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Revolutionizing Supply Chain Management Using Blockchain Technology

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Abstract: ***DSlesinger and M. Stephenson in the Enclyclopaedia of Social Sciences define research as "The manipulation of things concepts or symbols for the purpose of generalizing to extend, correct or verify knowledge, whether that knowledge aids in construction of theory or in practice of art"***
Research thus is an original contribution to the existing stock of knowledge making for its advancement.
In short, the search for knowledge thorough objective and systematic method of finding solution to a problem is research.[1]
This paper is written with the purpose exploring a possible use case of blockchain technology in supply chain management which has the potential to solve many of the existing problems related to the industry along with the scope of improving the same for better. Starting with the introductions of the technologies involved, the paper proceeds to discuss the limitations of supply chains in current scenario and then propose a method in which the adoption of this technology could take place followed by the limitations and hurdles associated with the adoption of this technology.
Keywords: Blockchain, Supply chain, Distributed ledger, smart contract, Network.

I. INTRODUCTION

A. *Preface*

As early as 1981, inventors were attempting to solve internet's problems of privacy, security and inclusion through cryptography. No matter how the reengineered the process, there were always leaks because third parties were present.
In 1993, David Chaum came up with eCash, a digital payment system that was" a technically perfect product which made it possible to safely and anonymously pay over the internet…. It was perfectly suited to sending electronic pennies, nickels, dimes, over the internet". Unfortunately, online shoppers didn't care about privacy and security online then. Chaum's Dutch company DigiCash went bankrupt in 1998. Nick Szabo, one of Chuam's associate wrote a paper entitled 'The GOD PROTOCOL'. In this paper, Szabo mused about the creation of a be-all end-all protocol, one that designated GOD the trusted third party in the middle of all transactions. "All the parties would send their inputs to GOD. GOD would reliably determine the result and return the outputs. GOD being the ultimate confessional discretion, no party would learn anything more about the other parties' inputs than they could learn from their own inputs and outputs"
A close practical realization of the god protocol later came forward in 2008 when Satoshi Nakamoto implemented the Bitcoin architecture based on a public Blockchain. A Network that was distributed, trustless and had an immutable record of every transection ever recorded on it. The bitcoin transection used proof of work consensus mechanism to validate transections thus, marked the start of three-party accounting involving two parties among whom the transaction would take place and the network which would validate the transaction. Essentially this network completely removed the need for trust between two parties and enabled almost immediate transections pan globe with the identity discretion [2]. This brought blockchain into the picture with a million revolutionary possibilities.

II. BLOCKCHAIN

Blockchain is a decentralized distributed and immutable ledger that combines data chronologically in an end-to-end manner such that it is cryptographically guaranteed to be tamperproof [3]. The ledger can hold data of records of tangible (cars, house, paintings, diamonds etc.) or intangible (stocks, bonds, cryptocurrency, patents, copyrights etc.) assets, perform transections, record and store information on a decentralized network. The records on blockchain are timestamped and thus becomes immutable as modifications to the previous blocks would be invalidated by the network and thus it cannot be changed. Blockchain technology marked the dawn of WEB3 also referred to as internet 2.0. As people understood the value of privacy, the power their data holds and how powerful agents of large organizations and govts are using this data to manipulate and control the masses, it became need of the hour to create a technology that will take the control of data from such agents and give it to the people vis-à-vis network.

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Blockchain handles all this data securely on private network which would be accessible only to the private key holder according to the permissions associated with the key or on a public network where anyone can be a part of the network and access the information. This also creates an easy way for assets transaction, tracking of ownership and value management, creation of an immutable record of data that can be accessed and assessed anytime by the network nodes.

PKI (public key infrastructure). For this paper, we have considered a technology such that the public key can only be used to read the data within the public permissions of the blockchain, the private key can be used to update information that too according to the permissions associated with the key. Only few private key holders will have full access to the complete data. These will usually be production and network managers, executives with higher clearance in the organizations.

An instance of the possible structure can be as – The information of the supply chain is stored in the blockchain distributed over the network with permissioned access. Only verified nodes and add block with none given the permissions to edit past blocks. How the blocks are linked, and the security of the network works is outside the scope of this paper.

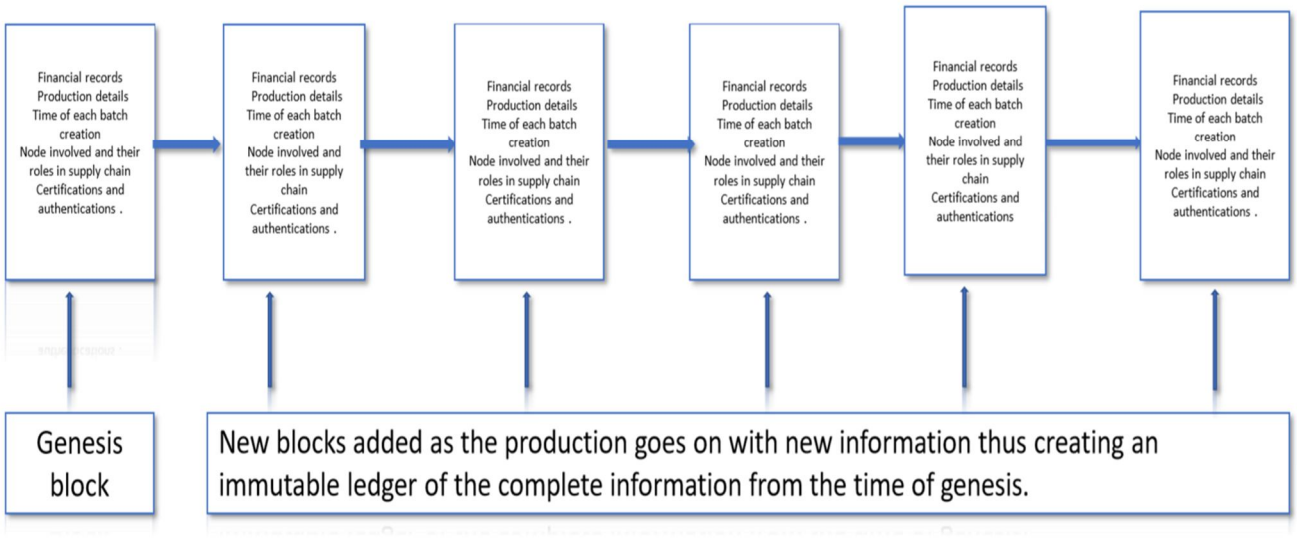


Fig 1: prospective structure for blockchain based supply chain

Now as the first use case of blockchain gained traction and initiated a new revolution in the financial market, innovators became curious and began uniting this new technology with existing ones across various industries and the results have been distinct in their own way. Some of the resulting outcomes are: -

1) Financial market: - NFT, Crypto, ICO's
2) Application development: - Decentralized applications (Dapp's)
3) Identity management systems
4) Replacing cloud storage: - storj (cloud data storing over a network instead of central database)
5) Supply chain management
6) DAO's
7) Self-implementing contracts: - Smart contracts, Ricardian contracts

A. Supply Chain Management

Supply chain management is the handling of the entire production flow of a good or service — starting from the raw material all the way to delivering the finished product to the consumer [4].

Companies create network of actors (producers, suppliers, transporters etc) and link them together in a way such that it maximizes the profits and minimizes cost, wastage, and tailor the production time according to the market demands. Modern day Supply chains are designed such that they are tailored to the current market demands of the consumer as opposed to the conventional method of providing options from which consumers can choose [5].

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Recently every organization tended to design their own supply chains depending on the market they work in, consumer they serve and products they create. Mass production goods are created in bulk every day and the supply chains are not affected by the everyday market and demand fluctuations (food products, adhesives, production cars etc) as opposed to on-demand products (luxury cars, designer suits, customized computers etc). Effective supply chain management requires simultaneous improvements in both customer service levels and internal operating efficiencies of the agents in the supply chain [6]. Customer service implies consistently providing high order fills, improved product support, on-time deliveries, and low return rate whatever the reason. Internal operating efficiencies consists of low operating cost, better return margins on the investments and inventory and the smooth operations between the different agents of the chain without incurring heavy costs.

B. Improvisation Could be Done in Following Ways

1) *Production:* - Instead of expensive market surveys about the needs of new products and how they should be designed, the process could be made dynamic and done on customized blockchain, it'll reduce the company expenses and will give the customers an incentive to participate hence more accurate and reliable information. Instead of paying market analysis agencies which will work on the periphery of market, direct contact with the customers will put them in the centre hence better product sales and reviews can be assured.
2) *Inventory:* - The day-to-day goods requirements can be updated on the blockchain by network agents, large scale dealers or in some cases by the consumers (incentives still provided). Working within a buffer range of product demand will provide with more accurate inventory and will reduce the cost by producing excess goods, storage costs, and in some cases, customers can directly put the demand with production facilities instead of facilities assuming the demands and then producing. Better sales, more efficient, less costs in logistics and perfectly tailored to market demands
3) *Location:* - land acquisitions for setting up of large-scale facilities, availability of resources etc account for a very determinant factor for the success of any industry. The use of political connections, corruption, forced acquisitions to get the land, these methods certainly have their consequences which are to be borne by people residing in the area. Online auctions on the blockchain could be held which would ensure the transparency and the best cost for properties and w
4) *Transportation:* - Logistic services are a crucial part to every supply chain as it involves the transportation of goods from one place to another. The services are usually outsourced through large or small corporations who charge hefty charges. The people who move the product are on the periphery and usually are commissioned with less money as compared to the organizations which lie on the centre and act as a central bridge between two nodes. Using blockchain we can bring such people towards the centre on supply chain with their network reputation being the crucial factor. People can select what kind of service they want from the many providers available on true network according to their needs. Real time ownership and asset tracking can also be implemented using this.

Rating will be used for each actor to provide information about each actor. The better the rating, the better chance the actor will get for business. Hence two-way incentives for all the agents

C. Inefficacies Revolving Around the Traditional Supply Chains Are

1) *Cost:* - more staff is required to manage and maintain the traditional supply chain as compared to when working on blockchain based supply chain, disruption in one part of the chain can completely disrupt the whole supply thus incurring heavy costs, communication between different network agents and links (trader, quality certifiers at different point of the production) increases the cost in production and thus would reduce the profit margins.
2) Logistics make up a large and one of the standing pillars of supply chains. The large, centralized providers have large percentage of fees in the operations they mediate all the while acting just as middle agent between the owner of goods which needs to be transported and the people who transport the goods. Through blockchain, we can remove the organized middle agents, costs of logistics would automatically cut down and new insurance policies could be created verified by the network such that the reputation of the transporter will affect the costs dynamically and the route, weather conditions and will decide the insurance costs dynamically.
3) End consumers have the access to information what the organizations allow them to have and not what they need to make an informed decision. This prevents them from knowing if any unethical means of production was adopted or even if the goods are authenticated or not. Companies are basically providing just the product from which to choose from as opposed giving a chance of making an informed decision while selecting the product. Information involving the product contents, how it was produced,

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the environmental impact it has and if any unethical method was used during its production (this can be ensured by the network which will continuously check for malpractices throughout the chain and not just periodically or when some suspicions are raised). This will further incentivise the companies to follow a more appreciable methods of production thus impacting the industries as whole.

4) It's not always what they show, the information companies/govts/organizations put out in the open is usually such that it improves the market value and the company's brand reputation, the authenticity and reliability of such information can also not be assured. Nonetheless they never show the complete picture. Time and time again many corporate/institutional scandals worth billions have been brought out in the open about fake earnings, duplicate certifications, and standardizations. Some of them are:

a) `Waste Management Inc. is a publicly traded US waste management company. In 1998, the company's new CEO, A Maurice Meyers, and his management team discovered that the company had reported over $1.7 billion in fake earnings.[7]

b) The Japan Gas Appliances Inspection Association (JIA) "revoked" Nissan's ISO 9001 certification for its automobile production activities within Japan on October 31, 2017. The reason being Nissan was using uncertified inspectors to conduct vehicle safety inspections. Nissan was subject to a requirement that only certified inspectors would be used. On September 29, Nissan executives admitted the problem and apologized, but the practice allegedly continued, prompting JIA to revoke Nissan's ISO 9001 certification.[5]

c) The US-based company has a long history of destruction and one of the biggest companies that contribute to deforestation, according to a report by NGO Mighty Earth.[6]

5) Organizations / governments function opaque, use public resources to meets their own ends, manipulate populations, and later create socio-political havoc with no responsibilities to bear. If the operations of these organizations are put on a permissioned blockchain, it would open the doors for transparency and the subjects could see the working wherein they are concerned, and financial data published by the organizations could be revied by the masses. Corruptions and scandals would reduce and improve the efficiency of their working.

6) Human errors, sometimes defective goods are produced, or they are damaged during the transportation. Who is to bear the cost of such damages? These rules can be hardcoded in the blockchain smart contract alongside of the ownership data and nodes can agree on the bearer of costs in different scenarios before they occur. This reduces a lot of corporate issues that arise in supply chains.

It can also be used to trace where exactly during the whole duration a defect occurred, or which part/node of the chain didn't perform up to the pre-decided standards instead or reviewing the whole chains. It would save a lot of costs and would constantly keep an eye on every agent thus encouraging to perform at par.

D. Functionalities using the Proposed System

1) Replacement of middle agents and links by the blockchain, which will work based on smart contracts designed to create the product from the raw material satisfying the functional standards / quality checks. If disruption occurs, the chain will automatically go for a predefined way of resolving the issue such that it will create the most efficient solution. In some rare case it can also isolate the part where the disruption occurred and replace it with another temporary replacement such that the product would move forward in the chain without causing a halt or sustaining heavy monetary or asset damages

2) The public product profile will contain all the information from the source of its raw material, the processing plants and the actors involved along with the public link to the profile of the actors. During production also the private data related to the product can be accessed and in real time by the actors along with the ownership rights which can be accessed using their own private key. This record will contain all the ownership records/ product details / role of actors involved and how they changed/updated the product. This information can be compartmentalized such that consumers will get all the data of product like from the origin of its raw material to their end which will prove authenticity / rule out ethical malpractice doubts all the while keeping the trade secrets safe.

3) The private data is also a key safe mechanism. In case of a faulty batch, product failure etc… the product blockchain data can be easily used to track the owner, recall the products and its private can be useful in backtracking which node/ or process during the production was faulty. This saves a lot of cost in reviewing the complete chain.

4) Authenticity can be well maintained using well acclaimed certifiers and all their information in case the information's held false so that the accountable can be held

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III. APPLYING THE DISTRIBUTED LEDGER

Supply chain manufacturing system comprises a series of system entities including people, physical resources, knowledge, processes and financial contracts and transections that facilitate moving a product from supplier to customer [10]. In large supply chain it is very difficult to keep track of all the information, ownership records and transections due the involvement of many actors at the same time and the central information being stored at varied location to which only people with certain clearance have access. This creates an opaque structure even for the actors involved as they cannot access information about the past contracts and upcoming ones. This leads to the possible issues as stated above and more.

The application of distributed ledger using the blockchain technology with improve the transparency, decentralize the central data, and reduce the transections and information exchange time between authorized actors drastically. An immutable record of possibly everything that ever occurred on the chain also improves the intrapersonal trust among actors and incentives them to improve their performance.

The proposed system is explained in the following section including the actors, how they become part of the network, the data flow and its authorization, validation, and storage.

The figure shows an overview of the supply chain in manufacturing system. The proposed system works though a decentralized blockchain system that hold all the key specific product details, ownership records, actors as its private node with the access permissions to update the data, registrars to register node and create their public profile and certifiers who would certify the product for quality assurances.

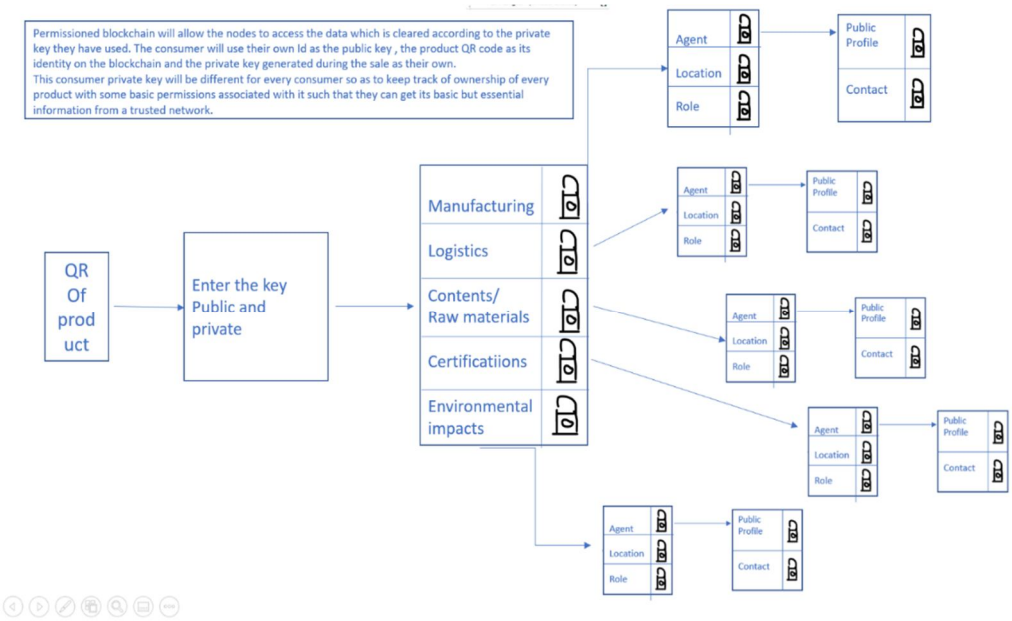


Fig 2: permissioned structure of the proposed system.

As the product moves froward in the supply chain, it is possessed by various suppliers' logistics, inventories, and manufacturing plants. Various quality checks are done by different certifiers at various stages and the actors are certified to show their trustworthiness, ethical work environment and environmental impacts caused by their involvement. These certifications can be used by consumers or supply chain entities to choose the best suitable option for them with better reputation.

CA: - A certificate authority or certification authority (CA) is an entity that issues digital certificates. A digital certificate certifies the ownership of a public key by the named subject of the certificate. This allows others (relying parties) to rely upon signatures or on assertions made about the private key that corresponds to the certified public key. A CA acts as a trusted third party—trusted both by the subject (owner) of the certificate and by the party relying upon the certificate. [11]

RA: - A Registration Authority (RA) is a function for certificate enrolment used in public key infrastructures. It is responsible for receiving certificate signing requests – for the initial enrolment or renewals – from people, servers, things, or other applications. The Registration Authority verifies and forwards these requests to a Certificate Authority (CA). [12]

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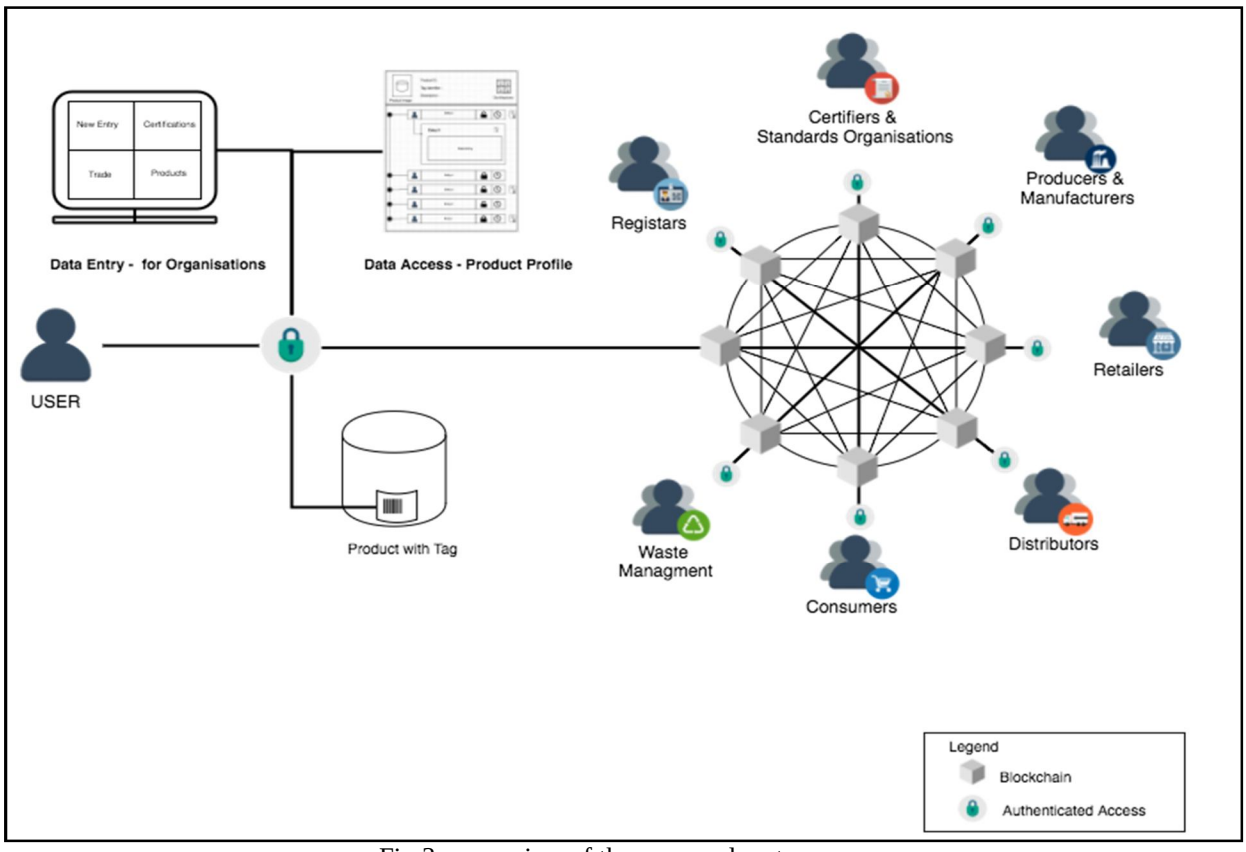


Fig 3 :- overview of the proposed system

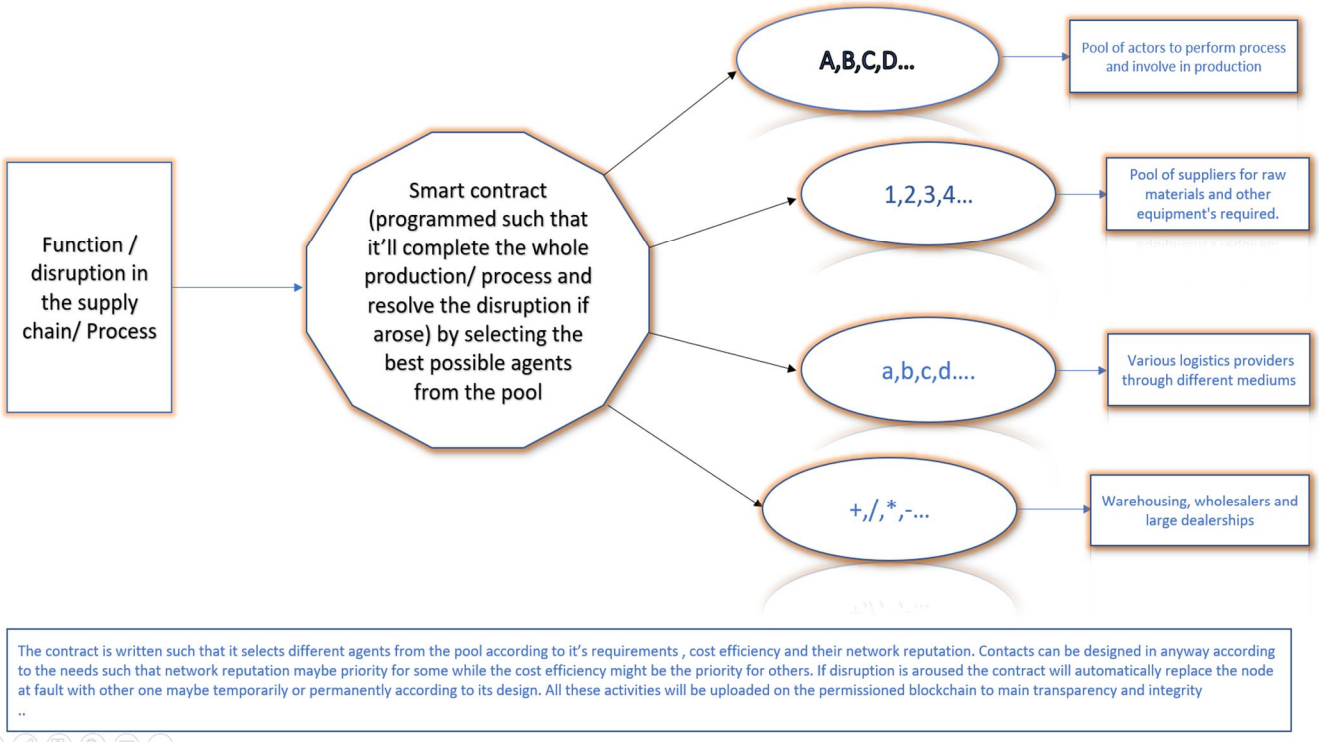


Fig 4: smart contract as central controlling unit

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1) Every actor register itself to the registrar of the sc. These actors are selected by the registrar such that they are the best viable option who would provide good service and later good image on the actor involved column. This incentivizes the people related to supply chain to perform better, in ethical ways while causing none to the least possible environmental damage.
2) Certifiers certify the actors regarding their working conditions, environmental impacts, and their contribution for the betterment of society (NGOs, providing poor the jobs, letting stray animals on plant campus, maintain green campuses). These certificates would improve the image of actors and would help them get more jobs.
3) Private key is provided to each actor at the time of registration. They will use this private key to access the distributed ledger and add information on the blockchain. Every private key will be associated with certain permissions thus they cannot access everything, only things they are concerned with. If due to some discrepancies they need such access, temporary access can be given by the network manager. (semi-private blockchain. Can use the combination of semi-private, private, consortium blockchain too)
4) Every time from the start i.e., the raw materials supply, everything will be added on the blockchain with the certificates. These certificates will provide authenticity and quality assurance throughout the blockchain. A public profile of the certifier will also be linked such that their repo is associated with the product / its quality they certify and thus keeps their reputation on the line. This will incentivize them to improve performance. (Batch certifications)
5) Every time good is transferred, a transaction will take through a smart contract which is tailored according to the needs that will transfer the ownership of the product form one party to another. This will also transfer the rights to update the information, update location and provide with a chronological data of when and what work had been one on the product and who had the ownership of the product.
6) Every time a product moves forward on the blockchain, it'll update the status. This will provide a self-sufficient way for the production line to move fwd. as when the actor completed its job along with the certification, the smart contract will automatically move it to the next stage /actor. Thus, the production line becomes automated.
7) Smart contracts can be designed such that they would handle the logistics. They would consider all the logistics provider on the network, compare them on the basis or availability, cost, reputation and other factors as designed by the network manager and will contract the logistics actor directly without involving middlemen. It will save cost, discrimination in business opportunities on different basis, stop money laundering and racketing for opportunities and will also ensure that if one actor fails to show up on his end of the commitment, it will show up on his public profile and will inform their future employers about the case. This will improve overall transparency in the business.
8) Reputation will be the key aspect for every actor, and it will be determined by the network simply based on quality or work.
9) Some contracts can be created such that if one node fail, or chain disrupts, it'll immediately provide the work to the next most suitable actor. Reduces delay, disaster management cost and will not disrupt the further node of sc.
10) The last entity set on the ownership register will be the consumers. They will be able to access all the previous public data about the product, its ownership register, performance register (as in for vehicles during their safety test, mileage of on road vehicle), the vendors it came from and their public profile. Such way people can select products involving local actors/ businesses to support them if they want too or go for products supplied by big conglomerates for their name/ quality assurance.

IV. LIMITATIONS OF THE PROPOSED METHODS:

1) Upscaling issues. Everyone involved should be able to be part of the network. This will require some technical knowledge that still isn't prevalent in many parts of the globe. This might create issues for people to get involved and thus would provide an unfair advantage to those who do know how to use technology. Thus, basic use of technology, handling of private keys, updating status & location on the blockchain must be taught to everyone involved (including truck drivers, inventories managers, wholesalers, and distributers etc.)
2) Increase in demands of computing power results in increase in need of electricity which mainly is generated from non-renewable resources.
3) Human errors if occurred while adding / updating some info on blockchain, it'll be immutable and cannot be changed
4) Corporate monopolies /govts are reluctant for its adoption and will not let such technology take over as it will bring their scams in the open, (politics, money laundering, unfair corporate practices etc)
5) Time: - it would take time for this technology to be adopted over the traditional supply chain management and it will not be without its own hurdles.

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V. CONCLUSION

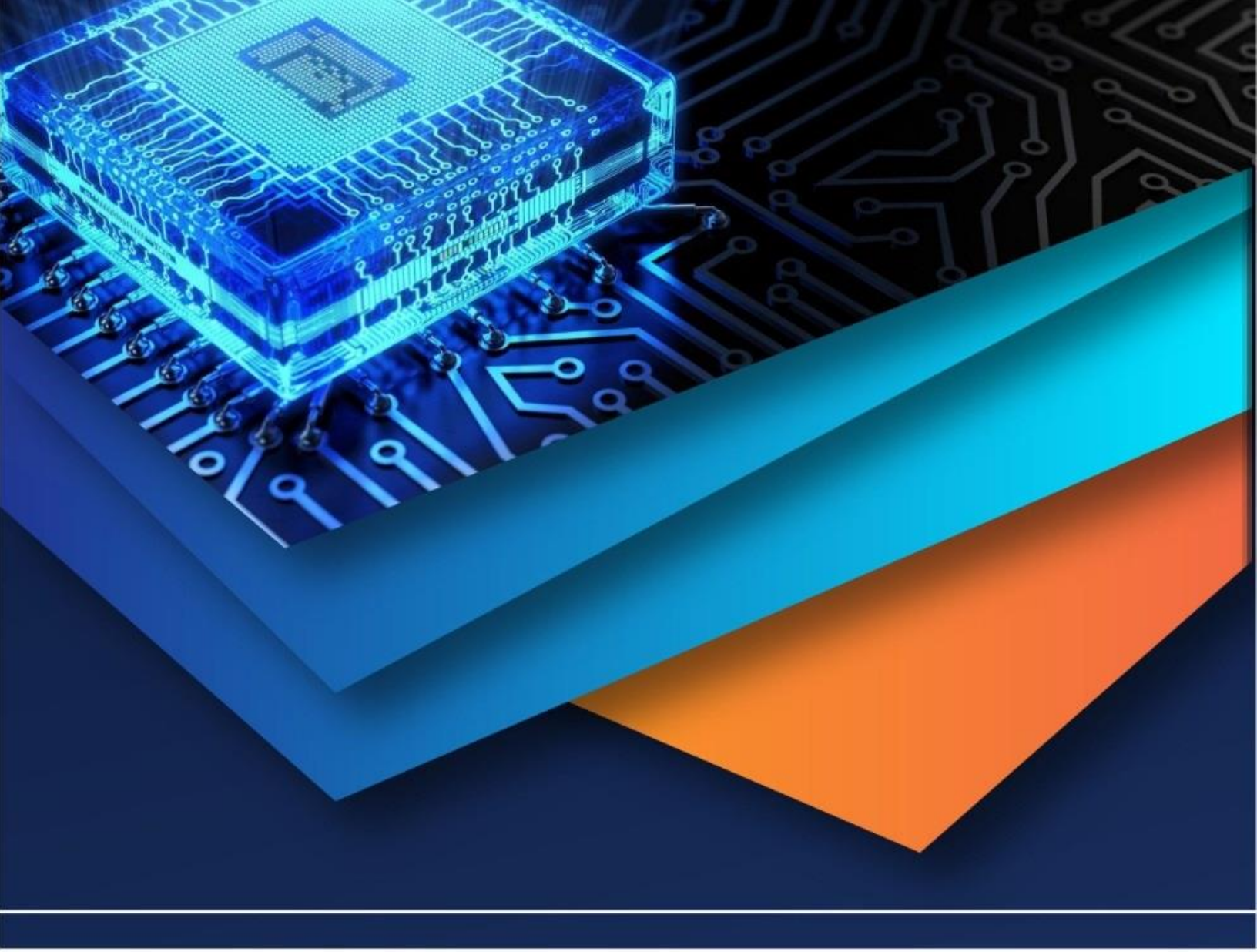
Blockchain technology is a revolutionary innovation with the capability to transform many traditional systems and enterprises into a more dynamic and distributed structure which is transparent, secure and empower the users.

This paper has reviewed its application in supply chain which would remove the centralize traditional structure and will distribute among the network which brings agents involved towards the centre all the while improving the overall performance and efficiency of the same. The wide scale adoption in open enterprise will require time but won't be without its revolutionary industry transforming effects and towards a new decentralized trustless future.

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