Implications of Blockchain in Industry 4.O

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IMPLICATIONS OF BLOCKCHAIN IN INDUSTRY 4.O

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Abstract— **Rapid advancements in Information Technology and industrialization methods have expedited the advent of industry 4.0 also known as integrated industry smart manufacturing or industrial internet. The notion of Industry 4.0 promises unprecedented progress in next generation of manufacturing technology by fundamentally changing the ways of production and value creation with the help of digital transformation in product/service offerings and horizontal/vertical value chains. Industry4.0 is underpinned by a spectrum of emerging technologies such as cyber physical systems,internet of things, machine learning, adaptive robotics, artificial intelligence,cloud computing,Industrial Integration, and Service Oriented Computing. Distributed ledger technology also known as blockchain can not only affect Industry4.0 but also has its direct implications in the above mentiond set of technologies. Lack of powerful tools for visibility, accountability and auditing is a major obstacle in complex processes and supply chains of Industry 4.0. In particular, issues of cloning of products, counterfeiting, trickier maintenance and IP theft are crucial teething issues for realizing Industry 4.0, which poses unique challenges. This paper is an effort to break the ground for demonstrating and presenting the use of Blockchain technology in 4th industrial era.In this paper we explore some concepts of industry 4.0 using blockchain technology and see how blockchain enablement is beneficial for industry 4.0. we explore different areas where we can use blockchain technlogy to foster the development in Industry4.0.**

Keywords: Industry4.0, Blockchain,Smart contracts, Supply chain, Identity management, micro payment, Internet of Things

I. INTRODUCTION

Advanced digitization within factories brings us an ecosystem right from the product being manufactured to the interconnected factories, supply chains, customers and various other stake-holders termed holistically as the Connected World. The combination of Internet technologies and other future-oriented technologies is poised to result in paradigm shift in industrial production leading to what is known as Industry 4.0.[10] Industry 4.0 brings us an ecosystem that is mainly based on automation included smart services, smart products and smart factories. This change creates many opportunities for game-changing ideas in sustainable industrial manufacturing.[3] Building such an automated environment requires internet connectivity along with the large number of objects.Originally such objects are not secured-by-design rather exposed to attackers, therefore hackers should be prevented from enrolling into botnets, to patch their vulnerabilities or to be able to update them.[2]
From past few decades many cryptographic techniques are used to protect sensitive information either in communication or in storage. Initially these techniques were only used in information security systems but now they are moving into other use spaces. [12] Originally blockchain was developed for the cryptocurrency known as the Bitcoin.Bitcoin's blockchain is a decentralized data management and transaction technology. The idea of blockchain technology was coined in 2008 and it got much interest because without involvement of any third party its central attributes provide data integrity,security and anonymity.[18] The implication of blockchain in Industry 4.0 has spawned a wealth of new innovations. Blockchain ensures that the cyber-physical systems making up smart factories can autonomously and safely order a necessary spare part, streamline their production processes to cut down energy consumption, pinpoint upcoming faults in the supply chain before they happen and many other advantages. Blockchains potential make us able to adapt ourselves to a new,optimized, flexible and more efficient business model based on trust and security of all stakeholders. This makes Blockchain technology a staunch ally in the development in Industry 4.0.[11] The products in an automated industry,from factory to end consumer, provides priceless information that is vital for various concerns. End consumers are interested in this; hence greatly concerned about finding out the exact traceability of the products. In any industrial environment, moreover, it is crucial for end users to know that items are original or counterfeit they have been exposed to. Blockchain can be used in many scenarios in industry 4.0. In this paper we explore the role of blockchain in Industry 4.0:

- in context with process optimization such as logistics process optimization and product life cycle improvisation,
- in context with a platform having properties of being tamper-proof and cross-referenced
- and in terms of security with implications in authentication, authorization, identity management and trust.

some from many applications of blockchains in industry 4.0 scenarios.The paper is divided into different sections each showing that how blockchains can be used in Industry4.0.The sections are organized as: Section II discusses the role of Smart contracts in Industry 4.O and Section III explains Automation and Integration of supply chain in Industry4.0. In section IV we will discuss Product life cycle tracking and tracing in Industry4.0. Section V will de-

scribe Copyright protection using blockchain in Industry4.0. Section VI represents Blockchain Based micro-payments in Industry4.0, In Section VII we will discuss Security and Privacy in Industry4.0. where we will discuss blockchain based Identity management and some other functionalities (availability, authentication, authorization , integrity and non-repudiation)that can be improved using blockchain. In last section VIII we will conclude the paper.

II. SMART CONTRACTS IN INDUSTRY 4.O

Blockchain is shared as a distributed ledger, across a broad business network .it means that we can re-engineer business methods using blockchain. Now a days, businesses keep lists of every assets they own and these lists can be changed in a specific way when ownership changes.By using Blockchain we can keep standardized list of all assets.if we want to change these lists Smart contracts can be used .[11] Smart contract also known as crypto contract is a self-executing computer program written to execute every relevant state of the contract. It can be used for directly transfer and controls assets and digital currencies between different parties under certain conditions and for many other purposes. Smart contracts are written in aseries of IF/THEN statements. For example IF [Company 4534] cannot provides[1500 devices] before [DEADLINE 15-Mar-1018] THEN charge[fine at the rate of 1 percent day of total bill] to User/Account0232-232323-223232
The technology underpinning smart conrtacts and industry 4.0 is known as blockchain. A unique identifier known as a hash is carried into the next transaction for linking them. Each new transaction is added to the old block, which gives a unalterable complete and objectively verifiable record in relation. The blockchain is the public element and open to inspection.The detailed contents of each transaction orblock remain protected and confidential by a private key.Underlying the transactions the blockchain provides a full replicated copy of the data making up the chain at each node.In every node there will be a full copy of the ledger. The concept of Permission involves all those participants who are involved in setting up the blockchain network can determine that which parts of the ledger other members can see. They can also give them the right to see everything in reat time if necessary

III. AUTOMATION OF SUPPLY CHAIN IN INDUSTRY4.0

Depending on the product the supply chains management process is extraordinarily complex.Different geographical locations contain different links for supply chains to create and distribute goods.There can be hundred of stages,multitude of payments and invoices.It can also extend over months of time and have several entities individuals involved. Insufficient transparency and increased complexity broke our supply chain from several points in many ways. The unique attributes of blockchain could transform the industry of supply chain and logistics in better form. Supply chain in industry 4.0 can based on following two different dimensions[7]:

● **PHYSICAL SUPPLY CHAIN DIMENSION:**

In physical supply chain we use blockchains in self-controlled and Autonomous sub systems of logistics like **transport**(e.g. autonomous trucks providing and supplying materials. Using smart contracts products and services could be made available to customers by the process called autonomous delivering.) **order processing**(smart contracts) order processing systems can use blockchain technology for facilitating seamless business executions (e.g.condition monitoring , object self-service or remote usages). **Turnover handling** (e.g.piece picking robots or trailer unloading)

● **DIGITAL DATA VALUE CHAIN DIMENSION:**

Different type of data is collected through machines and sensors on end-to-end supply chain that is entirely physical at level called physical thing. High value data can be placed on blockchains for record keeping and provided for any kind of analytics that could results in business services which are potentially highly value-added services . Early models of blockchain-based smart contracts assume a single transaction. These models becomes more complex when coordination of several transactions involves.

For example, a manufacturer order some critical components from a supplier to provide a system to end-users. That supplier order different elements from different parts of the supply chain, eventually reaching back to source raw materials in the extractive industries. Now suppose if each link in the supply chain operate on a just in time basis, then ability to meet an order is dependent on dynamic procurement in whole chain. So there might be a need for the immediate contracts between the End-users to manufacturer, manufacturer to suppliers, suppliers to suppliers forming all the links to be conditional upon the conclusion of all contracts back to the root of the supply chain.So if there is delay in process whole chain can be viewed for delayed reason and no legal action can be taken against wrong person. Alternatively, there can be legal force, only if suppliers can give an assurance (probably written on smart contract) that he is responsible for any contractual delay in chain necessary to meet the order.

There is nothing, that is insurmountably complicated in the supply chain. It simply require the smart contract to be formed only when different components of the supply chain can generate a request or confirmatory message. However,providing for the consequences of default of any such message and methods for ensuring their validity would have to be an explicit element of any smart contract system. [11]

IV. PRODUCT LIFE CYCLE TRACKING AND TRACING

In the world of the Internet of Things (IoT) every product we use has a entire lifecycle starting from inception phase, passing through engineering design and manufacturing of product and reaching to the service and disposal of manufactured products.[9] Product life cycle management (PLM) theory and software are used to manage and use this data. Blockchain with its abilities can help to securely organize and manage disparate development strategies,capabilities and information.This would allow a clear view to all the stakeholders of a products life cycle to measure out the

performance of any product and how its being used in real time, without waiting for the reporting of customers. Also different buyers and the valued customers of these products find it so difficult to truly find out the actual value of products in current system due to the lack of transparency. Similarly suspicion of unethical or illegal practices in supplychains is very difficult to investigate. Also it can be highly inefficient as suppliers and vendors are trying to connect several dots on different requirements like who needs what, how and when. The prominent use of blockchain for any tracking, exchange, agreements/contracts and payment can provide a highly secure way in supply chain management. Additionally it is extremely efficient and scalable. Block chain can help in various aspects in products life cycle which include:[16]

- Maintaining version history and control
- Managing your changes over time
- Keeping record of past, present,and future concepts and products
- Logging the raw materials and parts
- Keeping your organization up-to-date with the product knowledge
- Managing product intent and customer expectations
- Integrating the enterprise systems
- Tracking the manufacturing procedures
- Cataloging the chemical and physical properties

Blockchain technology can help organizations coping with challenges like engineering difficulties, increasing complexity and developing different type of new products for all the globally competitive markets.It will also make contribution in improving the quality and reliability of products,reducing prototyping costs and providing products timely with more accuracy . we can re-use original data for development of new products and it also provide framework for product optimization.

V. COPYRIGHT PROTECTION USING BLOCKCHAIN

In industry 4.0 one of the important approach that cause disruption is 3D printing technology.Value-added networks are used instead of traditional supply chains.The development of components is spatially distributed, e.g. demand of rapid spare part delivery is creating a big issue that whether it is "original part","counterfeit" or "copy". It is necessary to differentiate between them specially in safety-critical products.Hence counterfeiting and protection against it is highly important and need to be provided the required attention,as counterfeiting of products and trademark cause billions of losses to German companies [15] Due to these challenges a cryptographic approach to licensing model can be adopted to reduce the risk to minimum .Blockchain technology is used as registry of IP rights, to catalogue and store original works.Also it can be used as the security perspective for the authenticity of all type of printing data and prevention of unauthorized use of this data to some extend.By using Blockchain Licensing and Encoding of data provides a way to secure the data about the print template's identification and the printing process of the licensing. [8]

VI. BLOCKCHAIN BASED MICRO-PAYMENTS

In the era of IoT an enabler technology is to make things able to make payments to other things ubiquitously and automatically without intervention of humans.This would make any device in IoT to make decisions on its own e.g. a device can rent a cloud server for additional computational power when required, to pay directly to other devices for access of internet or automatically pay for electricity consumed. At present we are moving towards these things to things payments which will be small but numerous and autonomous. Current payment systems are not well suited for these massive micro-transactions because they have high transaction cost and limited capacity. Also there is big challenge in using current credit-card systems that we have to share credit-card information with our device and allow it to share it with other devices for payments.[15] So there are three immediate issues which required attention:

- Reduce the fee of transaction
- Minimize the time for the transaction
- Creation of a fair and transparent distribution system.

So Blockchain could be the best choice. Heres the way blockchain technology used to resolve the issues associated with micro-payments:

Low transaction fee: By using blockchains we can avoid third-party payment services which are quite expensive. Pay in tokens and get paid in tokens. he fee for crypto transactions is low or non-existent and can be further reduced in future. we can either use tokens to pay for other services or products on platform or sell these tokens for other cryptocurrencies. These tokens get accumulated in our crypto wallet.

Immediate payment: Instead of waiting for days to get money credited, you get paid within few minutes in tokens or cryptocurrencies. Crypto transactions are processed 24x7.

Fair distribution: Since every agreement is bound by smart contracts, the distribution of payment would be automated.[5]

VII. BLOCKCHAIN BASED SECURITY AND PRIVACY

Wide scale of IoT systems in Industry 4.0 consists of many devices that are heterogeneous in nature and generate, process, and exchange huge information that is safety critical as well as privacy-sensitive.High level of security threats are appealing targets of various cyber attacks.[14] Traditional approaches for enforcement of security and privacy cannot be applied directly to industry 4.0 scenarios due to scalability issues .Moreover limited amount of computing power in interconnected devices causes problems to define valid security and privacy models.[17] These devices consume this limited power for executing core functionality, creating complex challenges for these important non functional security and privacy requirements.Security methods in industry4.0 are tend to be quite expensive in terms of overhead after consumption of energy and lots of processing. Majority of

the security frameworks used until now are highly centralized therefore these frameworks are not well-suited for frameworks of IoT due to the single point of failure ,nature of the trafc that is many-to-one, and difculty of scale.[13] To protect user privacy, Traditional methods protect user privacy by revealing incomplete or noisy data, which may harm data and effect offering personalized services . Thus internet connected devices in industry 4.0 requires a safeguard that is scalable,distributed and lightweight.As a result of its private, secure and distributed nature the Blockchain (BC) technology has a great the potential to overcome these aforementioned challenges. [4] Blockchain can adresses the major drawbacks of the centralized infrastructure i;e by providing the privacy for identities and security for transactions in industrial environment.The decentralized communication in blockchain relies upon the cooperation of individual nodes for information propagation.Public key cryptography could be used to provide security and integrity of information.instead of relying on a trusted third party.Instead, we can relay on cryptographic techniques for maintaining security and privacy.[1] Blockchain can be employed to the IoT devices and data of these devices for providing secure access control.It generates history of transactions that is time-ordered and immutable and can be linked to each other giving specic services.Security in design can be achieved from different features includes:"Devices which are not directly accessible" and "different transaction structures".

For lightweight security purpose, symmetric encryption can be employed for devices to achieve availability,integrity and condentiality. Hence key security attacks such as Distributed Denial of Service (DDOS) attack and linking attack can thwarted and the overheads induced could be relatively small. [4]

A. Identity Management

Using a factory with Internet-connected machines that automate the workforce and streamline the manufacturing process for increasing production and/or reducing costs.As processes are automated securing these factories is obviously a key concern.Consequences of a security breach (or smart systems with too much access) could be catastrophic! so protecting these systems can avoid major problems which are affecting to extended growth of this trend. Securing things in the automated industry poses new challenges of identity of devices because of the great plurality and diversity of connected devices. Also during communication of devices, the traditional methods of authentication such as tokens or passwords cannot be used. As trustworthy information about identity of devices need to provide not only among themselves, but also to infrastructure providers.considering the large scale of devices, creating trust among them is a significant challenge . These devices could be susceptible to manipulations, physical attacks and the software used for communication is enormously very difficult to secure. Implementing blockchain could provide connected devices with a cryptographic solution allowing information within the industy4.0 to be transferred with a significantly lower

chance of manipulation. As more devices are communicating and generating more data,identities become more complicated. Traditional systems for identity management simply cant keep up with evolving needs. Blockchain provides a secure solution, that is decentralized, puts system back in control to validate communication and fosters innovation. Visibility of blockchain make all participants see the transactions of others participants in the network. Although the identity is not visible due to privacy concerns but a new participant that want to enter in the blockchain is verified.An identity is required to enter into a contract. The concept of decentralization of data make participants of blockchain able to have more control over their own identity and identity of devices. Various components of automated industry will be able to validate different aspects of participants identity. The identity of a participant will be validated and not be held with one provider. some principles of blockchain that help to maintain identities are:

Permission in blockchain will determine which part of transactions other participants can see and give right to see everything in real time if necessary . This principle can help in industry 4.0 to give access to only those users who have verified identities.[11]

Consensus (all participants in the blockchain's network must validate the blockchain as correct). This concept can help validate only correct identities.

Provenance (blockchain gives view of full transaction chain that shows the transactions of participants entered into the network.) This principle can help with DOS(Denial-of-Service) and DDOS (distributed denial-of-service) attacks,MitM (Man-in-the-middle) attack,Phishing attack and spear phishing.

Immutability (the record can not be altered) This concept will help to maintain identities and trust on identities.

Finality (participants cannot be added into the blockchain until it has been validated as correct).This is the most important concept that can help to maintain correct list of identities without any alteration.

B. Authorization, Authentication and Integrity

Numerous objects that we use in industry4.0 are small,being equipped with protocol suites and electronic devices.These devices are mostly connected to each other and with internet for communication purpose and exchange of important information. As there is no human intervention, there is great need of authentication and authorization of these devices from being target of malicious entities and to maintain the integrity of data exchanged . Traditional systems for authentication and authorization are centralized which are difficult to implement in industry4.0 due to size and other features.By using decentralized ledger system (Blockchain) for this purpose we can recognize and authenticate devices in efficient manner and protects the integrity of data. Security advantages provided by blockchain can help to provide a secure system where each device can be authenticated and authorized by consensus.

C. Availability, Scalability and Non Repudiation

Using blockchain in Industry4.0 scenarios can help in availability of IoT devices to legitimate users on demand. As blockchain based systems will be resilient against DOS attacks especially if an attacker want to target the authorization and authentication service of the system. Similarly using blockchain based approach we can also deal with the scalability issues such as if the size of the IoT system in Industry increased, it should not effect the overall performance of the system. By using blockchain we can ensure that if the devices used in a system explodes, the time of services provided by the system will not be effected.Non repudiation can be achieved as devices cannot deny any performed action because of the visibility of transactions in blockchain based systems.[6]

VIII. CONCLUSION

Involving Blockchain technology in Industry 4.0 offers huge oppertunities and serves as an intelligent platform.Blockchain ensures higher level of automation,speeding up processes,slashing costs and cutting out interparty friction with the net result of fleet-footedness and greater system flexibility. Blockchain can be configured in Industry4.0 in various ways by inputting in smart contracts , tracking of devices, copyright protection, micro payments or identity management. Thus providing huge benefits for all concerned: by applying its trademark features of security,traceability,immutability,transparency and robustness.In this paper we have discussed few applicaions but there can be lot of other implications of blockchain that boost industry4.0 for new innovations.

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