“The optimist thinks this is the best of all possible worlds. The pessimist fears it is true. ”

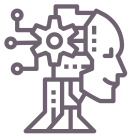
— J. Robert Oppenheimer

THE COMPONENTS OF THIS WORLD

Blockchain and distributed ledgers

Digital Assets

Smart Contracts



Artificial Intelligence

Regulations and laws

- SROs – Self Regulatory Organizations
- Regulatory Bodies – SEC, FED,OCC, FINRA, CFTC , MiCA, AFME, MAS etc.
- Legislative bodies
- Law enforcement – AML, KYC, FinCEN, OFAC etc.

Geo- Politics

- Monetary policy and influence
- Reserve currency
- Rules of trade

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WHAT ARE DIGITAL ASSETS

Cryptocurrencies

- No centralized trust
- Volatile
- Easy cross – border movement
- Not clearly regulated
- (E.g.: Bitcoins, Ethereum etc.)

Stable coins

- Pegged to fiat currency
- Regulatory implications unclear
- Can make DVP transactions easier on the chain

Central bank digital currencies

- Issued by central banks
- Regulatory implications unclear
- Can make DVP transactions easier on the chain

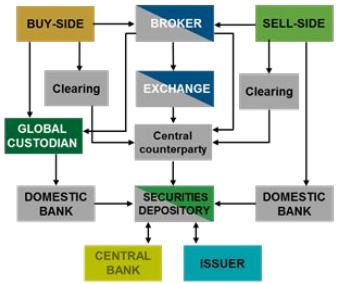
Tokenized securities

- Operational efficiencies
- Access to new markets (e.g., fractionalization)
- Reduction in risk
- Better Audit
- Cost of running two networks

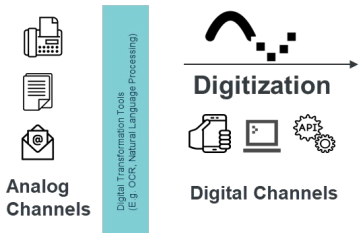
Digitally native securities

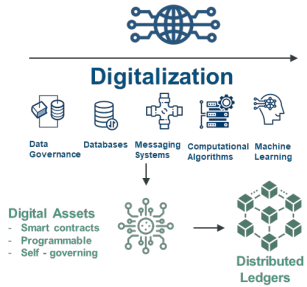
- Most cost – effective
- Can be well regulated
- Operational automation
- Disintermediation of central depository

COMPLEXITY OF CURRENT SYSTEMS



DIGITIZATION VS DIGITALIZATION





BLOCKCHAIN

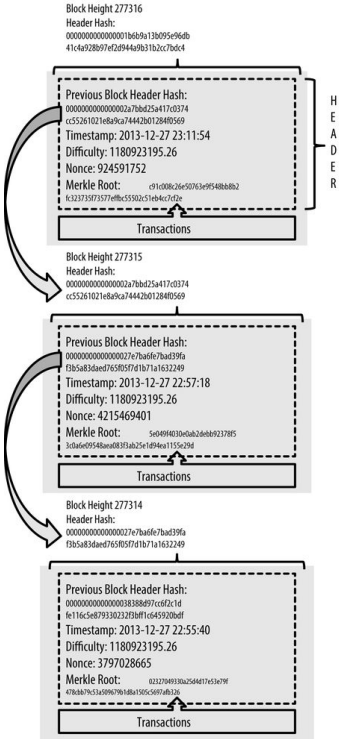
Blockchain - A cryptographically linked set of blocks containing data which may represent transactions

Decentralized - There is no central trusted arbitrator to reconcile any disagreements, deceptions and differences between copies of the blockchain

Consensus - An algorithm that is used to reconcile such differences without the need for a central trusted arbitrator

The consensus mechanism needs to answer the following questions:

- Who can change the past, and how? (This is also known as immutability.)
- Who can change the future, and how? (This is also known as finality.)
- What is the cost to make such changes?
- How decentralized is the power to make such changes?
- Who will know if something has changed, and how will they know?



MINING

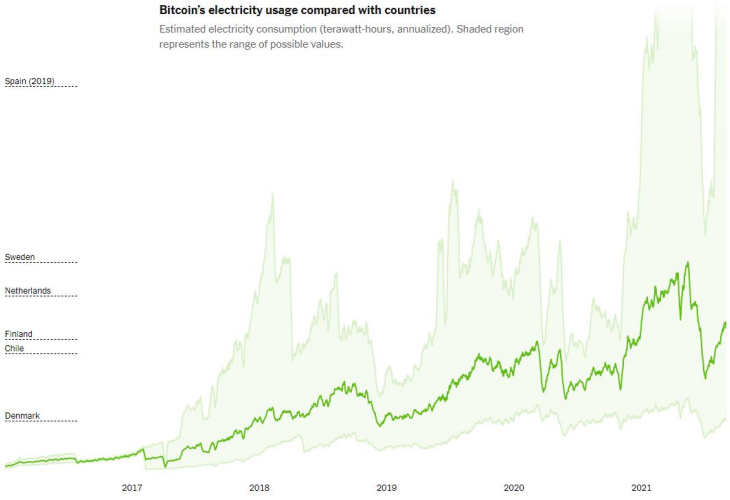
Mining is a type of consensus algorithm. The general principle of mining is to impose a cost for fraud (or mistakes). The cost should be high enough so that there is a disincentive to add incorrect or fraudulent blocks.

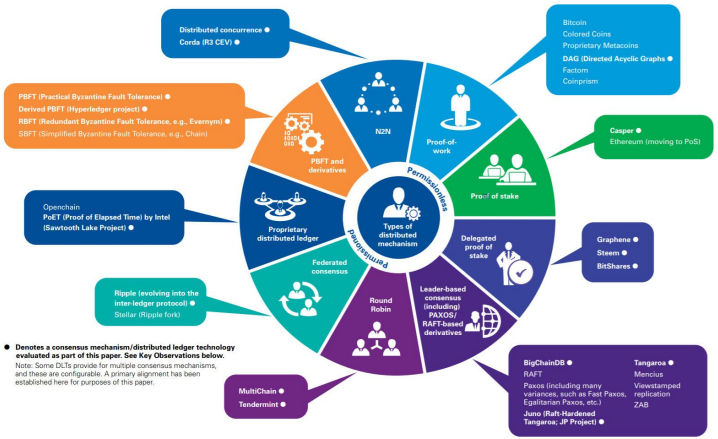
There are two common approaches for imposing the cost:

a) Proof or Work: This cost is external to the network. It is usually the cost of energy needed to solve difficult mathematical puzzles.

b) Proof of Stake: This cost is internal to the network. It is usually the loss of value of assets that a validator has to “stake” . The reasoning being that validators will refrain from fraudulent or sloppy work if it results in the loss of their assets.

Proof of work is extremely energy intensive; proof of stake is much less so. Bitcoin and Ethereum use proof of work, but Ethereum is in the process of changing to a proof of stake mechanism.





THE PROBLEM OF TURING COMPLETENESS

- A mathematical model for most practical computers and languages
- Most business applications need a Turing complete language
- Turing complete languages have a “halting problem” (they can get into infinite loops)
- Ethereum’s ability to execute a stored program, in a state machine called the Ethereum Virtual Machine, while reading and writing data to memory makes it a Turing-complete system
- Ethereum’s groundbreaking innovation is to combine the general-purpose computing architecture of a stored-program computer with a decentralized blockchain, thereby creating a distributed single-state (singleton) world computer. Ethereum programs run “everywhere,” yet produce a common state that is secured by the rules of consensus.
- To fix the halting problem Ethereum introduced “gas”
- DAPPs (Distributed Apps – Smart contract + interface)

SMART CONTRACTS

They're not contracts and they're not that smart, but they are:

A trusted, shared process

Potentially huge gains in operational efficiency.

A path to automation

Eliminating reconciliation and the attendant negotiations eliminates a LOT of friction.

DECENTRALIZED FINANCE

- Peer-to-peer financial services
- The terms of the financial contracts are coded in smart contracts
- Protocols – smart contracts that implements the rules of a particular financial product.
- Example: Aave – Allows users to provide liquidity and borrow assets based on smart contracts in the Aave network.

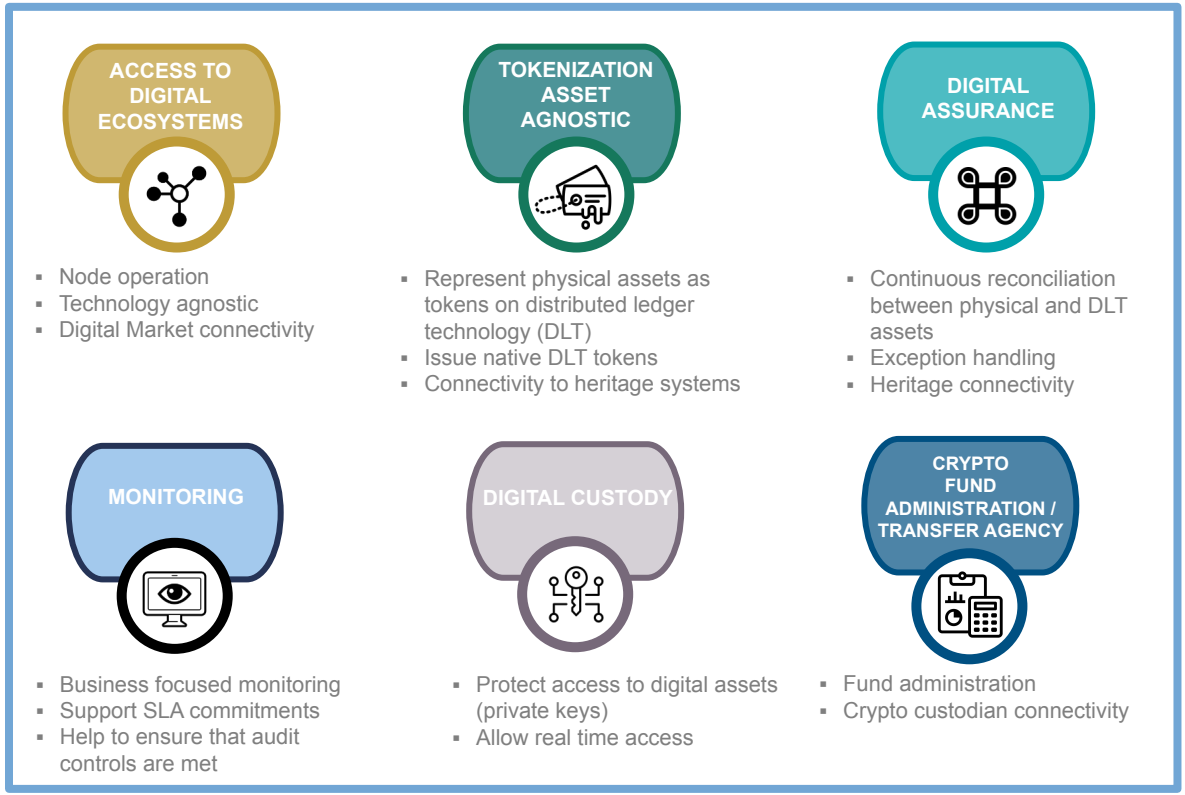
The promise

- Low barrier to entry for financial products (example: Fractionalization, Lending, Real estate etc.)
- Control of the rules of interaction is not monopolized by large institutions with capital to invest in infrastructure
- Instantaneous settlements (risk reduction)
- Greater security

Challenges

- Protocols are only as good as the smart contracts (code)
- Multiplication of scams. Example: “Rug pulls”
- Regulatory clarity
- Volatility

DIGITAL ASSET STRATEGIC CONSIDERATIONS FOR FINANCIAL INSTITUTIONS



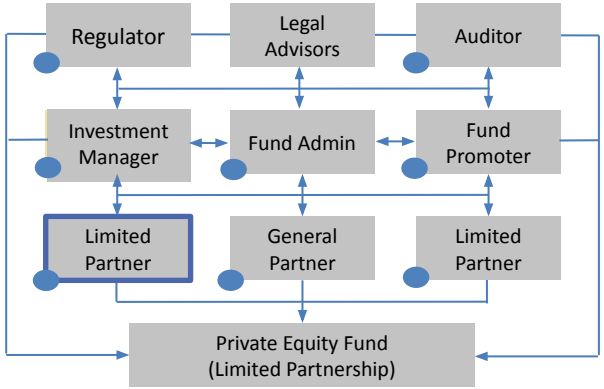
Financial services will continue to enhance in-house digital asset capabilities in relation to digitally native securities and asset tokens.

Cryptocurrency custody capabilities will be needed to compliment this strategy.

CASE STUDY , NORTHERN TRUST, PRIVATE EQUITY

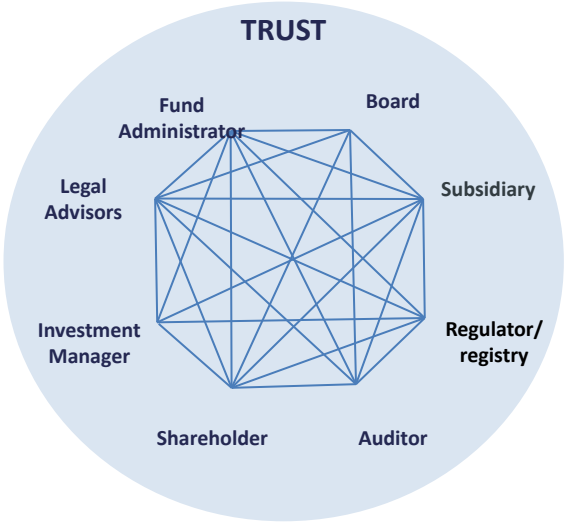
.....a collaborative platform delivering increased efficiency, security and transparency.

LEGACY STRUCTURE



= **Entity has a full or partial copy of the fund register**

BLOCKCHAIN STRUCTURE



TODAY	TOMORROW
• Time consuming administrative processes • Challenge to support Board best practice • Lengthy and fragmented business activities	• Governance records on a single platform • Real-time insight and transparency to all parties • Compliant with legal and governance codes assisted by Smart contracts

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CASE STUDY - NORTHERN TRUST AND BONDEVALUE - FRACTIONALIZATION

BondEvalue and Northern Trust Collaborate to Complete World's First Blockchain-based Bond Trade – Press release, August 2020

- BondEvalue's platform combines the power of distributed ledger technology (DLT) to enable enhanced transparency, liquidity and faster settlement, while making institutional grade investment opportunities available to new classes of investors.

- Northern Trust is providing securities services for the wholesale bonds and will support receipt of investments and payments of redemptions for the platform in a wide array of currencies. In what is believed to be a first for the industry, Northern Trust has built the market leading capability to communicate cash & securities settlement reporting directly to BondEvalue's DLT platform via an application programming interface (API).

CASE STUDY - NORTHERN TRUST AND STANDARD CHARTERED – CRYPTO CUSTODY

Standard Chartered and Northern Trust Partner to Launch Zodia, a Cryptocurrency Custodian for Institutional Investors – Press Release, Dec 2020

- SC Ventures, the innovation and ventures unit of Standard Chartered, and Northern Trust, a leading provider of asset servicing, launched Zodia Custody, an institutional-grade custody solution for cryptocurrencies.

- Zodia combines the traditional custody principles and expertise of a bank with the agility of a fintech company to provide an infrastructure that meets the high standards and expectations of institutional investors through a platform that adapts to the changing needs of clients and the market.

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TRUST