BLOCKCHAIN IN MODERN INFRASTRUCTURE

Abstract

This chapter tries to explain the incorporation and adoption of Blockchain technology in modern infrastructure sectors like corporations, power sector, healthcare, education etc. It starts with the introduction to Blockchain and details its history and early adoption and goes on to show its impact on our society, and how it will continue to shape our ideas and infrastructure going forward.

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I. HISTORY OF BLOCKCHAIN

A timeline of major events in Blockchain development:

1. **1991:** Stuart Haber and W. Scott Stornetta of Bell Communications Research conceptualized crypto-blocks.
2. **2008:** Satoshi Nakamoto, an individual whose identity remains elusive published a whitepaper "Bitcoin: A peer-to-Peer Electronic Cash System" conceptualizing the first blockchain.
3. **January 2009:** The bitcoin network came into existence – Satoshi Nakamoto mines the first block of the first blockchain to earn 50 Bitcoins (BTC).
4. **2014:** Kariappa Bheemaiah coined the term Blockchain 2.0 signifying applications of blockchain besides digital currencies.
5. **2017:** IBM's 2015 projections about the applications of blockchain in banking and fintech came true as more than 40 banks and financial institutions joined the Post-Trade Distributed Ledger Group (PTDLG)[1], a consortium for developing a trusted environment for blockchain application in banking.
6. **2027:** WEF projects that 10% of global GDP would be stored on blockchain based technologies.[2]

As time passes, the market for Blockchain-as-a-service (BaaS) evolves as businesses and governments seek guidance in testing and deploying blockchain technologies.

II. BLOCKCHAIN BASICS

1. **Background:** "Blockchain is an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way." [3]

2. **The two basic functions:**

   - Data storage and transfer: Blockchain can be used for the transfer and storage of data in various applications.
   - Transaction Authentication and Execution: Blockchain provides secure authentication and encryption over every transaction.

3. **The "Block":** Every "block" in a blockchain contains three properties:

   - **Transaction data** for all the transactions recorded on the block. Every participant is called a node. Any node can request a transaction which would be added to a block if and when all nodes arrive at a consensus regarding its validity.
   - **Timestamp** (date and time when the block was added). This timestamp is generally added by validators/miners. They earn a financial incentive for doing so and are usually paid in that blockchain's cryptocurrency.
   - **Hash pointer** (an encrypted reference to the previous block in the blockchain). The hash pointer of a block cannot be altered without altering the hash pointer of all subsequent blocks. This system of successive encrypted linkages is what makes data written to a blockchain immutable.

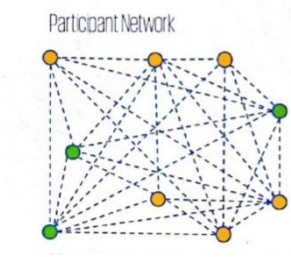

Figure 1: Participant Network In A Blockchain.

In the figure above, yellow dots are the nodes and the green dots are the miners. All miners/validators are nodes, but not all nodes are miners/validators. Miners/validators eliminate the need for a centralized third-party authenticator.

III. BLOCKCHAIN APPLICATIONS

Bitcoin and cryptocurrencies are only a small part of blockchain technologies. In fact, it is possible to develop blockchain systems without an associated cryptocurrency. All that is needed is a protocol for validating new transactions and an appropriate environment. Today, the largest class of blockchain applications besides cryptocurrencies is immutable data storage and smart contracts.

1. **Blockchain 1.0** (2009-2017): The dominant ecosystem was Bitcoin, and the dominant application was mining for cryptocurrencies and transacting. This early phase contributed to the advancement of concepts and the technology.
2. **Blockchain 2.0** (2017-2020): The dominant ecosystems were Ethereum, Bitcoin and Litecoin, and the dominant applications were smart contracts, banking and financial services.This phase contributed in maturation, testing, scrutiny and regulatory developments.[4]
3. **Blockchain 3.0** (2020-): The dominant ecosystems are Ethereum and permissioned blockchains and the dominant applications are connectivity, automation and Internet of Things (IoT). This phase contributed to the large-scale adoption of blockchain.

IV. BLOCKCHAIN ADOPTION

The Technology Adoption Lifecycle (TAL)[5] was a model for capturing adoption over time and was developed by Everett Rogers, a scholar of communication studies. This model can be used to understand the stage that blockchain is currently in and how it is expected to evolve in the future.

It is believed that blockchain adoption is now in the phase of early adopters. The characteristics of this phase is the high growth rate in users and the increasing amounts of investments.

For disruptive innovations, this stage is punctuated by something called a ‘chasm’. The transition to early majority would require proven demonstration to various target markets.

On December 12 2017, the total market capitalization of cryptocurrencies touched $500 billion. It remains to be seen if cryptocurrencies are being used for useful applications and decentralized apps based on blockchains see substantial usage. Also, blockchain is classified to be past the innovation phase, close to the peak of inflated expectations, but heading towards the trough of disillusionment, a phase of waning interest. Investments in the technology would continue only if the blockchain companies deliver on their promises to early adopters.

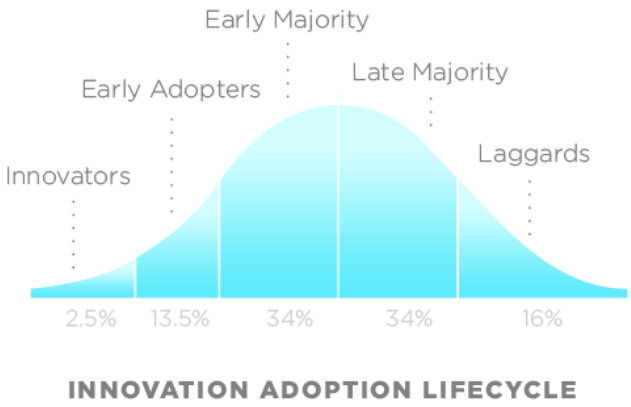

Figure 2: The Technology Adoption Lifecycle.

V. BLOCKCHAIN APPLICATIONS IN INFRASTRUCTURE

The infrastructure applications of blockchain technologies fall into six broad classes:

1. **Immutable data storage:** Data stored on a blockchain is secure and cannot be falsified. Capturing 51% of the nodes would theoretically facilitate data falsification, but it is practically impossible. Since data is stored on the blockchain in an encrypted format, retrieval is impossible without a private key.

2. **Decentralized Identity:** Blockchain facilitates storage of secure identity data along with transaction history, asset ownership and reputation scores. This is a significant safeguard against identity theft and tampering of public records. Sub-applications include Know Your Customer (KYC) compliance and credit rating services.

3. **Decentralized Business Models:** Blockchain provides a way for stakeholders in a decentralized business model to transact efficiently while eliminating the need for central trust-keepers such as clearing houses in the banking sector or energy exchanges in the power and utilities sector.

4. **Automated Efficient Contracting**: A smart contract is a computerized transaction protocol that executes the terms of a contract. Smart contracts can now be coded to retrieve data that is not stored on the blockchain.

5. **Internet of Things (IoT)**: Blockchain would facilitate implementation of hack-proof machine to machine communication networks and transaction protocols improving the security in Internet of Things (IoT) applications.

6. **AssetLifeCycle Tracking**: Multiple stakeholders to infrastructure projects can be nodes on a blockchain and seamlessly track asset status and performance through various stages of its lifecycle.

- **Blockchain in power and utilities sector:** The power sector blockchain companies going for Initial Coin Offerings (ICOs) at the moment are focused on stakeholder interactions within the sector. However, other interactions are unexplored, for example - credit monitoring and project utilization contracts.

The most common sector uses in the power sector are:

- Automation of billing
- Automation of load balancing and energy exchange
- Automation of transactions
- Decentralization of P2P energy trade

ICOs are also seen as a way to simply finance new projects. In this sector, blockchain is also being explored for registering and trading emissions reductions units within and outside the power sector. The value of the issued token would appreciate if the underlying technology or project performs well. The venture would then buyback tokens to give the investors a return. The corresponding may have applications such as maintaining water quality records over a large geographical area. It is to be noted that not all of these ventures have a sustainable business model or a token model.

- **Blockchain in health and healthcare sector:** Blockchain applications in health and healthcare are being explored for following applications:

- Improving security and implementing access controls for patient health records.
- Interoperable patient health records.
- Transactions among healthcare providers, pharmacies, patients, payers, insurers and pharmaceutical companies.
- Enabling big medical data by anonymizing patient health data written to medical blockchains.
- Enabling automated monitoring and emergency response by connecting wearable technology to patient health record systems.
- Improving patient-doctor connectivity through enhanced reach of telemedicine.

In this space, blockchain applications are unexplored for monitoring progress and performance on research aided by government grants and also on transactions between pharmacies and pharmaceutical companies.

- **Industry Specific Use Cases:** Given below are some examples of corporations that have applied blockchain technology in sectors like aviation, education and cities to simplify and revolutionize tasks that were difficult to perform or very impossible to do before.

- **Aeron:** It is a blockchain based aviation startup built on the idea that integrity of aviation data is central to aviation safety. Fundraising was done through sale of

tokens (ARN) that will be used to transact on the Aeron platform. Aeron database will be built on the Ethereum blockchain and it promises transparency and integrity.[6]

- **McFly:** It is an urban air taxi service being built on the blockchain. Transactions will be facilitated using McFly tokens. The McFly platform will be a decentralized ledger of air taxis, pilots, customers and service providers facilitating transactions in McFly tokens.[7]

- **Sony Global Education:** They seek to develop a blockchain-based platform for securely sharing and accessing academic records using a shared global education ledger. It is not certain whether Sony would create a platform of their own or use an existing platform like Ethereum.

- **Learning is Earning 2026:** It is a conceptual platform in which all forms of learning - formal, online, informal or experiential - can be added to the blockchain for the benefit of learners and employers. This model challenges the fundamental structure of academia worldwide.

Blockchain applications in cities also follow from what are IoT applications, more specifically, Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) systems. Some important functions of this system are traffic routing, road safety functions and energy efficiency. [8]

Other systems plugged into the smart city infrastructure are air quality monitoring, asset ownership databases, utility metering and telecommunications infrastructure. DigitalTown and SmartCity are smart city platforms based on distributed ledger technology plugging residents and machines into a single city-wide blockchain.

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