

Automating Trust Playbook

PwC Labs | AI and Emerging Technology
September 2021

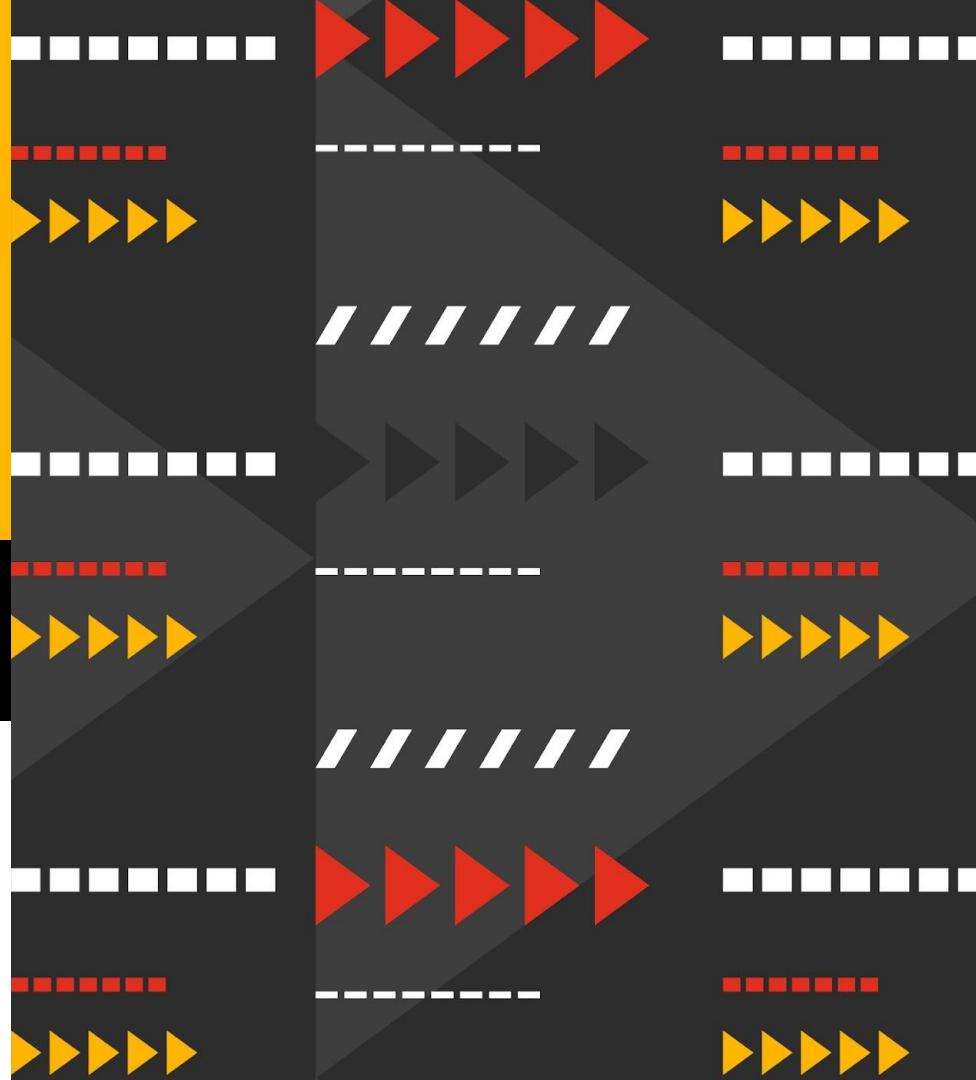


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How we arrived at automating trust

PwC analyzed more than 250 emerging technologies to pinpoint what we call the “**Essential Eight.**” These are the technologies we believe every organization must consider as they invest in the future. While each company’s strategy for how to best exploit these technologies will vary, **these eight technologies will have the most significant global impact across industries -- today.**

By leveraging these technologies in tandem, organizations can enhance the impact and value of their investment. **Blockchain is the connective tissue** between disparate technologies and allows for secure transmission and use of data.

Extended reality	Automating trust	Immersive interfaces	Working autonomy	Digital reflection	Hyperconnected networks
Essential Eight Technologies					
 Artificial intelligence	 Artificial intelligence	 Artificial intelligence	 Artificial intelligence	 Artificial intelligence	 Artificial intelligence
 Augmented reality	 Blockchain	 Augmented reality	 Blockchain	 Augmented reality	 Blockchain
 Virtual reality	 Internet of Things	 Robotics	 Drones	 Blockchain	 Drones
 Internet of Things		 Virtual reality	 Internet of Things	 Drones	 Internet of Things
			 Robotics	 Internet of Things	
			 3D printing	 Virtual reality	

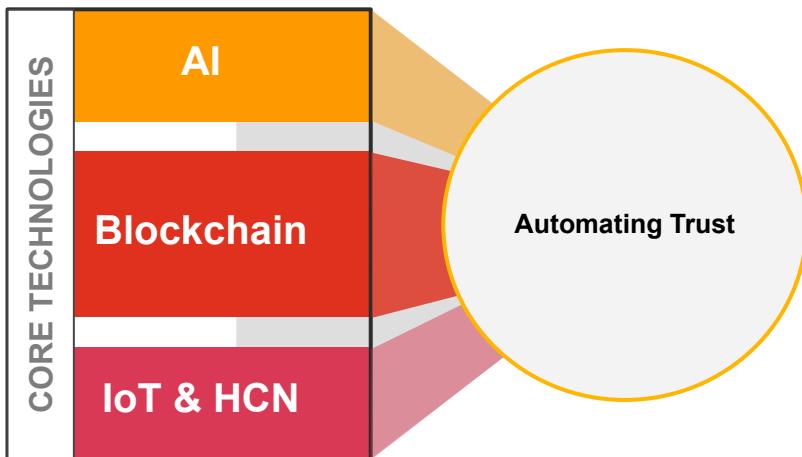
Overview of Automating Trust

Trust begins with agreed-upon, equitable and transparent human behaviors, while trust technology memorializes, enforces and enhances that trust.

Artificial Intelligence leverages blockchain networks for governance of data feeds and models while enabling blockchain ecosystems to learn autonomously.

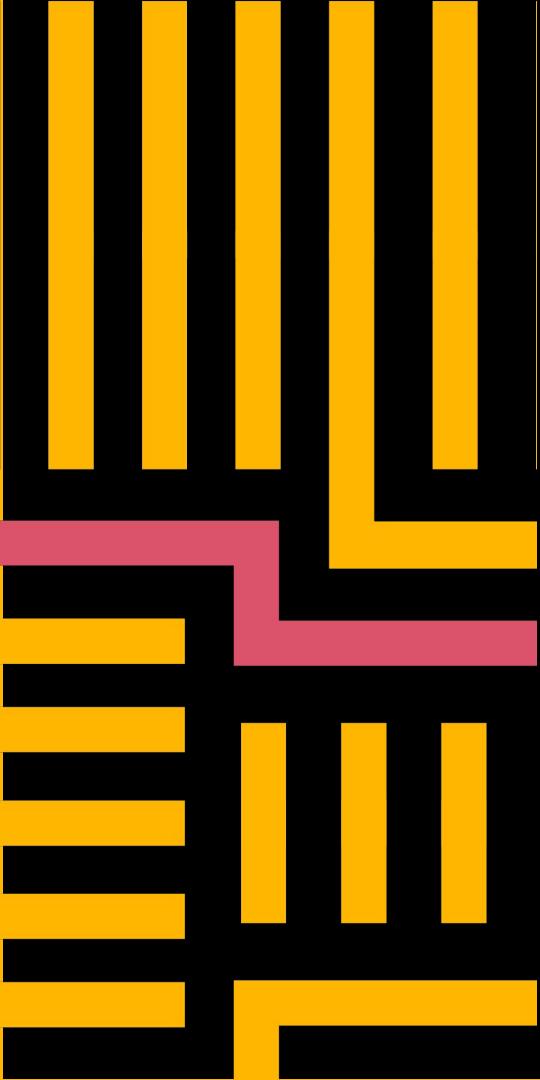
Blockchain services as a secure, immutable mechanism to drive consensus and transparency, in light of increasing amounts of data and complexity.

Internet of Things (IoT) / Hyperconnected Networks (HCN) enable the interaction of distributed ledgers and artificial intelligence models with real-world objects.



Our Automated Trust team focuses on defining, creating and deploying solutions that automate and authenticate processes, removing the need for central authorities and providing transparency for participants

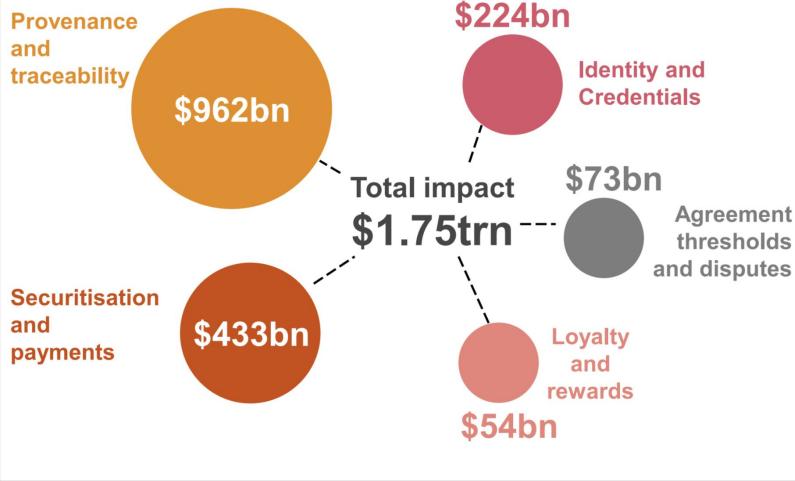
Market Size and Growth



Blockchain size and market growth



Blockchain has matured, is moving out of lab environments into production and transforming the way entities and ecosystems operate



Our simulation shows that applications of blockchain technologies can have an **economic impact equivalent to 1.4% of GDP in 2030.**
PwC's Global Blockchain Impact Report, 2019

\$125.34B

Invested in Crypto/Blockchain this year.
Pitchbook, September 2021

Net economic impact by sector, 2030

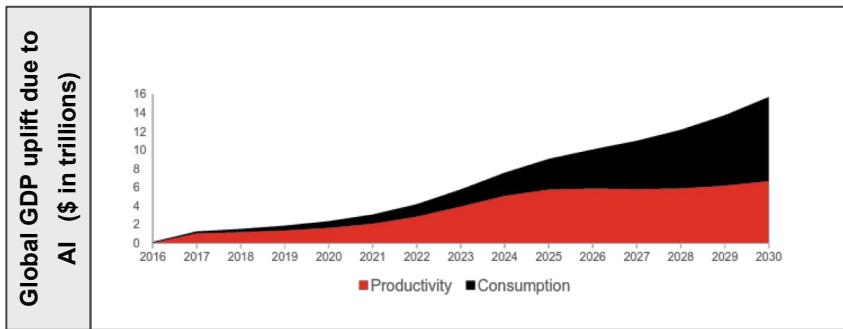
	\$574B	Public Admin, Education & Health
	\$325B	Business Services
	\$285B	Wholesale & Retail
	\$237B	Manufacturing
	\$49B	Agriculture, Mining, & Construction
	\$143B	Communications & Media
	\$116B	Financial Services
	\$28B	Transportation & Logistics

AI & Hyperconnected Networks market size



With significant growth projected in both AI and IoT markets, more industries will be impacted by these technologies and drive widespread adoption.

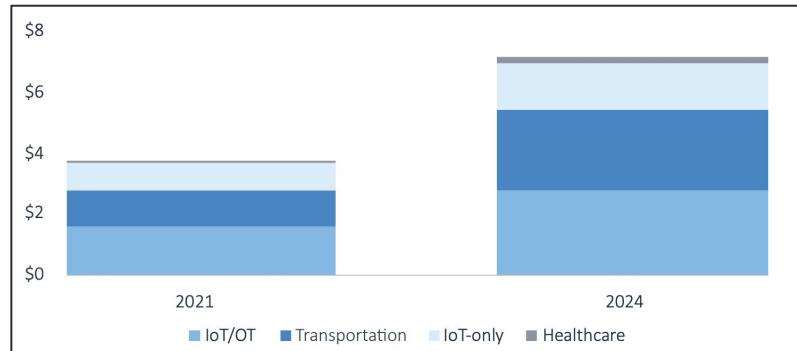
Global GDP Impact of AI through 2030



In the past 3 years, AI investment has increased by industry with more companies making initial and exploratory investments. Driving the pandemic, investments in workforce planning, simulation modeling, and contract tracking have all yielded a positive impact.

PwC 2021 AI Predictions

IoT security market size estimate (\$B) by use case



Although not as disruptive of a technology like AI, businesses are seeing improvements in their business processes and models with broadening capabilities and markets as a result of IoT adoption. Cybersecurity is a key hurdle needed to securely implement an IoT system, and pitchbook as investments doubling in the space over the next 3 years.

PwC IoT Report, Pitchbook

The crypto market consists of both newcomers and established organizations

Coinbase increased its user base 60% in one year: 35 million users in 2020 to 56 million users in 2021
Jan 2021

- Exchanges
- Storage holders
- Payment processors



- Industry Consortiums
- Individual developers and thought leaders
- Startup companies
- Innovative technology companies



HYPERLEDGER



Square not only owns over \$400m of Bitcoin - it is also building DeFi businesses, providing crypto grants, and developing a hardware wallet
July 2021

- Solving Industry-specific use cases
- Established companies solving long-held problems
- Large companies enabling the crypto ecosystem



AI & Emerging Technology | Automating Trust Playbook



- Central Bank Digital Currencies (CBDCs)
- Crypto payments
- Providing guidance and regulation



China's CBDC has been used for \$9.7B of transactions and 140 million people have opened wallets for its digital yuan, or "eCNY"
Nov 2021

- Venture capital investors
- Large companies purchasing crypto companies or cryptocurrency directly
- Individual Angel investors
- Other institutional investors (pensions, hedge funds, etc.)



Andreessen Horowitz (a16z) announced a \$2.2 billion fund to continue investing in crypto networks
June 2021

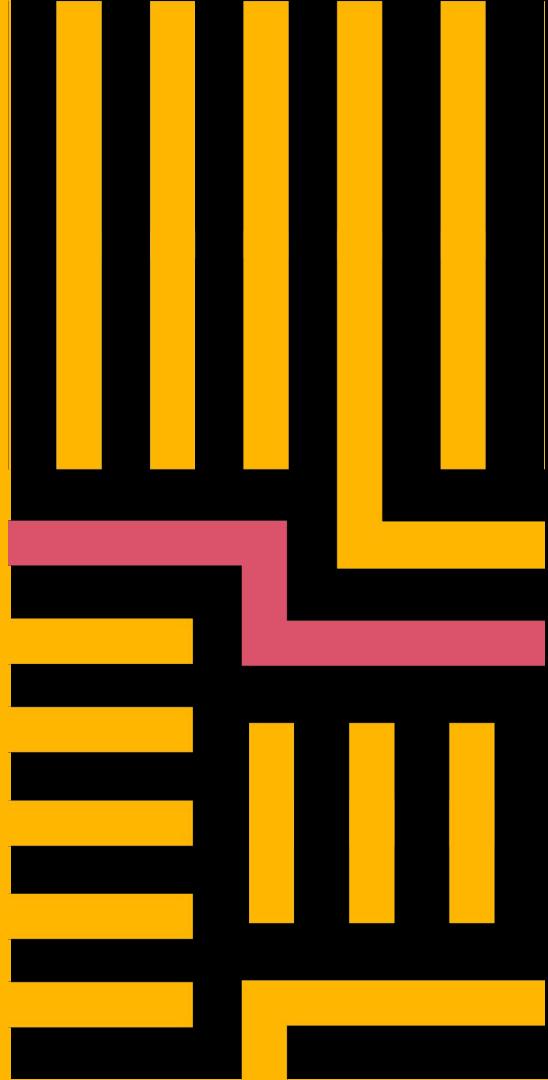
- Strategy consultancy firms
- Niche support services (crypto tracking)
- Increased visibility of ecosystem
- Research firms



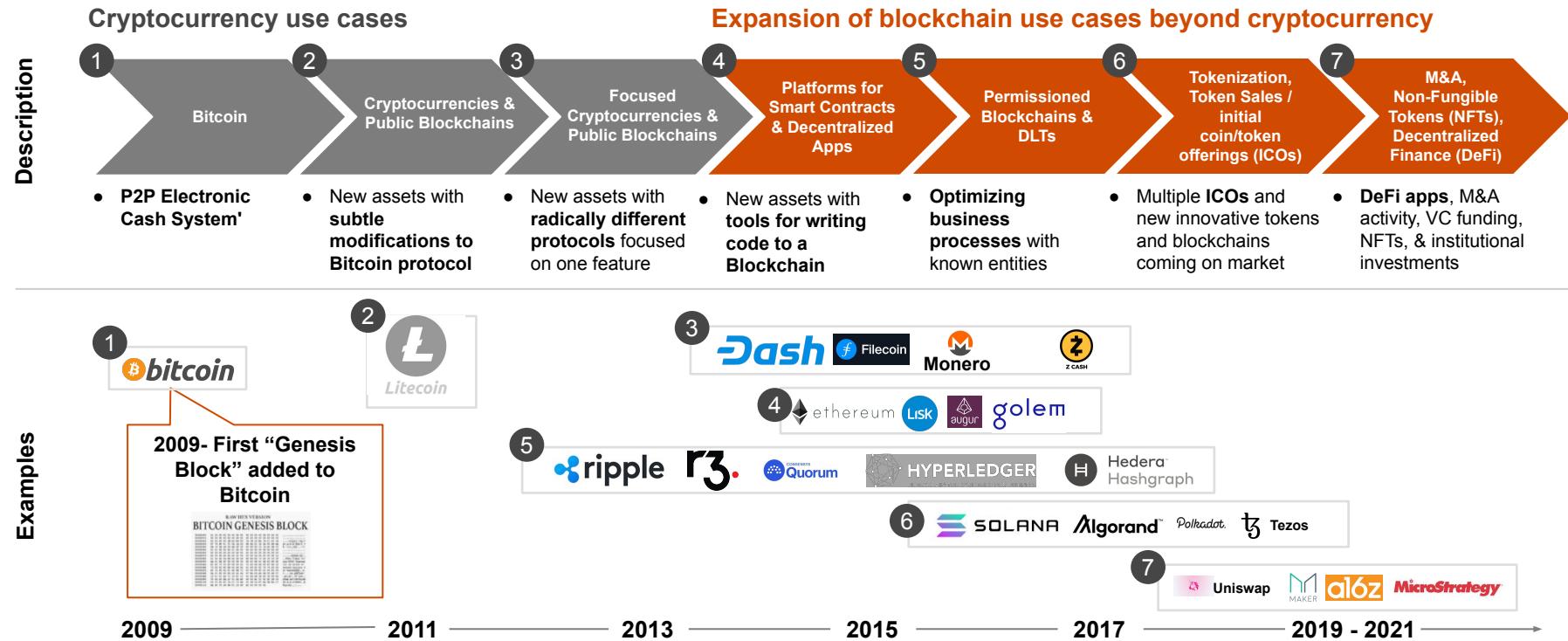
EY is investing \$100m to fund blockchain & crypto initiatives
May 2021

SECTION 1

Automating Trust Overview & Business Considerations



Blockchain is core to Automating Trust, and it has significantly evolved since 2009



How blockchain works

Technical concepts



Distributed ledger

Every participant in the network has simultaneous access to a view of the information



Consensus

Verification is achieved by participants confirming changes with one another, replacing the need for a third party to authorize transactions



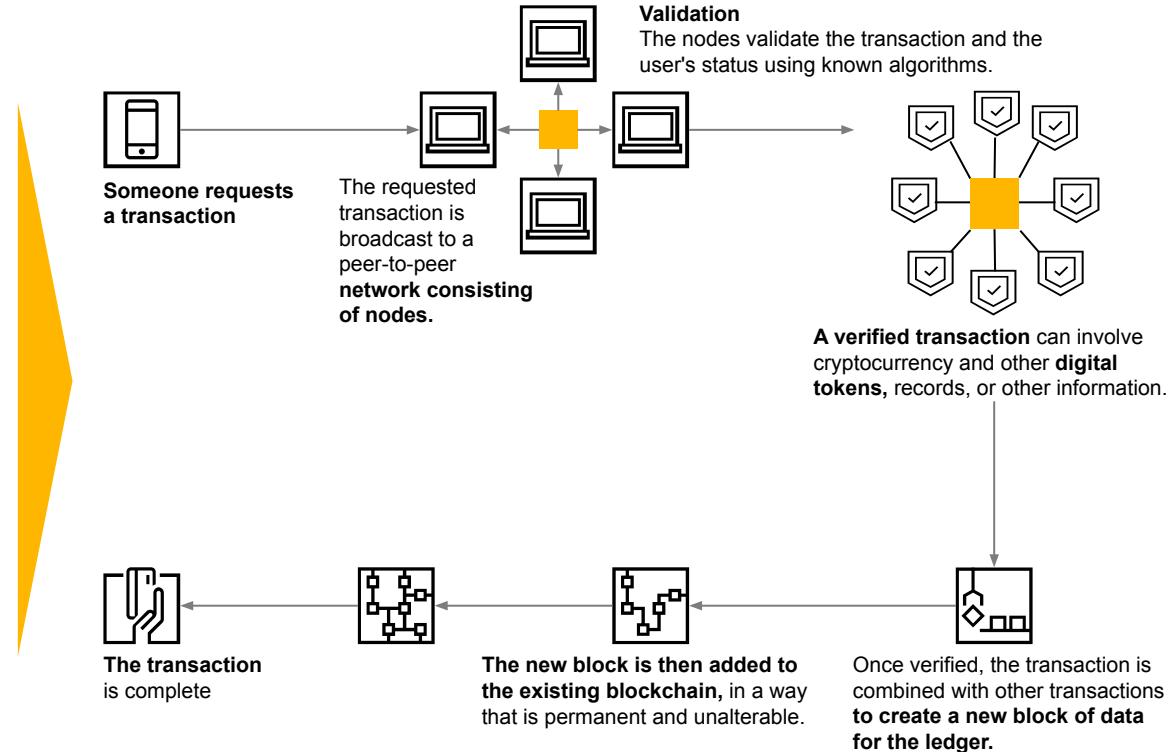
Cryptography

Integrity and security of the information on the blockchain are ensured with cryptographic functions



Smart contracts

The ability to run additional business logic means that agreement on expected transaction behaviors can be embedded in the blockchain



Blockchain makes sense in a variety of common situations



Multiple parties share data

multiple participants need views of common information



Multiple parties update data

multiple participants take actions that need to be recorded and change the data



Requirement for verification

participants need to trust that the actions that are recorded are valid



Intermediaries add complexity

removal of intermediaries can reduce cost and complexity



Time sensitive interactions

reducing delay has business benefits



Transactions interact

transactions created by different participants depend on each other

Benefits of blockchain solutions



Reduction of costs & complexity



Shared trusted transactions



Reduction of fraud



Audit trail & transparency



Security & Immutability



Resilience

Blockchain themes span both enterprise and crypto-specific use cases

Enterprise*



Supply Chain and Logistics

Tracking goods along their route to accurately estimate arrival time and collect data, as well as tracking asset condition



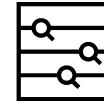
Records and Contract Management

Blockchains provide a mechanism for maintaining and updating contracts



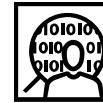
IP Management and Royalties

Managing contributions to a final product and subsequent royalties and other associated payments



Audit and Compliance

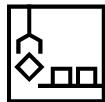
Enable real time transaction level assurance and provide additional transparency to stakeholders



Digital Identity Management

Authenticating identity on a blockchain for accelerated log in and increased data security

Crypto



Non-Fungible Token (NFTs)

Turning real-world or digital assets such as art or collectibles into a tradeable, digital token



Digital Currencies

Decentralized currency crosses borders and eliminates intermediaries; stablecoins can be used for making payments



Loyalty Programs

Turning loyalty points into cryptocurrency increases utility and value of loyalty programs



Decentralized Finance (DeFi)

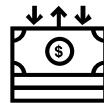
Provide decentralized applications ranging from lending, exchanges, derivatives, insurance, and asset management



Payments and Settlement

Accelerate the negotiation, payment, netting, and settlement of the financial payment process within and across borders; can also be done without crypto

What is Cryptocurrency?



Crypto currencies

Tokens with an attributed value for exchange/transactions, asset/value storage and/or unit of account



Utility tokens

Tokens offering access to platform and often used for supporting services/functionalities on blockchain-based platforms



Stablecoins

Tokens that provide underlying exposure to real world assets (e.g. cash, gold). Some stable tokens may be considered security tokens.



Security Tokens

Tokens with security characteristics, (e.g. equity, debt, derivative) with income generating component or potential rights vis-à-vis the issuer.



Non-fungible tokens

Tokens that are unique and cannot be interchanged with the scarcity verified without the need of a centralised organisation.



ethereum



vechain



STELLAR



CARDANO



TrueUSD



USD Coin



GEMINI



tether



PAXOS



VENTURE CAPITAL



22X



t ZERO



CryptoKitties



DECENTRALAND



crypto.com



Cryptocurrency “tokens” can be either fungible or non-fungible (NFTs)

Fungible

- Interchangeable
- Uniform
- Divisible



Fiat Currency



Precious Metals



Casino Chips



Bitcoin



Ethereum

Non-Fungible

- Not Interchangeable
- Unique
- Non-divisible



Fine Art



Physical



Show/Game Tickets



In-Game Skins/Collectibles (gaming)



Trademarks



Digital Certificates of Authenticity/Assets

Digital

NFTs are a transformative innovation that enable new use cases

- NFTs are digital assets owned by a single crypto wallet and verified using blockchain technology

Key Features

- Allow content creators and distributors to monetize digital content
- Are indicative of a larger trend towards smart contract platforms, like the Ethereum blockchain
- Can be enhanced with programmatic functionality, such as automatic royalty distribution
- Can represent anything digital
- Can be combined with DeFi (decentralized finance) use cases, such as collateralized loans

NFTs are uniquely serialized using cryptography, ensuring (to a mathematically certain degree) that others cannot recreate the same NFT. For example, the NFT shown to the right, which sold for \$69 million at a Christie's auction, can be cryptographically verified, but not recreated without the relevant private encryption key.



Marketplaces: Connect buyers and sellers, and manage the backend smart contract interaction.



Sellers: Content creators, owners, or distributors looking to monetize digital content.



Buyers / Collectors: The purchasing party.



Infrastructure: Additional frameworks and platforms that make use of NFTs or enable special use cases such as: collateral, collective ownership, index funds, and even tokenized insurance.



Games: Drive interaction and additional transactions.



The Metaverse: A collective shared virtual space being created that will make heavy use of verifiably owned digital assets.

Decentralized Finance (DeFi) is an emerging space in which open source applications and organizations are governed in a decentralized and autonomous manner, using public blockchain networks

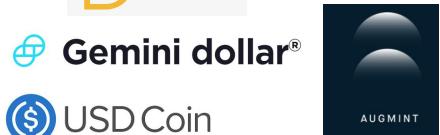
DeFi is largely considered consumer-centric in that it can reduce third party/bank fees and foreign exchange exposure, provide near-instant liquidity in global transactions, flexibility in the movement of assets, and provide cryptographic certainty of events, among other use cases. It has several primary characteristics which are defined below.

Autonomous	Transparent	Decentralized	Composable	Availability
<p>Programmed logic</p> <ul style="list-style-type: none">• No human intervention• Automatic smart contract execution	<p>Borderless</p> <ul style="list-style-type: none">• Global networks• Open source code• Public ledgers• Pseudo-anonymity	<p>Peer Managed</p> <ul style="list-style-type: none">• Sufficient node separation• No central decision-makers• Personal control	<p>Innovation</p> <ul style="list-style-type: none">• Open code development• Possible interoperability between protocols• Modularity	<p>Market Access</p> <ul style="list-style-type: none">• Available 24/7• Large community support• Instantaneous transactions

DeFi uses cases span across industries and technologies

Stablecoins

Digital assets whose values are pegged to a fiat currency, a basket of fiat currencies, or other stable-value assets. USDC and Tether are the largest.



Decentralized exchanges

Allow users to trade one digital asset for another. DeFi exchanges avoid taking custody of user assets.



Lending & Borrowing

Allow users to loan their cryptocurrency to other individuals and acquire interest on the loans.



Derivatives

DeFi derivatives connect buyers and sellers directly without the need for an intermediary.



Insurance

DeFi insurance provides protection against smart contract risk.



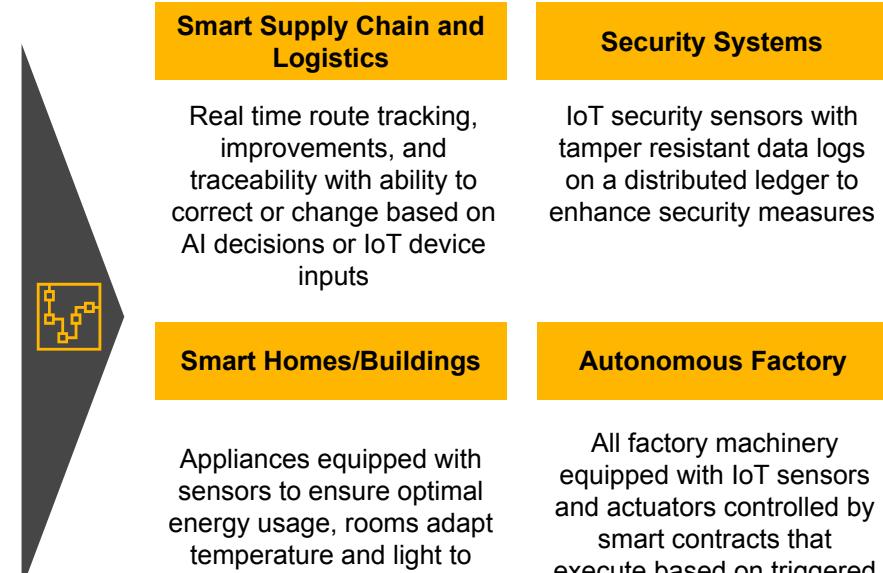
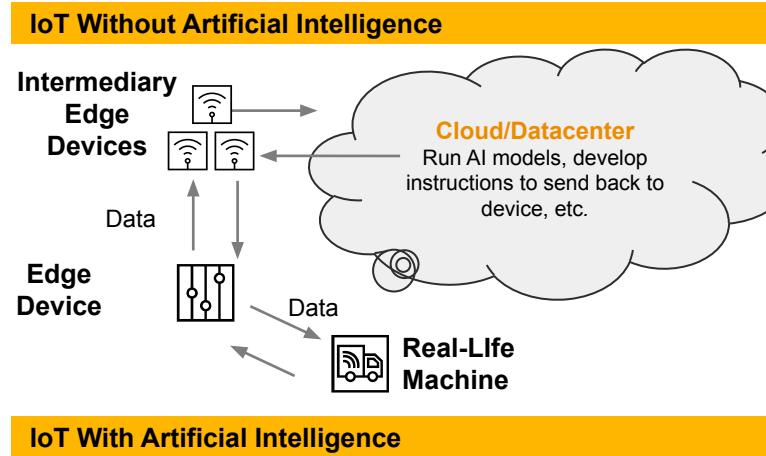
Asset Management

Allows users to pool underlying investments through smart contracts which serves as a diversified portfolio of digital assets.



How blockchain, hyperconnected networks, and artificial intelligence converge to automate trust

IoT devices are now able to run Artificial Intelligence (AI) models on the device themselves, and distributed ledgers provide an immutable record to have complete traceability and trust in the data.



What drives adoption of Automating Trust?

There are palpable movements in the IT environment that are changing the way businesses process, store, and communicate data. **Automating Trust** represents an **opportunity** to innovate across all industries.

Shifts in the current environment...



Large amounts of potential data are being generated, and advanced companies are using that data



The amount of data being transferred is rapidly increasing



New innovations are coming out each week which lack regulatory jurisdiction



Cyber attacks are more prevalent, and ransomware attackers usually demand payment in crypto

...and challenges in the current landscape



Organizations are unable to capture and make use of the plethora of activities within their environment



Data transfers across networks can quickly become expensive



Regulatory uncertainty or potential for enhanced scrutiny by regulators



Organization are unable to maintain strong security and trust in data

...present opportunities to utilize the benefits of Automating Trust



Smart devices and blockchain ledgers can capture large amounts of data for processing and storage



IoT, AI, and blockchain can reduce cost and increase transfer efficiency

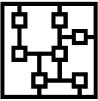


Blockchain tools can provide an enhanced level of transparency



"Intelligent" devices, AI models, and blockchain ledgers increase security

Potential challenges for adoption of Automated Trust



Adoption

- **Proper Incentives:** Potential participants will need to be sold on the value of the platform
- **Consensus Needed:** Participants must come to group agreement on acceptable platform and standards

Participant Trust

- **Safety:** Re-assuring participants that their transactions are secure
- **Public vs Private:** Evaluation of the key differences and criteria for private and public blockchains
- **Information Accessibility:** Level of information participants are willing to expose to participate in the network

Legal & Regulatory

- **Regulatory Body:** Currently there is no global regulatory body to set standards on blockchain transactions
- **Real-time Auditing:** Changes in nature of auditing from forensic analysis to real-time transaction monitoring that has yet to be tested or standardized

Technical

- **Interoperability:** Ability to integrate with participant's existing systems and other blockchains or devices
- **Architectural Role:** How blockchain may eliminate, replace, or work with current technological platforms
- **Scalability:** How blockchains will perform with increased transaction volume

The Automating Trust ecosystem is growing and becoming inclusive of more players spanning all industries

Third Party Custodians

Exchanges and wallet providers for blockchain, or telcos, cloud providers, and CDNs for IoT communications



Software Developers

Build platforms, software applications, or supporting technology software



Hardware & Connectivity

Build the physical devices, equipment, and other machinery to interface with software



Consultancies/Services

Specialists that provide advisory services, legal advice, tax support, or industry-specific services or activities



Regulators

Ensure legal compliance with jurisdictions' rules and regulations



Standards Bodies

Set industry standards and best practices



The Automating Trust community is increasingly open-source and collaborative in nature

Below are some industry participants as it relates to **open source collaboration**. PwC is or has been a member of all of the below organizations except ISO.



The EEA is a member-led industry organization whose objective is to drive the use of Enterprise Ethereum and Mainnet Ethereum blockchain technology as an open-standard to empower all enterprises.



MultiChain is an open source platform that helps organizations build and deploy blockchain applications with speed.



Hyperledger is a multi-project open source collaborative effort hosted by The Linux Foundation, created to advance cross-industry blockchain technologies.



BITA develops industry standards; educating members and others on blockchain applications/solutions and distributed ledger technology (DLT); and encouraging the use and adoption of new solutions.



The Chamber of Digital Commerce is an American advocacy group that promotes the emerging industry behind blockchain technology, bitcoin, digital currency and digital assets.



The IIC is a consortium to accelerate the growth of the industrial internet by identifying, assembling, testing and promoting best practices.



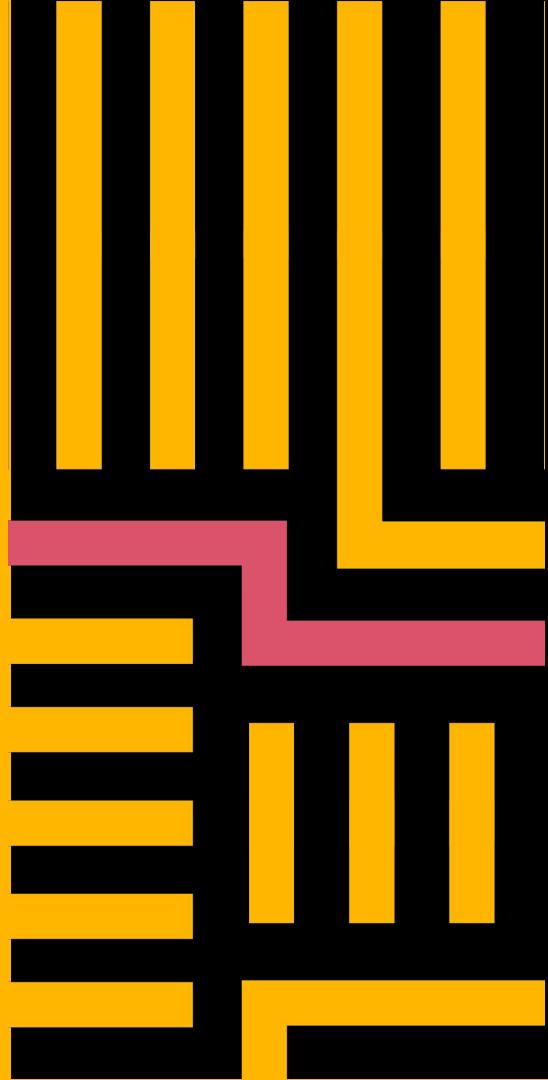
r3 is a leading provider of enterprise technology and services that enable direct, digital collaboration in regulated industries.



An independent, non-governmental organization and is the world's largest developer of voluntary international standards.

SECTION 2

Architecture & Technical Overview



Technology Convergence Stack

Below are examples of how the functions of various technologies can interact, with underlying data facilitated via blockchain.

Blockchain				
Examples	Artificial Intelligence (AI)	Hyperconnected Networks (HCN)	Extended Reality (XR)	Robotics
	<ul style="list-style-type: none">• Automatically-improving smart contracts.• Learning models to improve upon previous actions.• Trustless model validation.	<ul style="list-style-type: none">• IoT devices connected to factory machinery.• Capture normal & metadata from all other physical devices (XR, drones, etc.)	<ul style="list-style-type: none">• Virtual reality museums for non-fungible tokens (NFTs).• Virtual or augmented supported by NFTs to encourage participation.	<ul style="list-style-type: none">• Drones to collect data or perform actions (e.g., put out a fire).• Human-simulated robots with functional arms, etc.
Impact	AI learning models can be used to improve actions of smart contracts (blockchain), but also actions of IoT devices, and machinery (HCN, XR, and Robotics).	XR devices and Robotics can be treated as IoT devices, or can be equipped with IoT devices to serve specific use cases - actions performed by actuators (devices that perform physical actions) can be improved by AI models.	Virtual and augmented reality headsets can provide ample amounts of data to AI algorithms, which can be used to improve the XR devices as well as the applications built for them.	Robotics encompasses a wide variety of physical devices that can be improved with specialized IoT devices, AI models, and a XR environment.

Blockchain and cryptography basics

Key Terms

Encryption: Transforms inputs into an unreadable format using a *cryptographic hash function* such as SHA 512 or SHA-256. In SHA-256, each input produces a seemingly random output (called a *hash* or *digest*) of 256 characters.

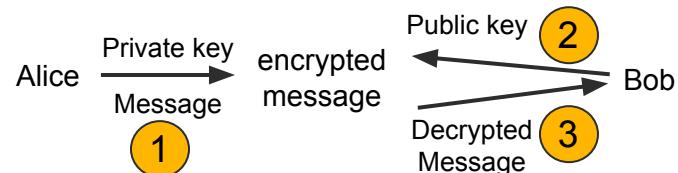


Examples

	SHA-256
Hello	185f8db32271...
Hello1	948edbe7ede5...

Note: if any part of the input is changed (even slightly), the output will be completely different.

Cryptographic Keys: Used to create a verifiable, *digital signature*. Only the individual with the *private key* can create the digital signature, and anyone with the *public key* can verify that the signature is from someone with the appropriate private key. Cryptographic keys are generated in pairs



Note: Other items (aside from the transaction message) that are encrypted include the signing key, the owner's unique address, and even the cryptographic hash function that miners need to solve for in proof-of-work consensus.

For more information, see the Key Management Accelerator [here](#)

Cryptography in action - Proof of Work example

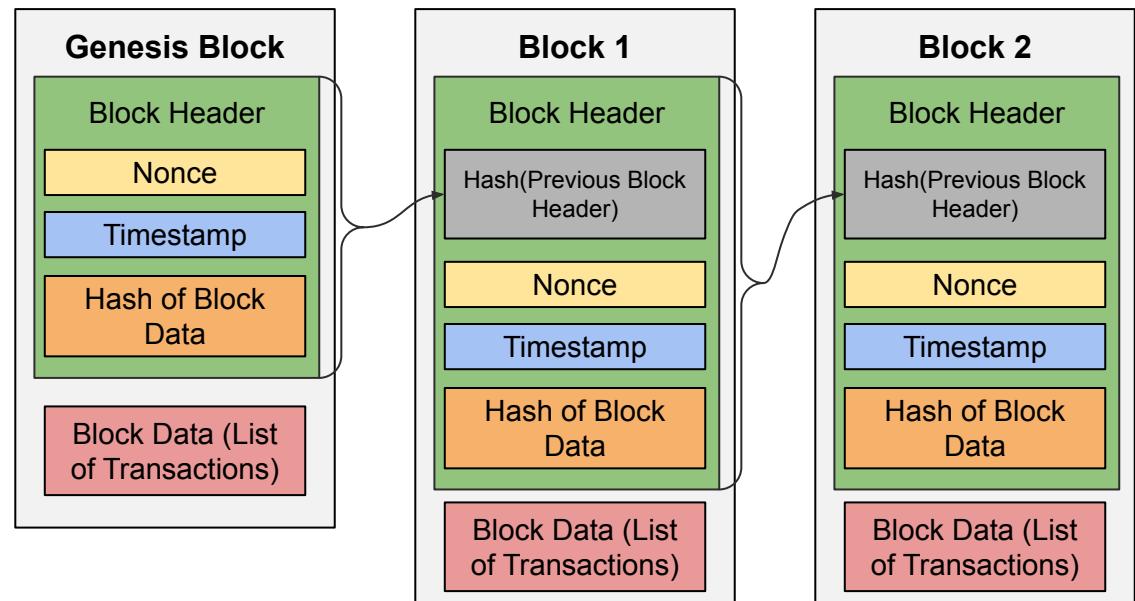
Bitcoin *miners* attempt to be the first miner to solve the hash for each block. The hash for each block is the totality of the following:

Nonce: A number only used once - a random hash that miners are solving for. Bitcoin miners must find the nonce hash that has a specified number leading zeros. Essentially, miners are constantly attempting SHA hash functions until they obtain the desired number of leading zeros to win the block.

Block Data (Transactions): Every normal transaction that is proposed to be a part of that block. Transactions are *hashed* and then included in the block header

Previous block: After the genesis block (the first block created in the blockchain), each block includes the previous block in its hash. If anyone were to change information in a previous block, it would be obvious in all future blocks.

Time Stamp: All blocks include a timestamp which specifies when they occurred.



Source: Nist Blockchain Technology Overview

Consensus protocols vary based on the use case, and new protocols are being developed each year

Proof of Work (PoW)

PoW requires “miners” to solve a cryptographic hash function for the reward of placing the next block and receiving a fee.



Pros

- Difficult to hack once it has scaled to many miners
- Strong incentive system which adjusts based on size of network

Cons

- Energy-intensive
- Slow transaction speeds
- Expensive fees

Proof of Stake (PoS)

Users can validate transactions according to how many coins they hold, or “stake”



Pros

- Less energy-intensive
- High scalability potential
- Low transaction cost potential
- Low barrier to entry

Cons

- Potential concentration of power (plutocratic)
- Less security efficacy

Private/Consortium

Blockchain Controlled by a single party or several known parties, often referred to as distributed ledger technology and used by enterprises



Pros

- High security, easy to find malicious users
- Can optimize for speed, regulatory compliance, or other use cases

Cons

- Less decentralized
- Typically can't act anonymously

Byzantine Fault Tolerant

BFT was originally created to solve the [Byzantine Generals Problem](#), and optimizes to reach consensus despite some malicious actors or failed nodes



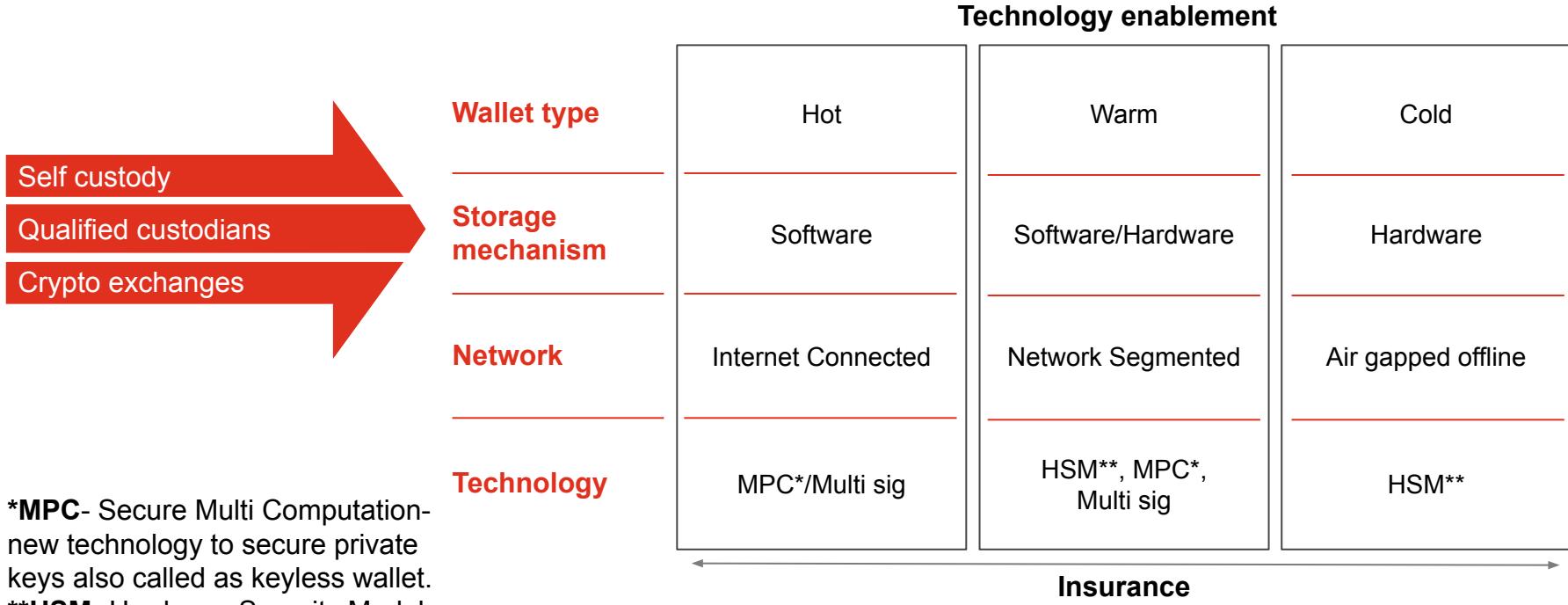
Pros

- Energy efficient
- Transaction finality (multiple confirmations not required)
- Decentralized consensus

Cons

- Can be difficult to scale
- Potential Sybil attacks

Crypto assets – Wallets and custody



***MPC**- Secure Multi Computation-
new technology to secure private
keys also called as keyless wallet.

****HSM**- Hardware Security Module -
existing technology to securely
generate and store private keys.

Blockchain Security Considerations

It is prudent to find appropriate balance between security and transparency through an analysis of the following security considerations.

Security of persisted data outside blockchain

Develop appropriate encryption standards to protect sensitive data

Security of Smart Contracts

Securely design, develop, deploy, upgrade, and maintain smart contracts

Security of data in transit

Properly encrypt connections to protect the contents of data in transit, including the API

Cryptography

Review the hashing algorithms being used and recovery mechanism for lost keys.

Confidentiality of shared data

Evaluate data that must be shared with others in the network to achieve the desired level of transparency

Governance

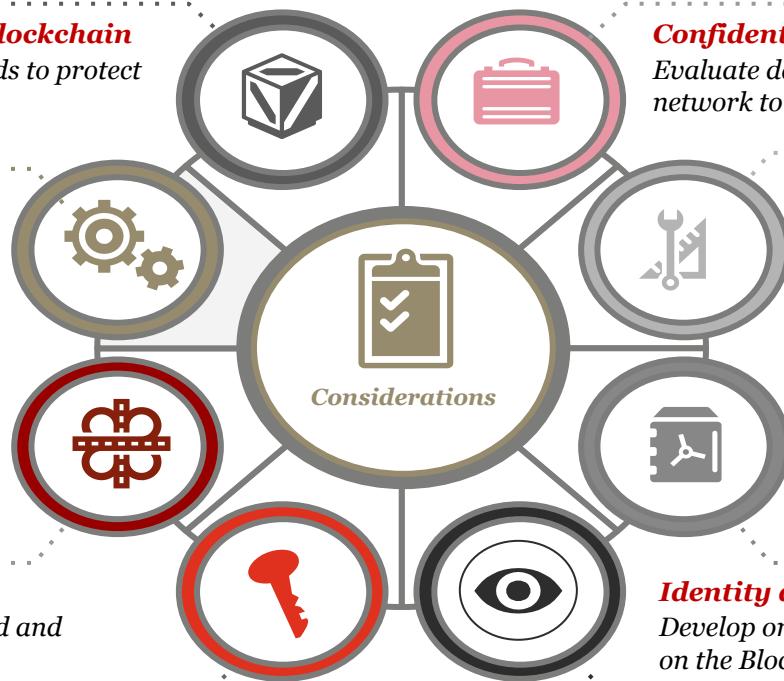
Develop security policies and consensus mechanisms aligned with business objectives and consistent with regulations

Security operations and infrastructure

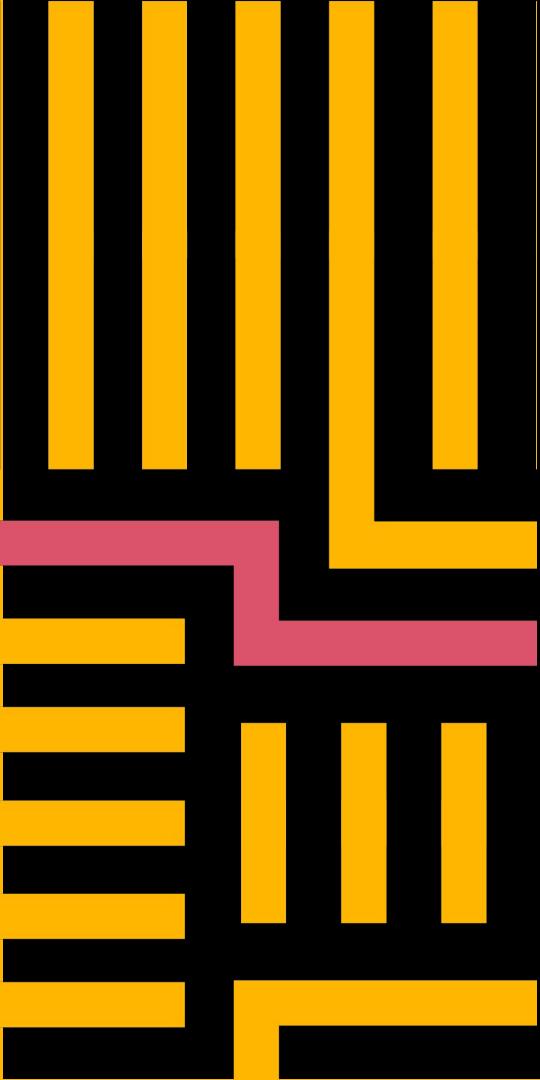
Ensure compliance with availability requirements and connectivity to the enterprise SOC.

Identity and access management

Develop onboarding processes for Users and Objects on the Blockchain and controls around access management



Terminology



Alignment on terms

Digital assets- Digital asset is a term that describes any asset in a digital form. E.g. an excel spreadsheet, email, etc.

Crypto assets- Digital assets that utilize cryptography in the design or operation of the asset. E.g., crypto tokens, cryptocurrencies. Crypto assets can take many forms currencies, art, representation of other assets (e.g. real estate)

Cryptocurrencies - Type of virtual currency, which can be traded and utilized as a form of payment for goods and services. Typical characteristics include:

- Have a native blockchain ledger to record transactions
- Decentralized, or at least without a central issuing authority
- Rely on code to manage issuance and transactions
- Built on a blockchain or other distributed ledger technology
- Allows blockchain participants to enforce rules of the system in an automated fashion
- Uses cryptography (advanced encryption techniques) to secure the system

Crypto tokens- are assets that organizations or projects can customize and develop on top of existing blockchains. Example:

- Ether is the cryptocurrency native to the Ethereum blockchain
- Many different tokens that also utilize the Ethereum blockchain. e.g., DAI, LINK, COMP, etc.

Crypto tokens can serve a multitude of functions on the platforms atop which they are built, including participation in decentralized finance (DeFi) mechanisms, accessing platform-specific services, and even taking part in games.

Several standards for creating crypto tokens. Most widely used standards are ERC-20 (tokens that can interoperate within Ethereum's ecosystem), and ERC-721 (non-fungible tokens that are individually unique and cannot be interchanged with others.)

Typically, crypto tokens are programmable, permissionless, trustless, and transparent. While crypto tokens, like cryptocurrency, can hold value and be exchanged, they can also represent physical or more traditional digital assets, or a certain utility or service. For instance, there are crypto tokens that represent real estate, art, and unused hard drive space.

Key terms and concepts

Key terms/Topics	What to consider
Blockchain Distributed ledgers that serve as the settlement layer for transactions	Users can interact with each other directly on a blockchain in a decentralized manner, using pseudo anonymous identities.
Digital Assets Describes any asset in a digital form. e.g. an excel spreadsheet, email, etc.	Digital assets are can be optimized for specific performance requirements such as speed, security, or composability
Wallets Software interfaces for users to manage digital assets	In a DeFi environment, wallets are often individually-controlled, meaning that users control access to their currency, not banks
Smart Contracts Software code that carries out, controls, and documents relevant events and actions according to terms & rules	Smart contracts can be developed and subsequently audited by anyone, increasing security and transparency
DApps (Decentralized Applications) Software applications built out of smart contracts that integrate with Global User Interfaces (GUIs) using apps or traditional web	DApps can integrate with each other, sometimes across different blockchain platforms.
Decentralized Autonomous Organizations (DAO) Entities who define and enforce rules across smart contracts in a network	DeFi organizations are governed by automated blockchain protocols, generally with reduced human intervention. Note that many apps and organization start out centralized, and move to decentralized.
Stablecoins Digital assets that derive value from a fiat currency or other stable asset; ease of access can serve as an "on ramp" for entry into cryptocurrency transactions	Stable coins can be held in wallets or used for loans when a user doesn't want to transact at a given time.
Oracles Data feeds that export information from the blockchain (ex. current stock or fiat currency price)	Oracles can also by physical internet of things (IoT) devices which provide real-time data to the blockchain



Thank you.

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