Blockchain Technology – Transaction Processing, Challenges and Trends

Bach Dong Nam
NACENLAS, National Center for Technological Progress, Hanoi, Vietnam
Email: namdongbach@gmail.com

TABLE OF CONTENTS

1. Introduction

Blockchain

as rapidly

growing foundational ICT technology

Developed over the last decade as one of the top 10 strategic technology trends for many

recent years

One of today's biggest ground-breaking technologies with potential to impact every

industry from financial to manufacturing and to educational institutions.

Emerging Technology Trends 2018

Democratized AI

- AI PaaS
- Artificial general intelligence
- Autonomous driving Level 4
- Autonomous driving Level 5
- Autonomous mobile robots
- Conversational AI platform
- Deep neural nets
- Flying autonomous vehicles
- Smart robots
- Virtual assistants

Digitalized Ecosystems

- Blockchain
- Blockchain for data security
- Digital twin
- IoT platform
- Knowledge graphs

Do-It-Yourself Biohacking

- Biochips
- Biotech — cultured or artificial tissue
- Brain-computer interface
- Exoskeletons
- Augmented reality
- Mixed reality
- Smart fabrics

Transparently Immersive Experiences

- 4D printing
- Connected home
- Edge AI
- Self-healing system technology
- Silicon anode batteries
- Smart dust
- Smart workspace
- Volumetric displays

Ubiquitous Infrastructure

- 5G
- Carbon nanotube
- Deep neural network ASICs
- Neuromorphic hardware
- Quantum computing

gartner.com/SmarterWithGartner

Source: Gartner

Gartner

CompTIA

Emerging Technology COMMUNITY

TOP 10
EMERGING TECHNOLOGIES

CompTIA's Emerging Technology Community selected the top 10 technologies that have near-term business and financial opportunity for the IT channel and those working in the business of technology.

1 Internet of Things

IoT is driving change and impacting efficiencies in businesses around the world by providing the data needed to improve marketing, increase sales and decrease costs.

2 Artificial Intelligence

AI is significantly impacting the way customers interact with businesses through the advent of intelligent bots and websites and is becoming increasingly commoditized, accessible and integrated with everyday tools.

3 5G

5G is increasing our ability to move, manipulate and analyze data across wireless platforms. It will continue to drive the development of more complex apps to solve problems and increase growth across a wide array of industries.

4 Serverless Computing

Server-less computing is enabling organizations to create a NoOps IT environment that is automated and abstracted from underlying infrastructure, reducing operational costs and allowing businesses to invest in the development of new, impactful, value-add capabilities.

5 Blockchain

Blockchain is solving the increased need to secure and manage an increasing number of transactions across the Internet as it provides an alternative to centrally managed record keeping.

6 Robotics

Robotics is automating routine processes by leveraging machines in all shapes and sizes to make businesses faster, cheaper and more efficient. This is driving conversations and opportunities due to its incredibly fast ROI and Significant opportunity for cost-savings and growth.

7 Biometrics

Leveraging biometric technology from facial recognition to retina and fingerprint scans will become the mainstream methodology for confirming your identity. These solutions, both stand alone and integrated, will form the secure foundation for solutions that we deliver moving forward.

8 3D Printing

3D printing is providing an effective solution for low volume manufacturing of complex parts and quick and local production of obscure products. The opportunity for the industry is expected to become bigger as more affordable products become available and will help to expand the market.

9 VR/AR

VR/AR is transforming the way we engage with machines, data and each other. Organizations are exploring opportunities to use VR, AR, mixed reality, AI and sensor technologies to enhance operational efficiency and individual productivity.

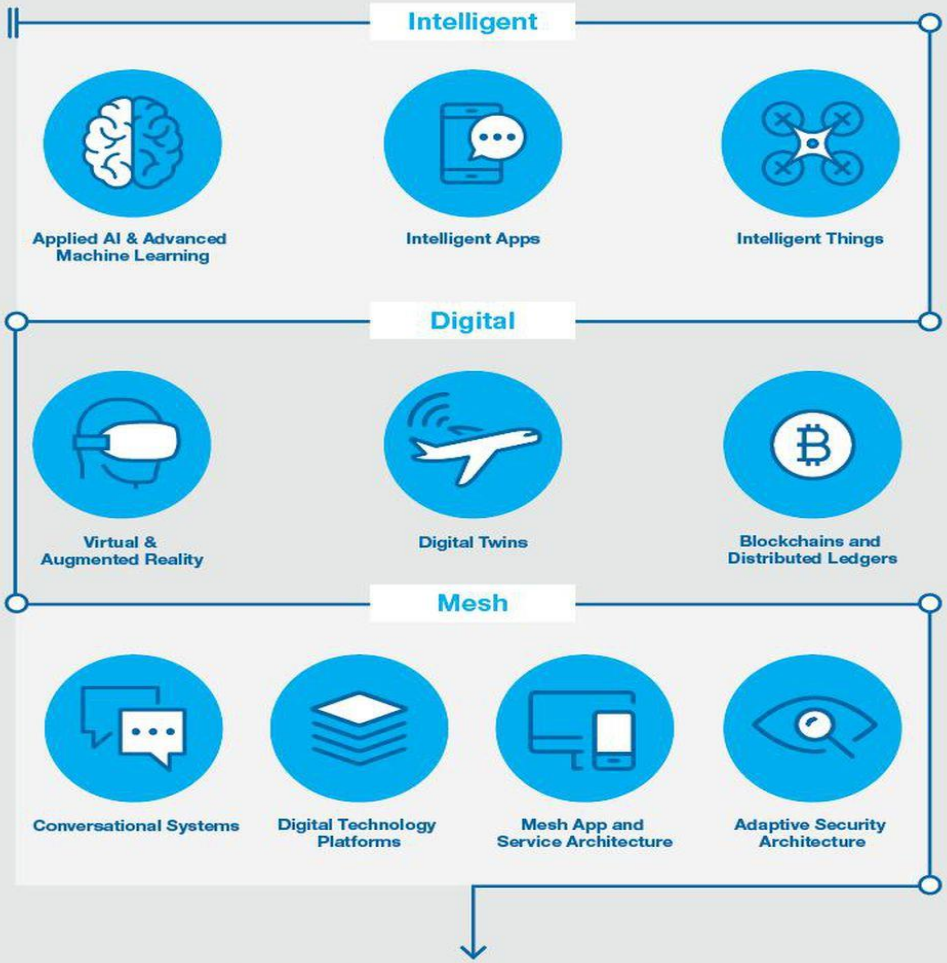
10 Drones

Drones are enabling robotic automation without geographic restriction and the opportunities for technological development and integration are high for the market.

1. 3-D Metal Printing
2. Artificial Embryos
3. Sensing City
4. AI for Everybody
5. Dueling Neural Networks
6. Babel-Fish Earbuds
7. Zero-Carbon Natural Gas
8. Perfect Online Privacy (Blockchain based)
9. Genetic Fortune-Telling
10. Materials' Quantum Leap

Gartner

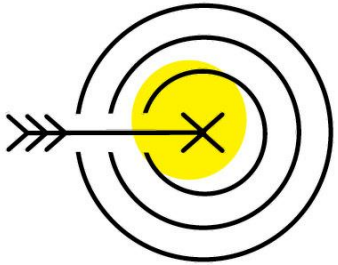
Top 10 Strategic Technology Trends 2017



gartner.com/SmarterWithGartner

Gartner

Top 10 Strategic Technology Trends for 2018



Intelligent

AI Foundations

Intelligent Apps and Analytics

Intelligent Things

Digital

Digital Twins

Cloud to the Edge

Conversational Platform

Immersive Experience

Mesh

Blockchain

Event-Driven

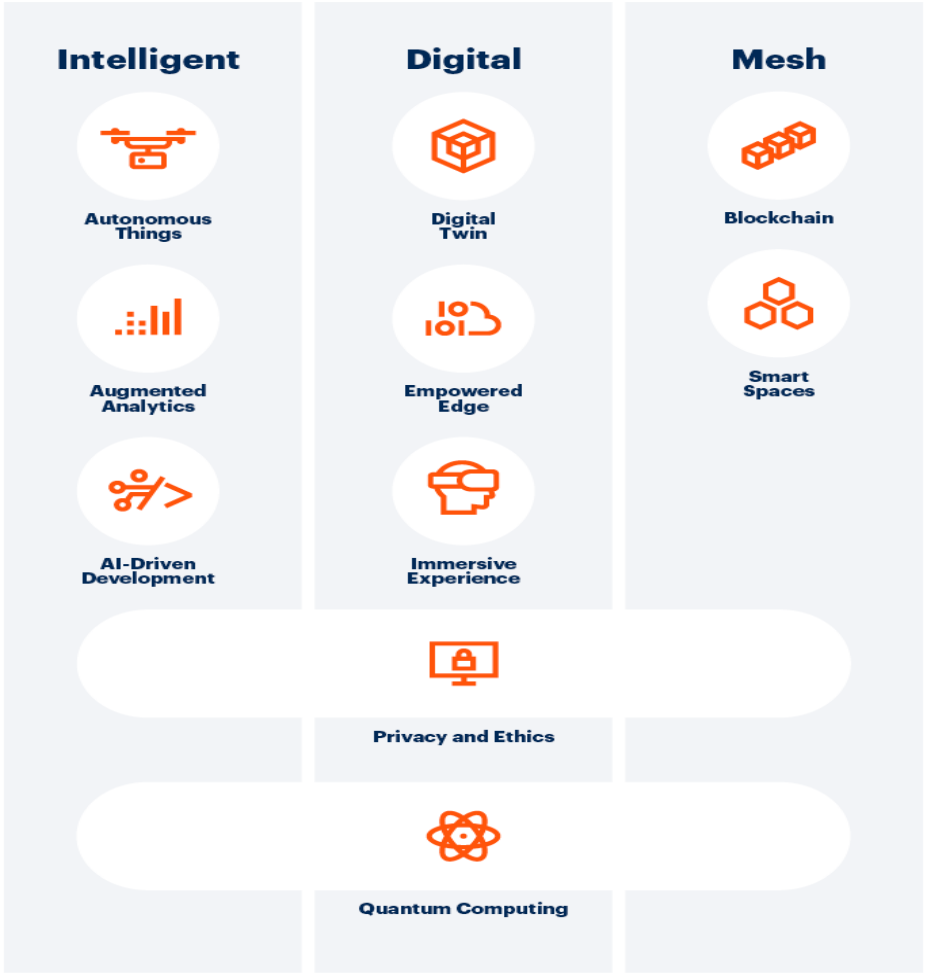
Continuous Adaptive Risk and Trust

gartner.com/SmarterWithGartner

Source: Gartner

Gartner

Top 10 Strategic Technology Trends for 2019



gartner.com/SmarterWithGartner

Source: Gartner

Gartner

Blockchain Technology

One of top 10 emerging technologies of 2019, which have near-term business and financial opportunities, blockchain technology is explored and implemented to solve the increased need to secure and manage transactions across the internet.

As blockchain-based one of 10 breakthrough technologies 2018, picked by MIT Technology Review, that will have a profound effect on the general lives. This blockchain-based solution, called Perfect Online Privacy, used a zero-knowledge proof, an emerging cryptographic protocol (zk-SNARK) for proving something without revealing the information underlying the proof and then something is done online without risking your privacy or exposing yourself to identity theft. The true internet privacy could finally become possible thus.

One of the top 10 strategic technology trends for 2019 with the theme of mesh technology, the blockchain technology refers to making, securing and exploiting connections between an expanding set of people, businesses and processes- as well as devices, content and services- to deliver digital business outcomes.

Definition

Block chain

Digital, open, distributed ledger

That can process and record transactions between two parties,

across a peer-to-peer network,

efficiently and in a verifiable and permanent way.

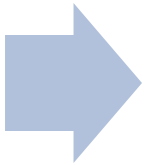
Identical copies of this distributed transaction ledger are maintained on multiple computer systems controlled by different users and anyone participating in the blockchain can review the entries in it, but can only update the blockchain by concensus of majority of participants.

Distributed ledger

Expanding chronologically ordered list of cryptographically signed, irrevocable transactional records shared by all participants in a network

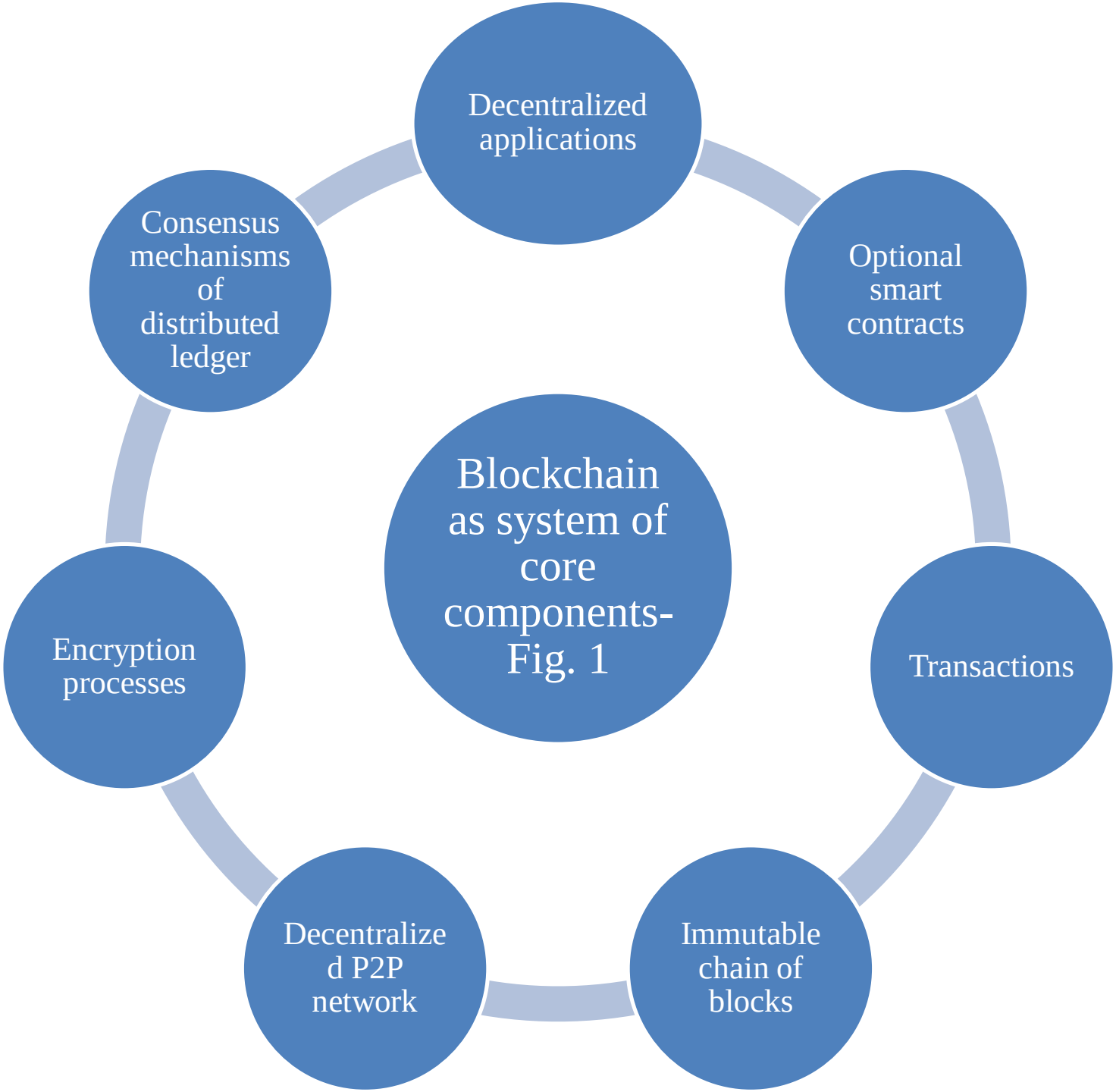
Replicated across a distributed network to create a consensus-based authoritative record of significant events

Exploring key definitions and concepts behind this revolutionary technology



Explaining basically

1. Common structure of blockchain
2. How blockchain 1.0 works?
3. Smart contract as central component of blockchain 2.0
4. Dapp of blockchain 3.0
5. Blockchain 4.0 for IR 4.0 with challenges and trends


Blockchain as system of core components- Fig. 1
Decentralized applications
Optional smart contracts
Transactions
Immutable chain of blocks
Decentralized P2P network
Encryption processes
Consensus mechanisms of distributed ledger

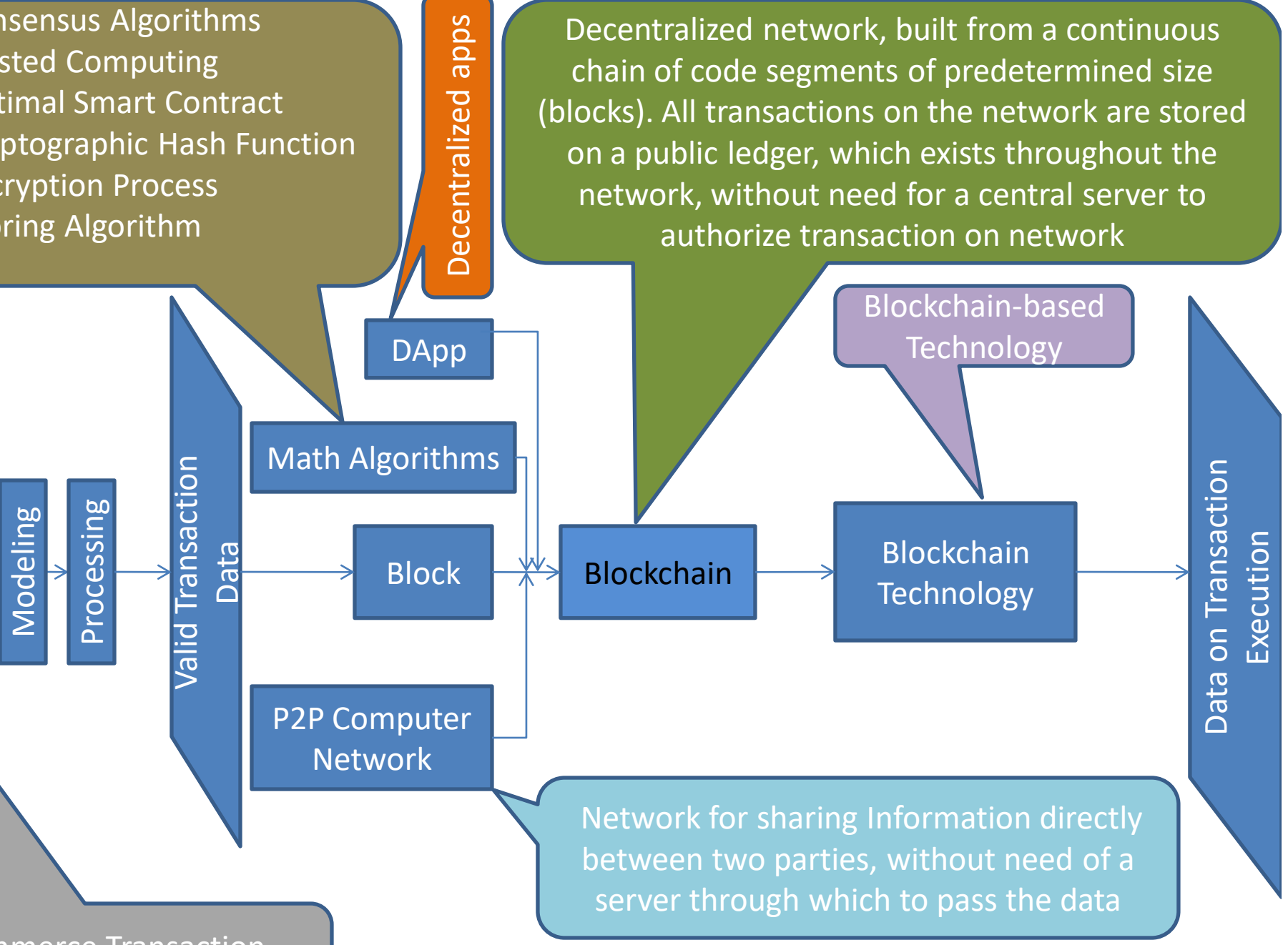


Figure 1: Logic Flowchart of Blockchain

2. Blockchain Transaction

Transaction	• An exchange, agreement, business deal or interaction between people or parties
Common transactions	• Commercial, real estate, enterprise Tab. 1, financial transactions Tab. 2[3]
Transaction processing system	• Transactions are processed and stored here • Security is the major concern for all transactions.

Tab. 1: Notable enterprise transaction use cases

Land registration – Replacing requirements for research of Deeds (Sweden Land Registration)
Personal Identification – Replacement of Birth/Death certificates, Driver's Licenses, Social Security Cards (Estonia)
Transportation – Bills of Lading, tracking, Certificates of Origin, International Forms (Maersk/IBM)
Banking – Document storage, increased back office efficiencies (UBS, Russia's Sberbank)
Manufacturing – Cradle to grave documentation for any assembly or sub assembly
Food distribution – Providing location, lot, harvest date Supermarkets can pin point problematic food (Walmart)
Audits – Due to the decentralized and immutable nature of Blockchain, audits will fundamentally change.

Tab. 2: The Global Foreign Exchange Market in USD

Year	Foreign Exchange
1997	475 Billion
2002	1.1 Quadrillion
2008	2.2 Quadrillion

Block

The blocks represent transactions made within the network, displayed on a public ledger

- Information about transaction like the date, time, exchange amount and the associated metadata. Batches of valid transactions are hashed and encoded into a Merkle tree.
- Who is participating in transaction using a digital signature, sort of like a username
- Information that distinguishes it from other blocks: The cryptographic hash of its own and of the most recent block added. Each block is identified via a cryptographic hash and timestamp

Each block

- Unique and only be created once.
- A newly created block is appended to an existing chain of blocks
- Can actually store up to 1…MB of data
- Can house a few thousand transactions depending on the size of the transactions

Peer-to-Peer Computer Network

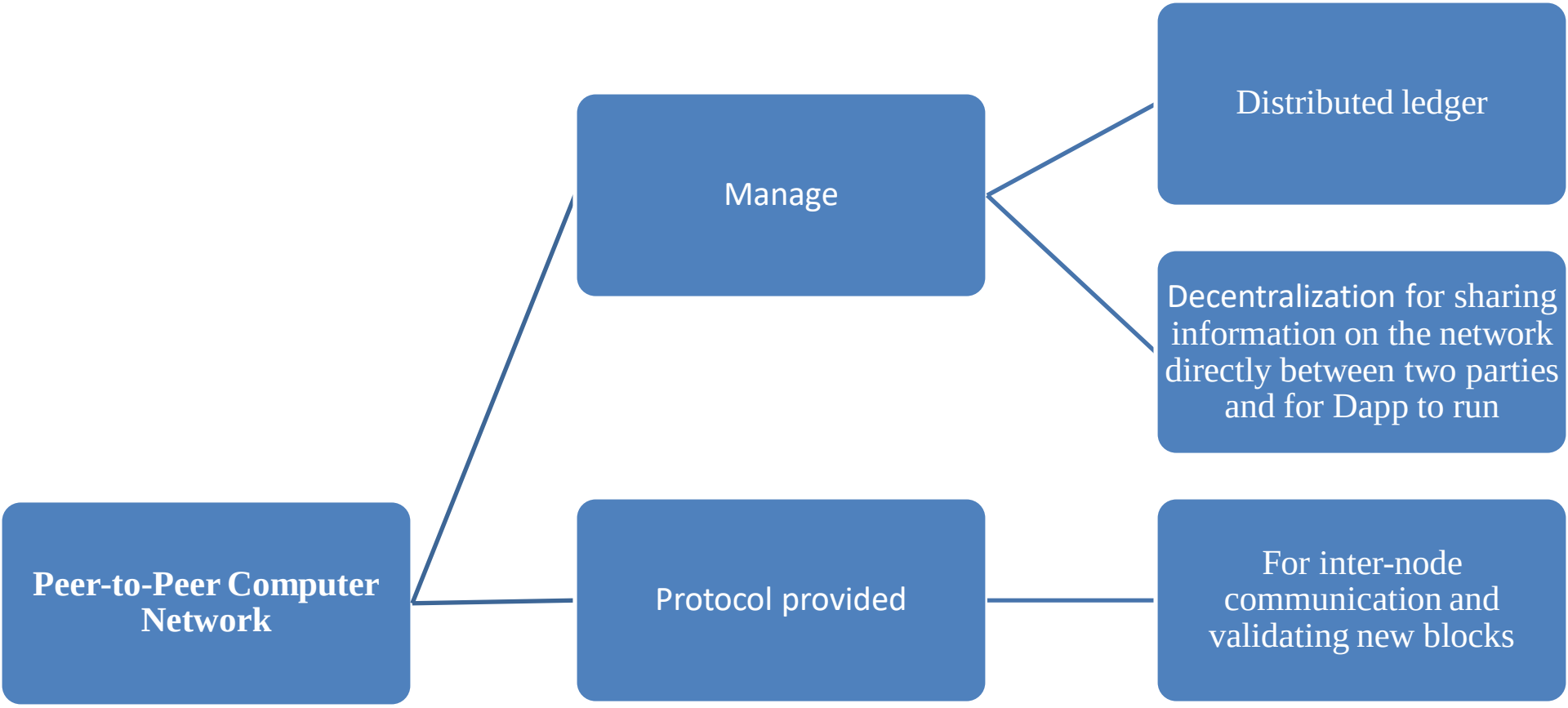
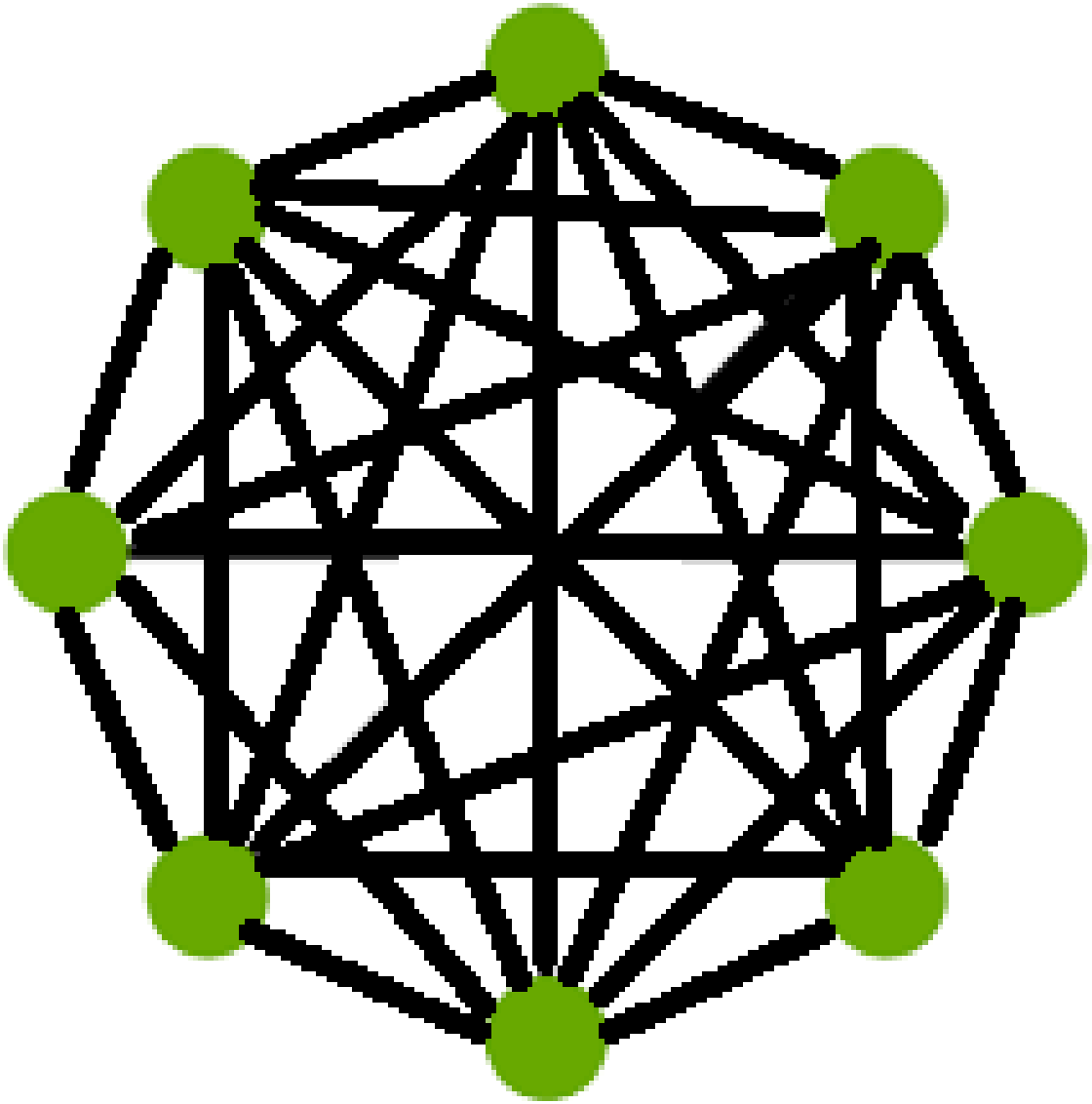
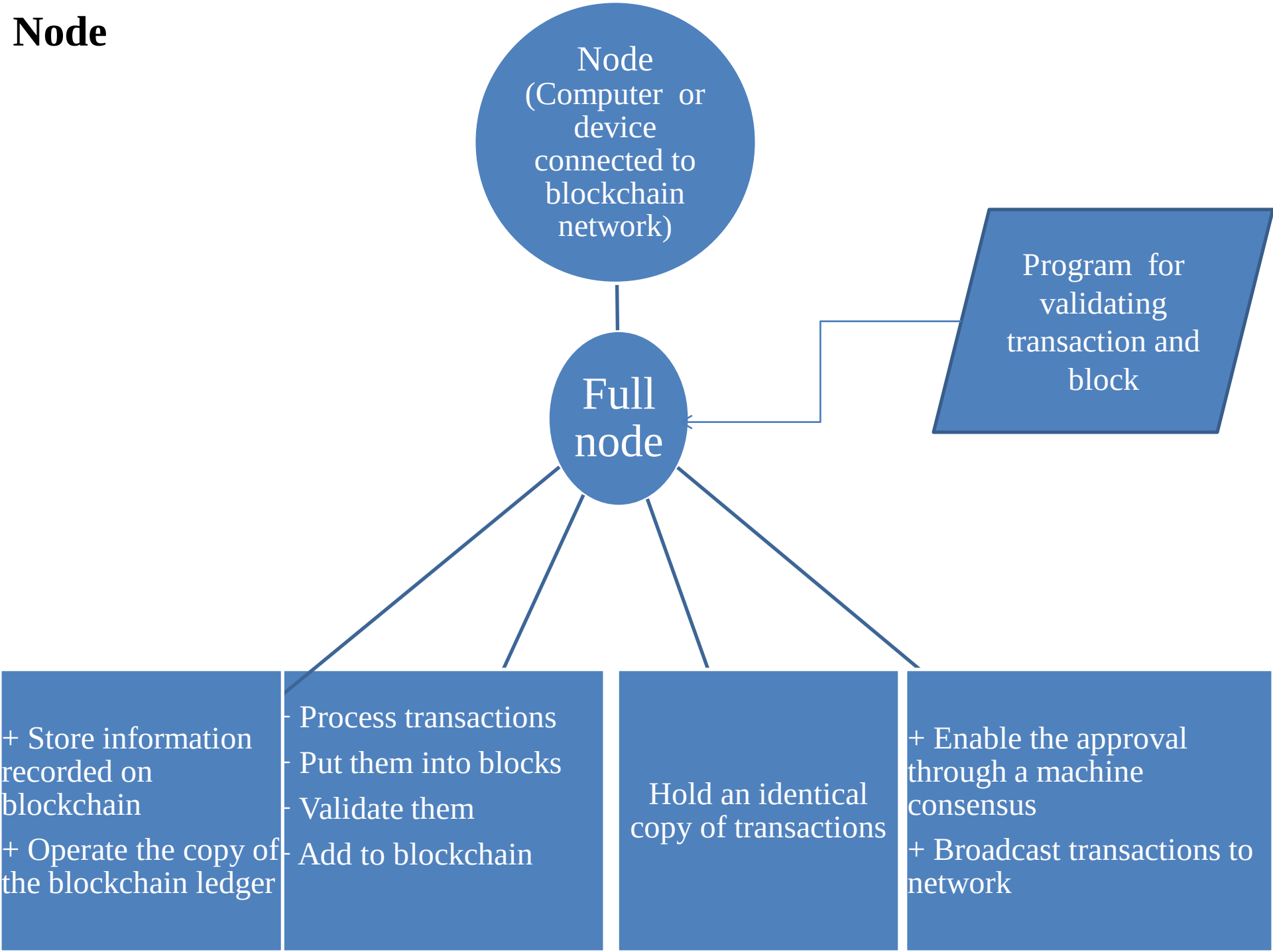


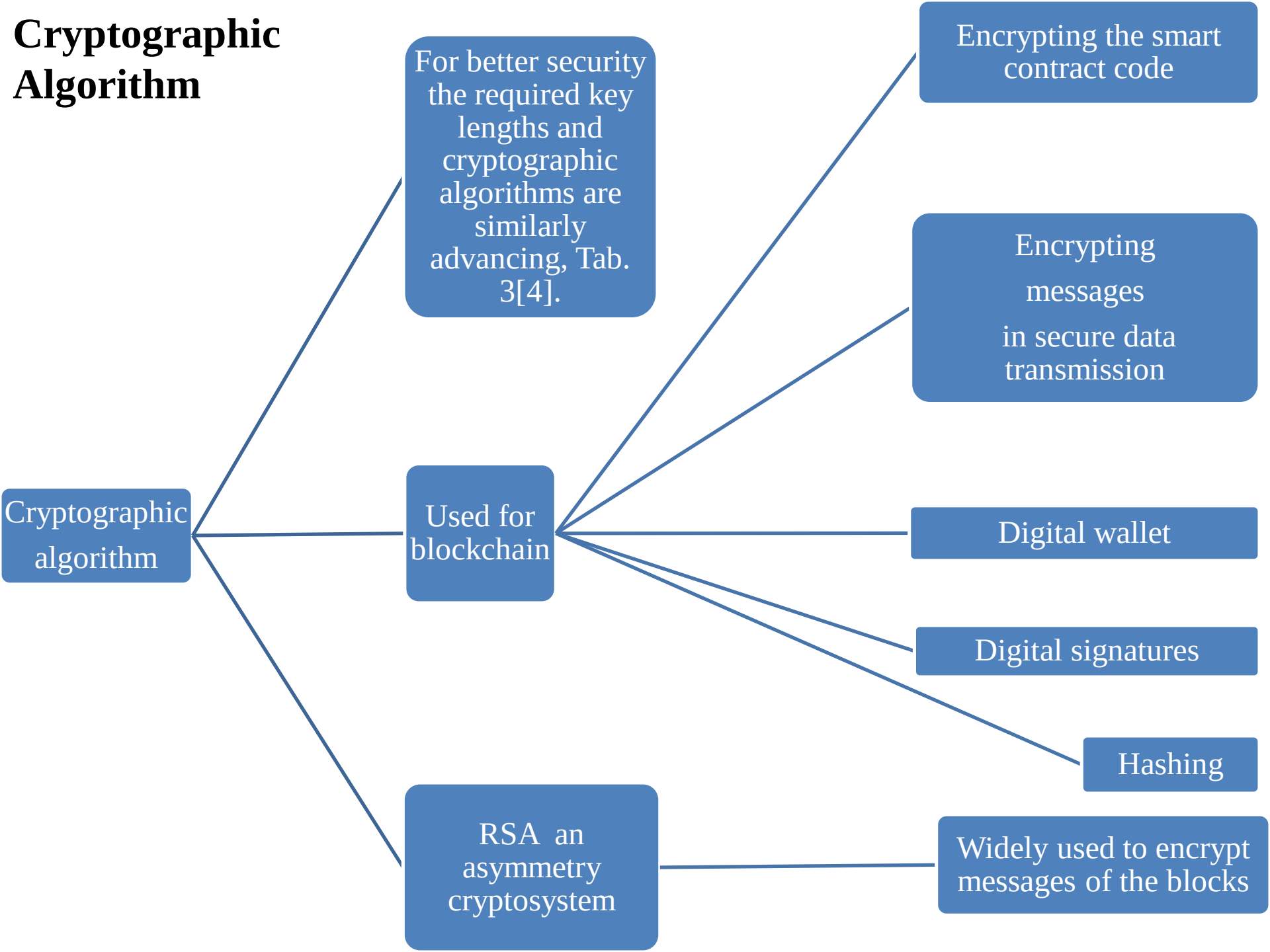
Fig. 2 P2P Computer Network



Node


Node (Computer or device connected to blockchain network)
Program for validating transaction and block
Full node
+ Store information recorded on blockchain
+ Operate the copy of the blockchain ledger
- Process transactions
- Put them into blocks
- Validate them
- Add to blockchain
Hold an identical copy of transactions
+ Enable the approval through a machine consensus
+ Broadcast transactions to network

Cryptographic Algorithm



Tab. 3: Standard Security in Comparision with the Quantum Computing based Security

Algorithm	Key Length	Security	In Comparison with Quantum-compute based Security
RSA-256	256	40	0
RSA-1024	1024	80	0
RSA-2048	2048	112	0
ECC-256	256	128	0
ECC-512	512	256	0
AES-128	128	128	64
AES-256	256	256	128

Hash Function

Hash function

- Map data of arbitrary size to fixed-size value
- Create a unified form of data

Utilization

- Identifying blocks of code of the blockchain
- Confirm coin transactions
- Validate the transaction
- Mine
- Sign
- Integrate the set of all blockchain parameters
- Signature for text or file

Algorithms

- SHA 256 is used as the basis for bitcoin's proof of work system
- SHA-512, with very strong uniformity guarantees, can provide very good general-purpose hashing
- Generally a good randomization and internal structure are the choice for the good hash function.

Consensus Algorithm

Mechanism through which a blockchain network reaches

consensus for maintaining the integrity and security of these distributed system.

Consensus protocol is set of rules describing:

1. How the information will be structured

2. How each device will send or receive it

3. How the communication and transmitting of it between electronic devices, such as nodes, should work.

These rules keep all the nodes on a network synchronized with each other, while providing an answer to the question: how do they all make sure that they agree on what the truth is?

Use cases:

1. agreeing on

the validity of transactions

2. agreeing on

which version of the blockchain is the real one

3. assures that the

protocol rules are being followed

4. It guarantees that all transactions occur in a trustless way

5. . It allows the creation of blockchain system with high

resistance to attack, such as the 51% attack, so-called majority attack

There are several types of

consensus algorithms such as Proof of Work, Proof of Stake, Proof of Elapsed Time, Proof of

Activity, Proof of Capacity, Proof of Burn, Proof of Importance…..

The 51% attack on the blockchain results in a group of miners controlling over 50% of the network's mining hashrate.

Hashrate is the number of hashes that can be performed by a bitcoin miner in a given period of time, usually a second.

Smart Contract

A computer program code and conditions defined beforehand, stored within the block, are capable of facilitating, executing, verifying and enforcing the negotiation or performance of an agreement using blockchain technology. It is impossible to tamper or hack smart contract.

It can be automatically executed by a suitable distributed ledger system, also described as a **digital self-executing agreement,** when the terms are met. The participating parties can be rewarded according to the contract's terms .

Central component to blockchain 2.0 and used in many cases, Figure 3. With blockchain the smart contract can hereby reduce transaction cost of management at higher levels of transparency, while aligning the interests of all stackholders by consensus rules.

The smart contract would work in three steps:

1. Coding what the parties want it to do

2. Distributed ledgers. The code is then encrypted and sent out to other computers via distributed network of ledgers. If this is done via public permissionless blockchain, the contract is sent out similar to the way that a network update of a transaction would occur. This can also be done in a permissioned or hybrid blockchain platform.

3. Execution. One the computers in this network of distributed ledgers receive the code they each come to an individual agreement on the results of the code execution. The network then updates the individual ledgers by recording the execution of the contract, and subsequently monitors them for compliance within the terms of the smart contract.

Fig. 3: Smart Contract Use Cases

Digital Wallet

Unique encrypted storage location for sending or receiving digital assets using its address.

The wallet can be online, offline, or on a physical device. Hot wallet is one directly connected to the internet at all times.

Definition of DAO

As blockchain-enabled, DAO was digital decentralized autonomous organization and a form of investor-directed venture capital fund for new decentralized business models.

Structure, operation & feature

Structure:

DOA exists as a set of contracts among people that resides on the blockchain with no physical address and no people in formal management roles. The management is placed in the hands of owners of DAO to remove the ability to misdirect and waste investor funds.

DAO operates as hub that disperses funds to projects. Investors vote on proposal submitted by contractors and on checking of a group of volunteers that check the identity of people submitting proposals and make sure the projects are legal.. The profits from investments will then flow back to its stackholders.

Feature:

1. Completely transparent, everything was done by the code, which anyone could see and audit.

Mature

DAO one of emerging technologies of 2019.

Blockchain Creation

- New block formed: It will contain

1. The transactions data
2. Block header with metadata

- The cryptographic hash from the block chronologically before it
- Mining competition
- Darootta structure as Merkle tree root

3. Block identifier

The cryptographic hash to uniquely identify the particular block

4. Merkle tree on structure of transactions in the block

- Chain formed by the cryptographic hashes

The blocks can form a chronologically ordered chain from the first block (genesis block) ever generated in the entire blockchain to the newly formed block.

The process is repeated over-and-over again to grow and maintain the network.

The blockchain network can be created using high-level programming languages or the blockchain platforms according to the flowchart in Fig. 4, 5, 6.

Genesis block is numbered zero and is hard-coded in the blockchain application. Each other block links to some previous existing block and for now it takes about 10 minutes.

The blockchain's operation and the application are also controlled from the command line interface using a great API library developed for the 23 core categories.

Blockchain Creation

Fig. 4: Flowchart of Blockchain Creation

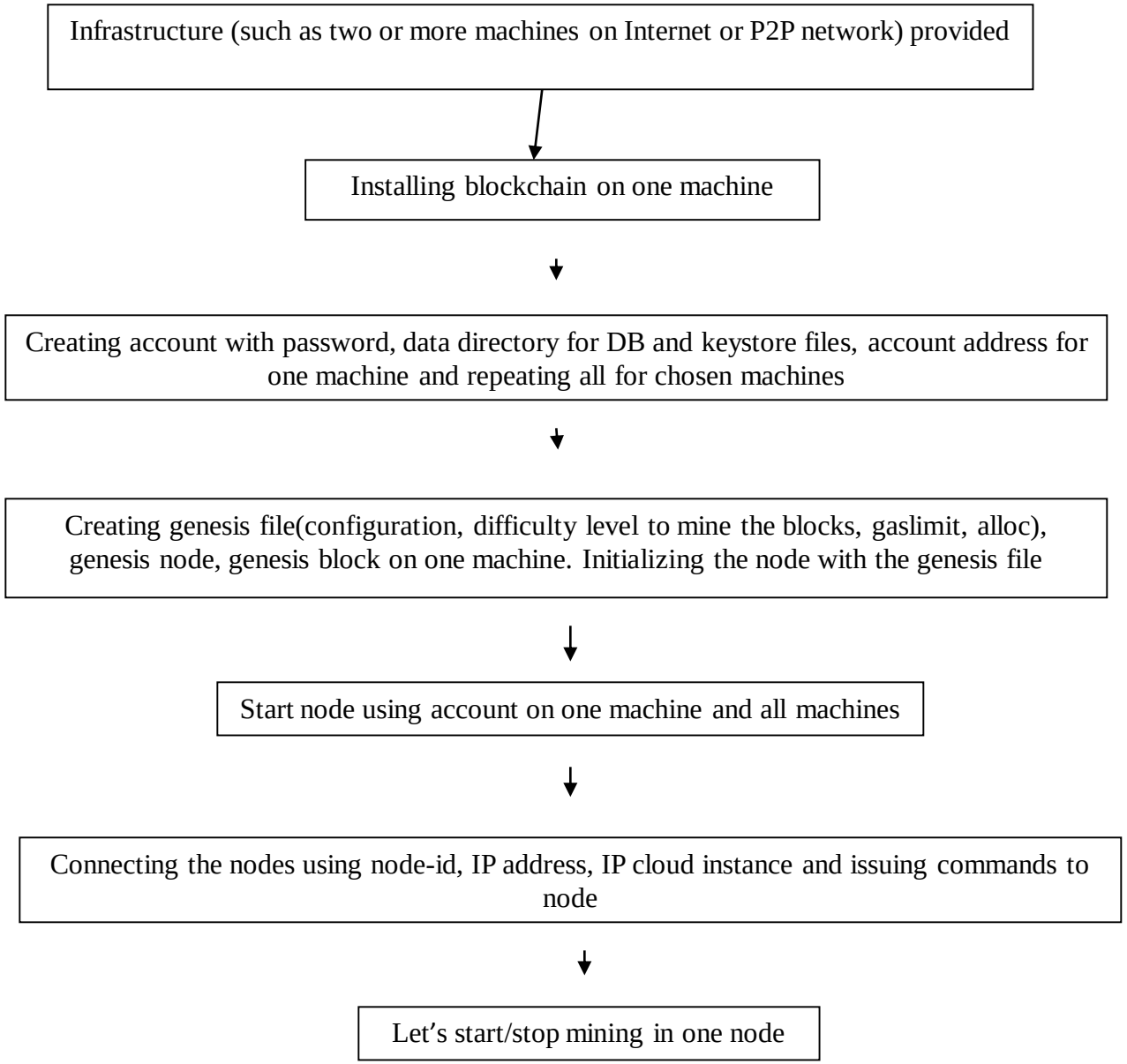
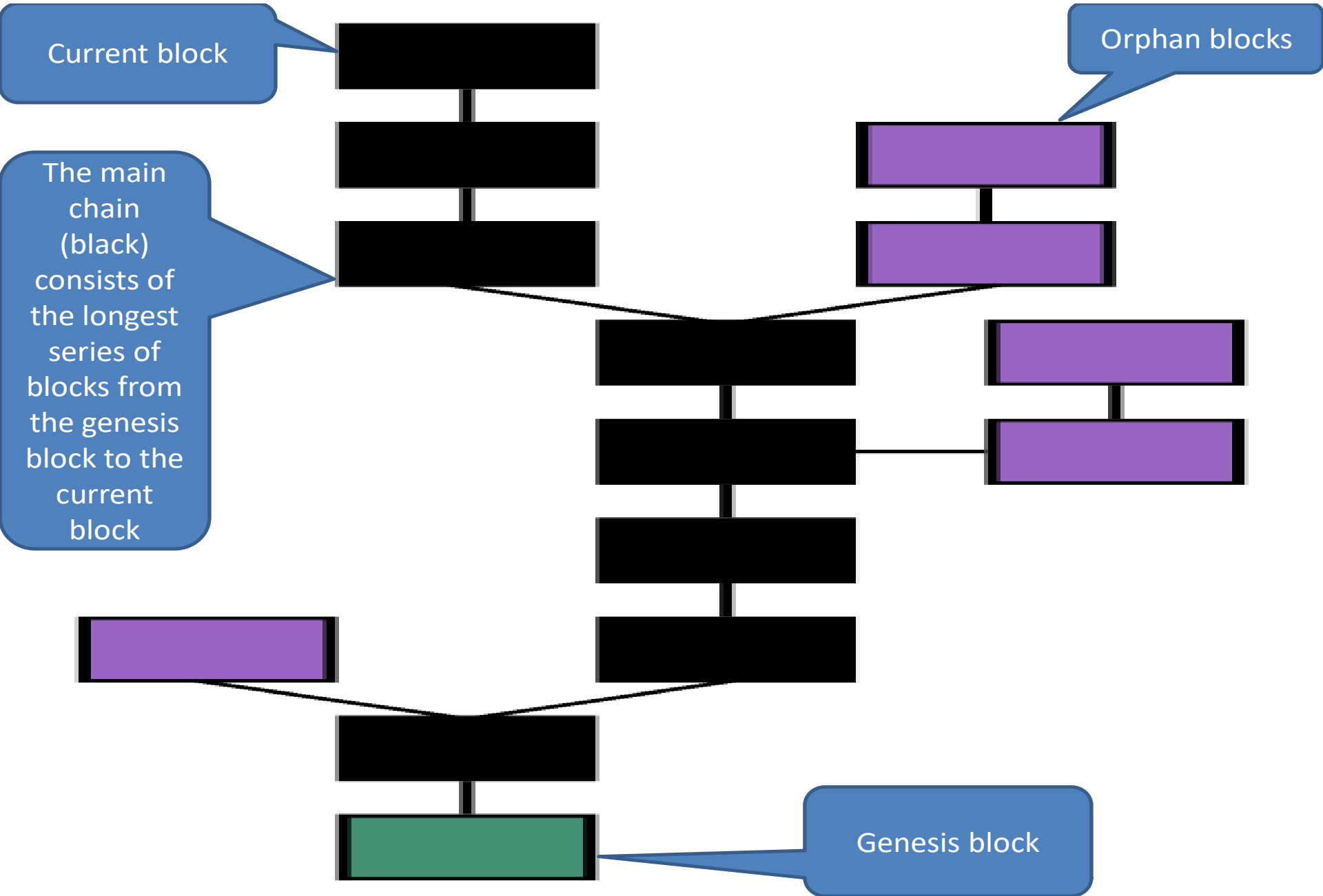


Fig. 5: Blockchain Formation



Transaction Processing on the Blockchain

The transaction process: Path of 6 steps in Fig. 7.

- Step 2: The transactions are packaged in the block, Fig. 8, 9, and broadcast to the network using software.
- Step 4: Nodes move to validate the transaction block which basically involves solving a computationally intensive random math problem. Here it is also discriminated between transaction validation and block validation, Fig. 10.

The incentive for node to validate transactions is new coins and associated transaction fees as reward for 'finding' the new block. The process of validating transactions in a block is called mining.

Mining*:* The process of solving the complex mathematical problem, successfully hashing a transaction block, in order to validate the transactions and add that block to the existing blockchain, will be done according to the difficulty level installed. There are companies who are working on different projects to implement blockchain without miners for Blockchain 3.0.

Block rewards: Mixture of coins and transaction fees, depending on the policy used by the cryptocurrency in question, and whether all of the coins have already been successfully mined. The current block reward for the Bitcoin network is 25 bitcoins for each block. The more verifying confirmations a transaction has, the harder it becomes to perform a double spend attack.

Mining pool is a construct created by a group of miners in order to process more transactions and receive more fees. The funds are then split between the pool's members. Today ASIC device has been designed strictly for mining.

Fig. 6: Core Components of Blockchain

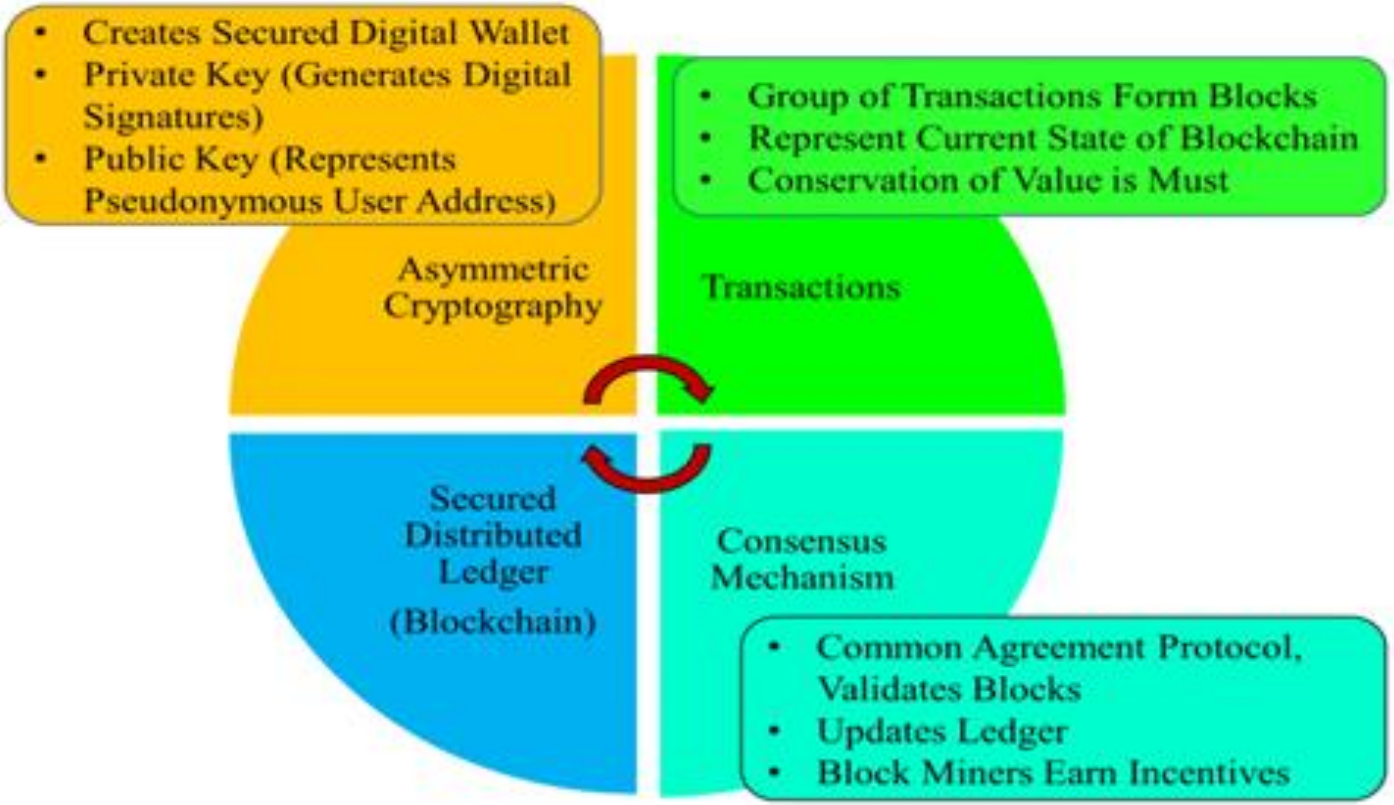


Fig. 7: How Transactions Are Done?

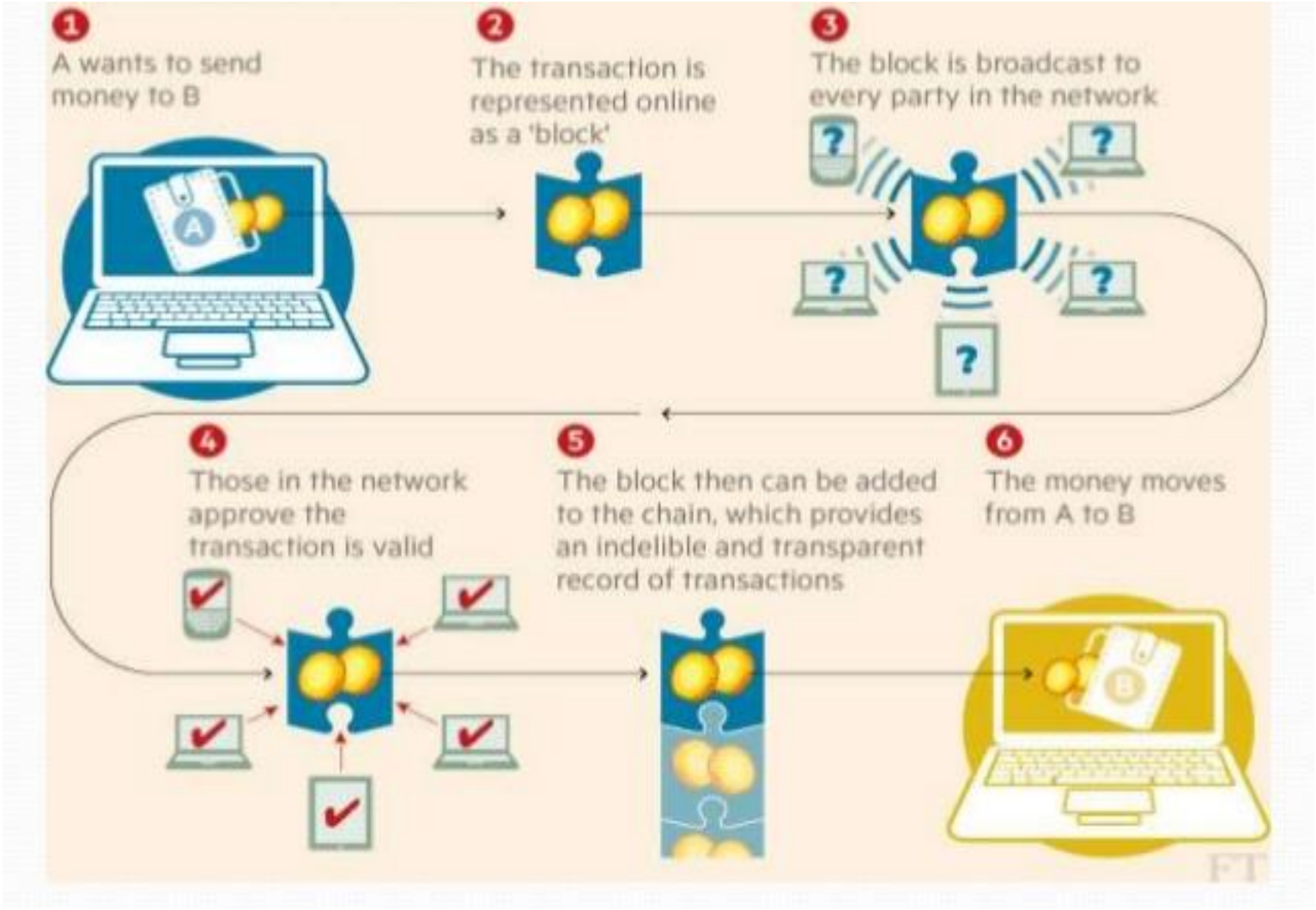


Fig. 8: Block Structure with Basic Components

```
type Block struct {
    Hash          []byte // Hash value of the block

    PrevBlockHash []byte // Hash value of previous block

    Data          []byte // Transaction data

    Timestamp     int64  //  Time block created
                  }
```

Fig. 9: Blocks

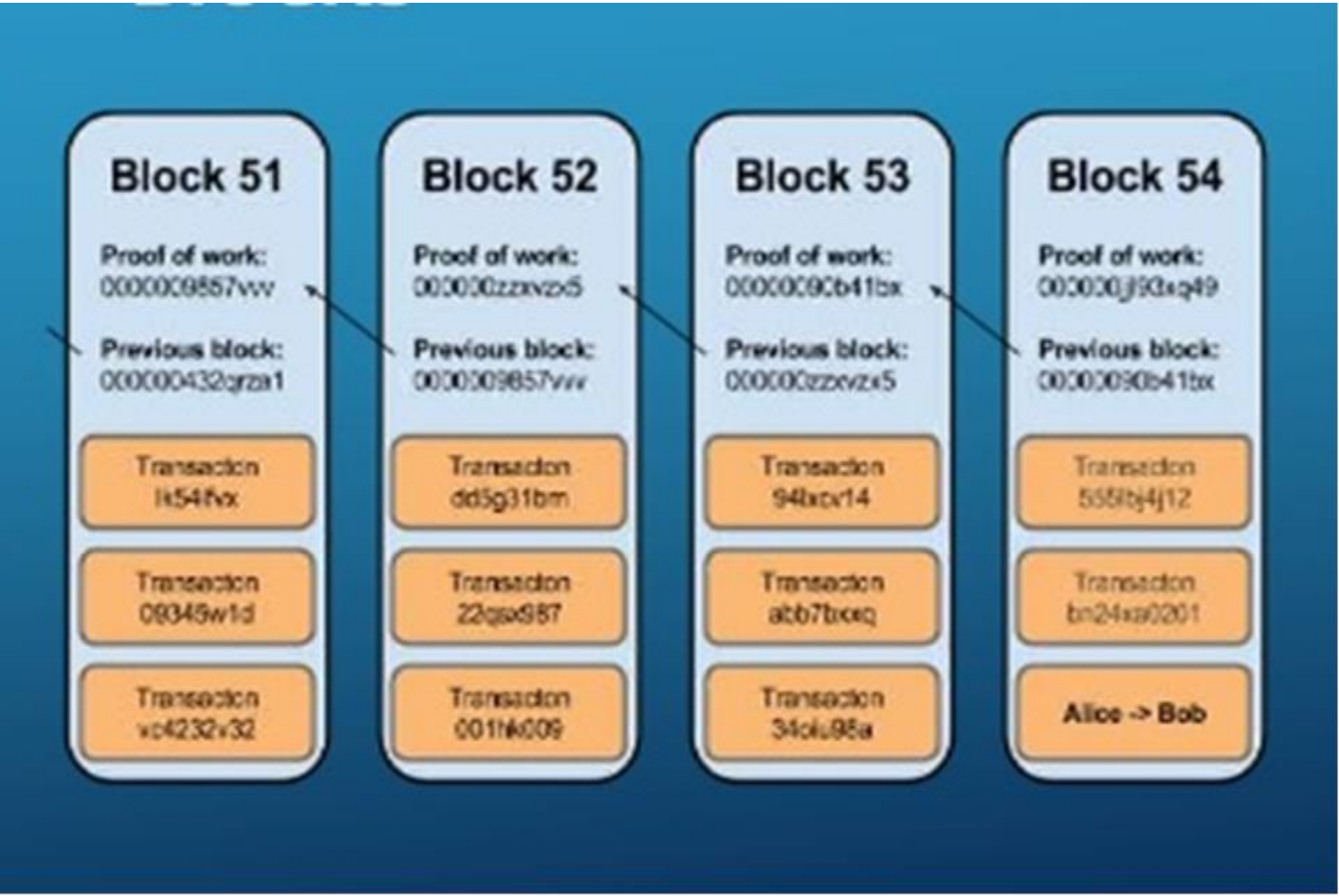
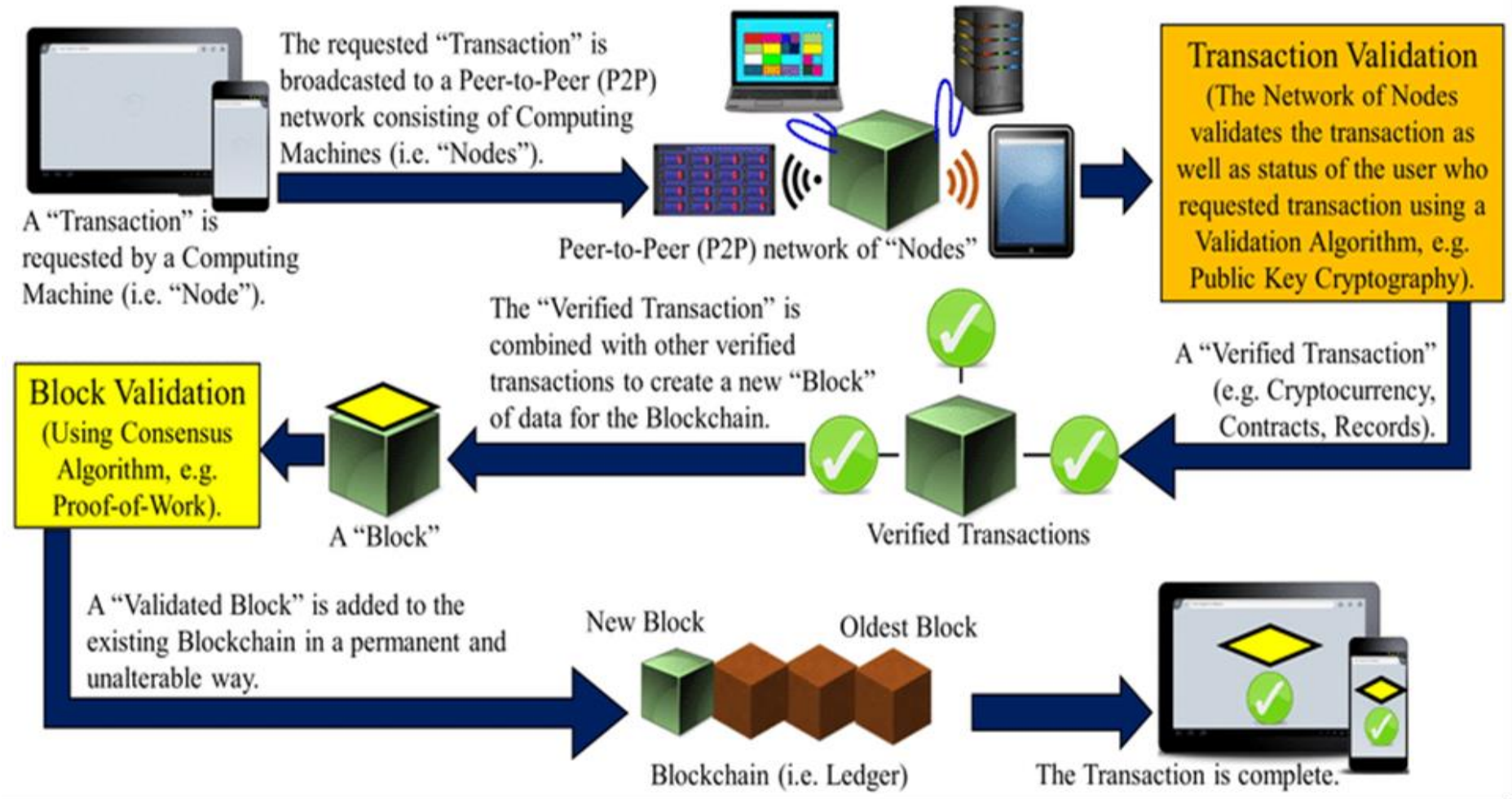

Block 51
Proof of work:
Previous block:
Transaction
Transaction
Transaction
Block 52
Proof of work:
Previous block:
Transaction
Transaction
Transaction
Block 53
Proof of work:
Previous block:
Transaction
Transaction
Transaction
Block 54
Proof of work:
Previous block:
Transaction
Transaction
Alice -> Bob

Fig. 10: Validation Process



Changing the Data of a Block

Once recorded, the transaction history data in any given block cannot be altered retroactively without alteration of all subsequent blocks, which requires consensus of the network majority.

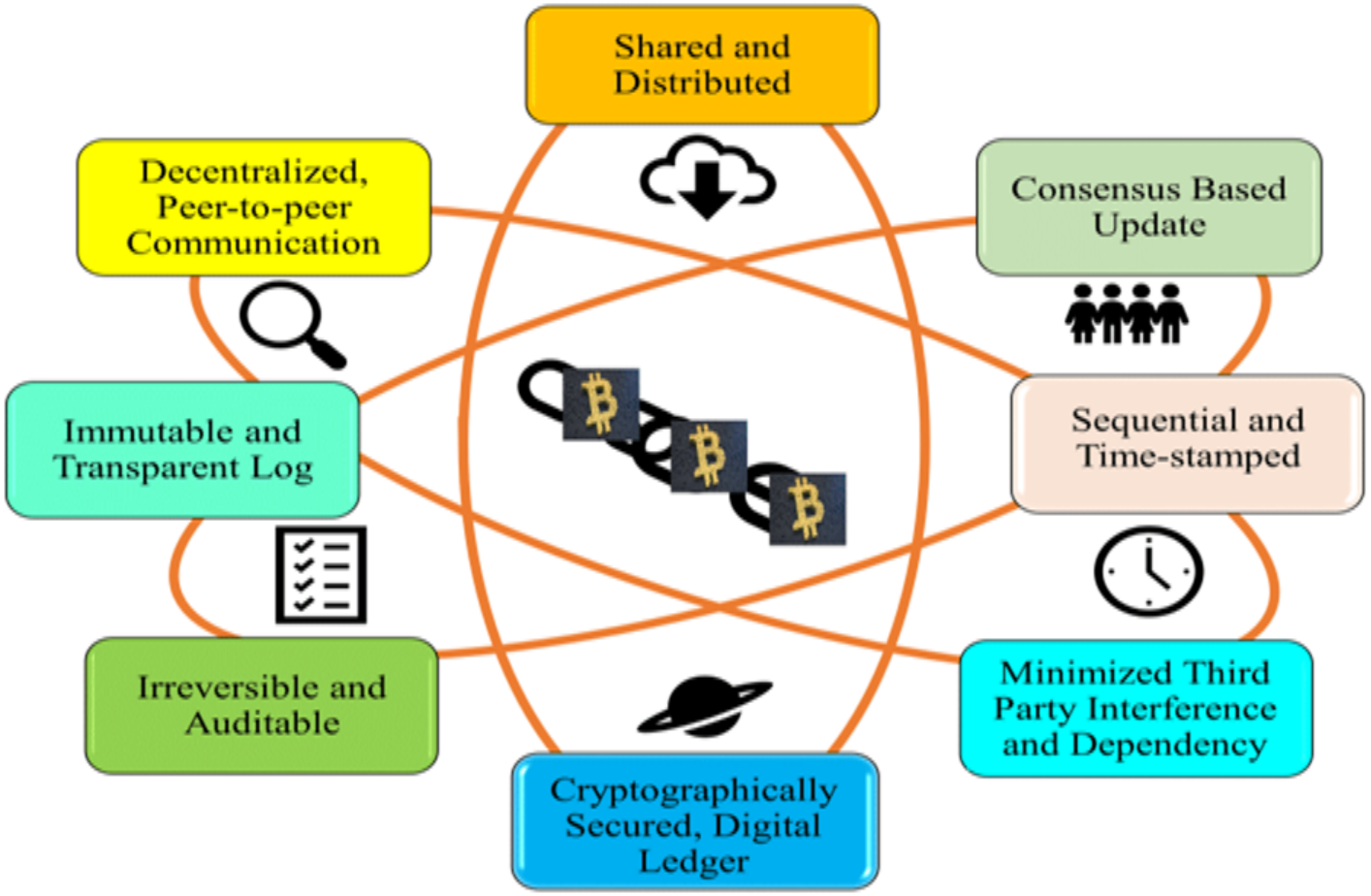
Although blockchain records are not unalterable, blockchains may be considered secure by design and exemplify a distributed computing system with high Byzantine fault tolerance.

Decentralized consensus has therefore been claimed with a blockchain. To change the transaction history data – say, if someone were trying to hack it – the ledger would have to be changed in the majority of participants owning all subsequent blocks.
With the number of people already using these, that's near impossible.

The transaction can first only be built upon, not changed and second all documented and verified, offering greater cybersecurity.

The vital characteristics, potential benefits, advantages-disadvantages, classification, spectrum and applications of blockchain are summarized in Fig. 11, 12, 13, 14, 15, 17, 18.

Fig. 11: Vital Blockchain Characteristics



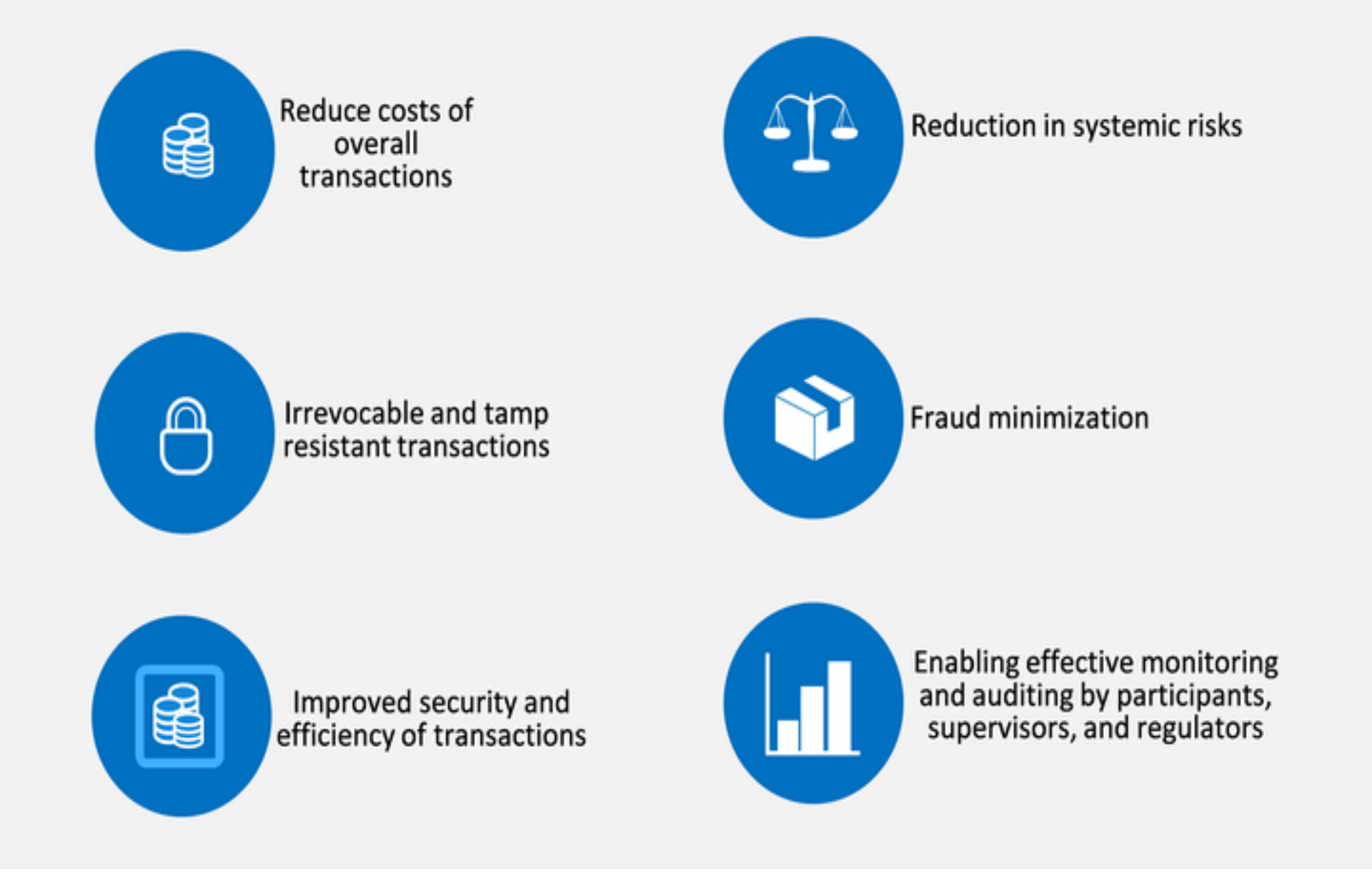


Fig. 12: Potential Blockchain Benefits

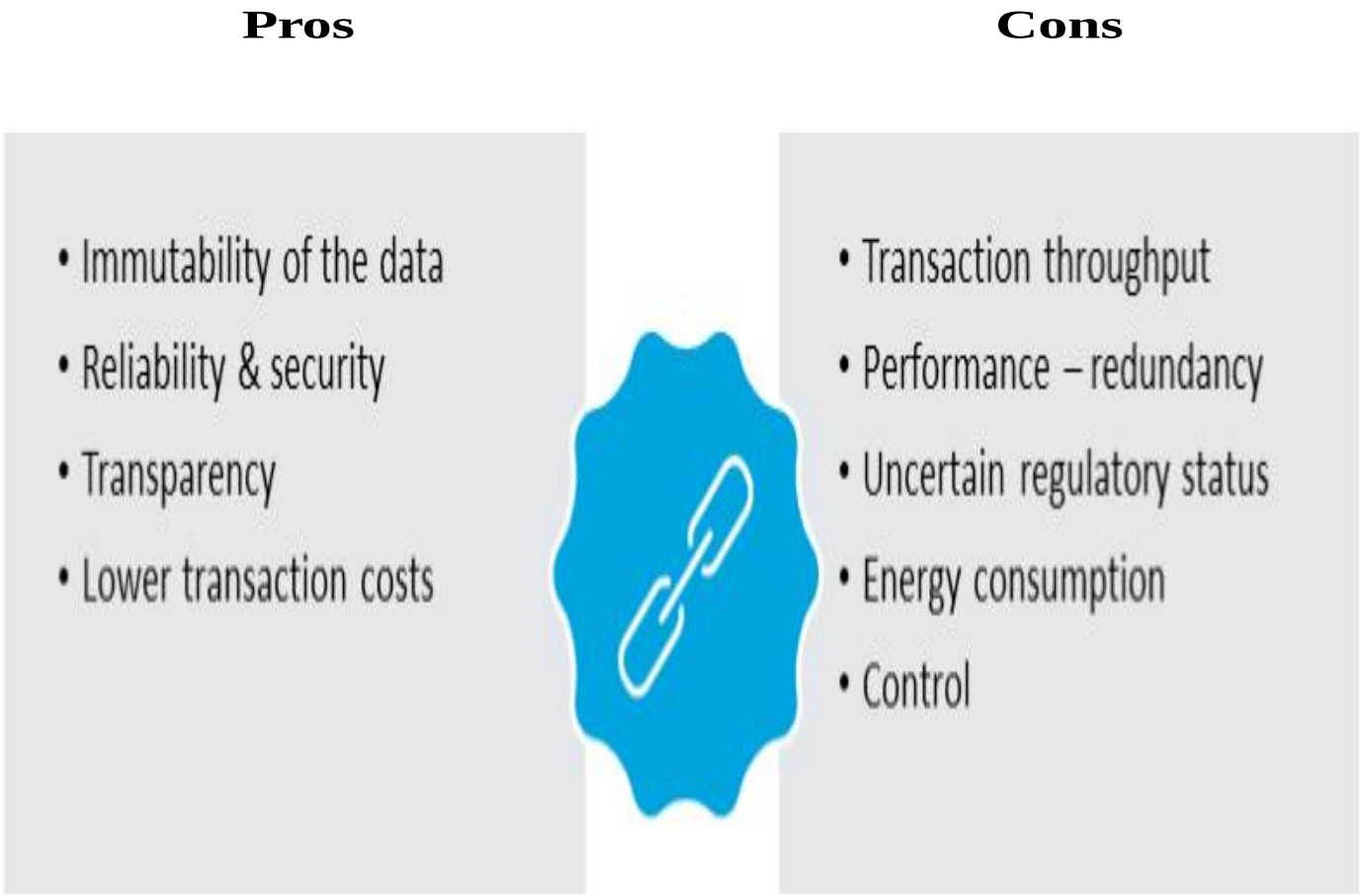


Fig. 13: Pros & Cons of Blockchain

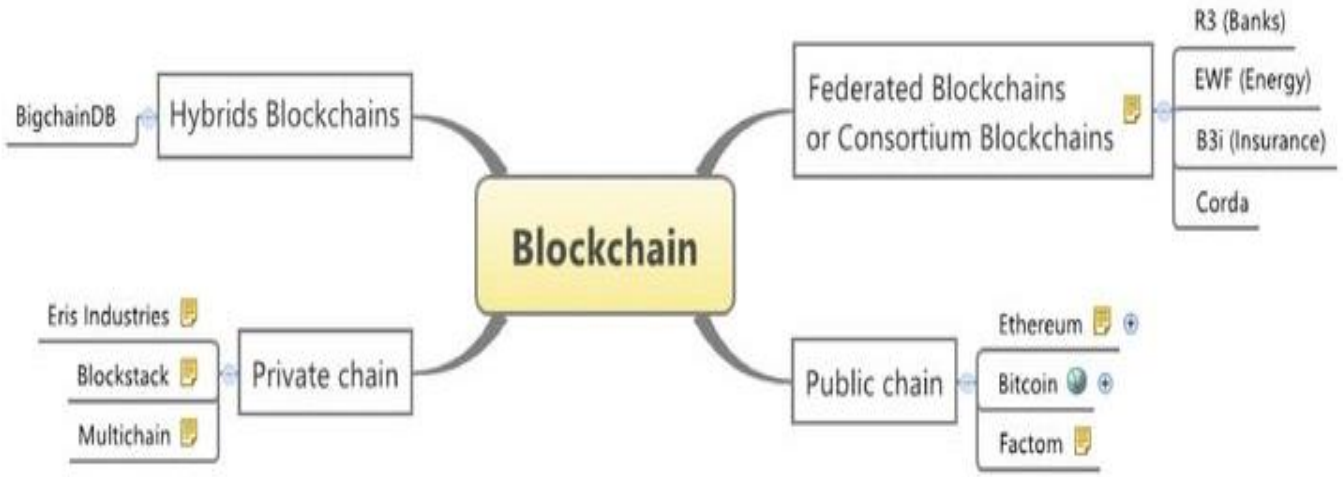


Fig. 14: Classification of Blockchain

Four Phases of the Gartner Blockchain Spectrum on Evolution and Potential Business Opportunities – Fig. 15

Gartner

1. Blockchain-enabling

These technologies → Building blocks
+ Cryptography
+ Distributed computing
+ P2P networking
+ Messaging

→ Future blockchain solutions

→ Part of non-blockchain solutions

2. Blockchain-inspired

Components from Blockchain-enabling phase →

Architectural aspects of pre-blockchain computing:
+ Centralized notary
+ Distributed or replicated data stores
+ Hashing / signing
+ Messaging layer

→ Limited-scope projects for most enterprise blockchain solutions
+ Lack the ability to tokenize
+ No basis for decentralized operations

Four Phases of the Gartner Blockchain Spectrum

Gartner

3. Blockchain-complete

These solutions → Completely new business models using
+ Smart contracts
+ Tokenization
+ Decentralized operational structures → Featuring
+ All the key capabilities of blockchain
+ A full value proposition.
such as tokenization enabled by smart contracts and decentralization
Currently, only startups are focused on this level of maturity

4. Blockchain-enhanced

Decentralized economic power and microtransactions combined with
+ The intelligent decision-making ability of AI
+ The sensory powers of IoT
+ Decentralized self-sovereign identity (SSI) solutions.

→ Creating never-before-possible technology constructs for business and sociaty.

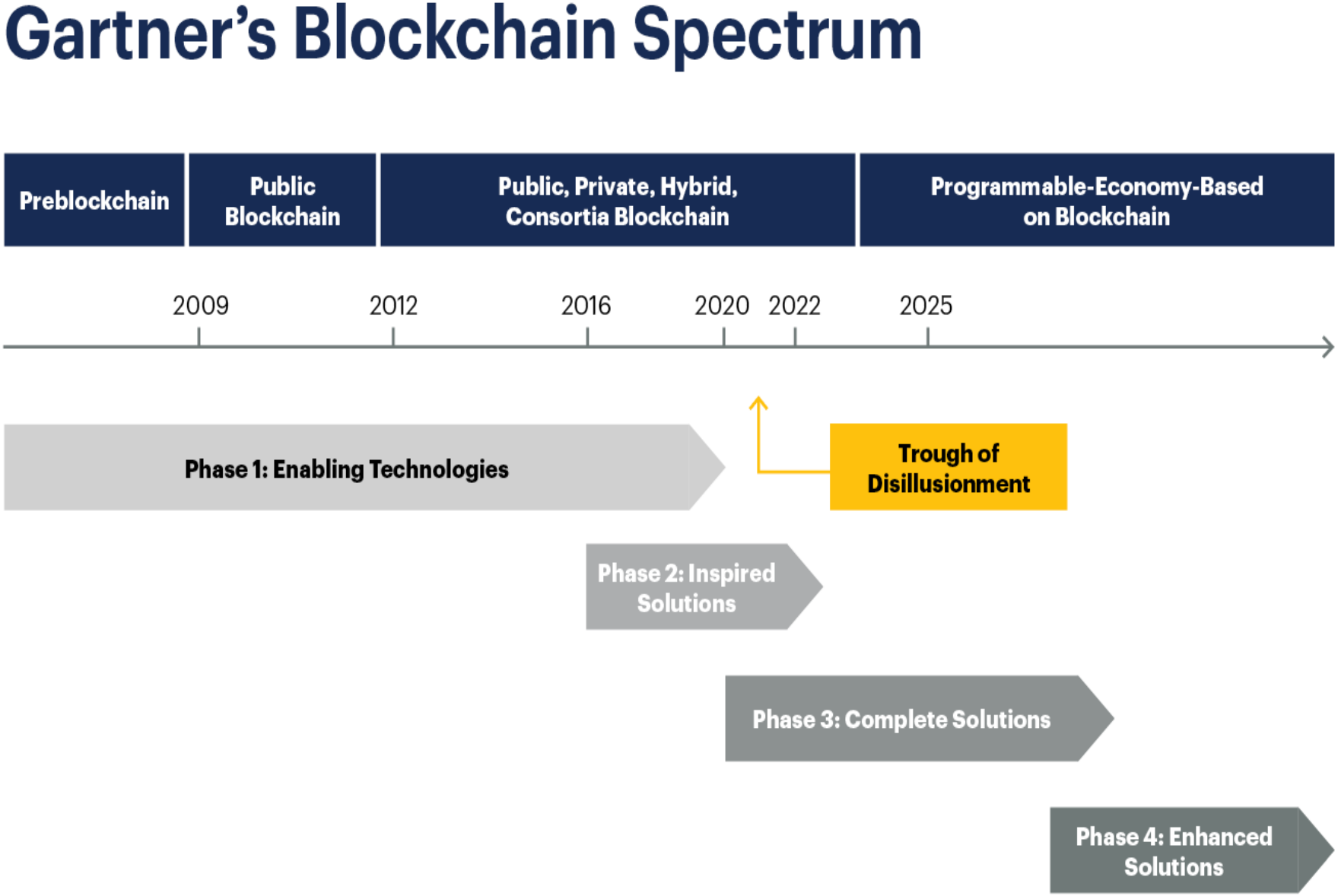
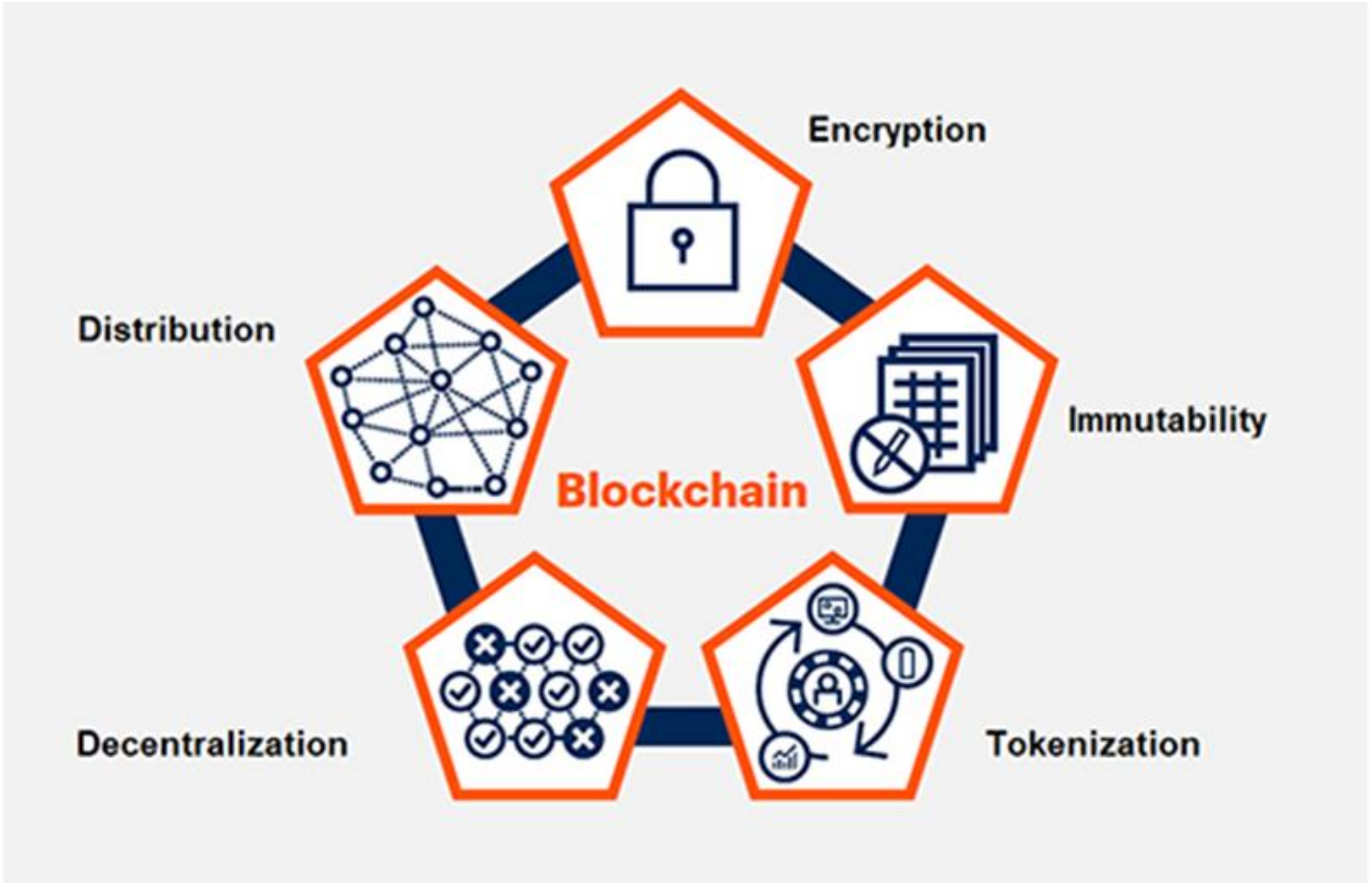


Fig. 15: Blockchain Spectrum

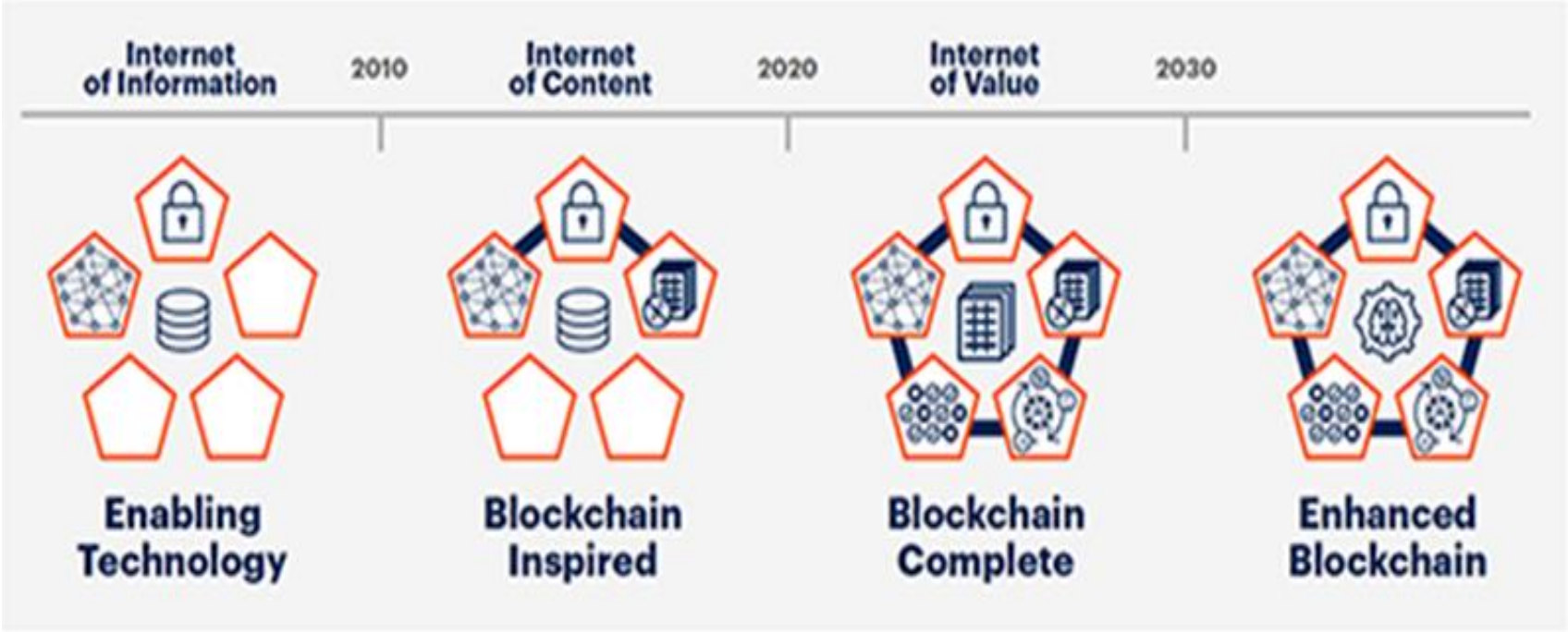
Gartner

Core Elements of True Blockchain

Gartner



Four Phases of the Gartner Blockchain Spectrum



Gartner

Development of Blockchain

The blockchain has been developed in accordance with other strategic technology trends as follows:

Blockchain 1.0: Currency and payments

The first blockchain application, based on distributed ledger technology, for cryptocurrencies allows financial transactions to be executed at most prominent level as a digital payment system.

Blockchain 2.0: Smart contracts, property and financial markets transactions

Smart contracts and conditions defined beforehand are reducing the cost of verification, execution, arbitration, fraud prevention and allow transparent contract definition overcoming the moral hazard problem.

Blockchain 3.0: Dapps – Fig. 16

The decentralized triple application, storage and communication pave the way for sharing between backend code, running on decentralized P2P network, and frontend code with user interface, that can make calls to its backend, to new applications on decentralized systems. The frontend can also be hosted on decentralized storage for running contracts.

Dapps are programs that use blockchain to create application that runs on a decentralized network and that provides a friendly user interface to smart contract.

Blockchain 4.0: Making blockchain usable in IR 4.0

The industrial revolution 4.0, meaning in short terms automation, enterprise resource planning, and integration of different execution systems, demands an increasing degree of trust and privacy protection - this is where blockchain kicks in. It will makes blockchain 3.0 usable in real-life business scenarios and blockchain promises come to life.

Blockchain Layered Approach

The blockchain layers are shown in Fig. 16 for the complete – enhanced solutions from blockchain 3.0, 4.0.

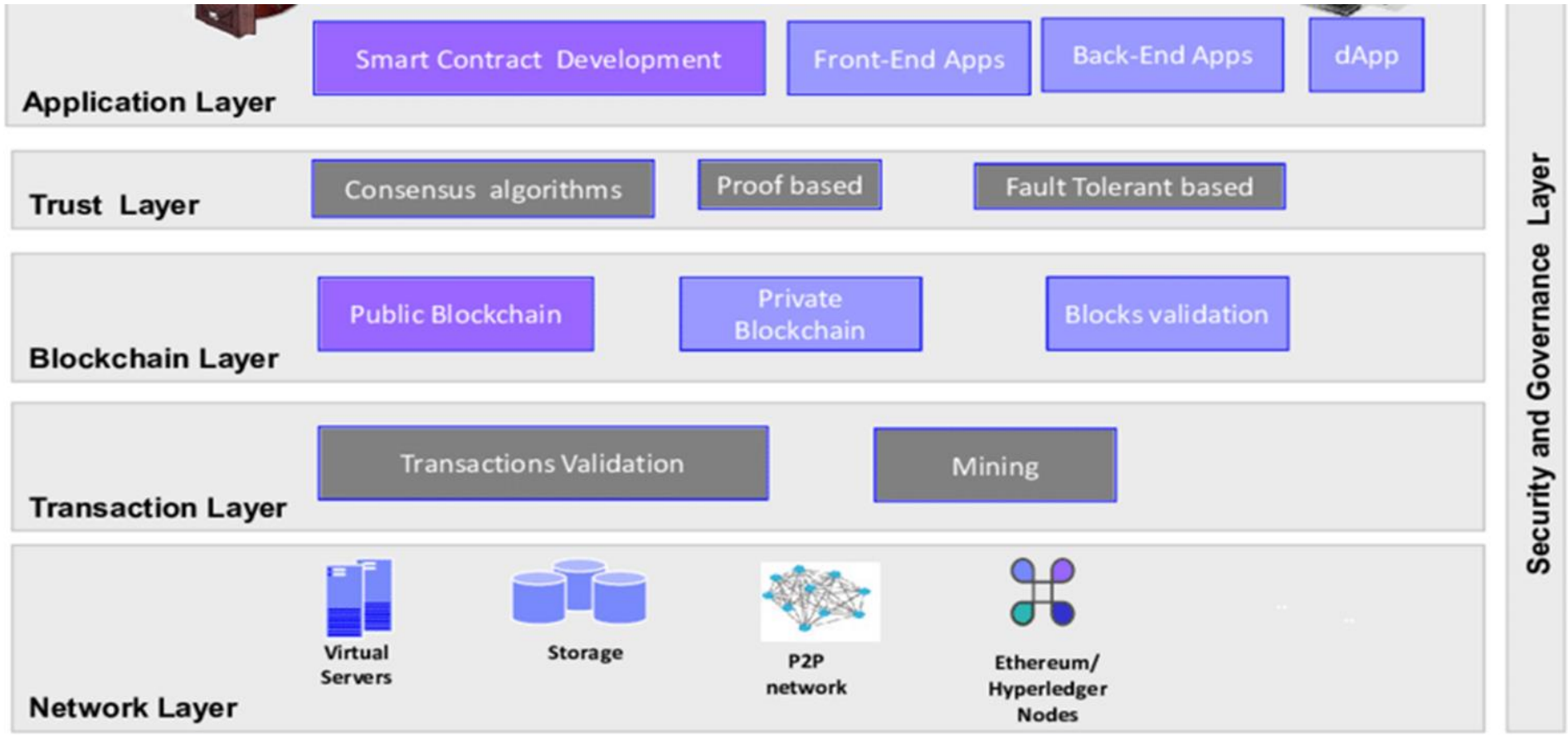
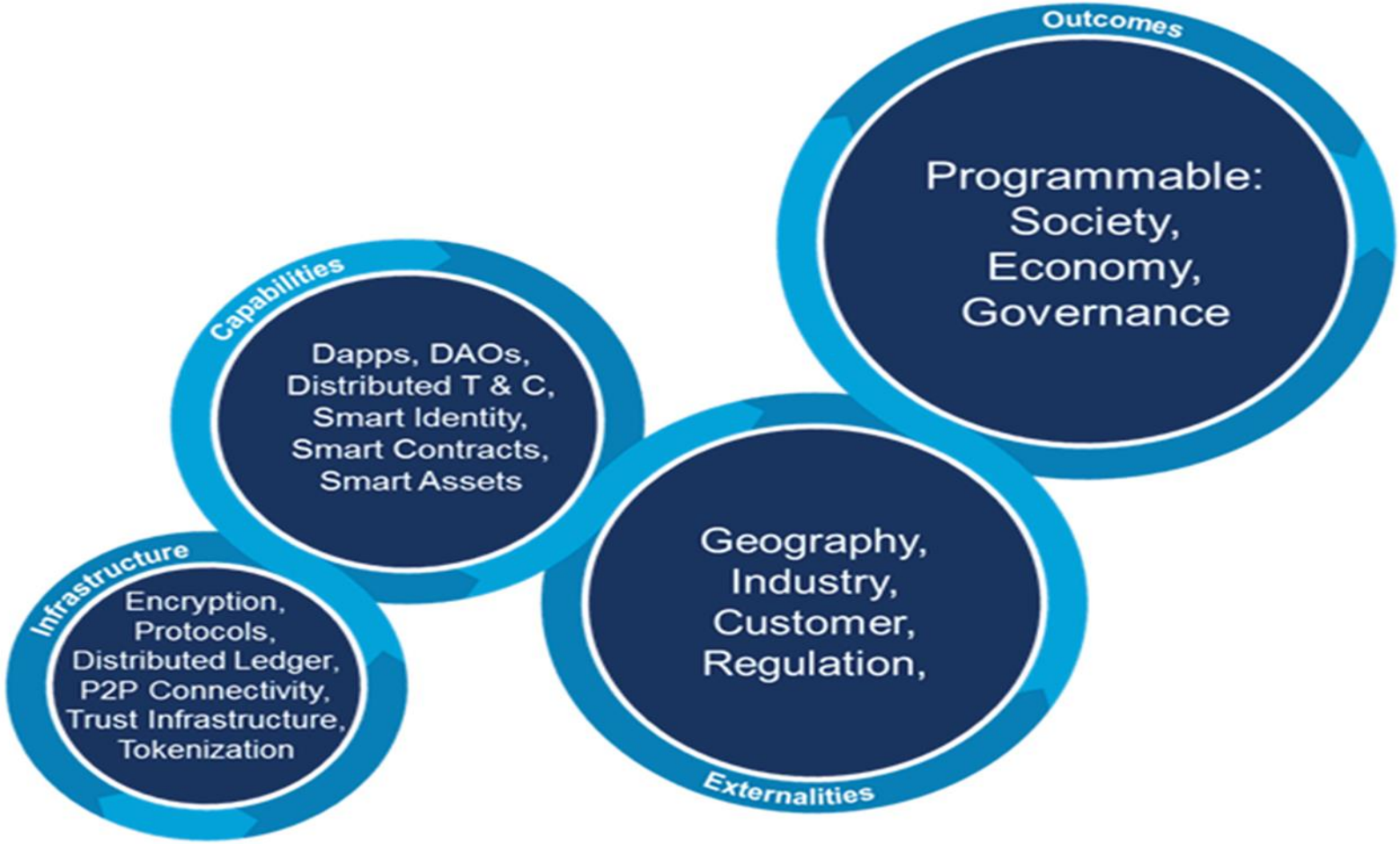


Fig. 16: Blockchain Layers Model

Fig. 17: Application Areas of Blockchain

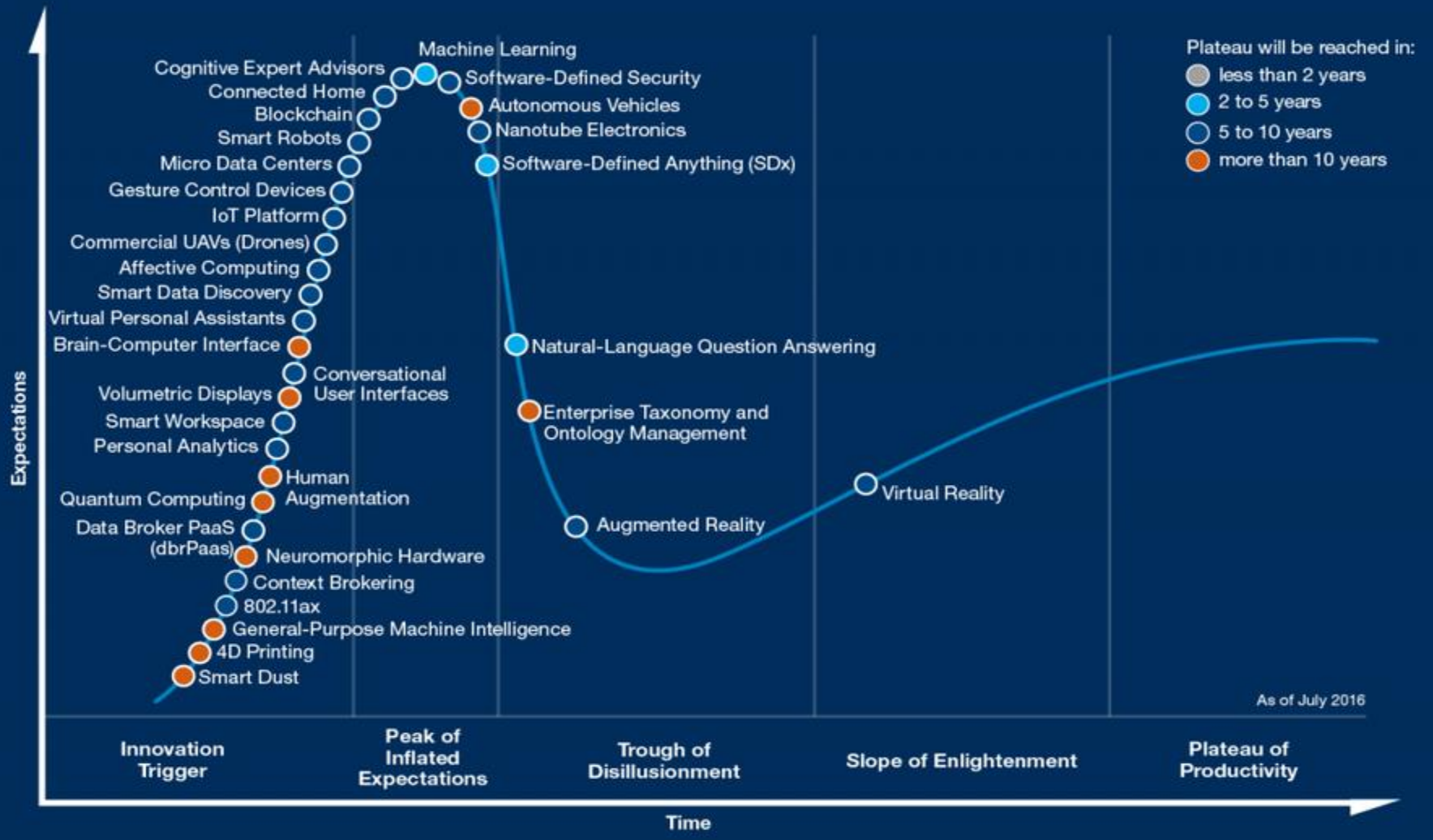
Fig. 18: Programmable Economy – Final Frontier of Blockchain Evolution



gartner.com/SmarterWithGartner

Gartner

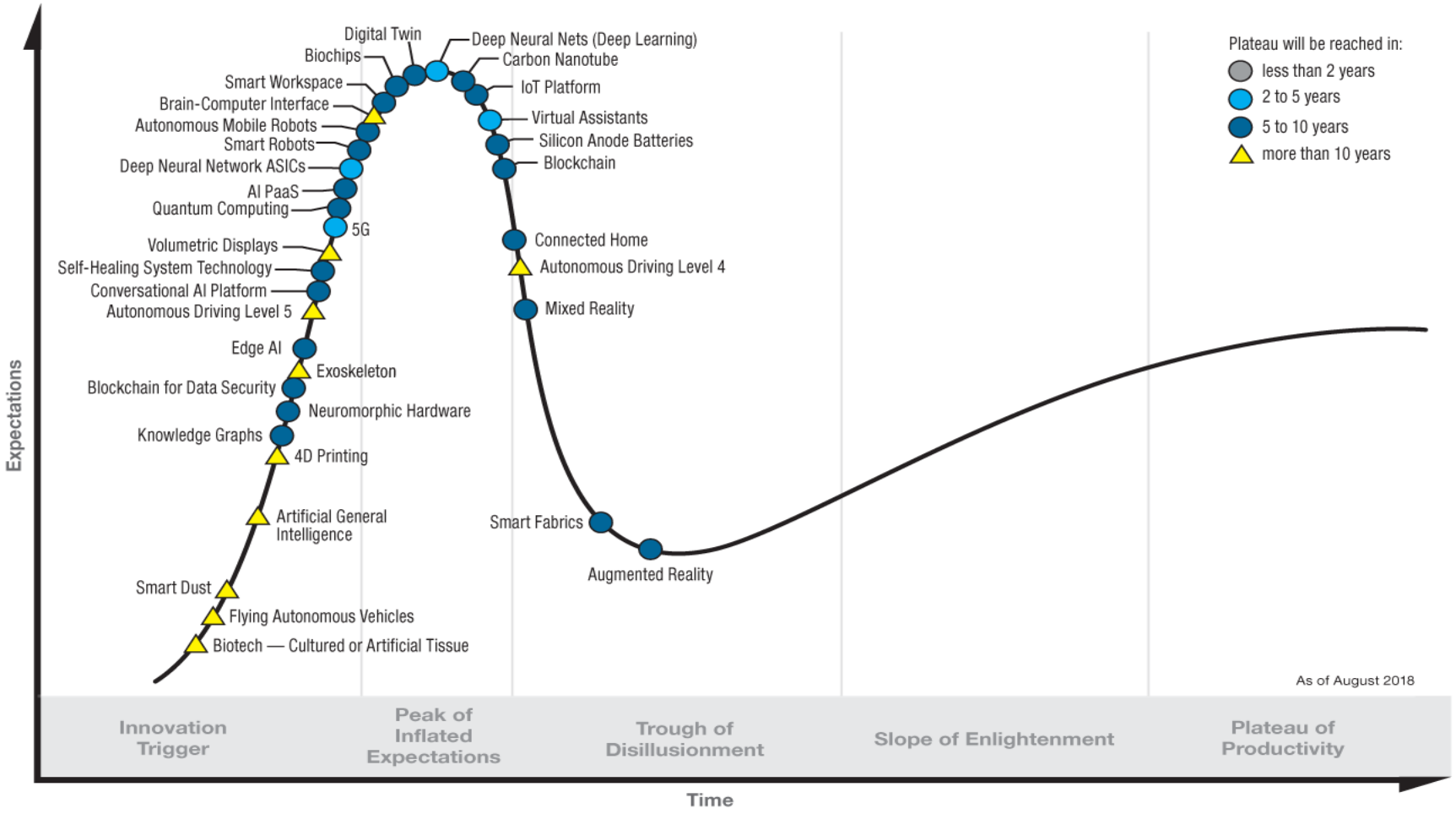
Gartner Hype Cycle for Emerging Technologies, 2016



Source: Gartner

Gartner

Hype Cycle for Emerging Technologies, 2018

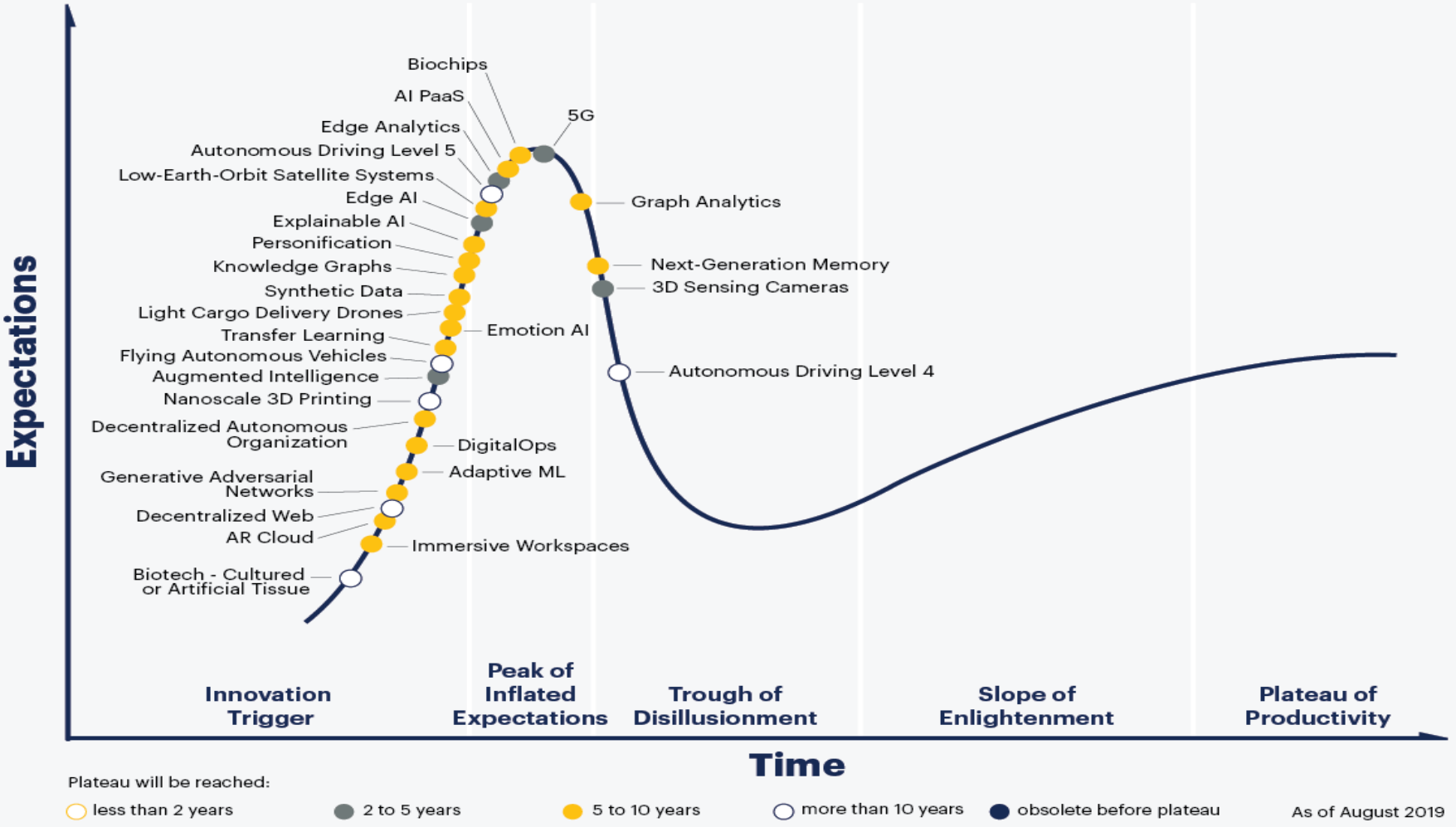


gartner.com/SmarterWithGartner

Source: Gartner (August 2018)

Gartner

Gartner Hype Cycle for Emerging Technologies, 2019



gartner.com/SmarterWithGartner

Source: Gartner

Gartner

Emerging Technology Trends 2019

Sensing and Mobility
- 3D sensing cameras
- AR cloud
- Light-cargo delivery drones
- Flying autonomous vehicles
- Autonomous driving Levels 4 and 5

Augmented Human
- Biochips
- Personification
- Augmented intelligence
- Emotion AI
- Immersive workspaces
- Biotech (cultured or artificial tissue)

Postclassical Compute and Comms
- 5G
- Next-generation memory
- Low-earth-orbit satellite systems
- Nanoscale 3D printing

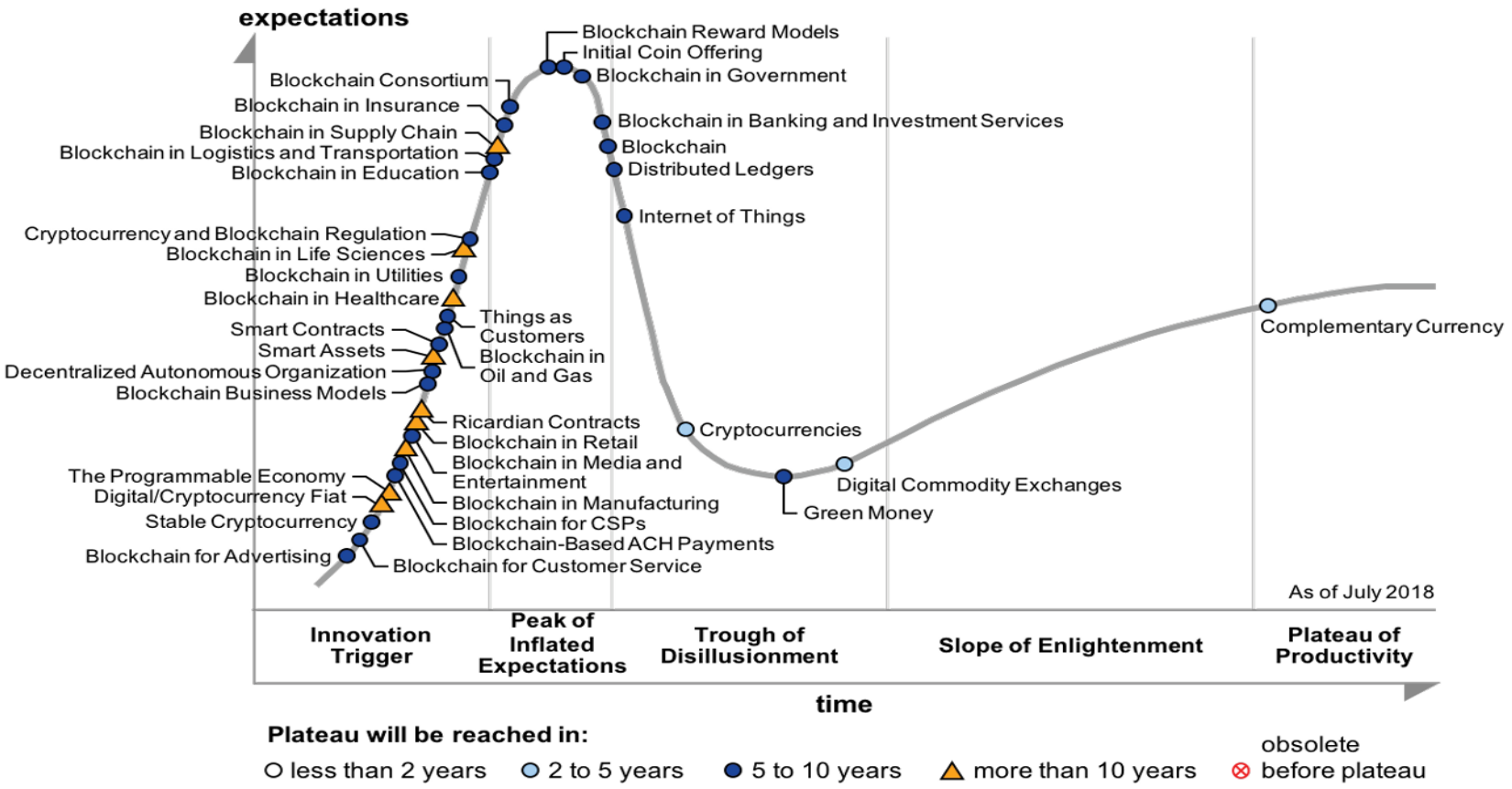
Digital Ecosystems
- DigitalOps
- Knowledge graphs
- Synthetic data
- Decentralized web
- Decentralized autonomous organizations

Advanced AI and Analytics
- Adaptive machine learning (ML)
- Edge AI
- Edge analytics
- Explainable AI
- AI PaaS
- Transfer learning
- Generative adversarial networks
- Graph analytics

gartner.com/SmarterWithGartner

Gartner

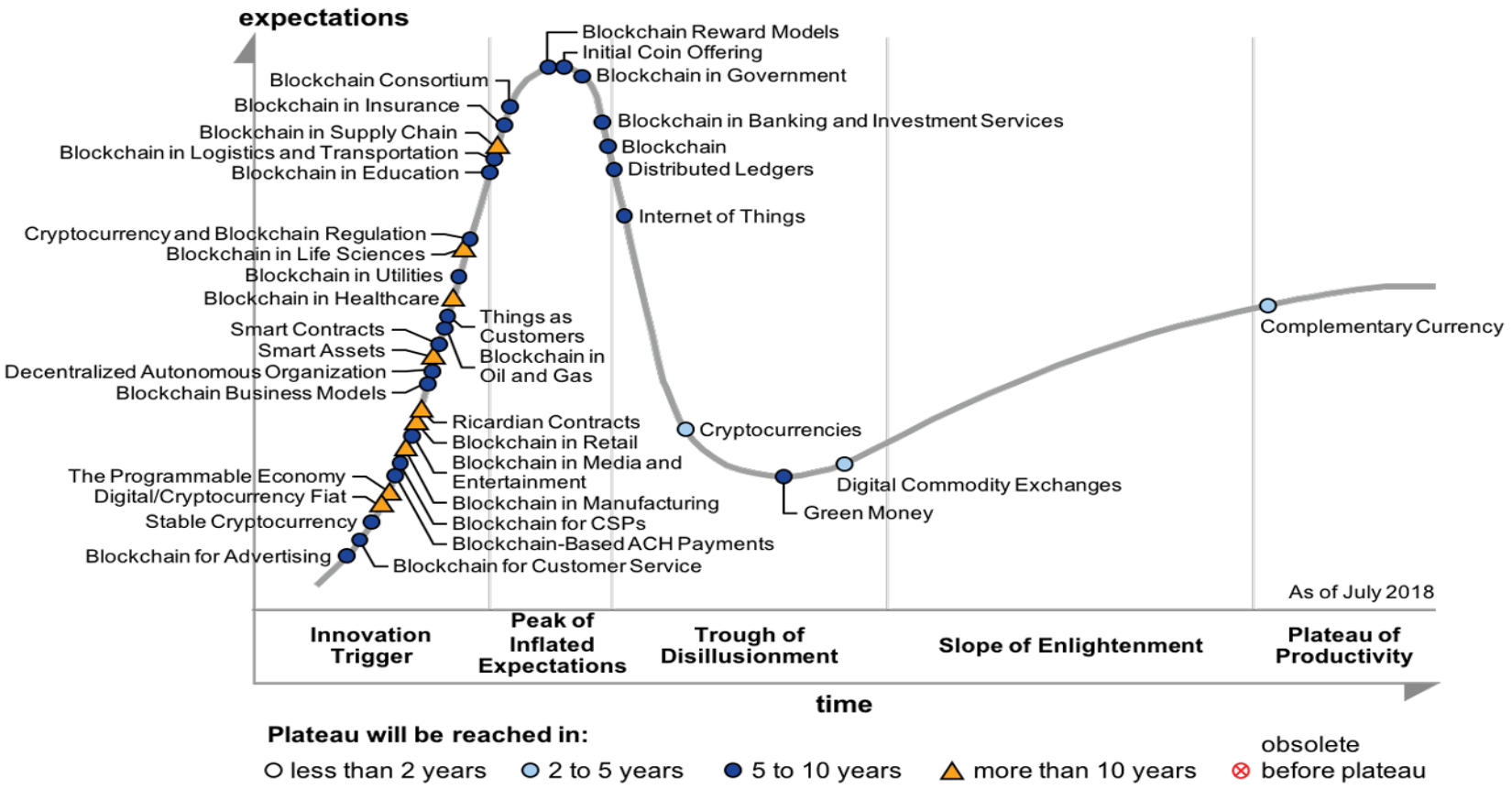
Hype Cycle for Blockchain Business, 2018



gartner.com/SmarterWithGartner

Gartner®

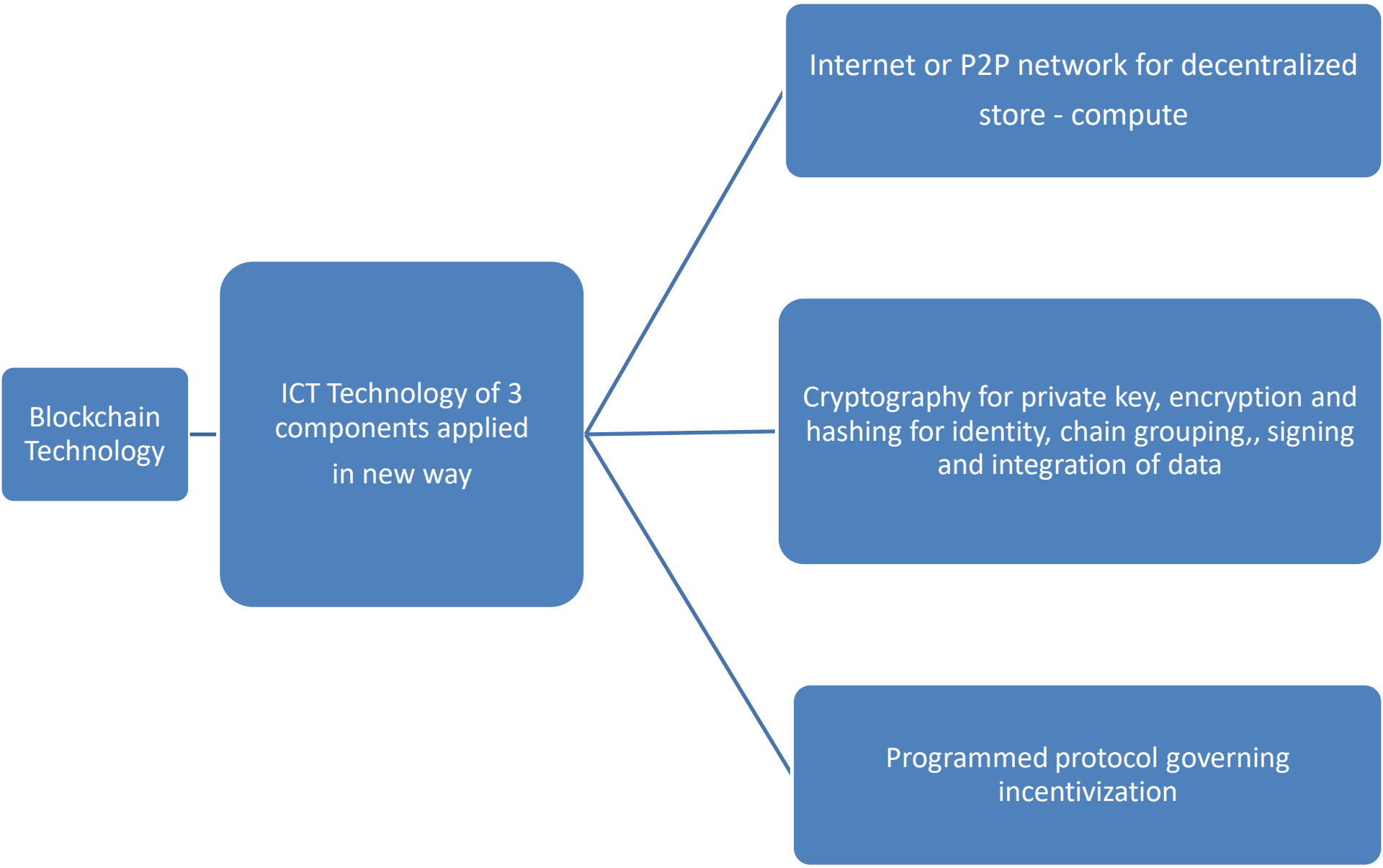
Hype Cycle for Blockchain Business, 2018



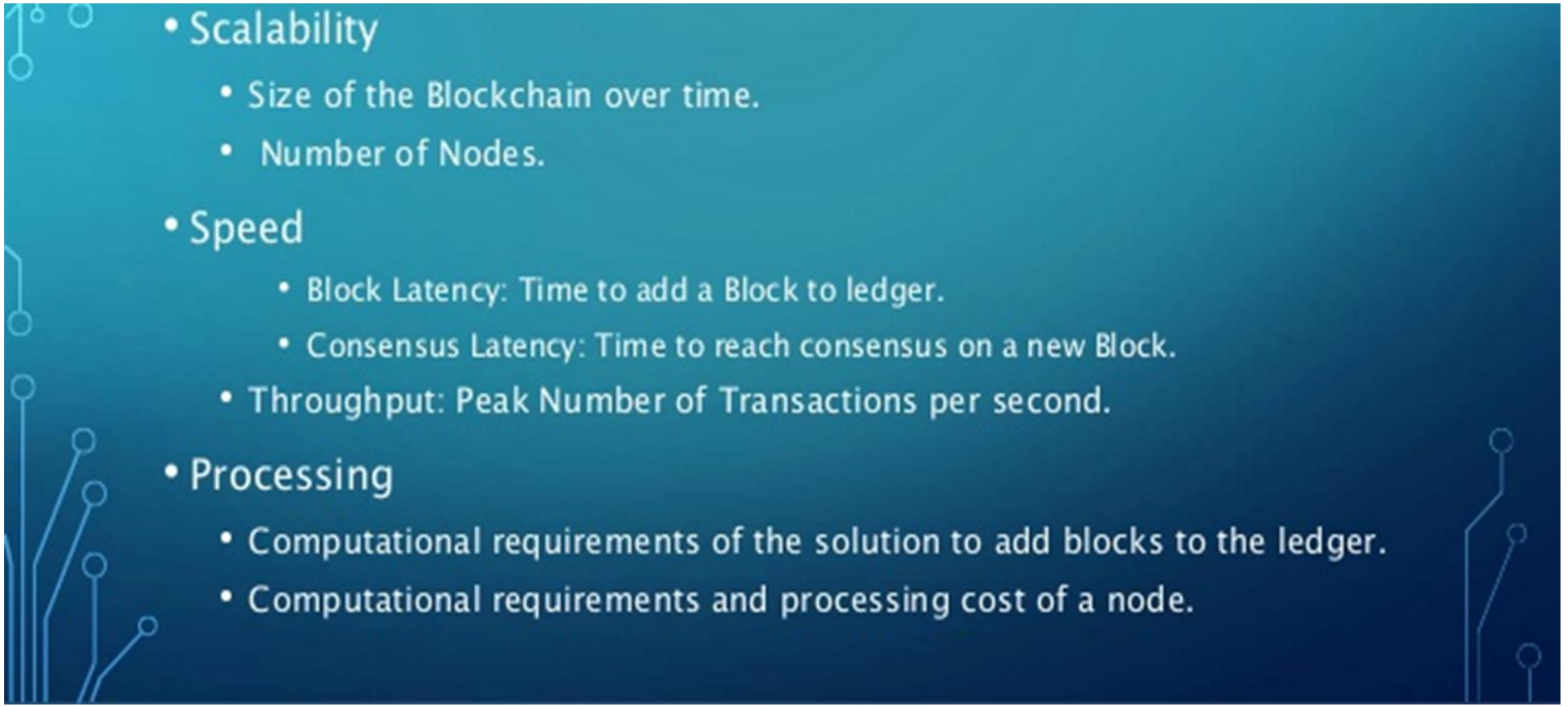
gartner.com/SmarterWithGartner

Gartner®

3. Blockchain Technology



Metrics of Blockchain Technology



Blockchain Ecosystem

The blockchain technology can be seen as the intersection of hardware and software technologies and people all work in one common environment, the blockchain ecosystem, and are dependent on one another for ultimate success.

Today there are three main blockchain ecosystems in the market:

1. Graphene ecosystem (Exchange, Payment/Processing, Marketplace, Social network, ect with three powerful blockchains and blockchain development toolkit)
2. Bitcoin ecosystem
3. Ethereum ecosystem.

Challenges

Critics have cited the 9 blockchain challenges:

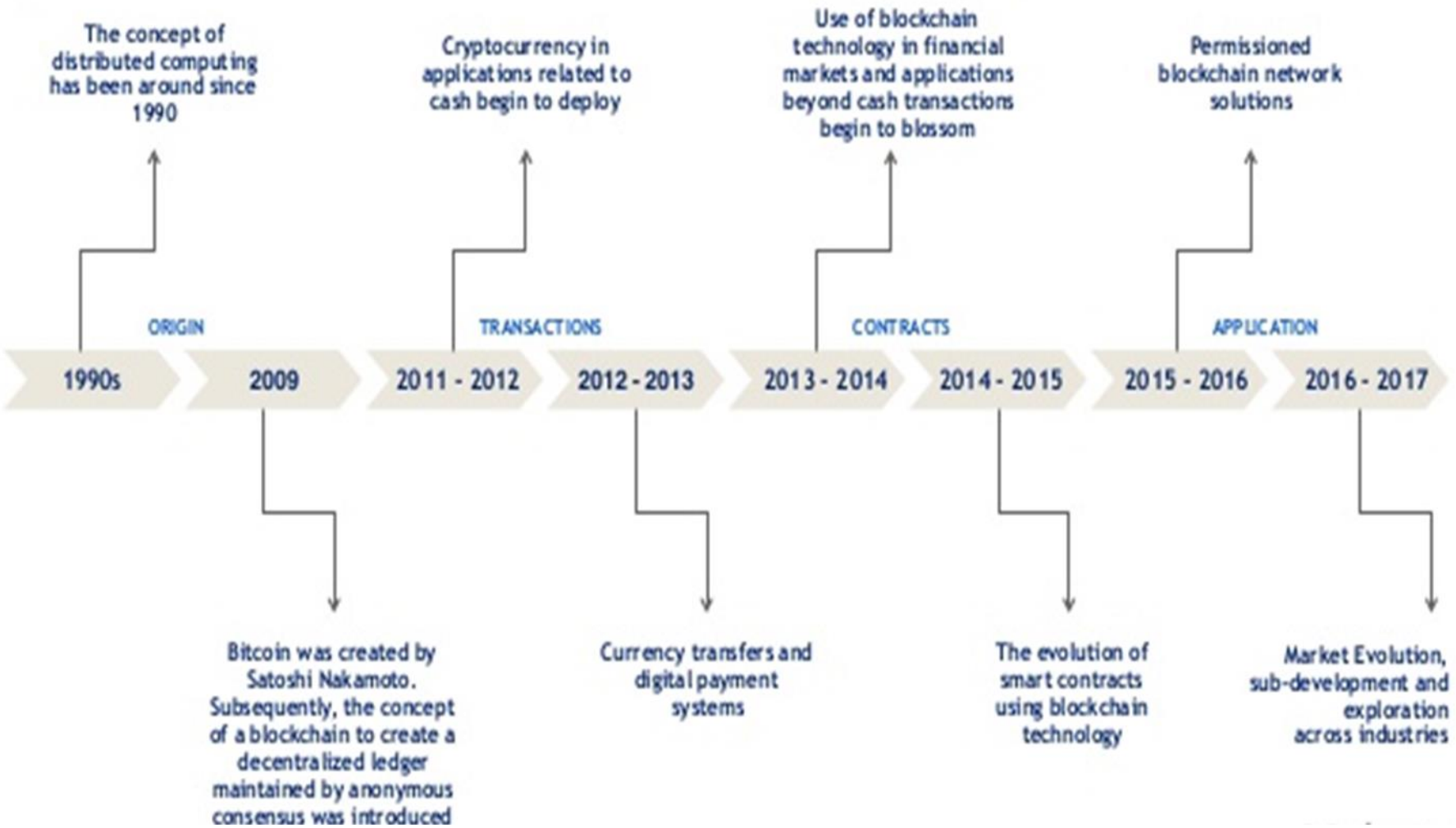
1. Nascent technology
2. Uncertain regulatory status
3. Large energy consumption necessary to process and store transactions
4. Control, security and privacy
5. Integration concerns
6. Cultural adoption
7. Cost from the more expensive resources required to process and store larger amounts of data
8. Challenges associated with audit, taxes, and compliance
9. Scalability is the most serious one. It is possible to deal with the scalability challenge by off-chain transaction, smaller network with fewer nodes and increasing block size.

Blockchain Trends

1. In the 2020s the blockchain technology will implement smart contracts and deliver the full value proposition of blockchain including decentralization and tokenization.
2. Smart Contracts will have real autonomy and advanced technologies will enable exchanges and transactions that aren't currently possible, e.g. Decentralized Autonomous Organizations (DAO) and microtransactions performed by machines.
3. Blockchain will need quantum computing for high computing power, advanced cryptographic algorithms and thus high transaction and block verification speed.
4. Blockchain in the IoT system will be used for the communications network required to coordinate driverless vehicles without need for a central server and for protecting autonomous cars from being hacked. The built-in blockchain can help maintain a continuously growing list of cryptographically secured data records protected against alteration and modification. For instance an IoT connected (e.g. RFID) device with sensitive location and temperature information moves along various points in a warehouse or in a smart home, this information could be updated on a blockchain. This permits all involved parties to share data and status of the package as it moves among different gatherings to guarantee the terms of an agreement are met.
5. AI impacts blockchain through deep learning and blockchain benefits by using of smart contracts in AI.

Blockchain Trends in 2019

Brief History of Blockchain



4. Conclusion

- Blockchain, a shared replicated decentralized ledger using advanced cryptography and game theory for the secure identity and integration of data, can open up fair business network by taking out cost, improving efficiencies and increasing accessibility.
- Blockchain addresses an exciting and topical set of challenges, which cross every industry and pave the way for many innovative solutions from Smart Contract, Dapp, tokenization…to DAO and microtransactions performed by machines.
- The combination of AI, and IoT with blockchain is promising other strange features. Making ASIC hardware for many components of the blockchain will bring up many progress in application.
- Blockchain technology's many concepts and features might be broadly extensible to a wide variety of situations.
- The decentralized model could be the great innovation in the possibility space for the future applications. However, this model should be considered individually for each use case.
- The blockchain technology can reach mature in 5 to 10 years.
- Blockchain-based complementary currency will reach mature in 2 to 5 years.

REFERENCES

[1] David W. Cearley, Brian Burke, Top 10 Strategic Technology Trends for 2019, October 15, 2018, Gartner Research, ID: G00374252.
[2] Suyash Gupta and Mohammad Sadoghi, Blockchain Transaction Processing, Department of Computer Science, University of California, Davis, CA, USA
[3] Jean de Maillard, Un mond sans loi, La criminalite financiere en images, 1999, Editions Stock, Page 28
[4] Nguyen Quoc Toan, Development of Cryptographic System in Quantum Computing Area, Information Security Journal 2-2019, Vietnam

THANK YOU