# The Use of Cryptocurrencies- How Blockchain is Making it Possible: A REVIEW

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***Abstract*—The blockchain technology has disrupted the early-age digital banking through concepts like bitcoin and ether [1, 3]. In this study, some major elements of the blockchain technology are examined- decentralized networks, smart contracts, cryptographic techniques, and consensus mechanisms of Proof of Work and Proof of Stake usage-and understanding how they contribute to safe, peer-to-peer transactions without intermediaries [2, 5].Bitcoin can do no more than about seven transactions a second (TPS) is a very paltry competition of an impressive 30 to 40 TPS of Ethereum. This depicts the ongoing scalability challenges that need to be tackled by initiatives linked with Ethereum 2.0 and the Lightning Network [4, 9]. While most industries, apart from banking, have effectively made their blockchain applications and transparency useful-Supply Chain Management, Healthcare, and DeFi- currently poses challenges of transaction speed limitations, the vagueness of regulations, and energy consumption by mining [8]. Emerging trends include Non-Fungible Tokens (NFTs), Central Bank Digital Currencies (CBDCs), and privacy enhanced through zero-knowledge proofs. There is hope for excellent feedback on the future of the blockchain from these and other initiatives yet to come into reality.**

## I. INTRODUCTION

### A. *Background*

Cryptocurrency is a form of virtual or digital currency that exists by virtue of decentralised networks, most often based on blockchain technology. They are predominantly encrypted. Since 2008, when the anonymous Satoshi Nakamoto introduced Bitcoin, cryptocurrencies have become increasingly popular with dozens of digital currencies now in use. Bitcoin runs on a decentralised distributed ledger called the blockchain, which is managed by a consortium of computers and guarantees transparency and immutability for the transactions recorded on it. From a simple platform of cryptocurrency transactions, this technology has developed to encompass several applications in numerous industries such as governance, healthcare, supply chain, and finance [2]. The most important developments driving blockchain technology are smart contracts, cryptographic methods, and consensus mechanisms like Proof of Work and Proof of Stake, which ensure security, provide scalability, and engender trust without needing an intermediary [6].

### B. *Objectives*

Coincidentally, waned on how blockchain technology enables cryptocurrency function. The simplest building blocks of blockchain architecture, decentralized networks, consensus algorithms, cryptographic operations, and data structures will be surveyed in the first section so that readers could comprehend how they operate to secure and simplify bitcoin transactions. It shall throw in some light on possible extent and legal challenges thrown by the inherent ambition of weed-blocking smart contracts to automate a few activities within the blockchain ecosystems. This evaluation is believed to offer an elaborate insight into how blockchain has supported cryptocurrencies in their birth and emergence [8]·

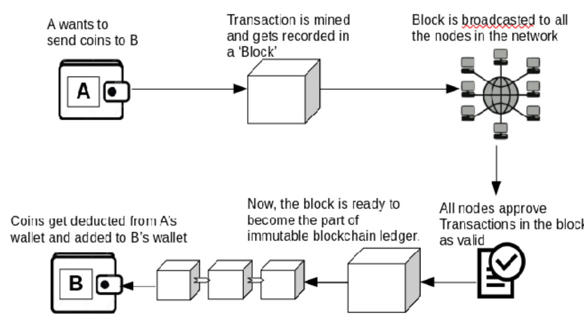


Fig. 1. How BLOCKCHAIN WORKS [12].

### C. *Structure of the Paper*

This document is organized as follows: an overview of the related literature on cryptocurrencies and blockchain technology that has highlighted major breakthroughs and findings in **Section 2. Section 3** deals with the environment of the blockchain and the cryptographic techniques ensuring the security of any cryptocurrency systems. In **Section 4**, smart contracts and their role in the automation of contracts and transactions within the blockchain ecosystem are covered. **Section 5** considers the problems blockchain technology faces, its outlook on the future, and the potential impact of cryptocurrencies on the global economy. The work is then concluded in **Section 6**, where the next leaps in further customizing research and development are outlined.

## II. Literature Review

### A. Blockchain Technology Evolution

The launch of Bitcoin by Satoshi Nakamoto, an anonymous being in 2008, ushered in blockchain technology [1]. Initially, blockchain was created as a platform on which Bitcoin would operate, with a transaction approach focusing on establishing a transparent and decentralized ledger that wouldn't require the aid of trusted intermediaries in peer-to-peer dealing. Today, blockchain has evolved into the backbone of smart contracts, decentralized applications, and many decentralized finance protocols alongside cryptocurrencies [3]. Such important advancements as cryptographic hashing functions and consensus algorithms like Proof of Work and Proof of Stake brought forth the possibility of creating secure and near-invulnerable ledgers.

### B. Cryptocurrencies and Their Impact

The emergence of cryptocurrency fundamentally transformed the way individuals consider money and trade of said money. Bitcoin was initially considered a niche technology, but its decentralized framework and the blockchain tech on top of it were very soon popularized as an alternative to conventional banking systems. There's a group around [10] that states cryptocurrencies brought about the dispelling of financial armaments in view of lowering the financial burden for unbanked individuals in developing countries. Further, it ushered in a new idea of digital scarcity, Bitcoin being the first example of a digital asset with a fixed supply, propounding a sea-change in thinking about investing and value.Blockchain-based currencies such as Bitcoin have significantly changed conventional banking. Block-chain-based cryptocurrencies are predicted to be more beneficial by minimizing transaction costs, expediting cross-border payments, and eliminating an over-reliance on central authorities [5]. The entrance of decentralized applications and smart contracts, made possible through large-scale automation of these complex financial and contractual processes, and cryptocurrencies including Ethereum, have unlocked a significantly more fluid space for finances. All these advancements enable the booming of decentralized finance (DeFi), opening doors for efficiency and financial inclusion. Thus, with the aid of decentralization, cryptocurrencies are therefore set to dramatically restructure and redefine the current global financial landscape while advocating a more decentralization and inclusion of financial services by getting rid of the brokers through the use of blockchain.

### C. Blockchain Security and Trust

One always welcomes security in blockchain systems, built on newer cryptographic practices. Research has shown that the decentralized structure of blockchain technology, along with cryptographic methods like digital signatures, hash functions, and public-private key pairs prevents data from being compromised or fabricated [11]. Blockchain diminishes the opportunities for fraud since all the participants would be privy to the same data through transaction records distributed across a network of nodes. The approaches to consensus, be they in terms of Proof of Work or Proof of Stake, are meant to dissuade malicious actors from altering transaction data or commandeering the network [10].

## III. Blockchain Architecture and Cryptography in Cryptocurrencies

### A. Blockchain Architecture

A blockchain system is fundamentally its architecture that guarantees decentralization, security, and transparency. It is this architecture that allows Bitcoin, Ethereum, and other such cryptocurrencies to run in a trustless environment without relying on intermediaries such as banks or governments.

*1) Decentralized Network:* The decentralized nature is one of the key characteristics of blockchain. No one organization runs the decentralized network however; several thousands of nodes (computers) spread worldwide continuously update a copy of the blockchain and take part in transaction validation. Since there is no central authority that can change or fabricate records, this ensures data saved on the blockchain is available and unchangeable. A decentralized network allows peer-to-peer transactions to occur, in which a user may communicate directly with one another without a middleman involved [2]. Once again, since consensus methods (elaborated below) ensure that there is consensus among the participants about the current state of the ledger, the requirement for any central trust has disappeared.

*2) Consensus Mechanisms (PoW, PoS, etc.):* Protocols, known as consensus mechanisms, are used for verifying the transactions and integrity of the blockchain. These mechanisms prevent double-spending of currency and ensure that all network participants agree upon an identical copy of data on the blockchain.

- **The Proof of Work (PoW)** consensus method is used by Bitcoin and many other cryptocurrencies. In a proof-of-work (PoW) competition for building a block in the blockchain, a miner who solves the cryptographic puzzle fastest gets to add the new block next to the rest of the chain. It is a safe procedure, but it is resource-intensive in that it demands a lot of processing power [1].
- **Proof of Stake (PoS):** This method is utilized by Ethereum and various other cryptocurrencies after an upgrade to Ethereum 2.0. PoS operates the inverse of

PoW. The validators owning a specified amount of cryptocurrencies would lock away some as collateral while minting new blocks under Proof of Stake. Compared to PoW, the PoS approach will provide added security for the decentralization feature without consuming huge amounts of energy [3].
- **Other Mechanisms:** Under certain conditions, specific consensus algorithms provide an advantage that enhances scalability, speed, and security, including DPoS and PBFT.

### B. *Cryptography in Blockchain*

Cryptography is the overarching means by which blockchain technology ensures the security, reliability, and integrity of transactions. It underpins data integrity through the establishment of immutable records, and it assures privacy through encryption and authenticity through digital signatures. Such cryptographic mechanisms safeguard diverse sectors against fraud, unauthorized access, and manipulation, providing security that is open and decentralized. Besides, they provide users with token power through private keys, swift data validation through cryptographic hashing, and collaboration through consensus protocols, which combinatively bolster trust in finance, health, and supply chain management industries.

*1) Public and Private Keys:* To enable safe transactions, a blockchain uses a combination of public and private keys. Every member of the blockchain network is given a unique private key, which they use to sign transactions and demonstrate ownership for the currency stored in the other party's public key, the latter serving as the address for receiving money or messages.

- **Public key:** A public key is a cryptographic identity that is publicly available and receives transactions or messages.
- **Private Key:** A private key, which is known only by the owner of a wallet, is used to sign transactions and prove the owner's consent of them - Whoever has access to the private key can access funds connected to it; thus, it needs to be kept as a secret.

A pair of cryptographic keys-a public key and a private key-do constitute a kind of fundamental composition to maintain and assure the integrity and security of the blockchain [11].

*2) Digital Signatures and Hash Functions:* **Digital signatures,** a form of a cryptographic proof, are used to verify transactions. A digital signature, when a user uses a private key to sign a transaction, is formed. It acts as evidence that the fund owner authorized the transaction. Other nodes on the network may use the sender's public key to validate the signature, confirming that the transaction is in fact authentic and has not been modified.A digital signature is a cryptographic process by which one certifies a network transaction for authenticity and security. It essentially appears by a user signing a transaction with a secret key unique to that user, furnishing formerly-unquestioned proof of permission. **Hash Functions,** In essence, hash functions are mathematical methods for converting input-transactions, for example-into a fixed-sizes output called a hash. Hash functions in blockchain technology are used to create a unique identification code for every data block. This means that, because any slight change in the input data leads to a new hash, it is extremely difficult to alter the data unnoticed. Using cryptographic hash functions such as SHA-256 ensures data integrity and prevents unauthorized manipulation of the transaction record in blockchain technology.

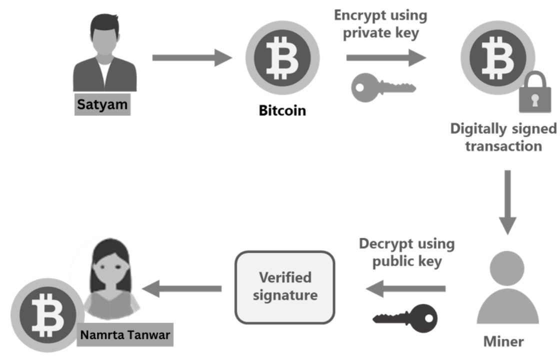


Fig. 2. Cryptography in Blockchain.

### C. *Security of Blockchain in Cryptocurrencies*

It is the consensus protocols, cryptography, and decentralization that contribute the security of the blockchain. In these attributes, the safe environment in which bitcoin transactions get completed is incredibly fraud-proof.

- **Tamper Resistance**: It is quite challenging to change the added blocks once they become part of the blockchain. This is due to the chain of blocks that uses a hash of the previous block from this standpoint: modifying the first block affects all other blocks that follow it. This very immutability guarantees that required transactional data will be extremely difficult to modify, thus providing security against fraud at very high levels.
- **Transaction Integrity**:

The combination of cryptographic techniques, including hash functions and digital signatures, offers legitimate parties the prerogative to initiate transactions on the blockchain, therefore preventing the modification of transaction data or unauthorized access to similar.

- **Protection Against Double-Spending**: This is a very common problem in digital currency systems which is prevented by the blockchains' decentralized framework and consent procedures. The blockchain guarantees users that every coin can be spent only once since all the nodes in a network are required to approve every transaction.
- **Resilience to Attacks**: These blockchains are extremely secure, but yet exhibit certain vulnerabilities to intrusions. One of these is called a 51 percent attack-a type of attack whereby it is assumed that a group of malevolent players gains a controlling interest on a number of staked assets

or processing power more than fifty percent, permitting the group to alter certain words on the blockchain. But as this blockchain becomes bigger and more decentralized, such attack groups would meet up with increasing challenge and cost.

## IV. Smart Contracts and Blockchain Programming

### A. Introduction to Smart Contracts

This is presented as a pair of two straightforwardly executed and agreed terms with voicing into computational lines to run on blockchain networks. It's in such a manner that smart contracts ensure automatic transactions devoid of the existence of intermediaries to create a system of trust and transparency. As the contract is executed automatically on the fulfillment of an intrinsic clause, it will be streamlined and devoid of injurious human error [3], thereby enhancing the validation and security through cryptography. Their applications include DApps, supply chain management, finance, and legal contracts. The mixture of smart contracts enables process automation and enforces contracts, altering the way entire industries run, such as trust or automation.

Smart contracts have quite a bit of respect and credibility across different blockchain ecosystems as they are decentralized.

### B. Blockchain Programming Languages

*1) Solidity (Ethereum):* Solidity [3] is an object-oriented, statically typed programming language used for writing smart contracts on the Ethereum blockchain. With the ability to use inheritance, the complex user-defined data structures, and secure transaction processing, the features built within Solidity make automation of blockchain-based contracts and development of decentralized applications, or DApps, simple for developers through its JavaScript-like syntax.

*2) Other Languages (Vyper, Rust, etc.):* Vyper is a contract-oriented programming language designed to be a safe and easy alternative to Solidity. It decreases complexity and enhances security by removing components that are considered a danger to vulnerabilities. Rust is commonly used in blockchain systems like Solana. It provides reliable, fast, and effective decentralized apps known for their performance and memory safety.

### C. Use Cases for Smart Contracts

Smart contracts generate efficiencies for some processes in many industries by reducing costs and providing security.

- **Decentralized Finance**:

Smart contracts form the bedrock of DeFi platforms and automate peer-to-peer lending, yield farming, automated trading, and liquidity management, respectively. By removing middlemen, they lower transaction costs and maximize accessibility to finance.

- **Insurance**: Once conditions are verified, smart contracts facilitate the prompt settlement of claims, resulting in speedy compensation. They reduce fraud, minimize human error, and increase efficiency. One implementation is parametric insurance, which pays out due to predetermined events, such as natural disasters.
- **Supply Chain Management**: Smart contracts create transparency since they store immutable data within the blockchain networks. After verifying delivery, they allow for the automatic processing of payment and shipment, name it an instant trackable supply chain. Further assuming aspects of tracking, they will ensure the authenticity of high-end goods, foods, and pharmaceuticals.

## V. Challenges, Future Prospects, and Conclusion

### A. Challenges Facing Blockchain and Cryptocurrencies

*1) Scalability:* refers to the ability of a blockchain network to scale, by serving increasing volumes of transactions without compromising performance. Among the major challenges are:

- **Transaction cost and speed**: There are scalability issues with popular blockchains, such as Ethereum and Bitcoin [8]. Bitcoin is capable of processing seven transactions per second (TPS), while Ethereum is capable of handling about thirty TPS. Relative to decades-old systems like Visa, which process thousands of transactions per second, this number is small. Due to this slower speed, transactions might start to see really high rates because the network tends to become congested due to the influx of transactions.
- **Due to block size and concurrent transactions**; when a block is full, it should contain a limited number of transactions of more-or-less equal size. Larger blocks could be more advantageous when scaling an application, but this presents potential problems for centralization, as only the players with sufficient resources may participate in validation.
- **Options**: To scale by enhancing throughput and reducing costs, Layer 2 options such as the Lightning Network for Bitcoin and Ethereum's switch to Ethereum 2.0 with Proof of Stake (PoS) are in the works [9].

*2) **Environmental Impact**:* PoW cryptocurrencies have come into the line of fire for negative effects on the environment [4], the latter of which stand out as the most important elements within it.

- **Energy Usage**: Mining cryptocurrencies such as Bitcoin uses much processing power, thus consuming vast amounts of energy. The energy expended by Bitcoin mining is greater than that consumed by most small countries.
- **Carbon Footprint**: Mining leaves a substantial carbon footprint due to substantial non-renewable electricity consumed during the process.

Some alternatives include carbon offset programs, mining operations that use renewable energy sources, energy-efficient mining hardware, and adopting a more energy-efficient consensus method, like Proof of Stake, as Ethereum 2.0 will do.

*3) Regulatory Uncertainty:* The way by which various jurisdictions tackle cryptocurrency issues leads to a jurisdictional environment that is in flux [8].

- **Regulations are noticeably absent**: in some places, such as El Salvador, cryptocurrencies have been fully embraced; while others, such China, have imposed restrictions so severe that they are functionally prohibitive.

As a result, businesses and investors are having a challenging time navigating the environment.

- **Unclear status**: In some jurisdictions, it is still unclear whether cryptocurrency is a commodity, security, or currency, with accompanying tax implications. This breeds uncertainty for users and companies wishing to implement blockchain technology.
- **Proposed remedies**: Though consensus is still terribly fickle, either through governments or agencies, efforts to tighten the guidelines are being made. A regular dialogue must take place to balance development with risk mitigation, through standardization: the insistent regulation of the ant-money laundering policies and know-your-customer processes of the country's inhabitants.

### B. *Future of Blockchain and Cryptocurrencies*

*1) Emerging Trends:*

- **Decentralized Financing (DeFi)**

Rise: Coined as communal lending, borrowing trade, and yield farming, DeFi revolves distinctly on decentralized platforms. It is rising as one of the fastest sectors with blockchain alternatives against traditional financial intermediaries (mainly banks). Interoperability: As DeFi ecosystems open up, a requirement for cross-chain interoperability emerges. This allows for the transfer of assets between different blockchain networks and thus improves efficiency and scalability for decentralized finance. Non-Fungible Tokens (NFT)

- **Beyond Art**: NFTs have now innovated to holding rights over music, games, virtual real estate, and collectibles. This will pave the way for new sectors that may adopt NFTs to ascertain ownership and facilitate the transfer process.
- **Central Bank Digital Currency (CBDCs)**

Governments are exploring CBDC options very much under the concept of bringing a blend of the effectiveness and security of blockchain technology with backing from a central authority.Will this have any impacts on global finance, especially international payment-and monetary policy?

Global Trends: While the digital yuan (e-CNY) is far ahead in introducing CBDCs, many other countries, including the US, the EU, and India, have begun researching or investigating central bank digital currencies.

- **Institutional Adoption**

Corporate investment: Big public companies like Tesla MicroStrategy and Paypal have begun adopting and investing in cryptocurrencies in a direct manner. Indicates strong interest from traditional investors who are beginning to regard cryptocurrency as a store of value, means against inflation threats.

*2) Technological Advances:*

- **Layer 2 Solutions**

Scaling Blockchain: Technologies like the Lightning Network for Bitcoin and Optimistic Rollups for Ethereum are aimed at improving blockchain scalability by enabling off-chain transactions. This reduces network congestion and lowers transaction costs.

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Platforms such as Ethereum 2.0 try to enhance the processing performance of complex smart contracts. These advancements allow for more sophisticated decentralized applications with more functionality and performance. All these advancements contribute to improving the usability and optimization of blockchain technology across industries.

- **Quantum Computing and Blockchain**

Security Issues: With quantum computation advancing, a conventional cryptography solution to the secure blockchain network can become vulnerable in the future. Blockchain developers consider quantum-resistant cryptography to overcome such a threat in the future. Potential Synergy: On the other hand, quantum computing may be able to enhance blockchain performance through improved consensus methods or optimized transaction processing.

- **Privacy Enhancements**

Zero-Knowledge Proofs (ZKPs): ZKPs, like zk-SNARKs, enable a user to prove that they know a given piece of information (perhaps the validity of a transaction) without having to disclose that knowledge itself. This has the significant potential to improve substantially the privacy of blockchain transactions, which is the largest area of concern in the industry. Privacy Coins: The Monero and Zcash now offer far more privacy features, and future releases will witness more mass blockchain offerings integrating privacy.

*3) Applications:*

- **Healthcare**

Blockchain technology will also be used for maintaining patient medical records in a safe and transparent manner, with only authorized personnel accessing the records. This would increase data privacy, reduce fraud, and improve healthcare outcomes. Blockchain technology can be utilized to track pharmaceuticals from manufacturing to distribution so that no adulterated drugs reach distribution channels, and the right treatment is dispensed to the right patient.

- **Supply Chain Management**

Transparency and tracing: Since blockchain contains an unalterable ledger, it makes supply chain translucent and also enables live flow of products. The authenticity of food products and luxury goods will be guaranteed. Sustainability: Blockchain allows for sustainability improvements through recording all the environmental implications of items through their lives to allow businesses to make more environment-conscious decisions.

- **Voting Systems**

Blockchain-based voting systems [2] will balance worries of fraud, transparency, and security in elections. It establishes trust in the democratic process:a decentralized ledger that records and authenticates votes must be verified.

- **Smart Cities**

Blockchain technology can help smart city operation through traffic control, electricity distribution, waste collection, and public utilities. The smart contracts can be applied in conjunction with transparency made possible by blockchain to realize efficiency and cost-effectiveness in such operations.

### C. *Conclusion*

Blockchain technology and cryptocurrencies are having a deep-seated influence in the way people perceive digital transactions, financial institutes, and the security of information. This study looks at how blockchain technology played a crucial role in allowing decentralized cryptocurrency to evolve, disrupt established financial systems, and possibly bring disruption in other industries.

Blockchain technology, which is decentralized, immutable, and transparent, serves as the foundation for cryptocurrencies. It makes peer-to-peer transactions in a secure and efficient manner, sans middlemen. It thereby alters our thinking on trust within the digital sphere. Bitcoin and other cryptocurrencies prove that blockchain enabled new types of digital assets as well as DeFi.

But its full potential aside, there remain problems to solve: scalability-a primary challenge-by often leaving blockchains unable to accept high transactions and by large numbers of wasteful energy mining methodologies, more often than not on Proof of Work consensus types-and legislative certainty still being on hold, whereby all governments over the world keep on debating and on how exactly regulate cryptocurrencies not in a prohibitive manner towards innovations.

Blockchain technology is changing, with advancements in Layer 2 solutions, smart contracts, and quantum-resistant cryptography that will help solve the scalability and security issues [9]. DeFi, NFTs, and CBDCs are revolutionizing the future of the blockchain ecosystem, creating new opportunities and problems for developers, investors, and regulators.

Blockchain's applications can go beyond finance to health, supply chain management, intellectual property protection, and voting systems [2]. As more companies use blockchain for transparency, security, and efficiency, the effects will spread from bitcoin to all business models.

The future of blockchain and cryptocurrency is exciting but entirely unpredictable. With technology developments that address the present barriers such as scalability, energy consumption, and regulatory clarity, blockchain utilization is bound to increase. Blockchain will be rapidly plugged into conventional organizations, leading to new ways to manage and exchange digital assets, data, and value.

This technology is expected to be like the internet in its importance for the world's economy: new financial systems, maximum transparency in governance, and new economic models. However, getting widespread acceptance will require overcoming infrastructure, a regulatory framework, and public understanding of problems.

The advancement of blockchain technology will likely result in a decentralized, secure, and transparent digital world. Provided that the key barriers are resolved through cooperation among the IT sector, governments, and other relevant stakeholders, the future of cryptocurrencies is bright.

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