ISSN: 2583-7346
DOI: https://doi-ds.org/doilink/10.2023-62741634/IJAEAST.2023.09.0002, September 2023, Volume-1, Issue-6, pp.12-20
International Journal of Advances in Engineering Architecture Science and Technology

# Blockchain – Enabled Smart Contracts

Ashwini Prasad S[1*], Pratima B[2], Dhikshitha G[3], Swathi K S[4]
[1] Assistant Professor, ASC Degree College, Karnataka, India
[2] Associate Professor, ASC Degree College, Karnataka, India
[2,3,4] UG Scholar, ASC Degree College, Karnataka, India

**Received:** 10-09-2023 **Accepted:** 18-09-2023 **Published:** 20-09-2023

## Abstract

***Background:*** Businesses in a variety of industries frequently deal with middlemen who charge commissions, take a long time to complete tasks, slow down operations, and raise costs.
***Objectives:*** In an effort to do away with middlemen and automate the execution of specific agreements, businesses are turning to blockchain development services.
***Methods:*** This allows for the creation of a distributed peer-to-peer network where deserving members can communicate directly with one another and verify the veracity of agreements without the need for a third party.
***Statistical Analysis:*** Four main concerns with smart contracts are codification, security, privacy, and performance issues.
***Applications:*** There are numerous potential uses for smart contracts in sectors like healthcare, supply chains, energy, etc. The development of smart contracts could automate processes across a wide range of industries.
***Improvements:*** The advantages of utilising blockchain technology in smart contracts are speed, accuracy, trust, and cost-effectiveness.

**Keywords:** Middleman, Block Chain, Smart Contracts, Shared Database, Transaction

## 1. Introduction

A blockchain is a particular kind of shared database that differs from other databases in how it stores data; data is kept in blocks that are connected by cryptography in a blockchain. With a decentralised and immutable system, blockchains can be used to track assets, record transactions, and establish trust. While blockchains are most frequently connected to cryptocurrencies like Bitcoin, they can also be used in other industries like supply chains, healthcare, voting, and more. A legally binding agreement that outlines the rights and obligations of two or more parties is known as a contract. Coded contracts that are kept on a blockchain are known as smart contracts. They automate agreements between the giver and the recipient, rendering them unchangeable and irrevocable. They primarily serve to automate the execution of contracts without the use of middlemen, ensuring all parties can confirm the agreement's terms right away.
In terms of smart contracts, the state of blockchain at the moment is:
Developers can now create unique smart contracts in a variety of programming languages, including Solidity, Rust, C++, and Go, thanks to blockchain platforms like Ethereum, Solana, Polkadot, and Hyperledger Fabric.

[*] Ashwini Prasad S, Assistant Professor, ASC Degree College, Karnataka , India
Email: ashwiniprasadsairam@gmail.com

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Peer-to-peer payments, asset encoding, decentralised exchanges, financing and lending agreements, electronic identification verification, voting methods, and other types of transactions are just a few of the transactions that are made viable by smart contracts.
Aside from collaborating with other technologies, such as cloud computing, big data analytics, the internet of things, and artificial intelligence, smart contracts are also being used to develop innovative ideas for a range of applications and industries.

## 2. Significance and Growth of Smart Contracts in Blockchain Technology

As a foundation for decentralised applications (DApps) that may function on the blockchain, smart contracts serve as crucial for blockchain because they modify it from just a record of transactions.

**Figure 1.** Blockchain

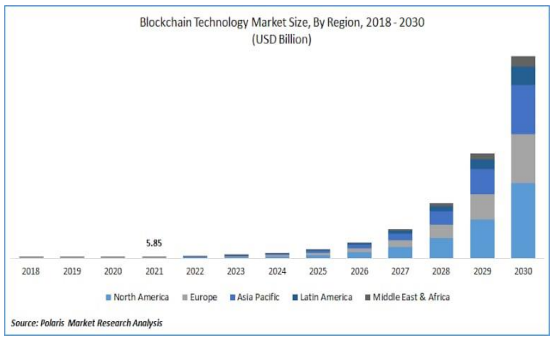


**Figure 2.** Blockchain Technology Market Size

In 1994, Nick Szabo made the initial proposal for smart contracts. After Bitcoin was introduced in 2009, smart contracts gained in popularity. With the launch of Ethereum in 2015, smart contracts attracted more attention.
By opening up new opportunities and possibilities, smart contracts have the ability to revolutionise many industries and sectors.The size of the global smart contract market was estimated at USD 684.3 million in 2022 and is projected to increase at a CAGR of 82.2% from 2023 to 2030.
Furthermore, according to the report, 10 to 15% of all global business and infrastructure projects will incorporate blockchain in some form by 2030.The future growth of blockchain-based smart contracts will be seen as more businesses and individuals choose the system and begin to investigate the opportunities it offers.

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## 3. Operational Mechanism

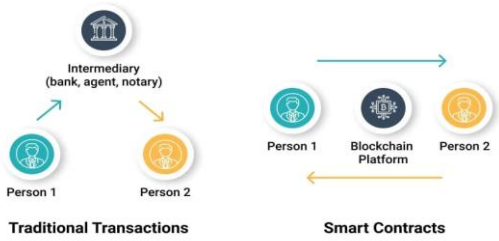


**Figure 3.** Traditional Transactions and Smart Contracts

The mechanism of blockchain is summarised in six shots as follows:
The contract's terms and conditions and its operational details are accepted by the parties.
An appropriate programming language, such as Solidity for Ethereum, is used to create the smart contract.
The code for the smart contract, which is put into effect on the blockchain, specifies the contract's rational thought and laws.
When they carry out an action that sets off the contract, like sending an invoice or delivering a service, one or more parties must invoke the smart contract.
In accordance with the code and conditions, the network of nodes examines and carries out the smart contract, and it upgrades the blockchain with the transaction's end achievements.
The contract is completed when the parties receive the outcome of the smart contract, such as a payment or service.

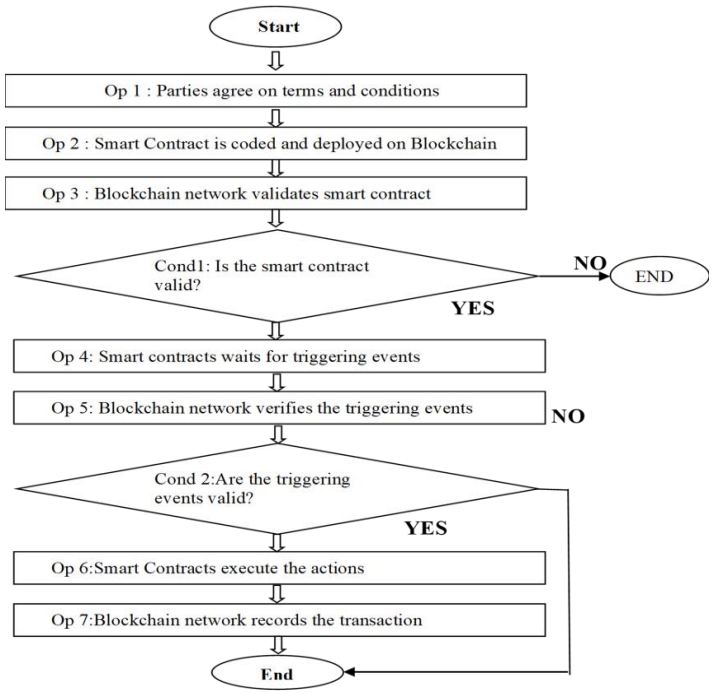


**Figure 4.** FlowChart

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**Challenges Faced by Smart Contracts:**

**Codifying Issue:**

Coding problems can be difficult because, once deployed, the code cannot be altered or changed and must be clear, precise, and unambiguous.
Since any flaw or vulnerability can be used by hackers or other bad actors to attack the smart contract or steal the assets, the code must be secure, dependable, and bug-free.
Given that most countries do not recognise or regulate smart contracts under their current legal systems, the code must be in compliance with the legal and regulatory frameworks of all relevant jurisdictions.
Digital contract programmers must use official validation techniques, best practices, and privacy laws to tackle these difficulties. Also, they must adopt defined protocols, have specific terms and conditions, and interact with the necessary legal frameworks.

**Security:**
As they handle priceless assets and transactions on blockchain networks, smart contracts must address the crucial issue of security.
Some strategies for ensuring safety include
**Code Review:** Reviewing the code can help find and fix flaws and holes by using tools and frameworks.
**Testing:** To ensure the effectiveness and efficiency of the smart contract, smart contract developers should use a variety of testing techniques.
**Verification**: Verification can assist in preventing errors and attacks that are challenging to find through testing alone.
**Auditing:** This technique aids in finding and addressing any problems or risks that developers may have overlooked or looked into.
**Monitoring:** It aids in spotting any irregularities or suspicious conduct that might point to a malfunction or a security breach.
**Governance:** Both developers and users should establish transparent, accessible rules and procedures for managing and maintaining their smart contracts.

**Privacy:**
The parties' and the data's privacy must be preserved against unauthorised access and disclosure in smart contracts. Among the techniques to attain privacy are:
**Encryption:** Anyone attempting to read or modify the data without a decryption key can be prevented by encryption.
**Zero-knowledge:** Parties may use zero-knowledge proofs to prove that certain conditions have been met without providing the specifics of those conditions.
**Oracles:** Oracles can significantly aggregate or filter data before transferring it to the smart contract.

**Performance:**
Smart contracts must execute transactions quickly and effectively on blockchain networks, so performance is a major concern. Many obstacles confront smart contracts, including:
**Throughput bottleneck**: The processing of a large number of transactions by smart contracts must be done quickly.
**Limited Scalability**: On the other hand, the blockchain network's fixed size and structure can restrict how large smart contracts can grow.

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**Transaction Latency:** Due to the blockchain network's unpredictable and random agreement mechanism, transaction confirmation may take longer than expected.
To overcome these issues Smart contract developers and users adopt effective measures such as parallel execution, sharding, and Layer 2 solutions.

**Advantages:**

**Cost-effective:** The time and money frequently spent waiting for and paying middlemen to conduct transactions is reduced through the use of smart contracts. The approach outlined by Khatoon makes use of blockchain to create a healthcare ecosystem. This study will help a variety of medical system stakeholders deliver better healthcare services while spending less money.

**Safety:** The encrypted transaction records on the blockchain are almost unhackable. Hackers will also need to alter the entire chain in a distributed ledger to change a single item. By creating an edge chain model, it was possible to demonstrate the cost-effective security benefits of blockchain and smart contracts.

**Self-assurance and Transparency:** Since there is no intermediary and participants exchange encrypted transaction records, there is no need to be concerned that information has been altered for illicit purposes. It has been proven that by providing a trustworthy administrator and an immutable record of experimental history, blockchain-based smart contracts offer a novel technical solution to the problem of data tampering.

**Precision, Effectiveness, and Quickness:** The contract is immediately carried out whenever a requirement has been met. Because smart contracts are digital and automated, there is no paper to manage and no time lost on fixing errors that frequently arise when manually filling out documentation. We devised a system where the sensors communicate with an intelligent gadget that performs smart contracts and records all events on a private blockchain on the Ethereum platform. Real-time patient monitoring would be made possible by notifications being sent to patients and medical professionals while a secure log of who initiated these activities was kept.

**Trust and Transparency:** The blockchain makes smart contracts' source code available, and they operate exactly as intended. Transactions become more reliable as a result of the reduction in the need to rely on confidence in middlemen.

**Protection:** Intelligent agreements are incredibly hard to tamper with and susceptible to fraud since they employ cryptographic methods and operate on safe blockchain networks. They are hard to modify once implemented.

**Robotics:** By automating the execution of predetermined activities when certain criteria are satisfied, smart contracts eliminate the need for manual involvement. The possibility of human error is decreased by this automation, which also boosts efficiency.

**Economical productivity:** By doing away with middlemen, smart contracts may greatly lower transaction costs. Financial services, supply chain management, and other businesses all greatly benefit from this.

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**Tempo:** Smart contracts work around-the-clock and complete transactions in a matter of seconds or minutes, as opposed to traditional systems, which might process transactions over the course of several hours or days.

**Accessibility:** Global access to services and financial transactions is made possible by smart contracts, which can be accessed and used from any location with an internet connection.

**Immutability:** As soon as a smart contract is implemented on a blockchain, it is added to the immutable ledger. This ensures that agreements and records are permanent and makes them difficult to change.

**Reduced Conflicts:** Smart contracts provide a precise definition of an agreement's terms and conditions, minimising the possibility of misunderstanding. Conflicts and the requirement for legal action may decrease as a result.

**Removal of Intermediaries:** Smart contracts do away with the need for middlemen in a variety of transactions, including financial transactions, supply chain management, and legal agreements, which results in cost savings and increased efficiency.

**Flexibility:** Large numbers of transactions can be processed by blockchain networks, and smart contracts can be scaled to meet increasing demand.

**World Reach:** By removing obstacles to doing business globally, smart contracts can facilitate cross-border transactions and international agreements with ease.

**Creative Thinking:** Decentralised applications (DApps) and the tokenization of assets like real estate and works of art are just two examples of the new business models and opportunities that smart contracts open up.

**Decentralised Governance:** Decentralised blockchain networks that support smart contracts reduce the power and influence of centralised organisations.
Notwithstanding these benefits, it's important to be aware that smart contracts have their share of drawbacks, such as regulatory concerns, code weaknesses, and the requirement for thorough testing and auditing. But as blockchain technology develops and becomes more sophisticated, smart contracts continue to play a crucial role in revolutionising how contracts and transactions are carried out in a variety of industries.

**Disadvantages:**

**Deals that cannot be undone:** A smart contract's execution results in an irreversible transaction. Correcting an error or a disagreement can be difficult.

**Potential vulnerabilities in the Code:** There could be vulnerabilities or programming errors in the smart contract code. Coding errors can result in data breaches and financial losses.

**The Degree of Complexity:** It can be difficult to write and implement smart contracts, and doing so requires a solid grasp of blockchain technology. The complexity may lead to mistakes.

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**Confined Features:** The complexity of operations that smart contracts are capable of performing is constrained. Implementing complex business logic might be labour-intensive.

**Human Mistake:** Despite the fact that smart contracts are designed to be completely automated, humans still write the code and can make logical or coding mistakes.

**Flexibility:** During times of high network activity, some blockchain networks experience scalability problems, which can slow down and inefficiently execute smart contracts.

**Regulation and governmental challenges:** It may be difficult to enforce smart contracts in some legal disputes because they aren't always recognised as valid contracts by the law.

**Confidentiality issues:** Due to the limited privacy provided by some blockchain networks, participants may be able to view sensitive information contained in smart contracts.

**Lack of Secret Keys:** A user may lose control of their assets or data if they lose access to the private key needed to interact with a smart contract.

**Exterior Source Feeds:** Smart contracts frequently rely on external data sources (oracles) to gather information. These sources might be manipulated or give false information.

**Expenses associated with Audit and Test:** Comprehensive auditing and testing are necessary to ensure the security of smart contracts, but they can be expensive and time-consuming.

**Poor Adaptability:** Smart contracts are frequently immutable, which makes it difficult to make changes or updates without deploying a new contract.

**Cheats and Exploits:** Malicious actors may take advantage of smart contract vulnerabilities to cause significant financial losses or the demise of a project.

**Legal Enforcement:** Using smart contracts in sectors like finance and healthcare can make it difficult to adhere to financial and data protection regulations.

**Resource-intensive**: The execution of smart contracts on some blockchain networks, such as those that use Proof of Work (PoW), requires a significant amount of energy. When implementing smart contracts in blockchain applications, it's crucial to take these drawbacks and difficulties into careful consideration. To reduce risks and problems, proper code reviews, security audits, and legal compliance are crucial. Keeping up with the changing legal and regulatory environment surrounding smart contracts is also essential.

## 4. Application

There are numerous potential uses for smart contracts in sectors like healthcare, supply chains, energy, etc. The development of smart contracts could automate processes across a wide range of industries. When a service is requested, they offer the data accessibility that is required. According to the paper's main focus areas—healthcare, potential study, supply chain, transparency, authenticity, privacy, and security—as well as its subtopics—energy, rights and data sharing, and construction payment

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**Monetary Facilities**: Cryptocurrency Transactions, Smart contracts are frequently used for sending cryptocurrencies like Bitcoin and Ethereum.

**Decentralized Finance (DeFi):** Platforms for lending, borrowing, trading, and yield farming are powered by smart contracts.

**Remittances:** Facilitating international money transfers and currency exchange outside of the realm of conventional banks

**Authenticity and Openness in Logistics Supervisors:** Tracking the source and route of goods to ensure authenticity and cut down on fraud

**Management of Inventories**: This involves automating payments and orders for inventory based on real-time information.

**Residential and Commercial**: Automating real estate transactions such as leases and sales of property

**Tokenization:** making real estate investment more accessible by turning real estate assets into tradable tokens

**Medical Care:** Patient Data Security ensures the safe sharing and storage of medical records. Pharmacy traceability is the process of determining a drug's authenticity throughout the supply chain.

**Judicial Services**: Notary Services: Validation and time-stamping of contracts and legal documents

**Automated Wills:** Streamlining the distribution of a person's assets after death

**Safer Elections**: Designing transparent, tamper-proof voting systems

**Shareholder Voting**: Allowing shareholders to vote using smart contracts Automating claim verification and payment processes in insurance pays out in response to predetermined triggers, such as weather information.

**Immaterial Assets:** Managing royalties and licencing for content creators through copyright protection. Streamlining the registration of patents and tracking is known as patent management.

**A Clever Grid:** Trading of surplus electricity directly between producers and consumers Energy bills are generated by the system and settled based on demand.

**Property Tokenization:** The administration of assets involves digitising and exchanging items like antiques, real estate, and works of art using tokens.

**Playing games and collecting** tokens (NFTs): producing one-of-a-kind digital assets like artwork, virtual property, and items used in games. Handling in-game resources and enabling peer-to-peer trading are two aspects of in-game assets.

**Powered Agreements:** Holding money in escrow until a contract's requirements are satisfied is known as trust services. Management of access and membership fee automation are provided by subscription-based offerings. The above are merely some instances, and as the technology for blockchain develops and businesses look for novel ways to streamline operations, improve security, and lessen reliance on middlemen, the potential applications of smart contracts grow.

## 5. Future Enhancement

The ability of the technology to be integrated with current structures and regulations will impact how blockchain-enabled smart contracts are used in the future. Experts estimate that blockchain-enabled smart contracts will follow a few future trends, including:
The creation of more user-friendly and interoperable platforms and tools for developing, deploying, and managing smart contracts. The adoption of more standardised and unified frameworks and guidelines for controlling the use of digital contracts in multiple sectors and economies Future developments in professions like data science, artificial intelligence, and theoretical gaming that can be included in smart contracts in blockchain systems have been thought about and shown to work.

## 6. Conclusion

Data is stored in blocks connected by cryptography in a distributed database called a blockchain. Codified contracts, known as smart contracts, are used to automate agreements between givers and recipients directly, cutting out the middleman. Smart contract difficulties and unresolved problems are noted for future research. This essay discusses the advantages, disadvantages, and difficulties that smart contracts may encounter. In order to further develop blockchain-enabled smart contracts, these problems must be resolved, making them more effective and efficient.

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