iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** XI **Month of publication:** November 2022

DOI: https://doi.org/10.22214/ijraset.2022.47435

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

Blockchain for Agriculture IoT

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Abstract: ***The most fundamental promise of blockchain (BT) for the agriculture industry is the elimination of the necessity for third parties to confirm confidence in buyer seller relations, or any source-destination relationship. Transactions become peer-to-peer in a blockchain-enabled setting with no need for mediators. Apart from allowing peer-to-peer transactions, blockchain can also be used to build "smart contracts," which enforce the terms of any treaty when certain conditions are met. Any time anything of value exchanges hands, whether it's tangible goods, services, money and the transaction can be registered, providing a permanent record of the commodity or transaction from beginning to end. Blockchain technology has the potential to be very useful.***

In this sector, blockchain technology can be extremely beneficial as it is secure and emphasizes privacy as well, but still, it poses new security issues like double spending and majority attack. In this paper, we propose a Machine Learning (ML) based blockchain model to make accurate decisions, where machine learning uses a reasonable amount of data. Therefore, combining ML and BT can give more precise results.

Keywords: Blockchain, Machine Learning, Agriculture, Smart contracts

I. INTRODUCTION

India is one of the top ten agricultural producers in the world. India's agricultural industry accounts for 13.7 percent of the country's GDP [1]. It generates 7.68 percent of total global agricultural production and feeds 1.35 billion people while employing approximately 60% of the population. The sector that was once regarded as the lifeblood of a country's economy is increasingly dwindling. All who work day and night to fill our stomachs go to bed with an empty heart and an empty stomach. Due to volatile climate conditions, the increase in middlemen, the division of land holdings, unequal prices, and the debt, the agriculture industry is plagued byfinancial uncertainty. According to a 2018 survey by the Centre for Study of Developing societies (CSDS), about 76% of farmers want to leave farming [2]. It was also discovered that 70% of respondents had never heard of direct cash transfer and only 27% had heard of land acquisition rules. It is estimated that 1.3 percent of GDP is lost due to undefined land titles. The cost of the procedure in relation to competing claims exacerbates the problem. The majority of farmers are unaware of the Minimum Subsidy Price, and as a result, they are underpaid for their produce. In the vicinity of a well-organized marketing scheme, middlemen and private traders pocket approximately half of the produce price [3]. Although the producers do not benefit from the middlemen's remuneration of services, it raises the burden on the customer. The government, non-governmental organisations, and a range of businesses have all taken measures to ease the pressure on farmers and use technology to improve their lives. In this area, blockchain technology can be extremely beneficial. Putting all information about agricultural events on a blockchain [4] will create a transparent and trustworthy framework. Farmers can also access real- time data on seed quality, climate-related data, payments, soil moisture, demand, and sale price, among other things, all from a single platform. Current agricultural growth and change necessitate new techniques and technologies in order to make the agriculture sector more transparent and accountable. Blockchain technology is one of the newer methods. Unlike traditional centralised and monopolistic agricultural management solutions, blockchain uses a decentralised data framework to store and retrieve data from several untrustworthy parties. As a result, it will be able to address a range of serious issues in current systems, which are triggered by the following factors: (i) Hackers can easily compromise data integrity by attacking the centralised system; (ii) insider abuse of the centralised database may compromise data integrity; (iii) a supply chain management system is too dependent on the centralised database (single point failure problem); and (iv) using a third party to validate and track transactions incurs high costs. In recent decades, a distributed database augmented by advanced cryptography has been suggested as a solution to these problems. Among these, blockchain is one of the most common new methods for resolving trust issues that have arisen since the invention of Bitcoin in 2008 [5]. Many advanced computational and cryptographic methods are built into distributed data systems in blockchain technology to establish a digital trust mechanism in an untrustworthy world [6]. The hash function, in general, is used as a key element for data authentication since it is an algorithmic way to produce unique IDs.

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To ensure data integrity, hash values may be inserted into a format of stored chain to check if the data has been tampered with. In stored transactions, digital signatures are used to verify the actual identity of data senders and receivers. Furthermore, the consensus process is designed to include all computer nodes, eliminating the possibility of data manipulation by a minority of attackers. Blockchain implementations in agriculture boost a range of aspects of agricultural processes, including supply chains [7] and IoT-based systems [8]. Food protection [9], food security [10], food quality monitoring and control [11], traceability for waste reduction [12], accurate operational data analysis [13], and effective contract transfers and transactions to minimise economic costs [14], thereby helping small-scale farmers [15], are just a few of these applications. Current blockchain frameworks can be used to build these applications, making them simple and quick to develop.

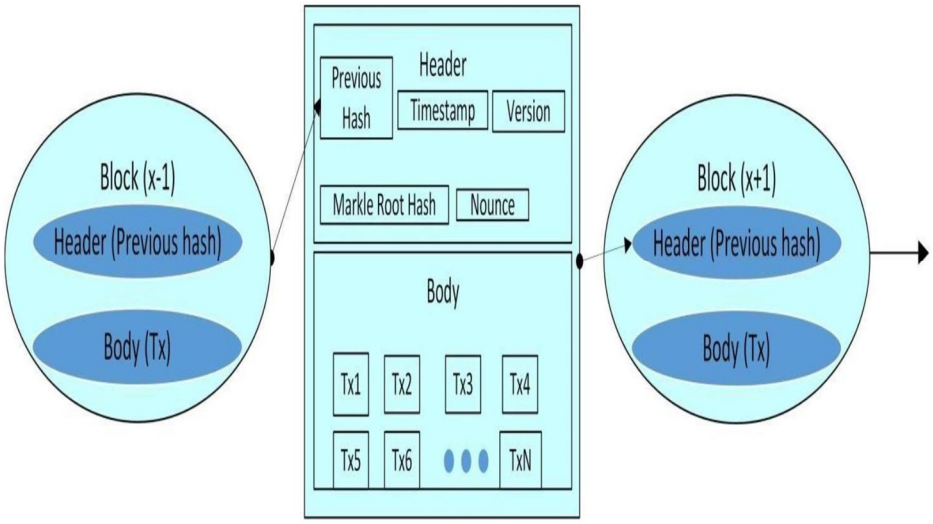


Figure 1: Block chain data structure

A. Blockchain

Blockchain has been a hot subject in both the finance and engineering industries. Bitcoin, which was launched in 2018, gave birth to the concept of blockchains. Data is spread and processed in each node in blockchain technology; it also uses the idea of cryptographic protocols or shared ledgers and disburses the ledgers in each node. Although blockchains are successfully accepted by industries such as medicine and finance, information of which require privacy protection, this study [16] created an identity managing framework to safeguard permissions of its user to data in order to deter violation of blockchain data.

Anonymity is used in this study [17] to protect the identity of a Bitcoin user. Our research uses blockchains to protect a user's access rights and prevent DDOS attacks from hackers. This review also compared the findings of performance analysis to studies.

II. BLOCKCHAIN TECHNIQUES

Blockchain is a distributed ledger that allows unauthenticated multiple stockholders in a decentralised network to exchange transactions or sensitive information [18]. Figure 1 portrays a simple blockchain framework. In contrast to other conventional data storage formats, the data is recorded in a sequential chain of hash-linked blocks that allow data dissemination in a more manageable manner. Selected nodes use an agreed-upon consensus protocol to verify and upload the blocks into the chain-like structure. When incorporating data/information flow on-chain, this consensus mechanism enables both stakeholders to partic ipate in the monitoring process. Furthermore, duplicates of these data are kept in all involving nodes to ensure that they are not tampered with. Before looking at existing blockchain implementations in the agricultural sector, this section provides a high-level overview of the blockchain ecosystem and technical specifics of implementation.

III. BLOCKCHAIN TECHNICAL COMPONENTS

To achieve a stable ledger with decentralised management, the blockchain architecture incorporates many key techniques such as hash, asymmetric cryptography, digital signature, Merkle tree, and consensus. Each block has two parts: a block header and a block body. Numerous elements are included in the block header, including the previous block hash value, nonce, Merkle tree root hash, and other details, such as block version and Timestamp. The actual
data, which is either transaction records or secure data, is stored in the block body.

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A. Hash Function

The hash function is a key technique in blockchain, and it's used for a lot of things like address generation, digital signatures, and consensus. Data of any size can be conveniently translated to fixed-size values using the hash function. Inversely, restoring the original data from its hash value is challenging.

For example, an immutable hash function can be used to obtain the resulting hash value for a given large amounts of data x. (x). When x is unintentionally changed to x', the hash output Hash(x') is totally different from Hash (x). Based on the complexity of data, the two common hash functions used in blockchain are message digest 5 (MD5) and SHA256 [19].

Data integrity can be checked during data transmissions using a cryptographic hash method. Consider the case where A sends some data x to B. The encrypted hash value Encrypt(Hash(x)) is enclosed with the data x. B will verify data integrity after receiving it by computing the hash value from received data x', Hash(x'), and comparing it to the predicted hash results decrypted from the received Encrypt(Hash(x)). If Hash(x') = Hash(x) means data is properly transmitted, and x' = x. Therefore, if Hash(x') ≠ Hash(x) it means the integrity of data has been compromised, and B can request that A to retransmit the data.

B. Asymmetric Cryptography

Asymmetric cryptography technique [20] is used in combination with a hash function to enforce digital signature technique to implement verifiable transactions in distributed systems. Each consumer in asymmetric cryptography has a pair of keys, namely a private key k and a public key K. The private key is kept private and only the owner knows it, while the public key can be identified by others. The public key can be determined from the private key, but the private key cannot be accessed in reverse with a given public key. Data can be encrypted and decrypted in pairs using the public key K and the private key k.

C. Digital Signature

To prevent issued transactions from being changed or rejected, each blockchain transaction needs a digital signature [21]. In terms of technology, digital signature is a hybrid technique that combines hash functions and asymmetric cryptography. A legitimate digital signature, like a paper signature, guarantees that unaltered data is submitted by a known sender and that it cannot be revoked. The file is first hashed to a fixed length and then encrypted with the sender's private key, with the result referring to the sender's digital signature. The asymmetric cryptography technique guarantees authentication and non-repudiation of this signature because only the nominated sender has his own private key. In the meantime, since anyone can access the sender's public key, anyone can check the signature's legitimacy by computing the hash value from the data and matching it to the hash value decrypted from the signature. Furthermore, if confidentiality is needed, the data can be encrypted using the nominated receiver's public key.

D. Merkle Tree

Verification by downloading all the antiquated transfers in blockchain requires a significant amount of storage space as the number of transactions increases. To solve this problem, the Merkle Tree technique is used to reduce database information without losing the hash of the block [22]. Merkle Tree is a binary tree comprised of leaf, intermediate, and root hash nodes. The hash values of individual transactions are stored in leaf hash nodes in each block. Let us assume a block containing transaction data as T_a, T_b, T_c, T_d respectively. Therefore, the Merkle tree with four leaves will be $Hash(T_a)$, $Hash(T_b)$, $Hash(T_c)$, $Hash(T_d)$, $Hashab$ and $Hash(cd)$ are the intermediate hash nodes which are the parents of the leaves.

$Hashab = (Hash(T_a) + Hash(T_b))$ ……(1)

$Hashcd = (Hash(T_c) + Hash(T_d))$ ……..(2)

Finally, the root hash values are given by:

$Hashabcd = Hash((Hashab) + Hashcd))$ ……..…(3)

Finally, old blocks can then be squished to shrink the size of the blockchain by spitting off branches of the tree.

E. Internet of Things (IoT)

Wearable devices to self-driving cars are all part of the Internet of Things. It is the concept of having all devices under a single control by linking them all to the internet and each other. Sensors in the smart devices gather data at preset intervals, which can then be analyzed. The data gathered can be used to identify trends.

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Sensors in the smart devices gather data at predetermined intervals, which can then be analyzed. The data gathered can be used to spot patterns, make decisions, and investigate anomalies as they arise.

IV. APPLICATION PLATFORM

As many cryptographic techniques are used in blockchain technology, it is a time-consuming task to build a blockchain system from scratch for practitioners and researchers. As a result, many open source and commercial platforms are provided to simplify and speed up the decentralized application (DApp) development in agriculture related projects. The predominant platforms used in these blockchain practices are discussed as follows.

A. Ethereum

Ethereum is a blockchain-based open software platform that allows developers to write smart contracts, create, and deploy decentralized applications. It's close to a public distributed blockchain network. It is like a distributed public blockchain network. Ethereum is the most popular blockchain platform in the world for blockchain professionals and scholars. It was launched in 2014. It is a permission-less blockchain that is conducive to the advancement of public blockchain-based applications.

B. Hyperledger

The Linux Foundation has endorsed Hyperledger to provide several distributed ledger frameworks for enterprise level blockchain creation, such as Fabric, Sawtooth, Indy, and Burrow [23]. Hyperledger Fabric [24] and Hyperledger Sawtooth [25] are the two most common platforms for developing agricultural-related projects in these frameworks.

C. Quorum

JP Morgan established Quorum to focus on enterprise-level blockchain systems [26]. It offers an Ethereum-based platform to support banking, supply chain, and retail applications, as well as additional privacy security for transactions and contracts. To maintain data privacy, transaction data is encrypted.

V. PROBLEMS IN THE AGRICULTURAL SECTOR

A. Issues With Internet Of Things (IoT) Industry

Currently, the IoT industry is in its early stages of growth. The requirements for large-scale application are quickly evolving, and industry growth is approaching a critical stage [27]. However, several issues remain in the IoT industry at this time, limiting its growth. The cost of implementing the IoT is extremely high due to the difficulty of integrating the IoT with various industries, and privacy and security concerns must be addressed immediately.

At almost the same period, infrastructure building and local technology creativity are driving the current IoT technology. Integration's enormous importance in a variety of industries has yet to be fully realized. At this time, most IoT technological research focuses on market application layer [28], network layer, and awareness extension layer. The query and storage processing of large sensor data is one of the key problem facing the IoT' future growth, but technological research in this field is still partial.

B. Characteristics of Agricultural IoT Data Analysis

The Agricultural IoT connects real-world agricultural items to a computer storage system to help farmers to make better decisions. It collects different information from agricultural objects using sensors and sends the data to a data layer storage centre through a computer network. The data layer of the agricultural IoT is gradually showing two main problems, one is that the volume of data is showing a trend of quantification, and the other is the heterogeneity of data categories, as a result of the in-depth implementation of IT in the agricultural IoT [29].

1) *Huge Quantification Of Agricultural Iot Data:* The essential sensors of the IoT need to gather richer complex data information through decision support and data analysis or real-time control in order to allow fair use of various effective information to provide more precise decision-making decisions for agricultural items. This would eventually contribute to the need for sensors to capture more information and complex data at a higher frequency, resulting in a direct increase in the amount of data stored, putting greater demands on the data center's storage space.

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2) *Data Heterogeneity In Agricultural IoT:* The IoT system includes a variety of sensors. The IoT system includes a wide range of sensors that are not only different in structure and purpose, but also in the data they collect. The complexity of designing software and processing data is significantly enhanced by this heterogeneity.

VI. THE INTEGRATION OF BLOCKCHAIN AND THE INTERNET OF THINGS

A. Blockchain's Technical Characteristics

Melanie Swan proposed dividing the framework of the blockchain from various viewpoints of development stages in her book "Blockchain: A Roadmap for a Digital Economy and a Guide". Blockchain 3.0 specifically applies to non-financial applications, such as scientific science, industry and agriculture, and the IoT. Enterprise partnership chains and private chains are two types of blockchains that exist in general. There is currently no industry-ready blockchain 3.0 platform.

Blockchain is a technique of applying transaction processing in a peer-to-peer network by using transparent and reliable rules to create noticeable data structures (also known as a distributed network or peer to peer). Decentralized chain data block, peer-to-peer, tampering security, anti-counterfeiting and, openness, integrity, and high reliability are all features. Three aspects of application capabilities can be supported by blockchain: The first aspect is to use a peer-to-peer network to supply base installation resources such as network, storage, computing, and platform. In peer-to-peer networks, the second component is data management, querying, and analysis. The third factor is to use peer-to-peer networks to deliver application services like digital asset transfers, financing, payment, and settlement.

Since blockchain has distinct technological characteristics, it may be useful in addressing issues such as trust, big data management, privacy, and protection that may arise as the IoT evolves. It has the ability to help the IoT industry grow into a distributed and intelligent advanced type.

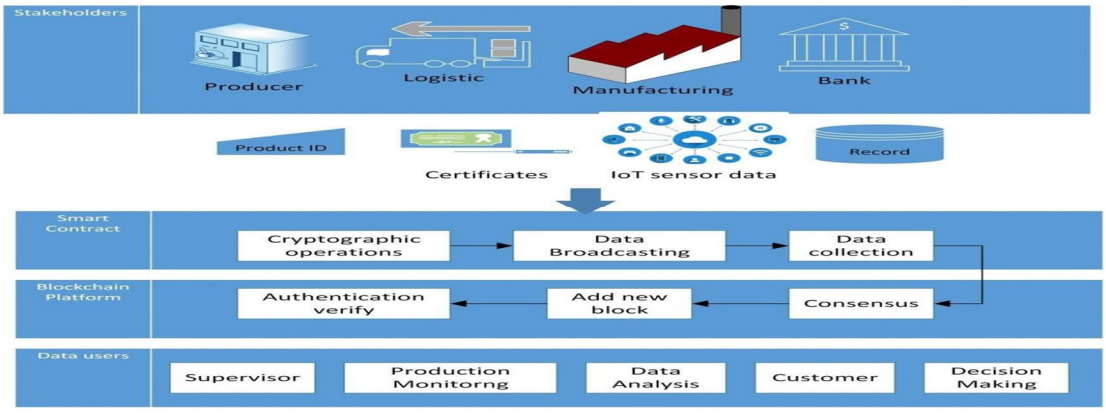


Figure 2: Agricultural stakeholders

B. Application of Blockchain Technology in Modern Agriculture

In general, the Agricultural IoT uses a centralised management structure. Data centre hardware and software infrastructure, maintenance costs, and electricity usage are all facing unparalleled challenges as more smart devices link to the IoT. Blockchain technology's decentralized management approach will effectively reduce the production and maintenance costs of agricultural IoT. The monitoring equipment linked to the network will achieve self-management and maintenance by integrating agricultural IoT and blockchain technology. It will help to minimise the future maintenance cost of Internet tools, as well as increase the level of intelligence and size of the agricultural IoT. It can save high infrastructure building and maintenance costs as well as energy usage costs based on cloud control.

VII. BLOCKCHAIN-BASED AGRICULTURAL INTERNET OF THINGS

The use of blockchain in smart agriculture has the potential to have a significant economic impact. According to a report on the effect of blockchains in the grains sector in Australia, the Gross Domestic Product (GDP) increased by around 2.5 percent. In a study published in 2019, the UN's "Food and Agriculture Organization" collaborated with the "International Telecommunication Union (Bangkok)" to show the growing presence of blockchains in various agricultural sectors, as well as the threats and opportunities they present.

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A. Creation Of A Blockchain-Based Agricultural Data Sharing Model

As shown in Fig. 1, the blockchain based agricultural data-sharing model is made up of four parts: data demand, decentralised data-sharing network, data source and data owner. According to various application areas, data demand side refers to researchers, research agencies, businesses, or project teams that have access to data. They can be divided into scientific research, public services and business applications. The data owner is an entity or organisation that has complete control over the data, such as agricultural science research organisations, businesses, laboratories, and individuals. A data source is a computer, central server, or cloud server that can provide remote data access and performs the elementary functions of a database management system.

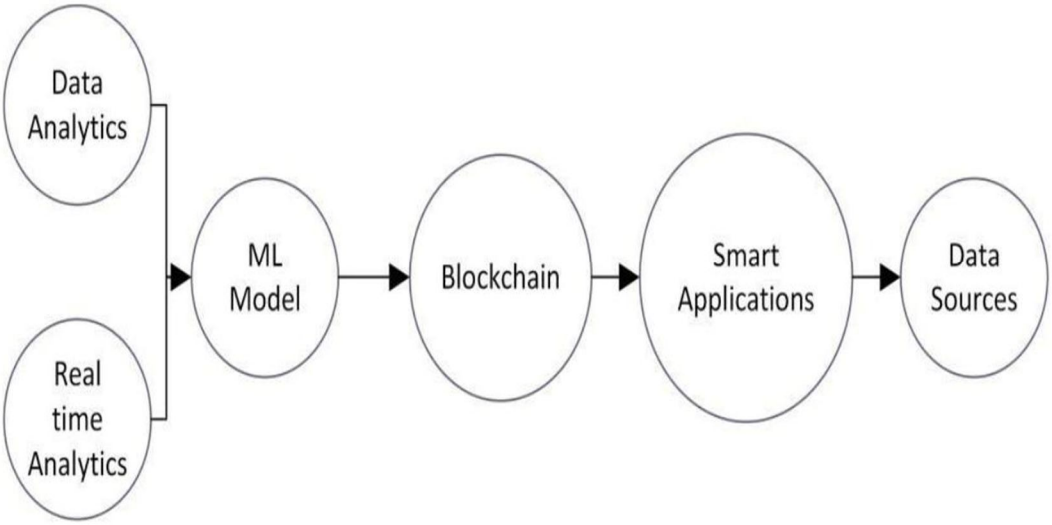


Figure 3: Data sharing model using Blockchain

Each model topic has a unique set of characteristics in this model. Every individual model topic has a distinct role in this model. The roles will turn and rely on each other. As the starting point of the knowledge flow, the data owner reliefs" data through a decentralised data exchange network. Both parties may then recover data, inspect data quality, and publish data subscription specifications. Finally, the two parties would be able to exchange data on the platform with trust, accountability, and equality.
Blockchain has benefits that conventional distributed databases and centralised databases cannot match because it is a combination of different technologies. Big data's current criteria for system security, data trust, and scalable reliability are all in line. P2P network transmission protocols, consensus algorithms, encryption algorithms, and other technologies make up blockchain technology. A distributed ledger database that operates on a peer-to-peer network and provides decentralised trust for data sharing. The following things are included trustworthy:

1) system security
2) data rights management
3) data privacy protection

B. Development of the System Design

A layered architecture focused on blockchain for agricultural data sharing, including a management plane, control plane, and data plane. As shown in Fig.2, it is made up of a consumer layer, a service layer, a platform layer, and a facility layer. The management plane is in charge of packaging the control plane's usable interfaces into various data management services, and it uses a variety of visualisation methods to present the management functions of agricultural data sharing to users in a variety of ways.

VIII. METHODOLOGY

The advent of blockchain technology (BT) has become a new, disruptive, and trending technology in recent years. Data protection and privacy are prioritized in BT's decentralized database. It also has a consensus system that ensures data security and legitimacy. Nonetheless, it poses new security problems, such as double spending and majority attack. Therefore, combining ML and BT can give more precise results.

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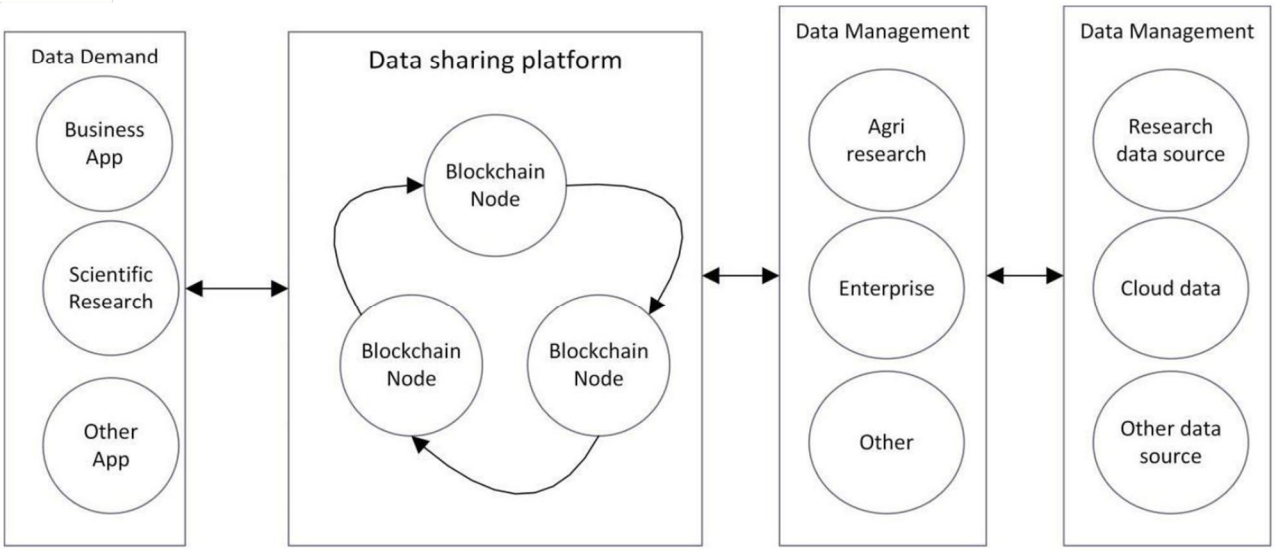


Figure 4: Proposed architecture for ML in Blockchain

A. *Machine Learning*

Machine learning is a form of data analysis that optimises the development of analytical models. It's a subset of artificial intelligence focused on the concept that computers can learn from data, recognise patterns, and make decisions with little or no human input. Machine learning can be defined as software that modifies itself when it learns from new knowledge. It is not necessary to manually implement new rules as it is self-adaptive. There are various types of machine learning algorithms like supervised learning, unsupervised learning, semi-supervised learning and reinforcement learning. The Figure 4 illustrates the association of ML with BT.

IX. CONCLUSION

Farmers will be able to access real-time data about their crops with the click of a mouse thanks to smart agriculture. This will help them in future data review and well-informed decision-making. When data from sensors is used in supply chain management, it can remove the need for middlemen, resulting in a more transparent and productive method.

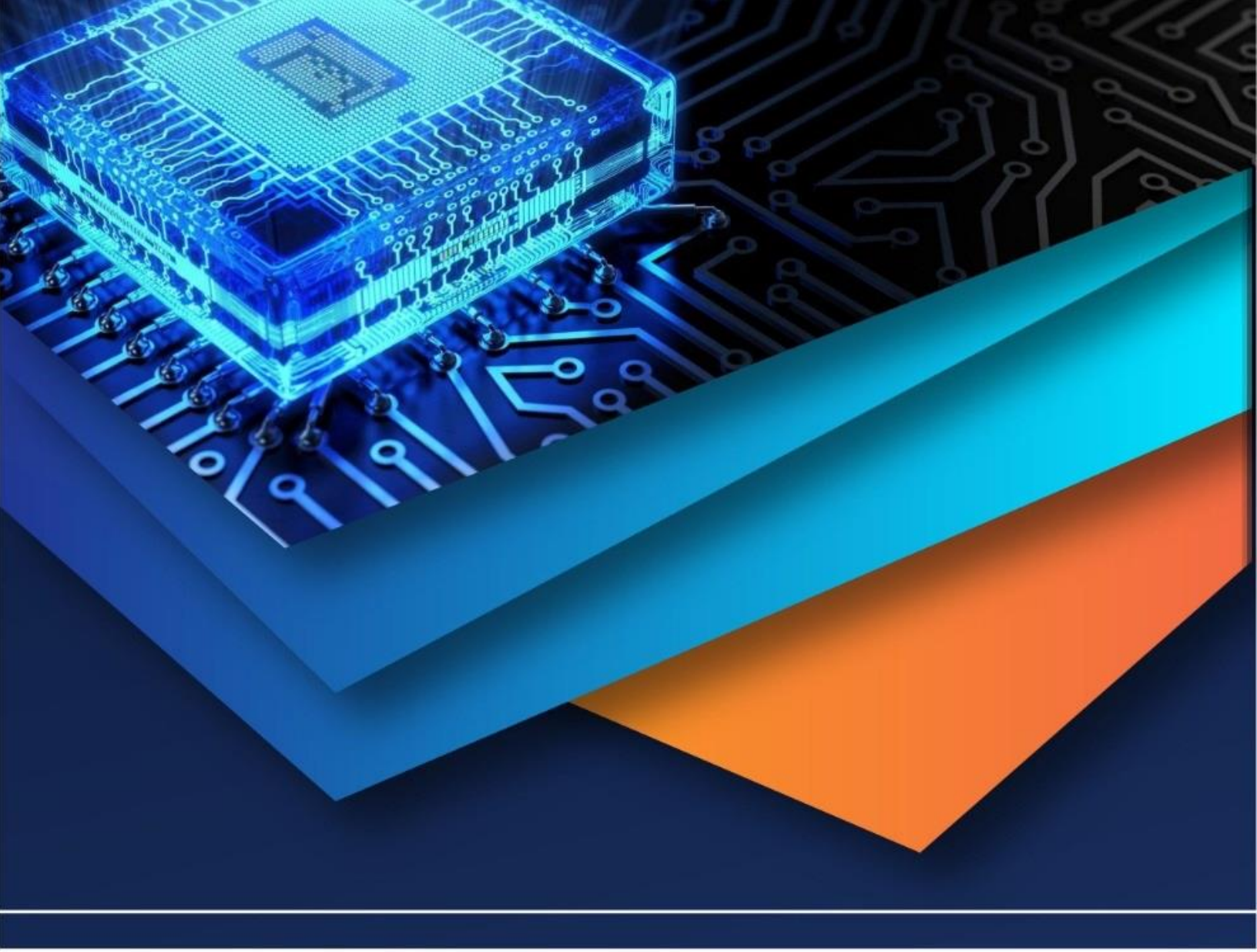
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