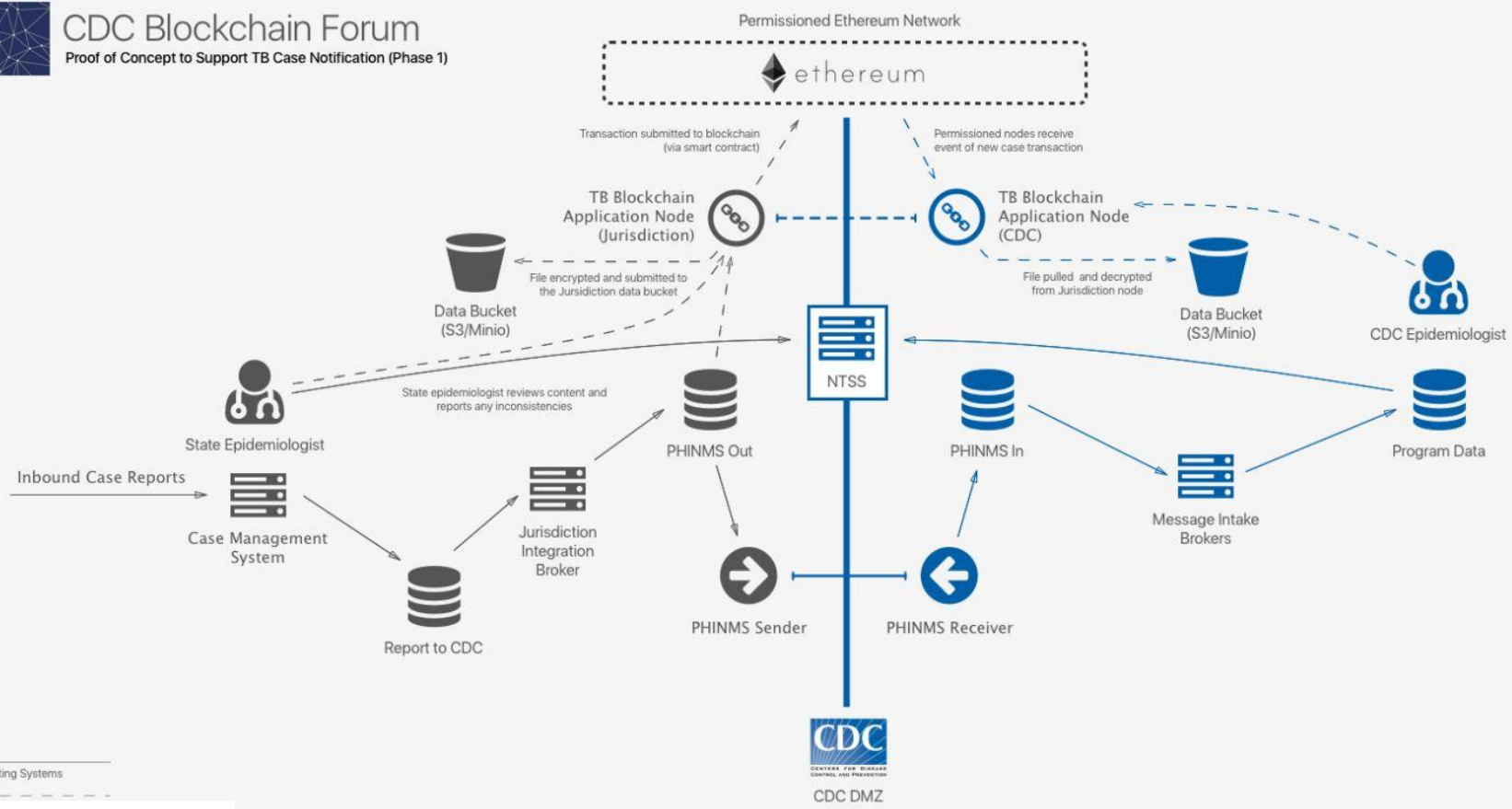
Blockchain: What about public health?

- Many use cases to consider (with varying levels of effort & numbers of stakeholders)
  - Prevention
    - Vaccination campaigns, wellness programs, health awareness campaigns
  - Communication / Alerting
    - Health alerting, decision support, public communications, health training and communications

TB Blockchain Proof of Concept

CDC Blockchain Forum

Proof of Concept to Support TB Case Notification (Phase 1)



Last updated 06/27/2018
Rishi Tarar & Drew Morris

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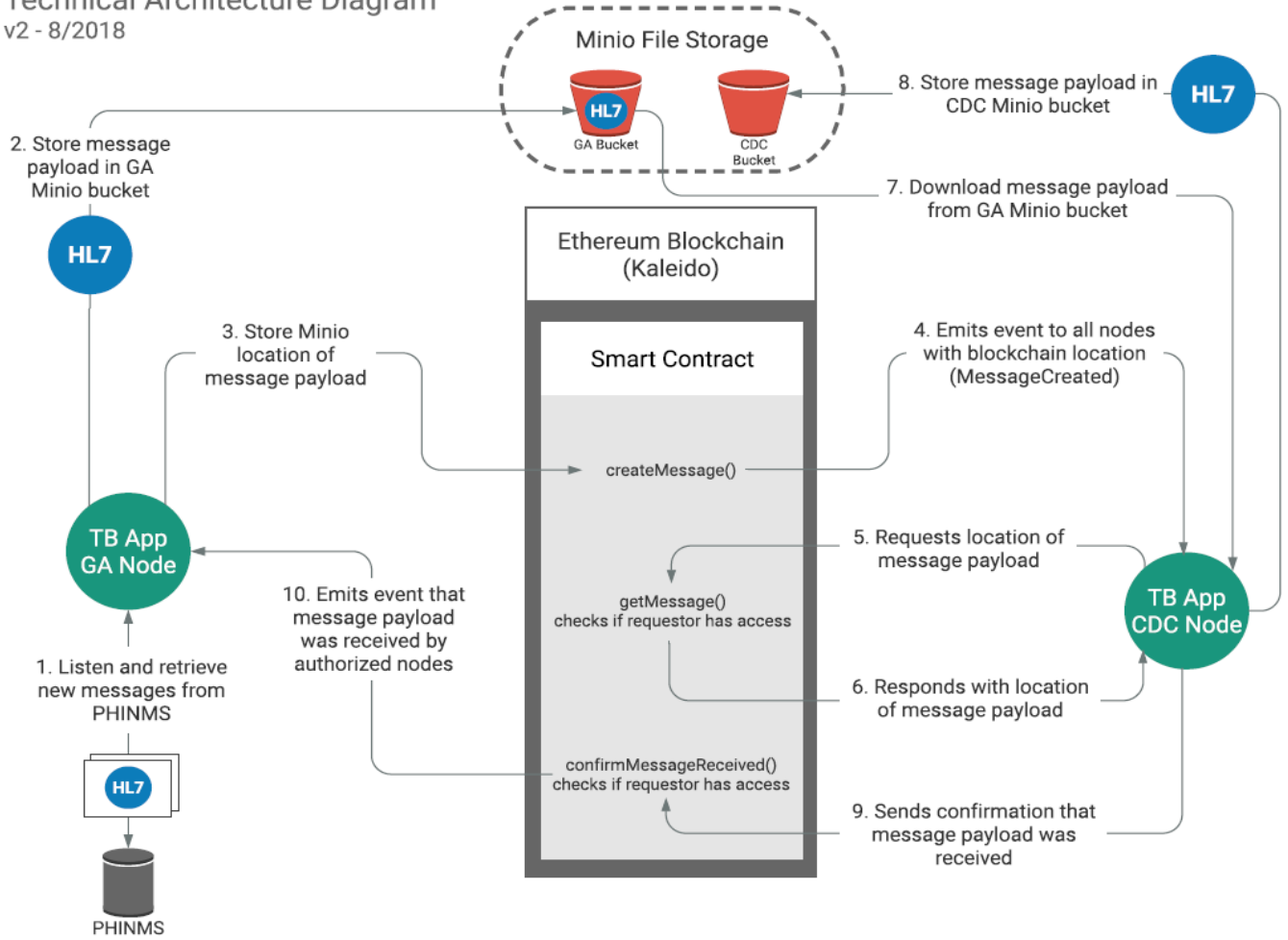
TB Blockchain
Technical Architecture Diagram
v2 - 8/2018



	Name	Created By	Time Created	Received By	Time Received		
1	gorgeous_cotton_tuna_internal_deliver.txt	FL	8/6/2018 2:57:56 PM	CDC	8/6/2018 2:58:06 PM		
2	markets_tuna.txt	FL	8/6/2018 2:42:56 PM	CDC	8/6/2018 2:43:06 PM		
3	berkshire_product.txt	FL	8/6/2018 2:27:56 PM	CDC	8/6/2018 2:28:06 PM		
4	games.txt	FL	8/6/2018 2:10:26 PM	CDC	8/6/2018 2:10:36 PM		
5	black_alarm_web_readiness.txt	GA	8/6/2018 2:10:06 PM	CDC	8/6/2018 2:10:16 PM		
6	quality_models_officer.txt	GA	8/6/2018 1:55:31 PM	CDC	8/6/2018 1:55:41 PM		
7	24/365_key_gorgeous_plastic_tuna.txt	FL	8/6/2018 1:55:26 PM	CDC	8/6/2018 1:55:36 PM		
8	outdoors_sdd_bedfordshire.txt	FL	8/6/2018 1:40:26 PM	CDC	8/6/2018 1:40:36 PM		
9	projection_west_virginia.txt	GA	8/6/2018 1:40:01 PM	CDC	8/6/2018 1:40:11 PM		
10	generating_small_frozen_soap_data.txt	FL	8/6/2018 1:25:26 PM	CDC	8/6/2018 1:25:36 PM		
11	communications_graphic_interface.txt	GA	8/6/2018 1:25:01 PM	CDC	8/6/2018 1:25:11 PM		

Blockchain: Challenges

- The challenge is that the shift to blockchain is a fundamental change on many levels
  - Historically:
    - Centralized system
    - Single point of failure
    - Manual Processes
    - Sending / Receiving data “messages”

Blockchain: Challenges

- The challenge: the shift to blockchain is a fundamental change

  Decentralized / Distributed data / value exchange ecosystem

  Control is given back to the data owner / stakeholder

  Increased transparency

  Increased Security

  Post/Link data to blockchain – not to specific stakeholders

  Automated Processes

  Improved Efficiency

  Works well with microservices

  Enhanced Metrics

  Permanent longitudinal record / log

Blockchain: Next steps

- All of us need to become familiar with the technology
  - What does it does well? What are its limitations?
  - Understand which blockchain tools and resources best fit with public health use cases
  - How does blockchain tech. fit into the larger picture of an ecosystem of services
- Continue to explore new and existing use cases and implement small pilot projects
- Gradually implement and expand successful blockchain solutions

Blockchain: Next steps

- Overall Goals:
  - Reduce costs & Improve efficiencies
  - Improve transparency and security
  - Make blockchain-based solutions invisible to the users----
    - IT JUST WORKS (just like our phones)
    - “If users see cryptographic hashes- we have failed”

Thank you!

Questions?

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For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

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