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ENHANCED AND OPTIMIZED INDUSTRIAL PROCESSES MANAGEMENT USING MACHINE LEARNING (ML) AND BLOCKCHAIN

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Abstract- **The development of the fourth Industrial Revolution 4.0 and inventive smart manufacturing gave rise to a predictive maintenance system for monitoring or tracking industrial equipment. At present, Industry 5.0 has emerged, smudging a significant milestone. Smart factories are on the rise in business productivity, thereby showcasing the limitations of Industry 4.0. The latest industrial revolution is represented by Industry 5.0, amalgamating technologies such as IoT and artificial intelligence. It encompasses an extensive network of interconnected devices, that ensures prompt data transport, especially within a 5G-capable setting. However, going forward, the protocols that are based on centralization and conventional access control techniques are unlikely to remain relevant. Hence, for device-to-device interaction and communication, a robust and efficient decentralized access control system is required. Privacy, confidence and reliability stand out as the most significant issues Privacy, security and reliability stand out as primary concerns in the context of industrial process management. The melding of Blockchain (BC), Industrial IOT, MQTT communications protocol, and ML techniques are emphasized in this research study. Through industrial machinery, real-time data from sensors measure characteristics like current, vibration and temperature. Machine learning(ML) models are utilized for examining this data in order to detect any abnormalities or deviations and failures forecast. With the help of the MQTT communication protocol the consistent interaction among the cloud server, gateway devices and sensors. The system underwent testing using an up-running machine data set, employing the ML model linear regression (LR) algorithms for the processing in the proposed framework and analysis of collected/gathered data to forecast machine failures and provide enhanced and secure maintenance level. This method minimizes costs and operational interruptions through optimized maintenance decisions and schedules, illustrating an Industry 5.0 approach for advanced and smart manufacturing.**

Index Terms**-- Blockchain (BC), Binance, Smart Contracts, Machine Learning ML, Linear Regression LR, Artificial Intelligence AI, MQTT**

I. INTRODUCTION

Transformation plays a pivotal role in the technology sector and technology innovation has reshaped conventional domains such as manufacturing, education, healthcare and agriculture. The commencement of the initial industrial revolution, Industry 1.0, unfolded in 1760 in UK and had a profound impact on sectors like mining, textiles, agriculture, and glass. The evolution resulted in a move from crafting to machinery, influencing industries such as fabrics, mining industries and agriculture. The subsequent revolution called as Industry 2.0, transpired among 1871 and 1914, facilitating swift transformation of innovative ideas, people and boosting productivity and fostering economic expansion. On another, at this precise moment, there was also a spike of insecurity as machinery took the role of the manufacturing workers of the factory. The industrial automation revolution which is also known as the Third Industrial Revolution, began to develop the form in the 1970s and enables for the technological advancement of controllers and programmable-memory computers. This stage [15] focused on large-scale manufacturing and the adoption of integrated circuit, digital logic, smart phones, computers and internet connectivity. Traditional products and business procedures transformed the digital revolution. The fourth Industrial Revolution 4.0 amalgamates existing assets with cutting-edge innovation like IOT, AI, 3D printing, robots, and the use of cloud computing. The version 5.0 of Industry represents the forthcoming automation tailored for smart and efficient machines. [15]

Achievements in the industrial manufacturing sector is not only focused on product quantity or volume but also by manipulating the technology to improve product quality, meet market demands and optimize operations as can as

possible. The sub-branch Artificial Intelligence (AI) Machine learning (ML), is the imitation of human brain learning mechanism, in this emerging technology many application fields are found such as the usage of AI in speech and image recognition, text methodology and exhortation systems. In 2008 Satoshi Nakamoto introduced the Blockchain which is a decentralized and secure digital ledger ensuring data integrity, trustworthiness, security, and decentralization. The fusion of Machine Learning ML and Blockchain has the tendency and potential to set up and introduce a secure, efficient network transaction, administration system, decentralized and smart system. In both fields of industry and academia, it indicates an interest in including model handouts and enhanced statistics, which can improve confidentiality and security, also be authentic in decision-making by using ML. Hence the integration of Blockchain (BC) and ML helps in storage of large datasets transparently. This integration enables the secure and transparent storage of large datasets, empower the models to train the data. It also cushions control and data privacy by offering decentralized authorized access and possession. Moreover, it can also play a major role in facilitating the development of decentralized the models of machine learning, permitting the participants to provide computational resources while encouraging more collaboration, shielding the data privacy and efficient machine learning environment. Handling the generated information is a challenge that needs to be addressed.

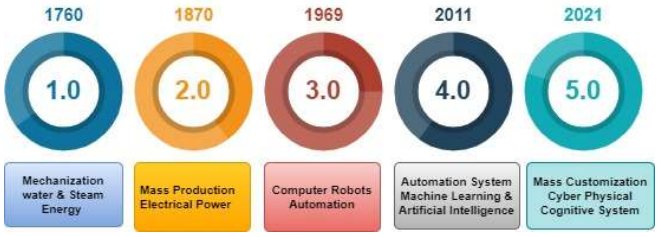


Figure 1: Transformation Towards Industry 5.0

Optimizing Industrial Processes with Machine Learning and Blockchain pursues the following research objectives:

- ML techniques help in identifying anomalous situa- tions or conditions early on, automating the optimization tasks of supply chain which traditionally require human oversight.
- Machine learning can proactively be monitoring equip- ment condition, affirm the predictive maintenance and alerting users against the unusual issues.
- Computer Vision (CV) can automatically identifying the safety issues such as workers or forklifts straying into unpredictable zones that can augment existing cameras for low latency and high reliability.
- Blockchain in Industry 4.0 provides the confidentiality towards the sensor data and a more reliable data security platform.
- This enterprising approach led in minimizing costly downtime and preventing machine failures.
- In summary, Blockchain and machine learning technolo- gies are revolutionizing industrial tasks and manufactur- ing operations.

The leftover paper includes Section 2 with a literature review, and in Section 3 the description of the background. Section 4 involves a portion of protocols employed, while Section 5 discusses prevailing algorithms currently utilized in the industry. Section 6 outlines the proposed solution, followed by a comparative analysis of existing work in Section 7, and the conclusion is included in Section 8.

II. LITERATURE REVIEW

The fourth industrial revolution 4.0 has resulted in a transformation by prioritizing the large-scale automation for adopting a client-oriented approach [16]. This shift is determined by hyper-cognitive systems, integration of broaden and vir- tual reality, trusted machine boundaries, digital machinery prototyping, artificial intelligence-based supply chains and concerted robots. The emerging wave Fifth Industrial Revolution

5.0 is expected to capitalize on large-scale production with a focus on user-friendly customization, catering to diverse industrial verticals such as smart farming, health protection, smart grids, drones, and supply chain production. Although, the imperative for information sharing across various networks is vital for securing industrial perimeters and synchronizing. For Industry 5.0 ecosystems Blockchain emerges as a favored security enabler, attributed to its essential qualities of invariability and examination. The paper takes the initiative in the survey on Blockchain as an essential security enhancer in Industry 5.0, elucidates its major possible applications, and impacts, and presents an conceptual and architectural view of the Blockchain-based industry across several essential dimensions. According to the research, endeavors furnish industrial strategies educationalist, practitioners, and scholars & researchers, encouraging the development of innovative solutions based on Blockchain in 5.0 Industry sectors. [16]

Industrial Revolution 5.0 [15] demonstrating the evolution from Industrial Revolution 4.0, signifies a fundamental change that prioritizes the collaboration between machines and humans to overcome the client's requirements and needs through optimize the product items. The relevant work [15] explores the opportunities, obstacles and contemporary research prospects of Industry 5.0, emphasizing a focus on association among machines and humans. The goal of the paper is to scrutinize prospective applications of Industry 5.0, supply chain, cloud manufactur- ing, spanning healthcare, Internet of Things, big data analytic, Blockchain, future 6G systems, collaborative robots and dig- ital twins. It also highlights the issues in the collaboration between human workers and robots on the production line, development in this field and underscoring the need for future research. The latest and modern industrial revolution called as Industry 5.0 [14], amalgamating advanced technologies like Internet of Things and artificial intelligence. This revolution includes the millions of interlinked devices facilitating quick data transformation, especially in a 5G-enabled environment. Even so, in the future due to centralized mechanisms many challenges such as data retrieval times from disperse devices, access control mechanisms and applicable protocols may face obsolescence. Thus, there is a need for device-to-device (D2D) communication across various industrial sectors for an efficient decentralized access control mechanism [14]. Privacy security and reliability assume major roles in this ecosystem.

This article [14] highlights enterprise shaping the future, enabling cost-effective businesses, deliver higher-quality services and goods and efficiency. 5G networks have been coherently integrated while sensors are becoming more affordable, error-free, responsive and affordable. The establishment of cloud provides the development of modern models that perceive the cloud's scalability, and accessibility, and encourages the figuring and computational power, data transfer capabilities and run-time communication capabilities to create smarter and more auto- mated systems. Protocols that are utilized by Decentralized networks contribute towards in achieving decentralization and mesh network can expand to enhance reliability, security and cohesion by utilizing these technologies. Novel model [14] principles in data authenticity, preservation are essential for distributed systems and cyber security. This article describes the potential applications of Blockchain (BC) in developing smart homes solutions, autonomous cars, hospitals, smart agriculture and supply chain management within 5.0 Industry. [14] Industry 5.0 underscores the significance of the Internet of Things (IOT) with Artificial Intelligence AI based systems. This pattern establishes connections between humans and smart systems through accurate manufacturing and analytical thinking expertise. It equips organizations withtools that facilitate cost-effective operations and adaptability without substantial investments.

It can form a network of interconnected devices for transmitting data wirelessly without human interruption. Devices of IOT enable the users to generate reports without any constraints or restrictions and remotely access the data. They can help the humans through intelligent decision-making using communication technologies. However, IOT devices amass extensive raw sensed data, necessitating pre-processing. Edge computing, an information inference methodology, becomes imperative. Artificial intelligence-based models helps in fetching the important and required information from raw data. Moreover, transferring data from one device to another device poses potential security risks. Further this article explains the IOT architecture, techni- cal details of IOT networks, AI-oriented IOT, edge computing, communication enabling technologies, AI oriented tools, and reliable models for IOT gadgets/appliances.

Intelligent Transportation Systems (ITS) of India [1] possess the potential to blend Blockchain technology (BC) and IOT to revolutionize transportation system. This approach can establish a transparent, efficient system, secure and alleviating congestion, enhancing security, and optimize efficiency. India's inefficient and overcrowded transportation system often causes accidents, delays and resource destruction and wastage. By establishing real-time tracking system, monitoring and optimization of stream of traffic, together Blockchain IOT can reduce the clogging, enhance overall productivity and improve safety. Further this paper evaluates if the building climbable ITS systems in India can be achieved through blockchain BC technology. This methodology introduces the developing a proof-of-concept Blockchain-based system for ITS conducting thorough maintenance and research to ensure sustainability and reliability and integrating the solution into existing frame- work. This research paper discusses the challenges and benefits of this approach, as well as its implementation in the field of transportation, including the perception of Green Sustainability.

[1] In Payment clearance and Finance Industry Blockchain technology [2] has gained remarkable attention and also for internet security infrastructure it is being used. successful trading execution, sectoral challenges, current application

sec- tors, open issues challenges in affectation, current research trends and analysis of existing Blockchain applications gets targeted in this article [2]. The purpose of this research is to accommodate the decision-makers while in investment and adoption of IOT Blockchain in Industry 4.0. Moreover, to facilitates and encourage the research in this field.

Day by day as these growing industries Blockchain and machine learning [3] are achieving the popularity in several industries, by introducing the transparent and secure techniques for recording, transaction recording and data-oriented decision-making. According to the research [3] by the fusion of these two technologies led to provide the benefits in various fields such as medicine, supply chain, finance and security. Blockchain BC ensures the transparency and security of data by maintaining storing it, while on other hand for valuable intuition ML algorithms can determine the large amount of data. Simultaneously, they both have the tendency to reshape industries by allowing data-oriented decision-making, fostering efficiency, and eliminating the security protocols. Although, still there remain various obstacles such as information processing, strategic planning, security issues and flexible mechanism which need to be addresses. [3]

In Economic and Social firmness livestock Agriculture plays a crucial role [4] along with transparency that is the dominant concerned and as well as on food safety. with the popularity enhancement of both technologies Blockchain and IOT now becomes the limelight that can provide the capacity to generate the large quantities of data that can be processed efficiently and can be employed by utilizing the deep learning DL methodologies. A hybrid model is proposed in this paper

[4] that can be relied on recurrent neural networks (RNN) and its main aim to target the food industry of 4.0.

The fourth revolution Industry 4.0 benchmark a model to switch in the industrial environment [5] by revolutionizing the quality control along with manufacturing through smart and automated systems This evolution [5], triggered by the ma- chine learning (ML) with Internet of Things (IOT) successful in replacing the labor work with AI oriented robots. Real-time data can be gathered through the surrounding environment by sensors that can supports efficient decision-making and predictive analysis. From 2017 to 2022 28 articles were examined, through this research numerous tools, algorithms, protocols and technologies were explored under the umbrella of Industry 4.0. It can suggest those areas where more inspections and investigation needs to occur and system be improved in future. [5]

Systems of monitoring are growing rapidly and plays an important in the manufacturing industry [6] in terms of management and decision-making. In order to analyze and interpret environmental data from IOT sensors, such as temperature, humidity, accelerometer and accelerometer, the proposed recommendation combining the IOT with Machine Learning (ML). For further processing unstructured, large-scale, and current data, Big data approaches are used [6]. To remove inconsistencies or anomalies from the received sensor data and assistance in defect identification, Random Forest classification a hybrid prediction model is implemented. By the analyzing this system Data integrity is ensured [6] in South Korea's automobile production industry, enforcing the changes with fake data and system transactions. when compared to other methods the generated outcomes reflect the effectiveness of the proposed system along with the hybrid prediction model that going to produce fault prediction accurately. In production processes, the targeted aim is to improve the decision-making and reducing errors as much as possible [6]

AI algorithms plays the vital role in forth revolution Industry because they introduce the automated smart contracts [7] that helps in reducing the need for mediators and enhancing the security of Blockchain networks. Blockchain introduces the permanent or unchangeable, apparent ledger for supply chain transactions, and AI examines this data to extract the important conclusions about the supply chain as a whole. Through AI's intellectual powers manufacturing processes ensure the quality control and predictive maintenance. AI Blockchain Technology collaboration helps in protecting the integrity and im- mutability of the vast amounts of data generated by Internet of Things (IOT) devices. On other hand, Blockchain ensures safe and transparency of transaction data through smart contracts, AI algorithms maximize the distribution of energy. Moreover, it also enables productive and decentralized networks, enabling fair pay in tokenized ecosystems. By analyzing and exploring the benefits of AI-Oriented Blockchain Technology in Industry 4.0, this investigation [7] goal is to improve efficiency, security and transparency for industrial operations. [7] Foundation of cryptocurrencies the Blockchain used with (ML), to improve its effectiveness [8]. Even so, due to the use case, nature of data, and regulatory restrictions, ML has consistency issues even with its data encryption. To ensure

the security of new technologies, following the privacy and security provisions. In the field of machine learning Blockchain applications are revolutionized [8], that means for completely understanding the importance of ML research is going to be required. By analyzing the articles from 2012 to 2022, study determines the current situation and provides an overview of security challenges issues [8]. Nevertheless, pros and cons still remains, for the future study highlighting the importance to concentrate on privacy issues and technological integration. Enhancing the security in machine learning and Blockchain requires the major improvements in automated learning and zero-expertise proofs. [8]

Table 1:Literature Review Summary Table

Paper Title	Suggested Protocols	Proposed Technology	Smart Contracts Used	Algorithms/methodology
Alladi, et al [2]	Proof of Trust(PoT),WSNs	Implemented Blockchain (Ethereum)	Not Used	Proof of Concept,PoA
Raut et alv [5]	MQTT,CoAP,LoRaWAN,BLE,RF	Utilized Blockchain	Used	FIS,BMO,GMDM,NN,UKF,FL
Pandian et al [4]	Not Mentioned	Implemented Blockchain (Ethereum)	Used	Advance deep learning hybrid RNN model, Genetic(GP)
Khan et al [14]	5G networks	Utilized Blockchain (Ethereum)	Used	PoW,PoS,DPoS,BFT,dPoSec ,PoET,PoX
Goundar et al [7]	Blockchain Protocols	Applied Blockchain	Used	AI Algorithms
Kumar et al [3]	Blockchain Protocols	Adopted Blockchain (Ethereum)	Used	Proof of work(PoW), Proof of stake (PoS)
Marko et al [15]	6G network systems	Incorporated Blockchain	Used	big data analytics
Taherdoost et al [8]	LCC-RML,KNN,SEC-Learning chain,SVM	Integrated Blockchain	Used	KNN,SVM,LR,DT,Random Forest Classifier
D. Ni, et al [16]	IOTA,Tangle and DAG,Tendermin,Omnile dger	Implemented Blockchain	Used	ML and deep RL algorithms
Kharche et al [1]	MQTT,CoAP,HTTP,OCF	Utilized Blockchain	Used	Tiny Machine Learning

III. BACKGROUND

A. IOT and Blockchain

The network of physical devices represents the Internet of Things (IOT) that are fit out with sensors, connectivity, software, exchange of data and facilitating the collection. Its prospective impact spans across industries like manufacturing, healthcare, transportation and Blockchain, characterized by its autonomous digital ledger technology, facilitates transparent and secure transactions, eliminating gatekeepers through cryptography to uphold immutability and data integrity. The paring and integration of Blockchain and IOT serves as a solution to challenges encompassing security, privacy, and interoperability. The amalgamation of IOT and Blockchain contributes to enhancing the privacy and security of IOT networks, establishing- ing a decentralized and tamper-proof and more secure platform for data sharing. The data with escalating volume in the environment, safeguarding personal and sensitive information from third-party interference becomes essential. Blockchain innovation empowers users to rely less on external entities, recognizing individuals as the rightful owners of their data. The utilization of asymmetrical cryptography, leveraging private and public and keys, assures the ownership and rectitude of transactions. Blockchain the decentralized framework inherent systems requires a peer-to-peer (P2P) concord mechanism, mitigating the risk of failure in data transmission for all single points. Blockchain technology facilitates encrypted information sharing among supply chain partners, traceability of products

and fostering enhanced transparency. This functionality aids in preventing fraud and reducing the potential for counterfeit items. Furthermore, Blockchain technology empowers the deployment of smart contracts, automating the fulfillment of contractual commitments between parties. This automation helps minimize the streamlining the overall supply chain process and reliance on intermediaries.

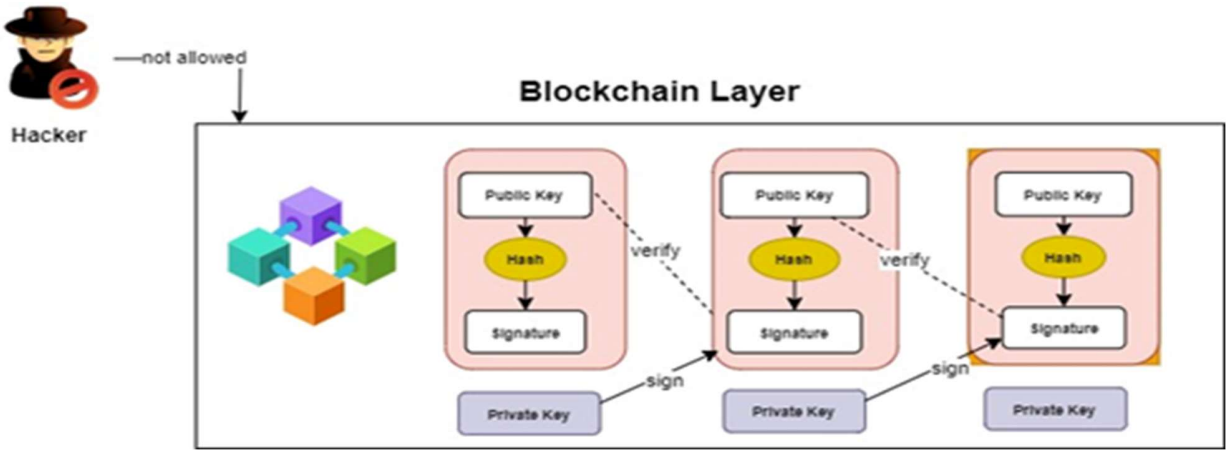


Figure 2: Blockchain's Layer

B. Blockchain and Smart Contracts

Under this new world of decentralized development smart contracts, Blockchain and Decentralized applications (dApps) becomes the essential components day by day.Without relying on central authority,Blockchain acts as a decentralized database (distibuted databases) that enables the safe and transparent distributed transactions. Intelligent contracts are self-autonomous computer programs that are based on Blockchain networks and execute on them. They also helps in authenticate the agreement contracts among the intermediaries and parties just like the regulatory or financial bodies. They are coded in languages like Robustness.By Providing decentralized operations and transactions instead of relying on a exclusive oversight authority, DApps play an essential role towards the advancement of smart solutions and Blockchain technology. Developers can execute the dApps and store the data inside of Blockchain networks along with versatile and expandable resources. For developing and implementing the decentralized applications (dApps) without any management and infrasturcture requirements, the cloud provisioning paradigm plays a vital role and makes this possible for the developers.Therefore, introducing and launching the Web3 or Web 3.0 era of distant, decentralized initiatives. Smart contracts automate the processes in a wide range of sectors including the process of manufacturing and supply chain which results in reduction of middlemen as well as helps in simplifying the business operations.To behave efficiently against the real time environmental data driven changes or responses, AI can reinforce these contracts by developing them more intelligent, and smart. A combination of both technologies Blockchain and AI algorithms integrated in order to monitor the intelligent contracts continuously, helps in improving the evaluation of deliveries, manufacturing processes and financial transactions.In the light of Industrial Revolution 4.0, blockchain seems to be appear a game-changing technology, especially for the fields of autonomous procedures and contracts. It assures security with enhancement, flexible contract structures, and dynamic and automated contract execution. Due to Blockchain's cryptographic and decentralized features, it certifies the invariability of smart contracts and security, while on the other hand AI bolsters security and dependability through the use of cutting-edge risk identification and mitigation techniques.

C. Binance (Blockchain)

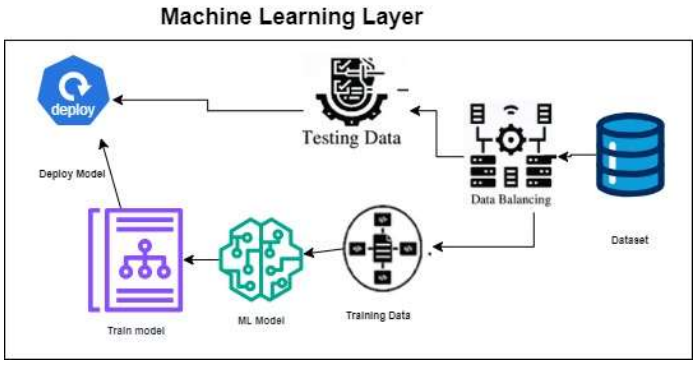
Binance was established in 2017 by Changpeng Zhao, a renowned entrepreneur, investor, and programmer, Binance quickly rose to prominence in the cryptocurrency landscape. Zhao initiated the exchange in July, and within just six months, it evolved into one of the largest crypto platforms worldwide. It is recognized mainly for crypto-to-crypto

Figure 3: Machine Learning layer

trading, involving transactions among the cryptocurrency pairs, and economical cryptocurrency exchange fees have been boasted through Binance. The platform exhibits high liquidity and provides discounts to users who utilize BNB—the exchange's native cryptocurrency token. With stringent safety and security standards and a multi-layered, multi-clustered architecture, Binance ensures robust processing throughput. Serving as an online exchange for cryptocurrency trading, Binance supports a wide array of the most commonly traded cryptocurrencies. Additionally, the platform furnishes a crypto wallet for traders to securely store their digital assets. Binance extends auxiliary services, enabling users to earn interest or conduct transactions using cryptocurrencies. Furthermore, it features programs for miners and aids traders in making informed investment decisions. The platform's native token, BNB, operates on its Blockchain. While Binance enjoys a global presence, certain regulatory restrictions limit its accessibility in countries such as the U.K. and U.S.

D. Machine Learning (ML)

Machine Learning ML which is recognized for its problem-solving automation through models or statistical computer algorithms, excels in analyzing patterns within datasets. ML's capability extends to interpose and producing the visual graphs that offer valuable insights for higher management. In the insurance company, algorithms of ML find application in predicting financial risks, providing precise estimations of the risks associated with setting new insurance premiums. Supply chain management is increasingly leveraging machine learning to boost efficiency, cut costs, and enhance overall performance [18][19]. ML's prowess lies in analyzing vast datasets, and identifying patterns and trends crucial for optimizing supply chain processes [20]. Notably, machine learning plays a pivotal role in demand forecasting by accurately predicting future requirements that are based on market trends and historical data. Furthermore, in the optimization of routes [20], ML identifies most efficient transportation routes, leading to



reduced costs and delivery times. In the empire of security, the integration of ML with Blockchain yields innovative and reliable solutions. For instance, Blockchain establishes a record of rigid transactions, complemented by algorithms of ML for detecting patterns of underhanded that are conducted in financial transactions. Additionally, Blockchain stores network activity data securely, while algorithms for ML halt and detect cyberattacks in real-time. ML's capacity is also harnessed to assess data, potential security breaches in supply chain security or identify the patterns of suspicious behavior. By creating a transparent and secure record of each and every step in a supply chain, Blockchain ensures accountability, while ML analyzes contract behavior, preventing loss of assets or money and pinpointing potential security flaws.

E. Cloud Technology and IOT

The trading environment is undergoing a transformation through the cloud computing and integration of Internet of Things (IOT) devices and, facilitating real-time machine monitoring and utilizing data storage that is cloud-based for enhanced collaboration and efficiency. This fusion results in numerous advantages, and cost-effectiveness, encompassing scalability, improved performance, increased reliability and heightened data security.

1. Flexibility and Scalability The amalgamation of IOT and cloud technology brings forth a significant advantage in scalability. Businesses can rapidly adjust resources according to their requirements and obtain information and applications from any location through cloud based computing solutions. The software services and tools access becomes simplified through the"as-a-service" model (IaaS, PaaS, SaaS), addressing potential challenges associated with in-house management due to technical constraints and cost limitations.

2. Cost-Effectiveness: Solutions of Cloud-based plays a pivotal role in reducing framing costs extensively, analytics capabilities, ensuring accessibility to scalable data storage. The outcome in heightened operational efficiency and lower initial investment costs through an automated roadmap. IOT sensors are processed on central cloud platforms for analysis and collect extensive data from diverse locations, contributing to cost-saving benefits and getting rid of the necessity for local hardware installation.

3. Enhanced Data Security: The fusion of IOT and cloud technologies not only amplifies expandability but also re- inforces data security measures. Safeguarding essential data from unauthorized access or potential manipulation attempts becomes imperative. The implementation of multi-factor authentication mechanisms and role-based access control policies emerges as effective strategies to mitigate risks linked to insider threat misuse and prosperous access.

IOT and cloud computing convergence prove to be an efficient contributor to industrial processes, improved performance, heightened reliability and establishment of real-time data.

IV. MQTT Protocol

Cloud-based Computing [10] grants desired access to a common pool of configurable computing resources, servers, encompassing networks, storage applications and services. Vast data generated system by Cloud Computing and IOT acts as the conduit for this data to reach its desired destination. The relationship between IOT and clouds is complementary, enhancing the efficiency of everyday tasks. Various communication protocols exist for data transmission in M2M systems and IOT. OASIS introduced the Message Queuing Telemetry Transport protocol MQTT in 2013 [11]. The M2M communication performance relies remarkably on specialized messaging protocols designed within IOT applications [13]. Apart from the web, HTTP which employs the single standard messaging protocol, IOT with its diverse characteristics, cannot cling to a ”one-protocol-fits-all” philosophy. Consequently, countless messaging protocols are available for different needs of IOT systems with MQTT, HTTP, AMQP, CoAP being widely emerging and accepted. MQTT, an open ISO and OASIS standard (ISO/IEC PRF 20922), operates as a publish/subscribe, client-server type messaging transfer protocol [12]. Its design concepts prioritize minimizing device resource requirements and network bandwidth, certify the reliable delivery. MQTT is accomplished by transmitting data over unreliable networks and low bandwidth with minimal power consumption [12], [14]. Due to MQTT open, lightweight, simple and easily deployable characteristics pit becomes an ideal communication protocol for constraint environments. The protocol runs over other organization conventions or TCP/IP, providing lossless, ordered and two-way connections. It uses port number 1883 for Non-TLS connections and port number 8883 for SSL/TSL connections. Messages delivery services for MQTT relies on three qualities. QoS 0, known as ”at most once,” ensures messages gets transmitted at most once in the working environment, allowing for the possibility of message loss. QoS 1, or ”at least once,” guarantees message delivery at least once, with the potential for duplicity. QoS 2, referred to as ”exactly once,” ensures messages are delivered exactly once, minimizing transport overhead and interchanging the protocol. This service is valuable in scenarios like billing or accounting systems, where recurrence or loss of messages may result in misleading charges.

IV. APPLICATIONS OF INDUSTRY 5.0

A. Smart and Intelligent Hospitals

5.0 version of industry strives towards the establishment of an intelligent hospital with real-time capabilities, offering remote/online monitoring systems, and enhancing in the field of healthcare that is COVID-19 pandemic. [21]. The main focus of this technology is to target infected patients, support medical students in their training and delivering efficient data for improved treatment. Apart from that Machine learning (ML) is employed in natural language processing, medical imaging and genetic data, focusing on disease prediction, diagnosis and detection. [22] The fifth generation of Industry 5.0 [23] enables the production of customized smart implants tailored to client’s specifications, engaging the AI technology to address issues such as the measurement of glucose level. It also facilitates mass personalization by manufacturing implants based on patent matches, especially crucial in orthopedics. Conventional manufacturing approaches are evolving, and the technology has the potential to elevate medical tools and devices. Industry 5.0

[24] personalized implants with enlarge lifespans, necessitates high-quality, tackling challenges like over-production, lack of transparency and tool selection in orthopedics. This technology plays a pivotal role in precise surgery, enhanced education, learning, and research, as well as expanded systems. [24]

B. Manufacturing Sector

The 5.0 version of Industry [25] evolves a new industrial framework that focuses in promoting the human-machine interaction as well as cooperation. Utilizing and reusing materials helps in reducing the environmental effects, and boosting resource efficiency and waste to make manufacturing enduring. In order to optimize the resource efficiency and enhance adaptability, digital manufacturing becomes vital. The Industry

5.0 [26] analysis and eliminates the repetitive labor from human workers and also revolution the production process systems. Manufacturing operate the areas and supply chains confront the difficulties of smart robots and systems. Many Designers save their works efficiently on the cloud, allowing for strong access control and effective resource management. [27], [28] Due to Cloud manufacturing designers are able to find the production facilities that are close to economic areas and sources of raw materials. In order to facilitate the clients with appropriate solutions, this service-oriented methodology merge the manufacturing capabilities with services. [29] Its main aim to enhance the market revenue, added-worth, and production efficiency by introducing service elements into the process. Through the cloud-based platform the manufacturing services are managed, which is utilized economically. Production resources are scattered and integrated in cloud-oriented manufacturing. [31] ,[30]

C. Supply Chain Management

Fifth Revolutionary Industry 5.0 [32] underscores the significance of collaboration among the smart machines like and COBOTS humans to meet the hyper-personalization and hyper-customization client's demands. AI based robots plays a vital role in standardized procedures for supply chain management but necessitate proper and complete guidance. [33] While the touch of humans may not be mandatory for products that are personalized, it assures end-to-end processes, such as selecting the raw materials for each clients. The Industry 5.0 amalgamates intelligent & automated ecosystems including leveraging human parameters to optimize work flows and customize end-user experience. Intelligent automation and Cognitive computing capabilities empower hyper-personalization, while technologies like robotic automation and machine learning assist employees in delivering high value to clients more expeditiously and enhancing business proficiency. ERP systems [34] oversee the supply chain for business organizations, from raw material delivery to transportation and transactions. The forthcoming era of electronic supply chain systems targeted to boost the digital supply chain, enhancing user satisfaction, introducing customization, and managing market margins and business efficiency. This mitigates the risks associated with the supply chain and also minimizes wastage that are based on existing business information. [35]

V. PROPOSED METHODOLOGY

An (AI) Artificial intelligence wields within the realm of utilizing machine learning algorithms to make decisions concerning novel data or predictions. The one notable algorithm in this domain is known as Linear Regression, specifically applied in the Things layer of an IOT system. In this context, Linear Regression forecasts the trust values for future of each node within the system. The layer called as "Things" encompasses diverse devices, including sensors, integrated into an IOT system. Linear regression operates under the assumption of a linear distribution of data points and constructs a fit line consecutive and utilizing the trust parameter values.

$$y = \beta 0 + \beta 1 * x,$$

This algorithm/methodology serves two primary purposes: first of all, it predicts the subsequent trust parameter value for each and every node in the system, and second one, it scrutinizes the trends in all trust values to anticipate potential malicious behavior in a node.

The system incorporates towards a predefined threshold value, which can be established by an individual or an expert in the network of vertex. When a reliance value surpasses the threshold, it attains the classification of a "working node"; conversely, if it diminishes, it is categorized as a potentially malicious node.

The data forwarded to a control system allocates removal services or maintenance for identified malicious nodes/edges and maintains supervision over potentially malicious nodes. Trust val- ues undergo either punitive measures based on completed transactions grounded on predicted values or rewards, later on updating the database with the actual values. To summarize, systems based on AI leverage machine learning algorithms for the prediction of trust values and trend analysis within IOT networks. Linear Regression stands out as a straightforward yet efficient algorithm seamlessly applicable in IOT systems.

A. PROPOSED SOLUTION

The transformation brought about by Industrial IOT in manufacturing processes, tracking the asset and supply chain

management is evident in the facilitation of predictive maintenance, run-time machinery optimization and monitoring of production/manufacturing processes. Nonetheless, the challenge lies in effectively managing this burgeoning information. The amalgamation of Machine Learning ML Blockchain presents a myriad of applications to address these challenges in the manufacturing sector. Blockchain, a decentralized digital ledger technology utilizing encryption, guarantees data integrity and immutability. In the ever-expanding landscape of industrial process data, securing and encrypting data from external entities or hackers becomes paramount. By considering on the heart of emerging technology is based on the collection of wireless sensor data, that is transmitted to online server, and then to the cloud via protocol of MQTT. The amassed record significantly activates alarms in response to unusual situations and influences the manufacturing design phase. Utilizing low-cost IOT sensors in the environment monitoring serves to prevent errors in design during the process of manufacturing, employing the Machine LML algorithm the Linear Regression.

Sensors generate run-time data, which is consolidated and transmitted through a sink node before being published securely to the cloud using the MQTT protocol for fast and lightweight transmission. Blockchain data undergoes the application of hashing ensuring decentralization and security and distribution into blocks.

Following data preprocessing, ML algorithms come into play, eliminating outliers and preparing the dataset for predictive analysis. The incorporation of Computer Vision (CV) AI models enables the detection of faults or defects in manufacturing, triggering alarms or alerts. Users gain the ability to monitor predictions or changes through an intuitive Graphical Interface. This communication system, characterized by its security and efficiency, ensures swift communication and streamlined data processing. Refer to Fig .4 for a comprehensive illustration of the system overview.

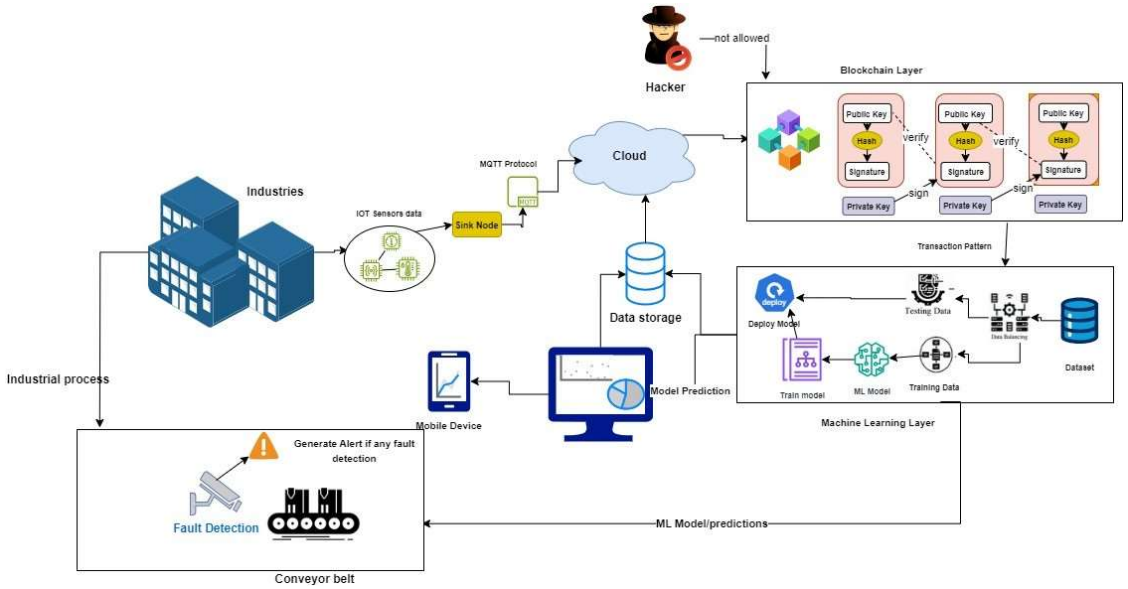


Figure 4: Proposed Framework for Industrial Process Management

B. COMPARISON OF CURRENT RESEARCH WORK

Table 2 come up with a clear elucidation of how the proposed solution in this research paper distinguishes itself from other works, aiming to enhance security efficiency, optimize industrial processes and enhance security.

Table 2: COMPARISON OF CURRENT RESEARCH WORK

Author/Paper	Smart Contracts	Binance-Centric System	Blockchain & ML	Linear Regression Algorithm	MQTT Protocol
Alladi, et al [2]	No	No	Yes	No	No
Kharche et al [1]	Yes	No	Yes	No	Yes
Pandian et al [4]	Yes	No	No	No	No
Kumar et al [3]	Yes	No	Yes	No	No
Jena et al [6]	Yes	No	Yes	No	No
Raut et alv [5]	Yes	No	Yes	No	Yes
Taherdoost et al [8]	Yes	No	Yes	Yes	No
Goundar et al [7]	Yes	No	Yes	No	No
D. Ni, et al [16]	Yes	No	Yes	Yes	No
Marko et al [15]	Yes	No	Yes	No	No
Khan et al [14]	Yes	No	Yes	No	No
Proposed Solution	Yes	Yes	Yes	Yes	Yes

VI. CONCLUSION

ML Algorithm Linear regression represents the notable advancement in the Internet of Things (IOT), specifically in the analysis of nodes, especially those with malicious intent, enabling proactive management to prevent corruption. This approach proves cost-effective and optimized for nodes, distinguishing it from neural networks, which incur higher costs. The integration of blockchain technology into this system to counteract the dissemination of fake data, ensure data security, reduce costs, optimize data transmission and fortify overall system safety. Within the automotive manufacturing industry, blockchain introduces opportunities to enhance competitiveness, diminish transaction fees, and streamline information transfer among users, simultaneously curbing fraud and systemic risks. Meanwhile, machine learning techniques within industrial settings contribute to enhanced data acquisition and system precision. In summary, the combination of linear regression and blockchain innovation yields substantial advantages in the realms of industrial applications and IOT-based industrial process management.

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