CSE1901- TECHNICAL ANSWERS FOR REAL WORLD PROBLEMS

Project Title:

A Blockchain Platform with Equipment ID for Industrial Internet

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ABSTRACT

This study develops a blockchain-based and Internet of Things-based strategy for industrial equipment traceability. The primary data that is recorded in the internal traceability solution of the blockchain is the digital summary of the detailed traceability data and the important traceability data of industrial equipment. The detailed industrial equipment traceability information and digital summaries produced by the traceability information are mostly recorded by the traceability solution outside of the blockchain. The suggested traceability mechanism in this study guarantees the accuracy of all traceable data and prevents the issue of blockchain data explosion.

INTRODUCTION

The development of industrial intelligence is supported by the Industrial Internet, a crucial infrastructure that links the entire industrial system, the entire industrial chain, and the entire value chain. A new generation of manufacturing technology and information technology were deeply integrated to create this emergent business and application paradigm. The relationship between factories and consumers has been further increased by the emergence of mobile communication. Wired and wireless networks are typically included in industrial internet. Industrial wired networks are able to guarantee very dependable communication when controlling and watching over physical equipment. However, as Industry 4.0 takes hold, the industrial manufacturing sector tends to advance wisely. The number of machines, sensors, robots, and other pieces of equipment has increased. Industrial wired networks are therefore unable to satisfy the present communication requirements. A new industrial communication technology is called Industrial Wireless Network (IWN). A theoretical and technical foundation is provided by industrial wireless networks for the quick adoption of the Internet of Things in the area of industrial production.

This innovation uses wireless communication technology to keep an eye on and manage physical equipment in a setting of industrial production. Industrial wireless networks provide several advantages over conventional wired industrial networks, including low installation and maintenance costs, great scalability, and excellent mobility. IWN is therefore being employed more and more frequently in the sophisticated industrial production environment. At the same time, as cloud computing technology advances, it will be possible to implement cloud-based data sharing and store the shared data in a data centre. However, there are security threats including data tampering and forgery, therefore this cannot ensure the security and privacy of shared data.

LITERATURE SURVEY

S.NO	TITLE/AUTHOR	ABSTRACT/METHODOLOGY	RESULT
1	S. Sun, M. Kadoch, L. Gong and B. Rong, "Integrating network function virtualization with SDR and SDN for 4G/5G networks, " IEEE Network, vol. 29, no. 3, pp. 54-59, May-June 2015.	The rapidly diversified market demands have presented a huge challenge to the conventional mobile broadband network architecture. On one hand, the limited machine room space and insufficient power supply make it impossible to accommodate exponentially growing amount of network equipment of operators. On the other hand, net heterogeneity caused by different specifications of wireless access equipment causes costly trouble related to management and optimization. This article, correspondingly, proposes a holistic solution involving different technologies, i.e. network function virtualization (NFV), software defined radio (SDR), and software defined network (SDN). In particular, we investigate both existing standards and possible extensions for 4G/5G mobile networks, followed by a few open issues for future research.	This study shows that, though the upgrade of mobile network infrastructure has to go a long way, the integration of NFV, SDR, and SDN will play an essential role in expediting this historical evolution.

2	N. Zhang, N. Cheng, A. T. Gamage, K. Zhang, J. W. Mark and X. Shen, "Cloud assisted HetNets toward 5G wireless networks," in IEEE Communications Magazine, vol. 53, no. 6, pp. 59-65, June 2015	With the proliferation of connected devices and emerging data-hungry applications, volume ofmobile data traffic is predicted to have a 1000-fold growth by year 2020. To address the data explosionchallenge, industry and academia have initiated research and development of 5G wireless network,which is envisaged to cater for the massive data traffic volume, while providing ubiquitous connectivityand supporting diverse applications with different quality of service (QoS) requirements. To support themassive mobile data, a large number of small cells are expected to be deployed indoors and outdoors,giving rise to heterogeneous networks (HetNets), which is considered as the key way toward 5G.With such large-scale HetNets, network operators face many serious challenges in terms of operationand management, cost-effective small cell deployment, and intercell interference mitigation. To dealwith those issues, a cloud based platform is introduced, aiming to simplify the deployment, operationand management, and facilitate round-the-clock optimization of the network, to pave the way forthe development of 5G. Two case studies are provided to illustrate the benefits of the cloud basedarchitecture. Finally, the related standardization activities are provided and some research topics essentialfor a successful development of 5G are discussed	In this article, we have introduced a cloud assisted HetNet architecture to realize 5G, whichcan simplify the complexity in terms of operation, maintenance, and deployment, caused bylarge-scale small cells. In the meanwhile, it provides the centralized management to efficientlyuse network resources by coordinating the transmissions of small cells. Case studies on cloudassisted deployment and interference mitigation have been provided, which demonstrate thebenefits of the cloud based architecture. It is anticipated that the cloud will accelerate the paceof 5G development.

3	Y. Wu, B. Rong, K. Salehian and G. Gagnon, “Cloud Transmission: A New Spectrum-Reuse Friendly Digital Terrestrial Broadcasting Transmission System,“ IEEE Transactions on Broadcasting, vol. 58, no. 3, pp. 329-337, Sept. 2012.	This paper introduces a new transmission system—“Cloud Transmission (Cloud Txn)” for terrestrial broadcasting or point-to-multipoint multimedia services. The system is based on the concept of increasing the reception robustness, and using the spectrum more efficiently. As such, the system is designed to be robust to co-channel interference, immune to multipath distortion, and is highly spectrum reuse friendly. It can increase the spectrum utilization significantly (3 to 4 times) by making all terrestrial RF channels in a city/market available for broadcast service. The system has the robustness required for providing mobile, pedestrian and indoor reception. It can be used for both small and large cell applications. The receiver is simple and energy efficient. The proposed system is scalable and can be implemented progressively, i.e., providing an easy transition from the traditional systems to the new Cloud Txn system. It can also coexist with the existing DTV systems and their newer versions, such as DVB-T2 or Super Hi-Vision systems.	This paper proposed a robust transmission system– Cloud Transmission (Cloud Txn) for terrestrial broadcasting or point-to-multipoint multimedia services. The system is robust to co-channel interference, immune to multipath distortion and spectrum re-use friendly. The system has the robustness required to provide mobile, pedestrian and indoor reception. The proposed system is scalable and can be implemented progressively. While it can coexist with the conventional DTV systems and their recent improved versions, it can also provide easy transition to the proposed new system. However, there is a lot of research and development work which needs to be done to make this new system a success.

4	B. Rong, Y. Qian, K. Lu, H. Chen and M. Guizani, "Call Admission Control Optimization in WiMAX Networks, " IEEE Transactions on Vehicular Technology, vol. 57, no. 4, pp. 2509-2522, July 2008	Worldwide interoperability for microwave access (WiMAX) is a promising technology for last-mile Internet access, particularly in the areas where wired infrastructures are not available. In a WiMAX network, call admission control (CAC) is deployed to effectively control different traffic loads and prevent the network from being overloaded. In this paper, we propose a framework of a 2-D CAC to accommodate various features of WiMAX networks. Specifically, we decompose the 2-D uplink and downlink WiMAX CAC problem into two independent 1-D CAC problems and formulate the 1-D CAC optimization, in which the demands of service providers and subscribers are jointly taken into account. To solve the optimization problem, we develop a utility- and fairness-constrained optimal revenue policy, as well as its corresponding approximation algorithm. Simulation results are presented to demonstrate the effectiveness of the proposed WiMAX CAC approach.	In this paper, we have proposed a framework for WiMAX CAC, in which the 2-D CAC problem is decomposed into two independent 1-D CAC problems. Then, we make the 1-D CAC an optimization problem and evaluate its different strategies. From the perspective of service providers, optimal revenue is the major concern. However, from the perspective of subscribers, optimal utility and fairness are the requirements. To successfully deploy a WiMAX system, we have to take into account the expectations of both service providers and subscribers. Accordingly, we develop a utility- and fairnessconstrained optimal revenue policy, as well as its approximation algorithm. Simulation results verify that our proposed WiMAX CAC approach can meet the requirements of both service providers and subscribers.

5	N. Chen, B. Rong, X. Zhang and M. Kadoch, "Scalable and Flexible Massive MIMO Precoding for 5G H-CRAN," in IEEE Wireless Communications, vol. 24, no. 1, pp. 46-52, February 2017.	Scalability and flexibility are widely considered as two major design goals for 5G networks. Aiming at these goals, this article first identifies a promising architecture based on the heterogeneous cloud radio access network (H-CRAN), reviews the challenges in MIMO precoding for H-CRAN, and then proposes a scalable and flexible massive MIMO precoding scheme by exploiting the null-space of user signals. Specifically, the system can accomplish effective radio resource management and flexible spatial coordination by distinguishing the intended and victim users' CSI, and avoid the interference by precoding within the null-space for the CSI of victim users. Simulation results indicate that the proposed scheme is capable to effectively alleviate the interference to victim users and support high QoS as well as spectral efficiency.	In this work, we present the flexible and scalable 5G H-CRAN architecture and focus on RRM and an interference mitigation massive MIMO precoding scheme. Furthermore, we propose a null-space-based hybrid precoding scheme with a flexible CSI acquisition process. By performing precoding within the null-space of the neighboring victim users, the proposed scheme counteracted the interference impact that could result in degradation of performance. Performance evaluation shows that the proposed design could acquire higher system throughput with a large amount of transmitting antennas and was capable of sufficient SE compared to other outstanding precoding schemes.

6	B. Rong, Y. Qian and K. Lu, "Integrated Downlink Resource Management for Multiservice WiMAX Networks, " in IEEE Transactions on Mobile Computing, vol. 6, no. 6, pp. 621-632, June 2007.	In this paper, we propose a novel downlink resource management framework for multiservice WiMAX (Worldwide Interoperability for Microwave Access) networks. Our framework consists of two major components: adaptive power allocation (APA) and call admission control (CAC). We formulate each of them as an optimization problem, where the demands of both WiMAX service providers and subscribers are taken into account. To solve the optimization problems, we develop a fairness-constrained greedy revenue algorithm for downlink APA optimization and a utility-constrained greedy approximation algorithm for downlink CAC optimization. Our simulation results show that, when combining the APA and CAC optimization methods together, the proposed resource management framework can meet the expectations of both service providers and subscribers.	To solve the optimization problems, we have developed a fairnessconstrained greedy revenue algorithm for the downlink APA optimization and a utility-constrained greedy approximation algorithm for the downlink CAC optimization. Simulation study demonstrates that the proposed APA and CAC optimization methods are efficient and can satisfy the requirements of service providers and subscribers.
7	S. Sun, L. Gong, B. Rong and K. Lu, "An intelligent SDN framework for 5G heterogeneous networks," in IEEE Communications Magazine, vol. 53, no. 11, pp. 142-147, November 2015.	In fifth-generation (5G) mobile networks, a major challenge is to effectively improve system capacity and meet dynamic service demands. One promising technology to solve this problem is heterogeneous networks (HetNets), which involve a large number of densified low power nodes (LPNs). This article proposes a software defined network (SDN) based intelligent model that can efficiently manage the heterogeneous infrastructure and resources. In particular, we first review the latest SDN standards and discuss the possible extensions. We then discuss the advantages of SDN in meeting the dynamic nature of services and requirements in 5G HetNets. Finally, we develop a variety of schemes to improve traffic control, subscriber management, and resource allocation. Performance analysis shows that our proposed system is reliable, scalable, and implementable.	We conduct performance analysis based on practical scenarios and demostrate that our schemes can deal with 5G network dynamics with low complexity and high flexibility.

8	X. Jin, A. Saifullah, C. Lu, and P. Zeng, "Real-time scheduling for eventtriggered and time-triggered flows in industrial wireless sensor-actuator networks," in IEEE INFOCOM 2019-IEEE Conference on Computer Communications. IEEE, 2019, pp. 1684-1692	Wireless sensor-actuator networks enable an efficient and cost-effective approach for industrial sensing and control applications. To satisfy the real-time requirement of such applications, these networks adopt centralized scheduling algorithms to optimize the real-time performance based on global information. Existing centralized algorithms mostly focus on scheduling time-triggered flows. They cannot effectively schedule event-triggered flows due to the dynamics and unpredictability of events. In this paper, we propose three fundamental centralized algorithms that reserve as few resources as possible for event-triggered flows such that the real-time performance of time-triggered flows is not affected. We then analyze their advantages and disadvantages. Based on the analysis, we combine their advantages, including those in terms of their resource requirements, into a centralized algorithm. Finally, we conduct extensive simulations based on both real topologies and random topologies. The simulations indicate that for most test cases the schedulability of our combined algorithm is close to optimal solutions.	We conduct extensive simulations based on both real topologies and random topologies. The simulations indicate that for most test cases the schedulability of our combined algorithm is close to optimal solutions

9	V. P. Modekurthy, D. Ismail, M. Rahman, and A. Saifullah, "A utilization-based approach for schedulability analysis in wireless control systems, " in 2018 IEEE International Conference on Industrial Internet (ICII). IEEE, 2018, pp. 49-58.	Recent advancements in industrial Internet-of-Things (IoT), more specifically, the development of industrial wireless standards such as WirelessHART and ISA100, are paving the way for the fourth industrial revolution, Industry 4.0. These wireless standards specify highly reliable and real-time communications as key requirements in industrial wireless sensor-actuator networks. Schedulability analysis remains the cornerstone for analyzing the real-time performance of these networks. While it is well-explored in the domain of CPU scheduling, schedulability analysis for multi-hop wireless networks has seen little progress till date. Existing work mostly focuses on worst-case delay analysis that runs in pseudo-polynomial time, making it is less suitable under frequent network dynamics which are quite common in industrial IoT. To address this, in this paper, we develop a schedulability analysis based on utilization bound for multi-hop, multi-channel industrial wireless sensor-actuator networks. Because of its extremely low runtime overhead, utilization-based schedulability test is considered to be one of the highly efficient and effective schedulability analyses. However, no work has been done yet on utilization-based analysis for multi-hop wireless network. The key challenge for a utilization-based test for multi-hop wireless network arises from the fact that wireless network is subject to transmission conflict and network dynamics which are not present in CPU scheduling. We address this challenge by bridging the gap between wireless domain and CPU task scheduling. We have evaluated our result through simulations using TOSSIM that shows that our schedulability analysis is safe and effective in practice.	Here evaluated thei result through simulations using TOSSIM that shows that their schedulability analysis is safe and effective in practice

10	D. Yang, Y. Xu, H. Wang, T. Zheng, H. Zhang, H. Zhang, and M. Gidlund, "Assignment of segmented slots enabling reliable real-time transmission in industrial wireless sensor networks, " IEEE Transactions on Industrial Electronics, vol. 62, no. 6, pp. 3966-3977, 2015.	Industrial wireless sensor networks (IWSNs) have the potential to contribute significantly in areas such as cable replacement, mobility, flexibility, and cost reduction. Nevertheless, the industrial environment that the IWSNs operate in is very challenging because of dust, heat, water, electromagnetic interference, and interference from other wireless devices, which make it difficult for current IWSNs to guarantee reliable real-time communication. In this paper, we present a novel method based on the segmented slot assignment, fast slot competition, and free node concept that will improve the reliability and real-time communication significantly so that more advanced applications can be enabled. The main purpose of the algorithms is to improve the retransmission efficiency for time-division-multiple-access-based multihop IWSNs by using limited shared slot resources more efficiently. More importantly, the proposed algorithms support efficient slot rescheduling caused by link or node failure. We evaluate the proposed methods by using simulations and a real implementation targeting monitoring of welder machines. Our obtained results show that the proposed method outperforms the first published and most widely used IWSN standard called WirelessHART.	Our obtained results show that the proposed method outperforms the first published and most widely used IWSN standard called WirelessHART.

11	C. Lu, A. Saifullah, B. Li, M. Sha, H. Gonzalez, D. Gunatilaka, C. Wu, L. Nie, and Y. Chen, "Real-time wireless sensoractuator networks for industrial cyber-physical systems, " Proceedings of the IEEE, vol. 104, no. 5, pp. 1013-1024, 2015.	With recent adoption of wireless sensor-actuator networks (WSANs) in industrial automation, industrial wireless control systems have emerged as a frontier of cyber-physical systems. Despite their success in industrial monitoring applications, existing WSAN technologies face significant challenges in supporting control systems due to their lack of real-time performance and dynamic wireless conditions in industrial plants. This article reviews a series of recent advances in real-time WSANs for industrial control systems: 1) real-time scheduling algorithms and analyses for WSANs; 2) implementation and experimentation of industrial WSAN protocols; 3) cyber-physical codesign of wireless control systems that integrate wireless and control designs; and 4) a wireless cyber-physical simulator for codesign and evaluation of wireless control systems. This article concludes by highlighting research directions in industrial cyber-physical systems.	This article concludes by highlighting research directions in industrial cyber-physical systems.

12	Wang W , Hoang D T , Hu P , et al. A Survey on Consensus Mechanisms and Mining Strategy Management in Blockchain Networks[J]. 2018.	The past decade has witnessed the rapid evolution in blockchain technologies, which has attracted tremendous interests from both the research communities and industries. The blockchain network was originated from the Internet financial sector as a decentralized, immutable ledger system for transactional data ordering. Nowadays, it is envisioned as a powerful backbone/framework for decentralized data processing and data-driven self-organization in flat, open-access networks. In particular, the plausible characteristics of decentralization, immutability, and self-organization are primarily owing to the unique decentralized consensus mechanisms introduced by blockchain networks. This survey is motivated by the lack of a comprehensive literature review on the development of decentralized consensus mechanisms in blockchain networks. In this paper, we provide a systematic vision of the organization of blockchain networks. By emphasizing the unique characteristics of decentralized consensus in blockchain networks, our in-depth review of the state-of-the-art consensus protocols is focused on both the perspective of distributed consensus system design and the perspective of incentive mechanism design. From a game-theoretic point of view, we also provide a thorough review of the strategy adopted for self-organization by the individual nodes in the blockchain backbone networks. Consequently, we provide a comprehensive survey of the emerging applications of blockchain networks in a broad area of telecommunication. We highlight our special interest in how the consensus mechanisms impact these applications. Finally, we discuss several open issues in the protocol design for blockchain consensus and the related potential research directions.	In this paper, we have provided a comprehensive survey on the recent development of blockchain technologies, with a specific emphasis on the designing methodologies and related studies of permissionless consensus protocols. We have provided in the survey a succinct overview of the implementation stacks for blockchain networks, from where we started our in-depth investigation into the design of consensus protocols and their impact on the emerging applications of blockchain networks. We have examined the influence of the blockchain consensus protocols from the perspective of three different interested parties, namely, the deployers of blockchain networks, the consensus participants (i.e., the consensus nodes) in the blockchain networks and the users of blockchain networks

13	Cong L. W., He Zhiguo. Blockchain disruption and smart contracts[J]. The Review of Financial Studies, 2019, 32(5): 1754-1797.	Blockchain technology provides decentralized consensus and potentially enlarges the contracting space through smart contracts. Meanwhile, generating decentralized consensus entails distributing information that necessarily alters the informational environment. We analyze how decentralization relates to consensus quality and how the quintessential features of blockchain remold the landscape of competition. Smart contracts can mitigate informational asymmetry and improve welfare and consumer surplus through enhanced entry and competition, yet distributing information during consensus generation may encourage greater collusion. In general, blockchains sustain market equilibria with a wider range of economic outcomes. We further discuss the implications for antitrust policies targeted at blockchain applications. (JEL C73, D82, D86, G29, L13, L86).	In this paper we argue that decentralized ledger technologies, such asblockchains, feature decentralized consensus and tamper-proof algorithmicexecutions and, consequently, enlarge the contracting space and facilitatethe creation of smart contracts. However, the process of reaching decen-tralized consensus changes the information environment on the blockchain,potentially engendering welfare-destroying consequences by promotingcollusion.

14	Salah K., Nizamuddin N., Jayaraman R., et al. Blockchain-based soybean traceability in agricultural supply chain[J]. IEEE Access, 2019, 7(2019): 73295-73305	The globalized production and distribution of agricultural produce bring a renewed focus on the safety, quality and validation of several important criteria in agriculture and food supply chains. The growing number of issues related to food safety and contamination risks has established an immense need for effective traceability solution that act as an essential quality management tool ensuring adequate safety of products in the agricultural supply chain. Blockchain is a disruptive technology that can provide an innovative solution for product traceability in agriculture and food supply chains. Today's agricultural supply chains are complex ecosystem involving several stakeholders making it cumbersome to validate several important criteria such as country of origin, stages in crop development, conformance to quality standards and monitor yields. In this paper, we propose an approach that leverages the Ethereum blockchain and smart contracts efficiently perform business transactions for soybean tracking and traceability across the agricultural supply chain. Our proposed solution eliminates the need for a trusted centralized authority, intermediaries and provides transactions records, enhancing efficiency and safety with high integrity, reliability, and security. The proposed solution focuses on the utilization of smart contracts to govern and control all interactions and transactions among all the participants involved within the supply chain ecosystem. All transactions are recorded and stored in the blockchain's immutable ledger with links to a decentralized file system (IPFS), and thus providing to all a high level of transparency and traceability into the supply chain ecosystem in a secure, trusted, reliable, and efficient manner.	We showed how our solution can be applied for tracingand tracking soybean supply chain. However, the presentedaspects and details are generic enough and can be applied toprovide trusted and decentralized traceability to any crop orproduce in the agricultural supply chain. To date, blockchaintechnology still faces key challenges related to scalability,governance, identity registration, privacy, standards, and reg-ulations. As a future work, we plan to look at addressingsome of these key challenges and develop solutions address-ing them.

15	Tse D., Zhang Bowen, Yang Yuchen, et al. Blockchain application in food supply information security[C]//2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). Singapore: IEEE, 2017: 1357-1361.	With the increasingly serious problem of food safety in China, it directly or indirectly endangers people's health, quality of life and safety of life. The global economy, politics and society as a whole have a greater impact. As an effective means of product quality and safety management and control, many countries and regions have been researched, developed and operated of the traceability system. On the one hand, these technologies have not been able to achieve more accurate traceability, these results cannot be directly used in Chinese market. Therefore, the article introduces the concept of Blockchain technology, putting forward the application of Blockchain technology in information security of the food supply chain and comparing it with the traditional supply chain system.	As above mentioned, although there still have some disadvantages, promoting the blockchain is a well worth technology for helping government track, monitor and audit the food supply chain and helping manufacturers to record the transactions in authenticity. Not only this technology can benefit the customers, manufacturers and the supervision departments but also improving the efficiency of food supply chain's processing and circulation.

SYSTEM ANALYSIS

EXISTING SYSTEM:

The blockchain system can be broken down into data layer, network layer, consensus layer, etc., according to the study that has already been done. To guarantee the security and privacy of data information, the data layer is utilised. Key technologies used primarily by the data layer include the encryption method, Merkle tree, chain structure, and timestamp. The network layer, which primarily consists of P2P networks, data distribution, and verification procedures, is the structural foundation of decentralised storage. The blockchain distributed network's smooth operation is made possible by the consensus layer. Commonly used consensus algorithms include the PBFT method, Kafka algorithm, Raft algorithm, PoW (Proof of Work), PoS (Proof of Stack), and DPoS (Proof of Stack Delegation).

DISADVANTAGES OF EXISTING SYSTEM:

1. All currently used methods involved gathering and storing data across wired or wireless connections, which were then placed on centralised (single node) servers where the data could be manipulated by hackers if the server was compromised.

2. There are security threats, such as data manipulation and forgery, and this cannot ensure the security and privacy of shared data.

Proposed System:

This article suggests a blockchain- and Internet of Things-based physical device identification system approach. The OID identifying system is the foundation of the solution. It achieves the global unique identification of physical equipment using the OID encoding method, which is compatible with other identification systems, and prevents the ambiguity of traceable objects in the traceability process. Then, the traceability information is selectively kept inside and outside the blockchain, and the internal and external traceability of the blockchain is built in accordance with the importance of the traceability information of physical equipment and the importance of the amount of data. The internal blockchain traceability solution employs blockchain technology to store critical traceability data on the creation, transfer, usage, and supervision of physical equipment related to OID identification, as well as comprehensive summaries of traceability data. To store detailed production information, logistics information, usage information, and numbers created based on detailed traceability information, the blockchain traceability solution uses the OID identifying information registration mechanism. The list of consumer electronics goods is related to this traceability data. The OID-identified stages of the supply chain correspond to each level. This data is kept on the traceable enterprise's associated identity management server.

Advantages of proposed system:

1. The traceability solution suggested in this study prevents the problem of blockchain data explosion and protects the legitimacy of all traceable information.

2. To guarantee the effectiveness of traceability information, the key and authentication mechanism, and the authority management are all included in the system's security design.

SYSTEM DESIGN

ARCHITECTURE:

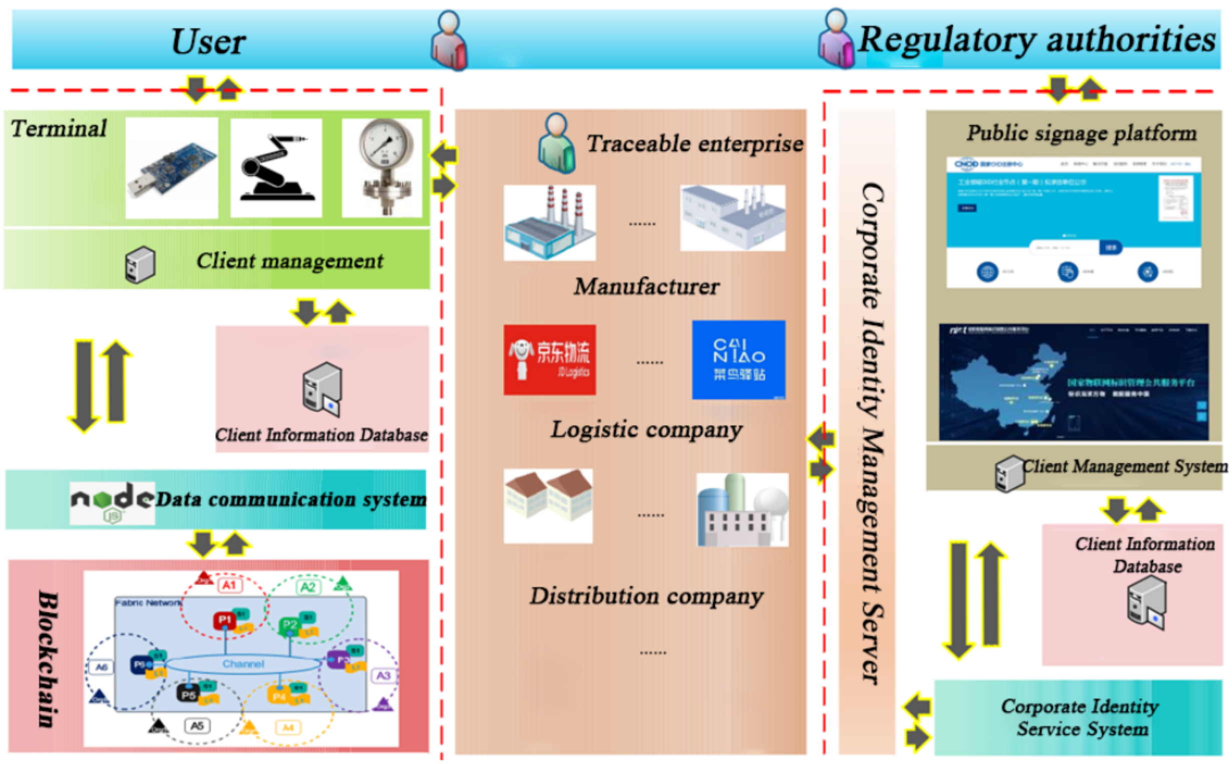
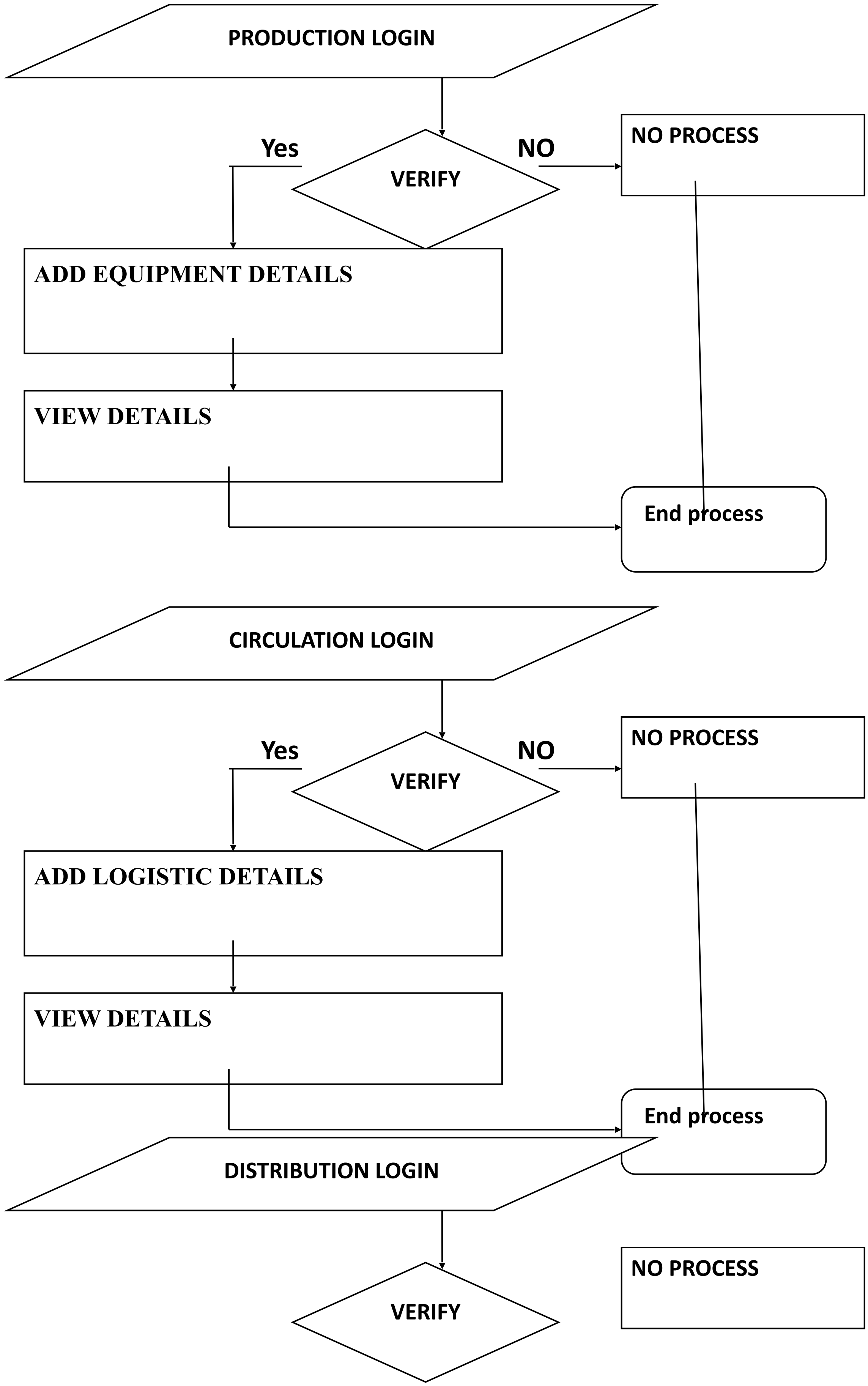


Fig. System architecture

DATA FLOW DIAGRAM:



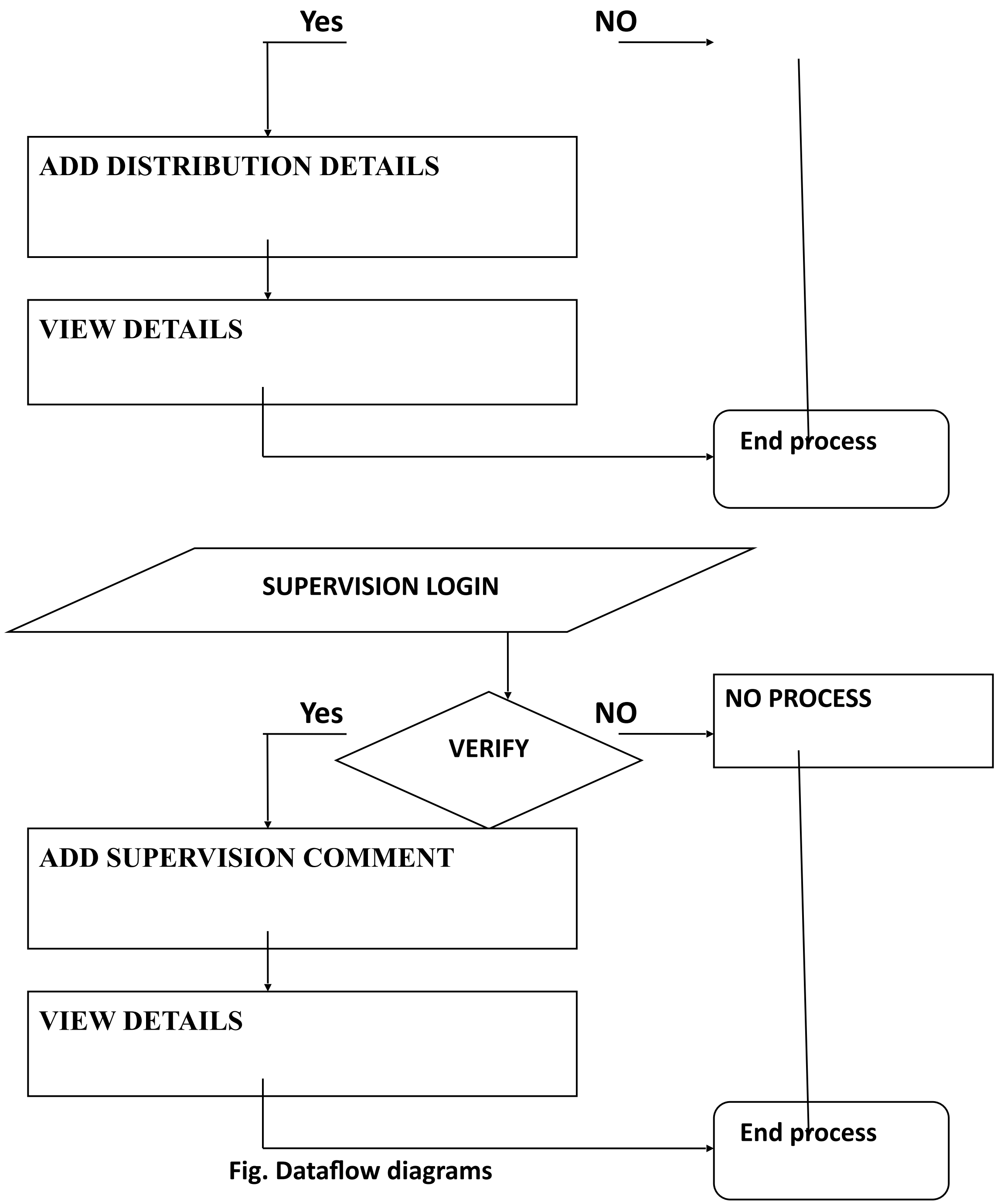


Fig. Dataflow diagrams

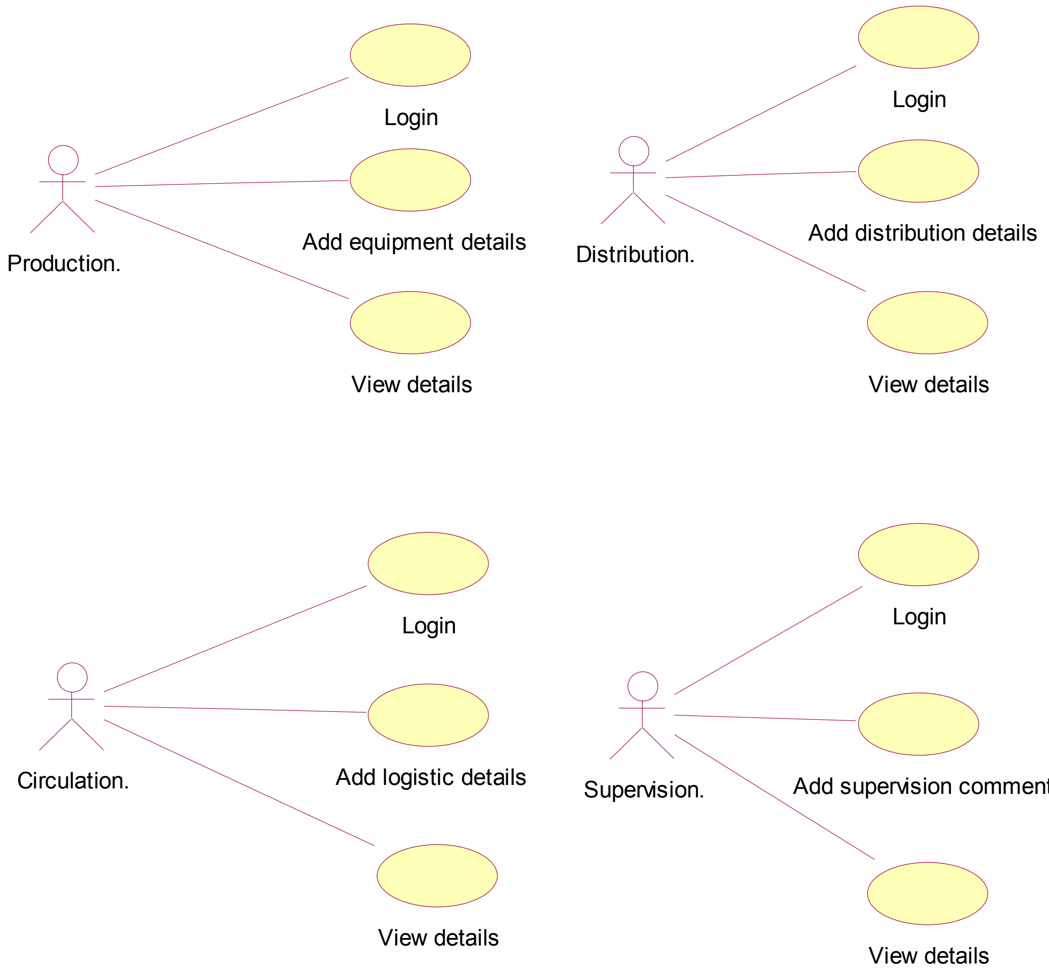


Fig. Use Case diagram

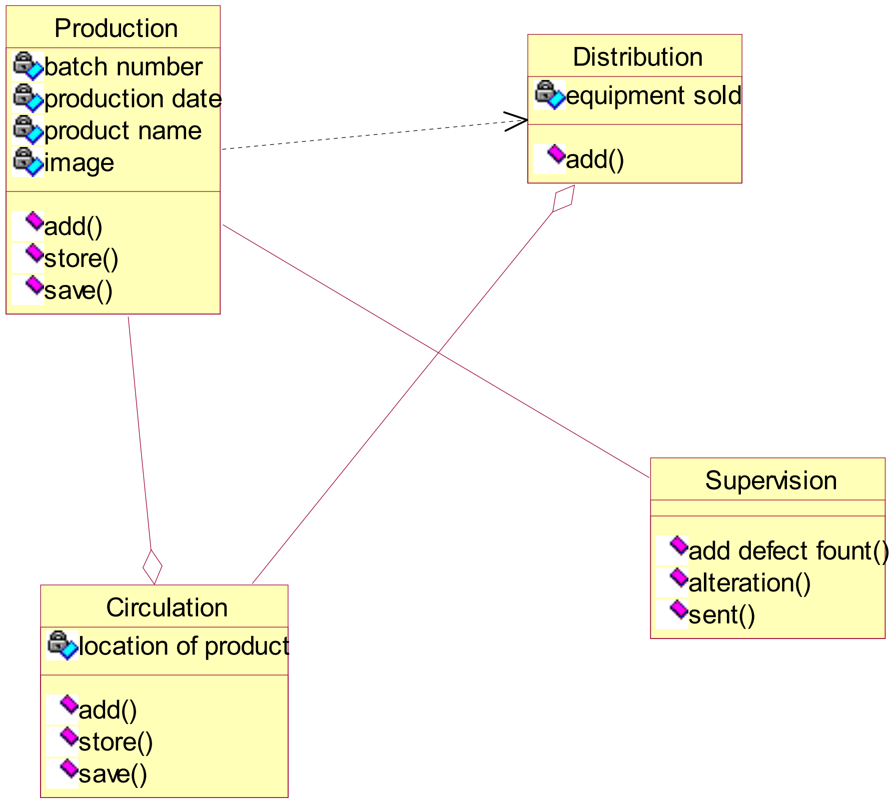


Fig. Class diagram

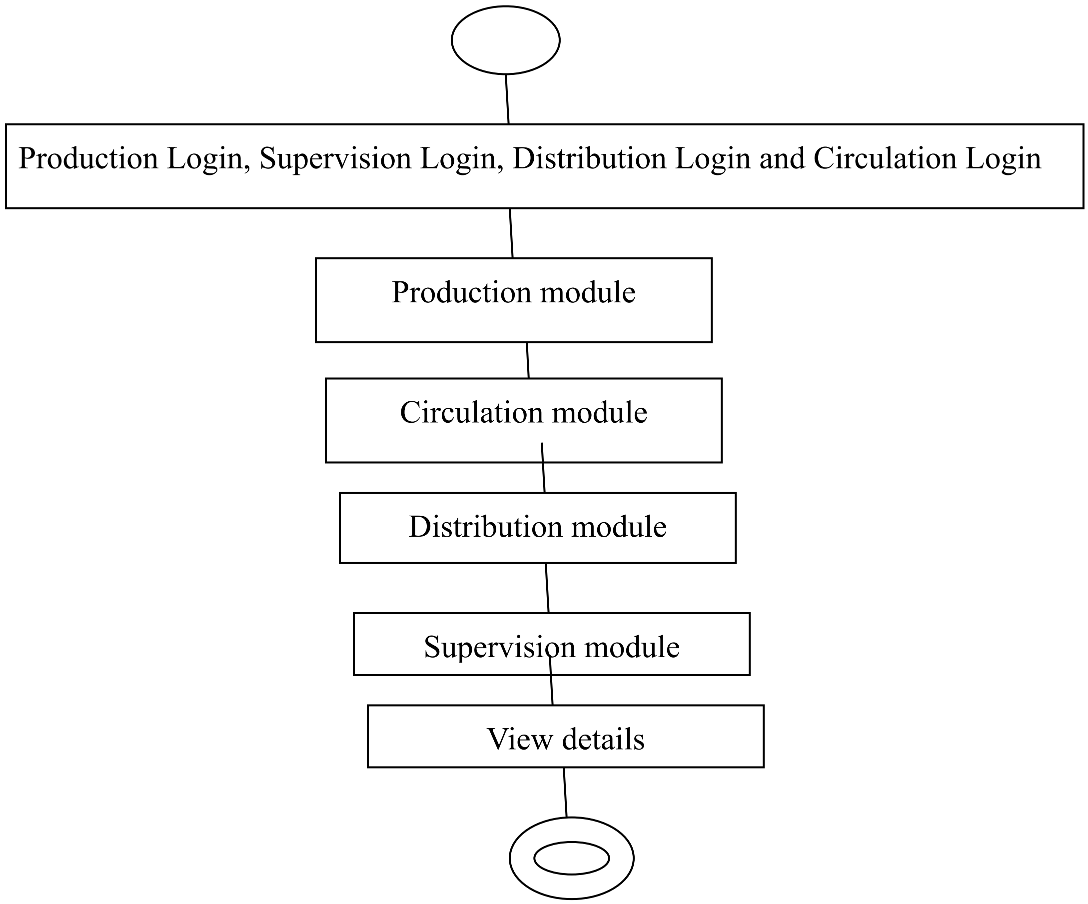


Fig. Activity diagram

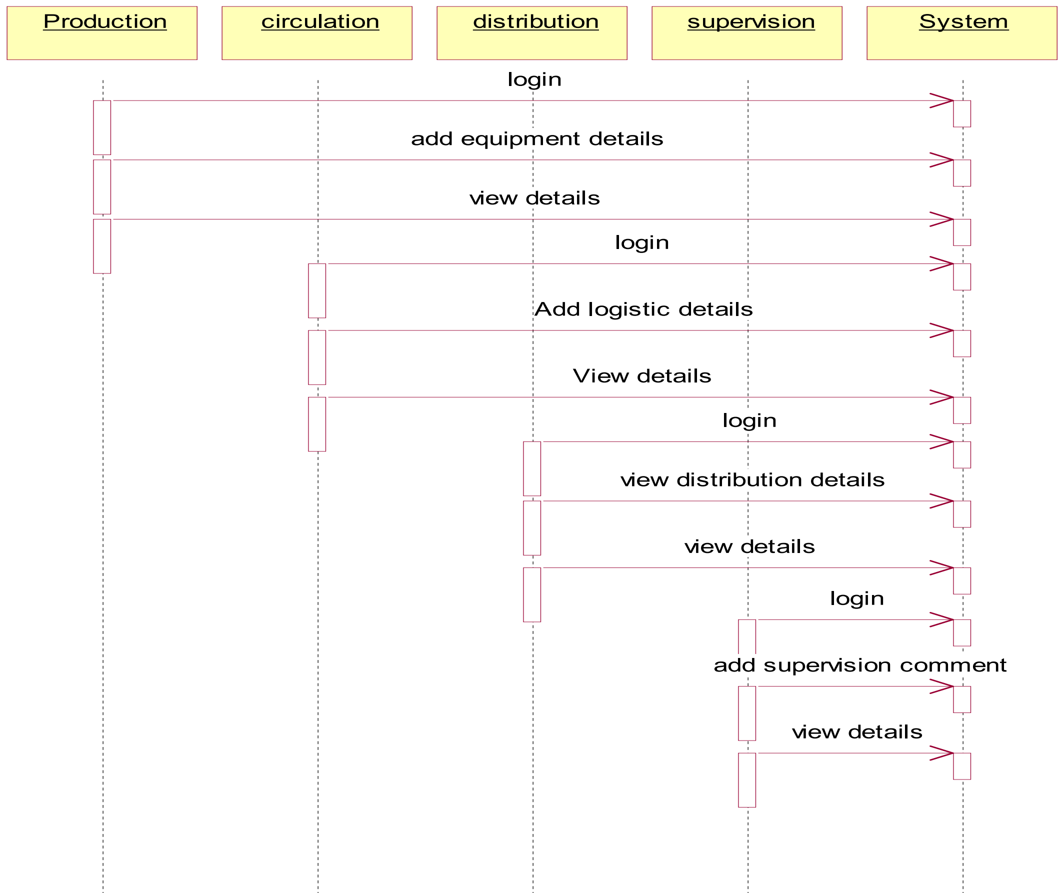


Fig. Sequence diagram

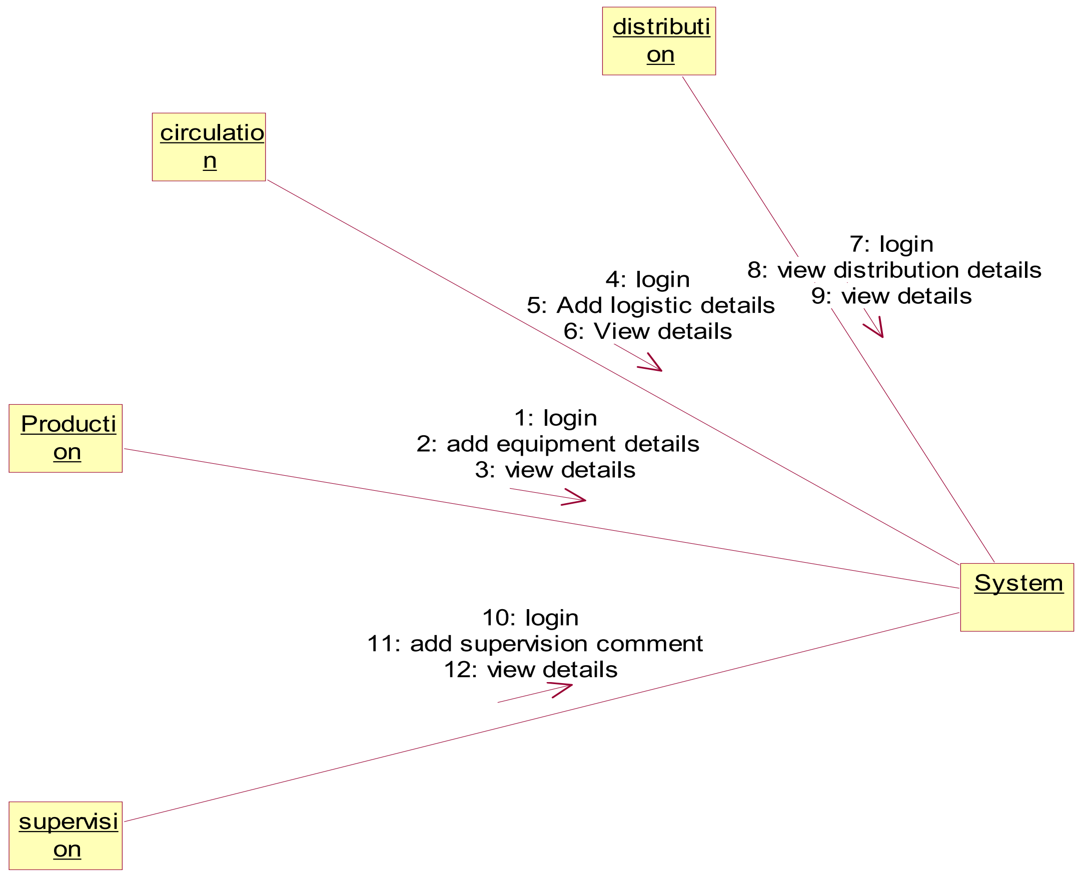


Fig. Collaboration diagram

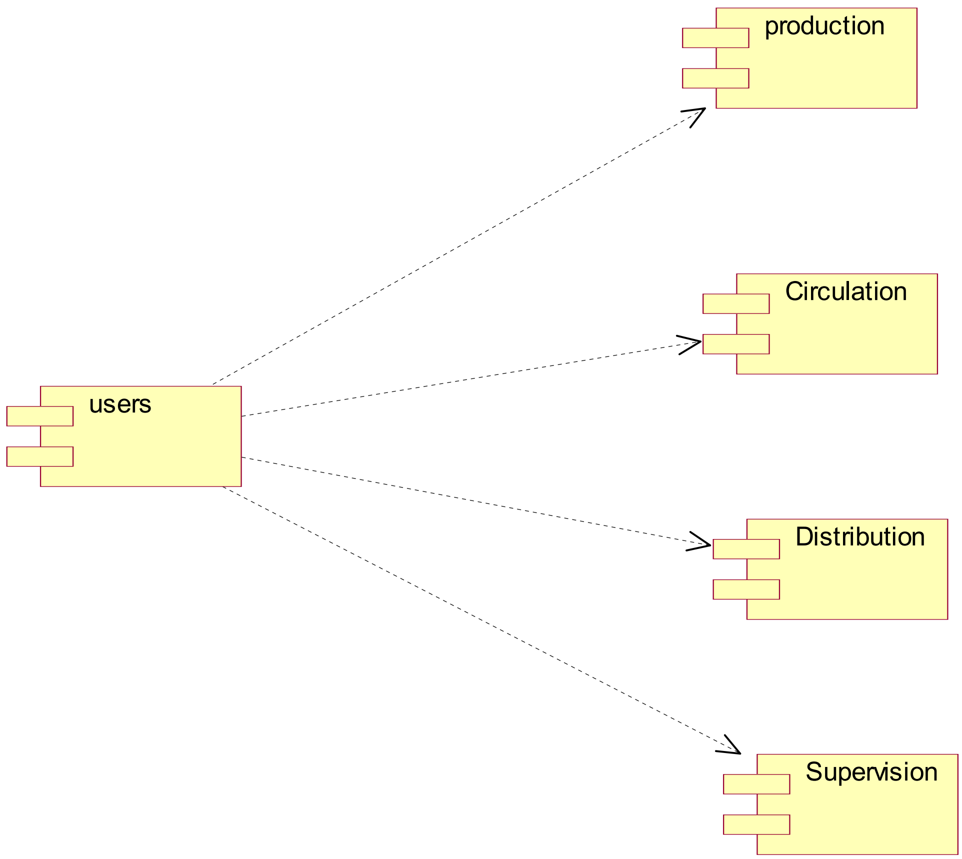


Fig. Component diagram

Fig. Deployment diagram

IMPLEMENTATION

The introduced concept to trace industrial equipment using Blockchain technology as all existing techniques were capturing and storing data using wire or wireless connection and then store in centralized (single node) server and if this server is hacked then data will be modified by hackers and there is no proper technique to trace the altered data and to overcome from this problem author storing tracing information in Blockchain. Blockchain support distributed (store data in multiple nodes/server) data storage and support immutable (data cannot be altered and if altered then it can be traced) data storage.

Blockchain will create and associate Hashcode with each block of data storage at multiple nodes and upon each new block or transaction storage Blockchain will verify Hashcode of each node and if data not altered then Hashcode will not change and provide proof of intact data. If data altered at any node then that node Hashcode verification will be failed and identify that node as attacked or hacked and collect data from other working nodes.

For each block or transaction storage Blockchain provides POW (proof of work) and in propose paper author is saving industrial equipment details in Blockchain so data cannot be altered. Industrial equipment data will be maintained by multiple users based on their permission and Blockchain will not allow any unauthorized user to alter the data.

Following modules or users who may access Industrial equipment details

1) Production Login, Supervision Login, Distribution Login and Circulation Login: This four users may login to application by using username and password as ‘Production or Supervision or Distribution or Circulation. After login they will perform below operations

2) Production Module: this user will provide unique code to each product and add other product details such as Batch number, production date, product name and image and al this details will be saved in Blockchain

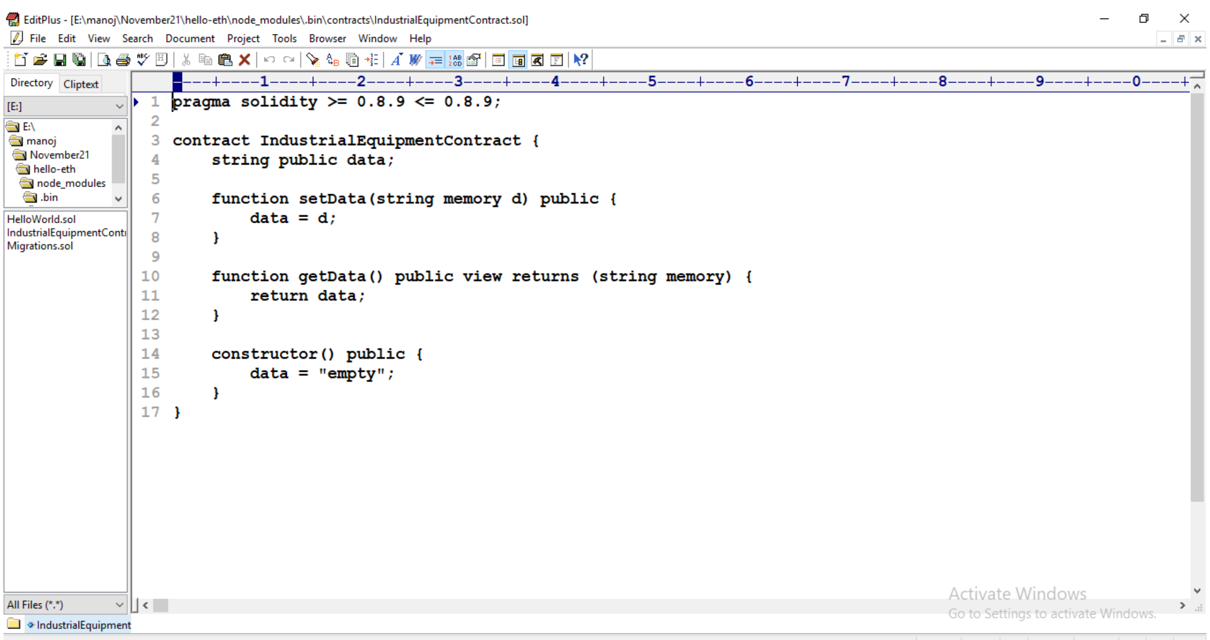
3) Circulation Module: using this module user can add Logistic details such as location of product out for delivery

4) Distribution Module: using this module user can add equipment sold to which distributor or retailer

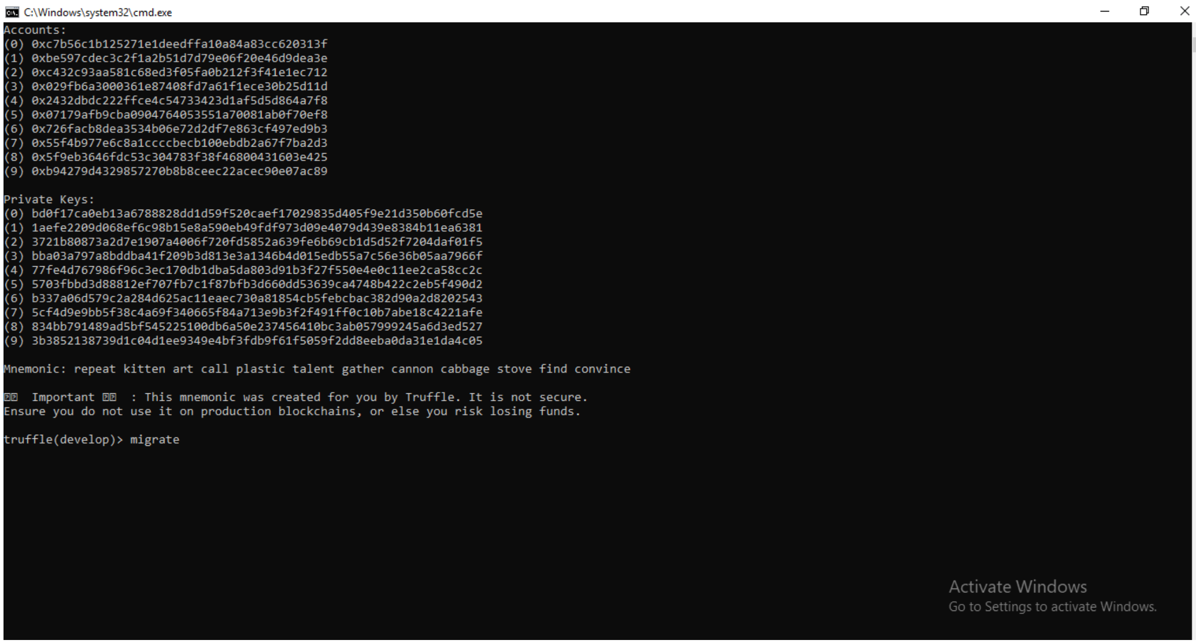
5) Supervision Module: using this module user will add defect found in the equipment so that product will be sent to production for alteration.

6) View Details: using this module all users may track different details such as product details, location, defect etc.

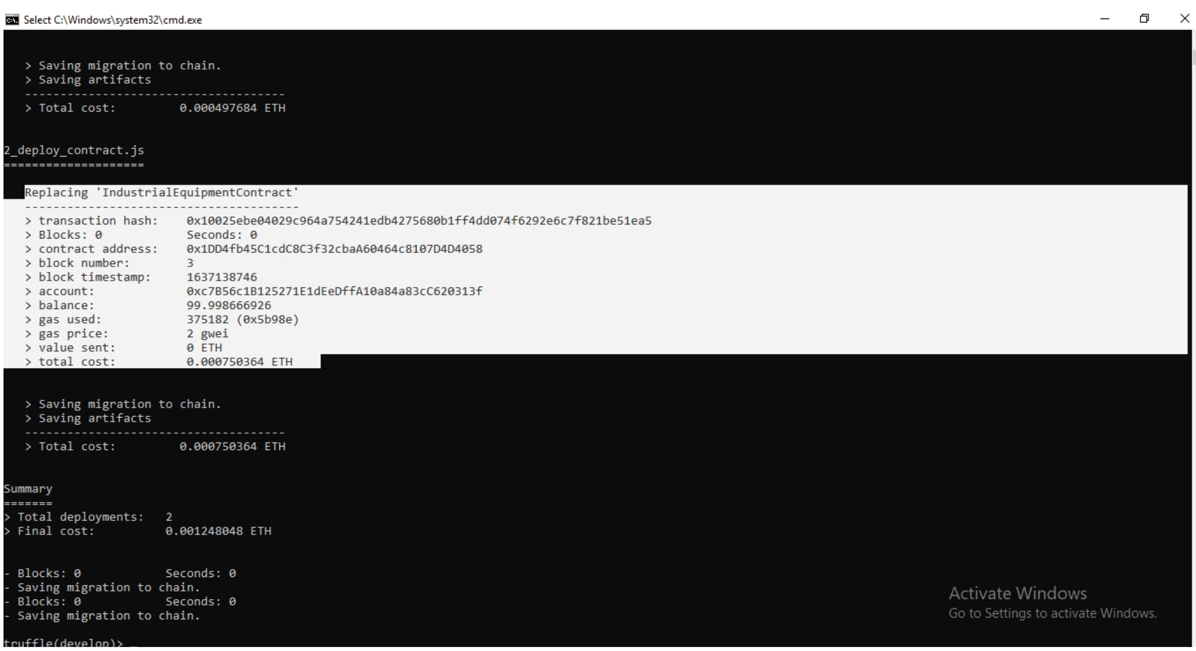
All the above details will be store in Blockchain and we have used python TRUFFLE Blockchain API to access ETHEREUM tool and we are using below SMART CONTRACT code to deployed in Blockchain to store and access Industrial Equipment Details.



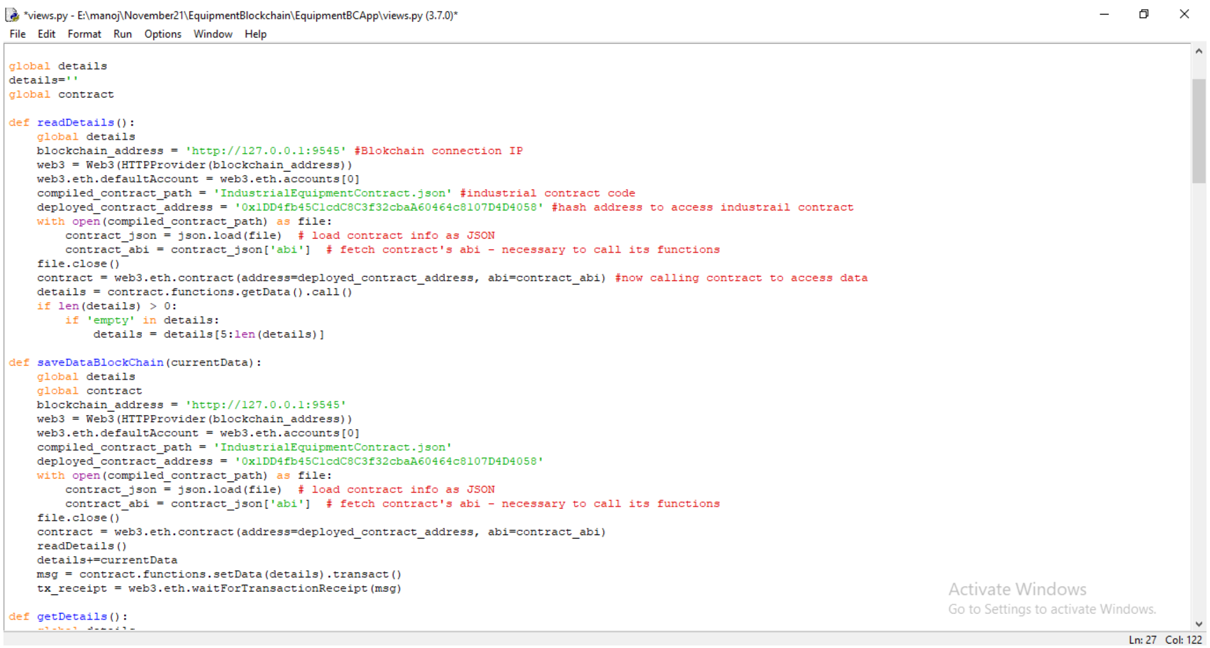
Now we need to deploy above code to store and access Industrial equipment data into Ethereum Tool and to deploy go inside ‘hello-eth\node_modules\.bin’ folder and in this folder you find with code and from that folder double click on ‘runBlockchain.bat’ file to get below screen



In above screen we can see Blockchain accounts and private keys are generated and now to deploy code type ‘migrate’ and press enter key to deploy code and to get contract access ADDRESS like below screen



In above screen you can see 'Industrial Contract' deployed and we got account address and by using this account address we can access Blockchain from python code and you can see this python access code in below screen




```
global details
details=''
global contract

def readDetails():
    global details
    blockchain_address = 'http://127.0.0.1:9545' #Blokchain connection IP
    web3 = Web3(HTTPProvider(blockchain_address))
    web3.eth.defaultAccount = web3.eth.accounts[0]
    compiled_contract_path = 'IndustrialEquipmentContract.json' #industrial contract code
    deployed_contract_address = '0x1DD4fb45C1cdC8C3f32cbaA60464c8107D4D4058' #hash address to access industrail contract
    with open(compiled_contract_path) as file:
        contract_json = json.load(file)  # load contract info as JSON
        contract_abi = contract_json['abi']  # fetch contract's abi - necessary to call its functions
    file.close()
    contract = web3.eth.contract(address=deployed_contract_address, abi=contract_abi) #now calling contract to access data
    details = contract.functions.getData().call()
    if len(details) > 0:
        if 'empty' in details:
            details = details[5:len(details)]

def saveDataBlockChain(currentData):
    global details
    global contract
    blockchain_address = 'http://127.0.0.1:9545'
    web3 = Web3(HTTPProvider(blockchain_address))
    web3.eth.defaultAccount = web3.eth.accounts[0]
    compiled_contract_path = 'IndustrialEquipmentContract.json'
    deployed_contract_address = '0x1DD4fb45C1cdC8C3f32cbaA60464c8107D4D4058'
    with open(compiled_contract_path) as file:
        contract_json = json.load(file)  # load contract info as JSON
        contract_abi = contract_json['abi']  # fetch contract's abi - necessary to call its functions
    file.close()
    contract = web3.eth.contract(address=deployed_contract_address, abi=contract_abi)
    readDetails()
    details+=currentData
    msg = contract.functions.setData(details).transact()
    tx_receipt = web3.eth.waitForTransactionReceipt(msg)

def getDetails():
```

In above screen you can see by using WEB3 Python API we are accessing Blockchain code.

SAMPLE CODE:

```
import
hashli
b
          import json
          from time import time
          from uuid import uuid4
          from urllib.parse import urlparse

          from flask import Flask, jsonify, request

          class BlockChain(object):
```

```
    """ Main BlockChain class """
    def __init__(self):
        self.chain = []
        self.current_transactions = []
        self.nodes = set()
        # create the genesis block
        self.new_block(previous_hash=1, proof=100)

    @staticmethod
    def hash(block):
        # hashes a block
        # also make sure that the transactions are ordered otherwise
we will have insonsistent hashes!
        block_string = json.dumps(block, sort_keys=True).encode()
        return hashlib.sha256(block_string).hexdigest()

    def new_block(self, proof, previous_hash=None):
        # creates a new block in the blockchain
        block = {
            'index': len(self.chain)+1,
            'timestamp': time(),
            'transactions': self.current_transactions,
            'proof': proof,
            'previous_hash': previous_hash or
self.hash(self.chain[-1]),
        }

        # reset the current list of transactions
        self.current_transactions = []
        self.chain.append(block)
        return block

    @property
```

```
    def last_block(self):
        # returns last block in the chain
        return self.chain[-1]

    def new_transaction(self, sender, recipient, amount):
        # adds a new transaction into the list of transactions
        # these transactions go into the next mined block
        self.current_transactions.append({
            "sender":sender,
            "recient":recipient,
            "data":amount,
        })
        return int(self.last_block['index'])+1

    def proof_of_work(self, last_proof):
        # simple proof of work algorithm
        # find a number p' such as hash(pp') containing leading 4
zeros where p is the previous p'
        # p is the previous proof and p' is the new proof
        proof = 0
        while self.validate_proof(last_proof, proof) is False:
            proof += 1
        return proof

    @staticmethod
    def validate_proof(last_proof, proof):
        # validates the proof: does hash(last_proof, proof) contain
4 leading zeroes?
        guess = f'{last_proof}{proof}'.encode()
        guess_hash = hashlib.sha256(guess).hexdigest()
        return guess_hash[:4] == "0000"

    def register_node(self, address):
```

```
        # add a new node to the list of nodes
        parsed_url = urlparse(address)
        self.nodes.add(parsed_url.netloc)

    def full_chain(self):
        # xxx returns the full chain and a number of blocks
        pass



# initiate the node
app = Flask(__name__)
# generate a globally unique address for this node
node_identifier = str(uuid4()).replace('-', '')
# initiate the Blockchain
blockchain = BlockChain()

@app.route('/mine', methods=['GET'])
def mine():

    # first we need to run the proof of work algorithm to calculate
the new proof..
    last_block = blockchain.last_block
    last_proof = last_block['proof']
    proof = blockchain.proof_of_work(last_proof)

    # we must recieve reward for finding the proof in form of
receiving 1 Coin
    blockchain.new_transaction(
        sender=0,
        recipient=node_identifier,
        amount=1,
    )
```

```
    # forge the new block by adding it to the chain
    previous_hash = blockchain.hash(last_block)
    block = blockchain.new_block(proof, previous_hash)

    response = {
        'message': "Forged new block.",
        'index': block['index'],
        'transactions': block['transactions'],
        'proof': block['proof'],
        'previous_hash': block['previous_hash'],
    }
    return jsonify(response, 200)

@app.route('/transaction/new', methods=['GET'])
def new_transaction():

    values = request.get_json()
    required = ['sender', 'recipient', 'amont']

    if not all(k in values for k in required):
        return 'Missing values.', 400

    # create a new transaction
    index = blockchain.new_transaction(
        sender = values['sender'],
        recipient = values['recipient'],
        amount = values['amount']
    )

    response = {
        'message': f'Transaction will be added to the Block
{index}',
```

```
    }
    return jsonify(response, 200)

@app.route('/chain', methods=['GET'])
def full_chain():
    response = {
        'chain': blockchain.chain,
        'length': len(blockchain.chain),
    }
    return jsonify(response), 200

@app.route('/nodes/register', methods=['POST'])
def register_nodes():
    values = request.get_json()

    print('values',values)
    nodes = values.get('nodes')
    if nodes is None:
        return "Error: Please supply a valid list of nodes", 400

    # register each newly added node
    for node in nodes: blockchain.register_node(node)

    response = {
        'message': "New nodes have been added",
        'all_nodes': list(blockchain.nodes),
    }

    return jsonify(response), 201



if __name__ == '__main__':
```

```
    app.run(host='0.0.0.0', port=5000)
```

SYSTEM TESTING

TEST CASES:

S.NO	INPUT	If available	If not available
1	Production Login, Supervision Login, Distribution Login and Circulation Login	users may login to application by using username and password as ‘Production or Supervision or Distribution or	There is no process
2	Production Module	this user will provide unique code to each product and add other	There is no process
3	Circulation Module	using this module user can add Logistic details such as location of product out for delivery	There is no process
4	Distribution Module	using this module user can add equipment sold to which distributor or retailer	There is no process
5	Supervision Module	using this module user will add defect found in the equipment so that product will be sent to production for alteration	There is no process

6	View Details	using this module all users may track different details such as product details, location, defect etc	There is no process

OUTPUT SCREENSHOTS

Now double click on ‘run.bat’ file from ‘EquipmentBlockchain’ folder to start python server like below screen

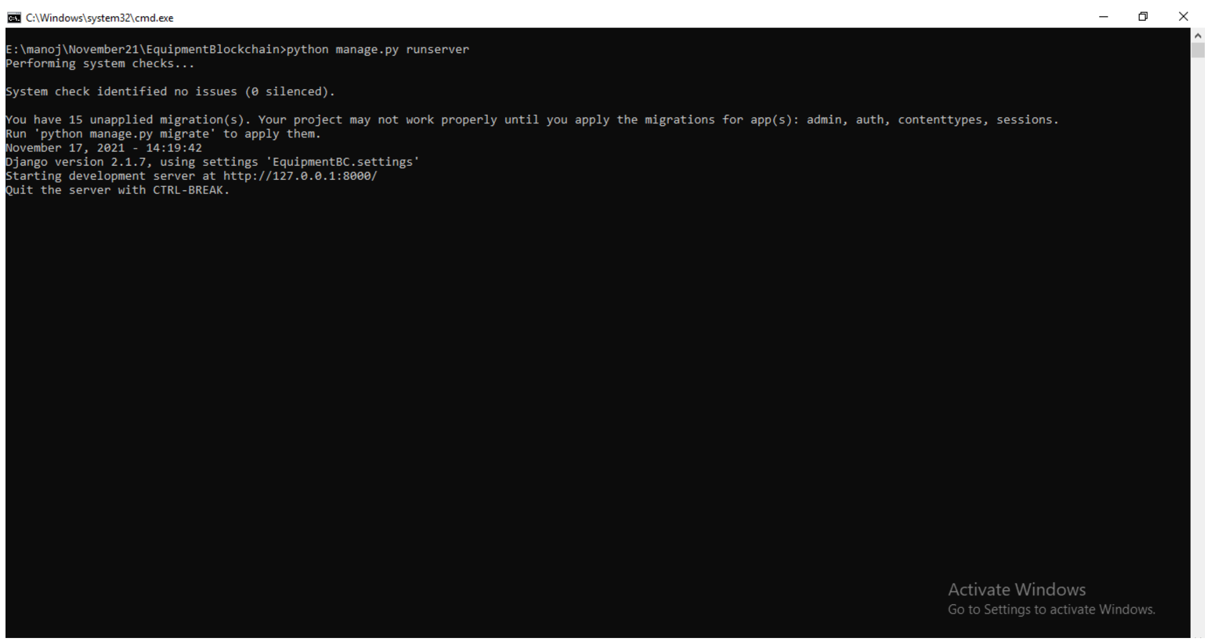


Fig: Output screen 1

In above screen python server started and now open browser and enter URL as ‘http://127.0.0.1:8000/index.html’ and press enter key to get below home page

Fig: Output screen 2

In above screen click on ‘Production Login’ link to get below login screen

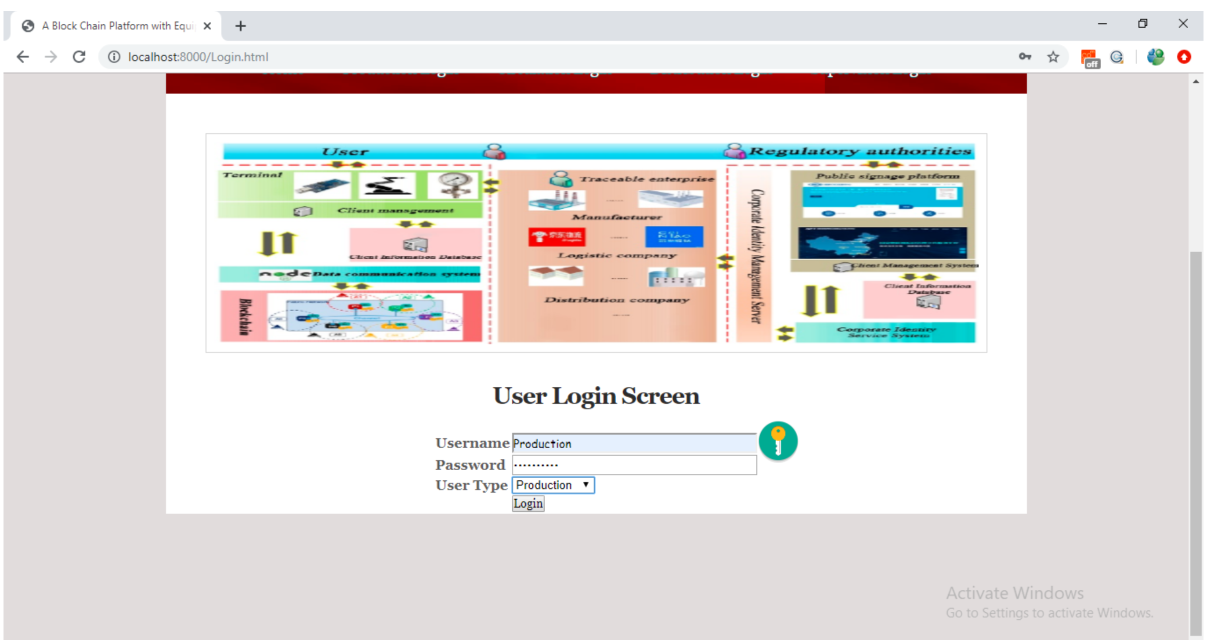


Fig: Output screen 3

In above screen "Production' user is login using both username and password as 'Production' and after login will get below screen

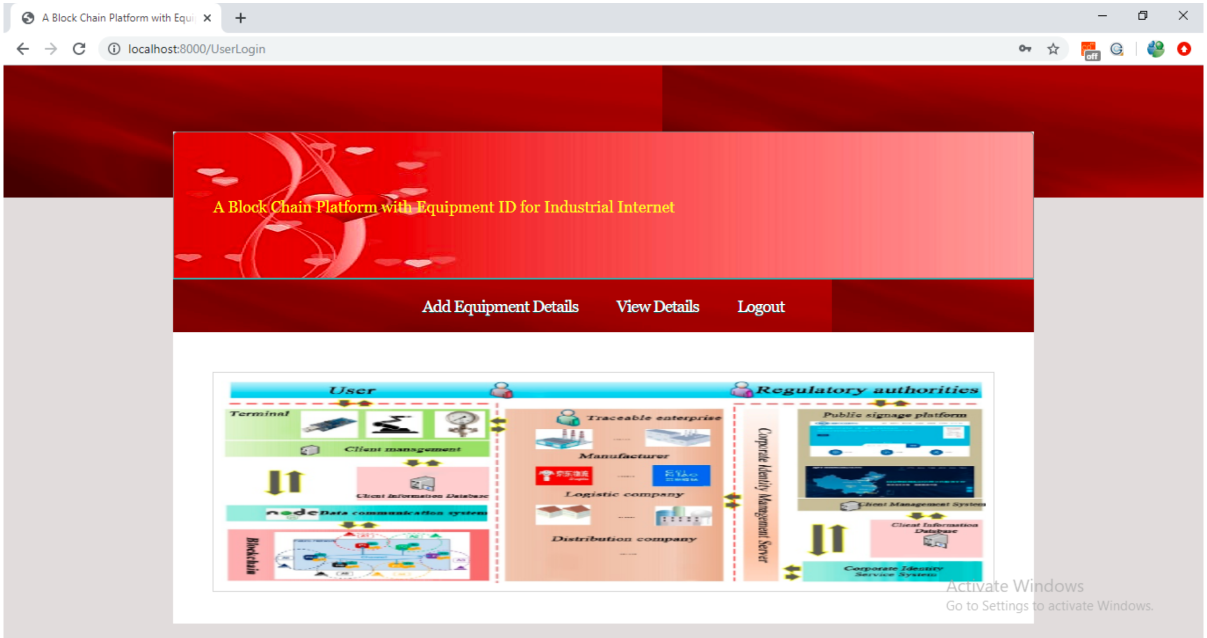


Fig: Output screen 4

In above screen click on 'Add Equipment Details' link to get below screen

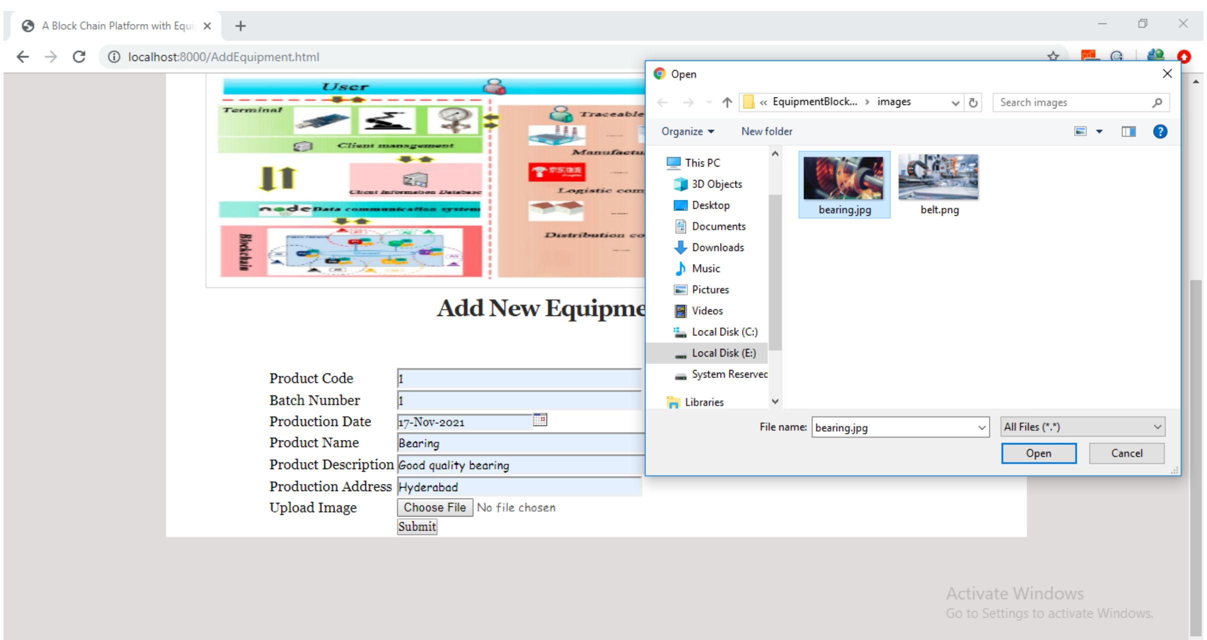


Fig: Output screen 5

In above screen adding all product equipment details and then select product image and then click on ‘Open’ button to store data in Blockchain and to get below screen

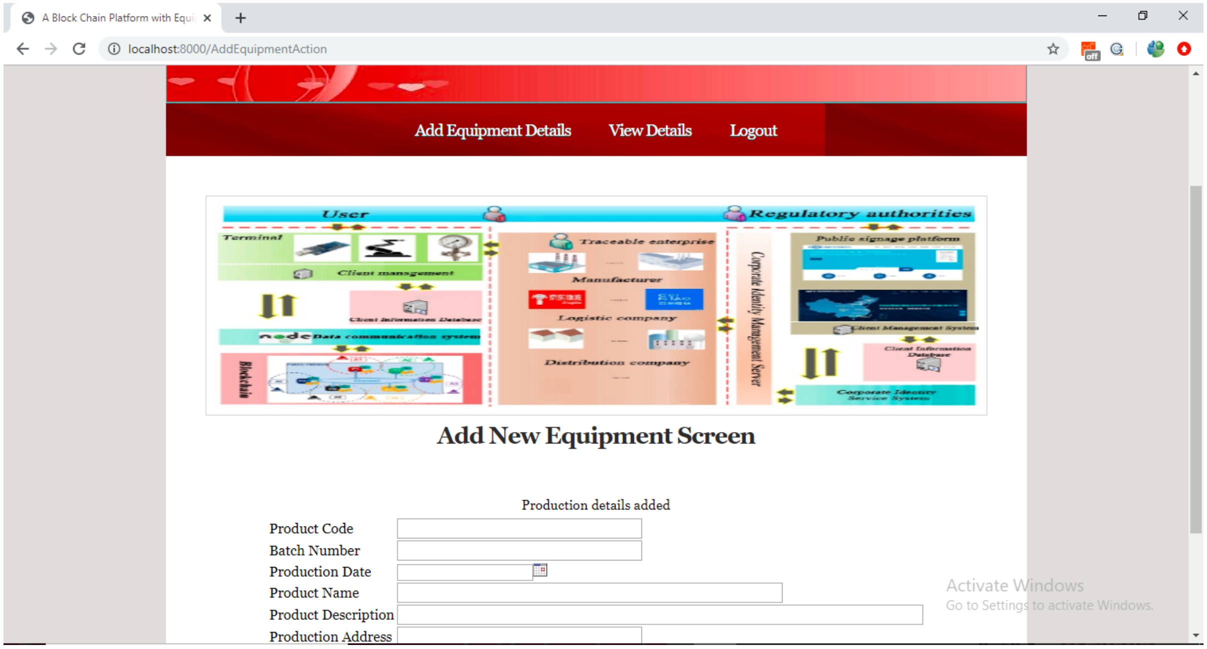


Fig: Output screen 6

In above screen production details added and now click on ‘View Details’ to view details stored in Blockchain

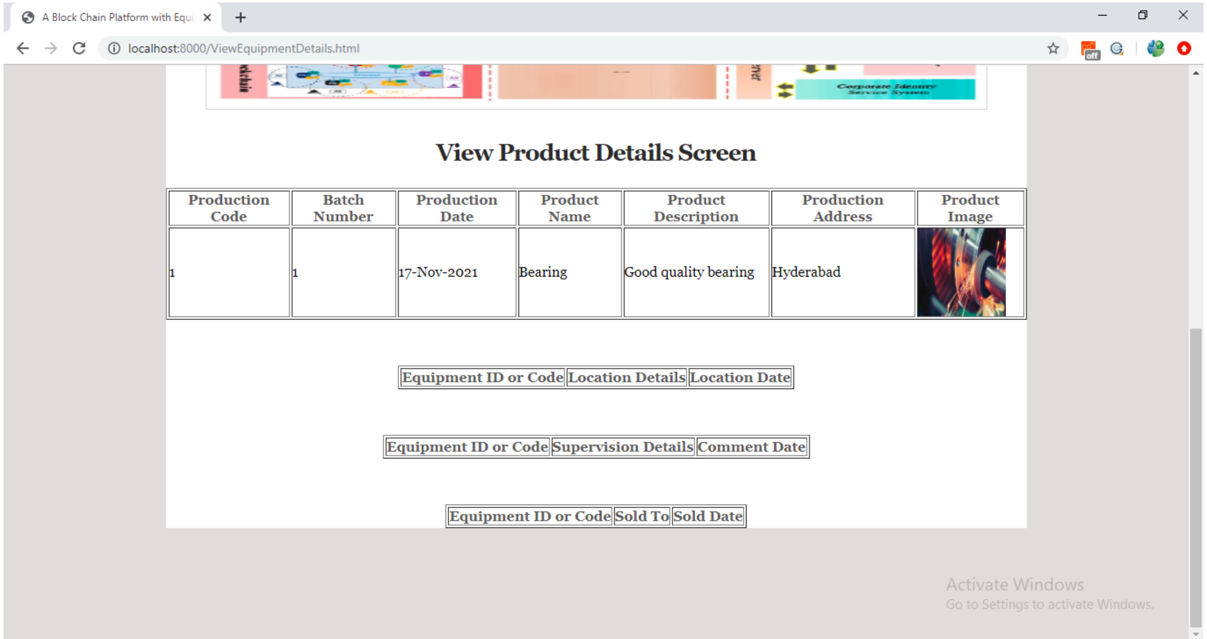


Fig: Output screen 7

In above screen user can view all production details and now to add 'Logistic Details' logout and login as Circulation

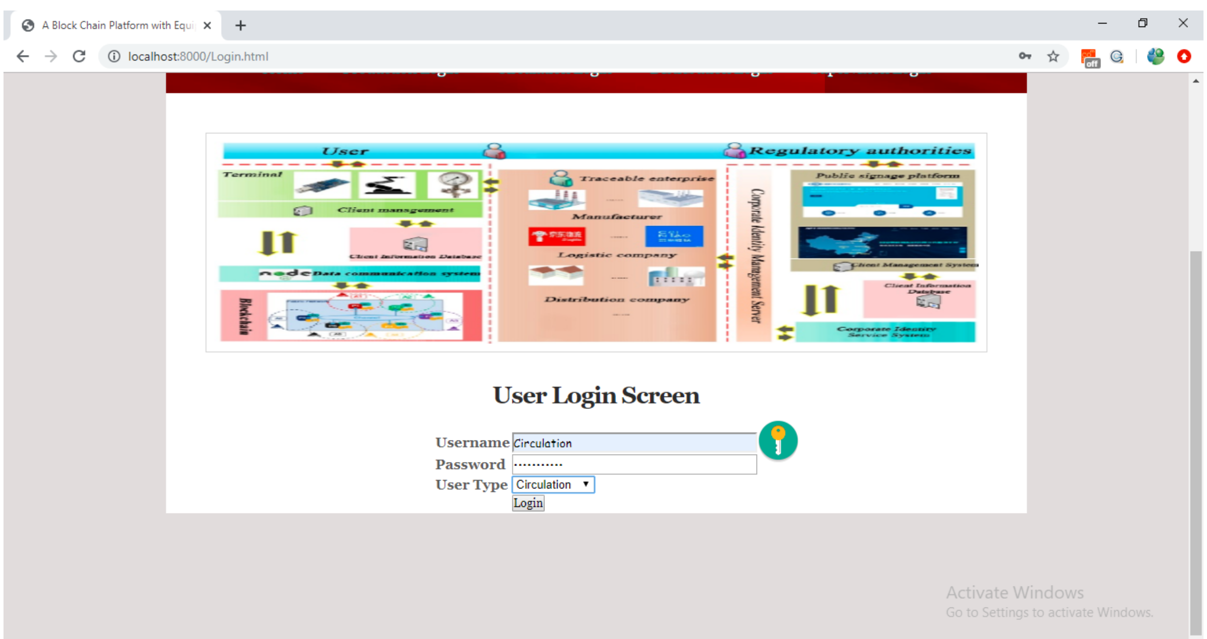


Fig: Output screen 8

In above screen 'Circulation' user is login and after login will get below details

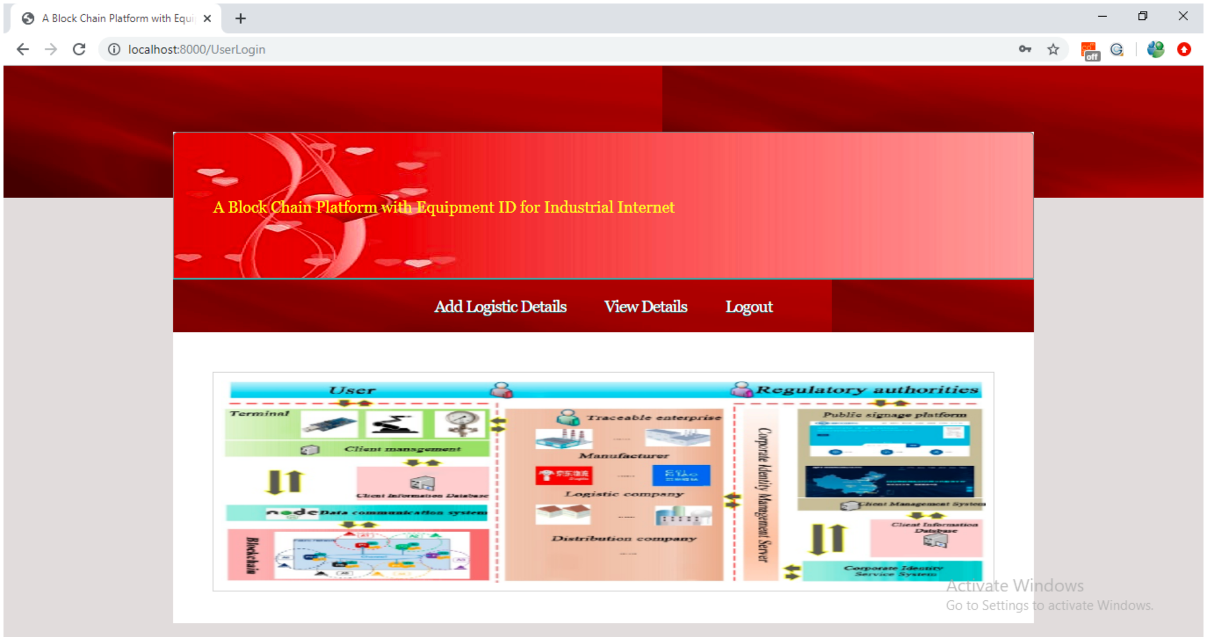


Fig: Output screen 9

In above screen click on 'Add Logistic Details' link to add current delivery location

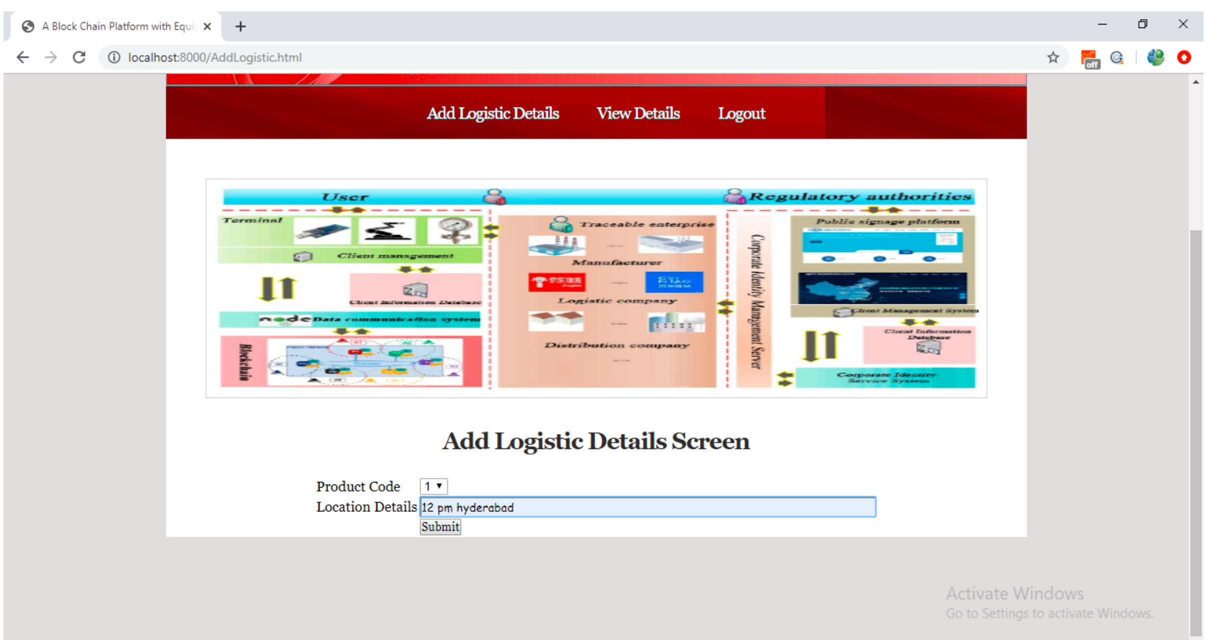


Fig: Output screen 10

In above screen user can select product code and then enter current delivery location address and press button to save logistic details and then click 'View Details' link to view logistic details

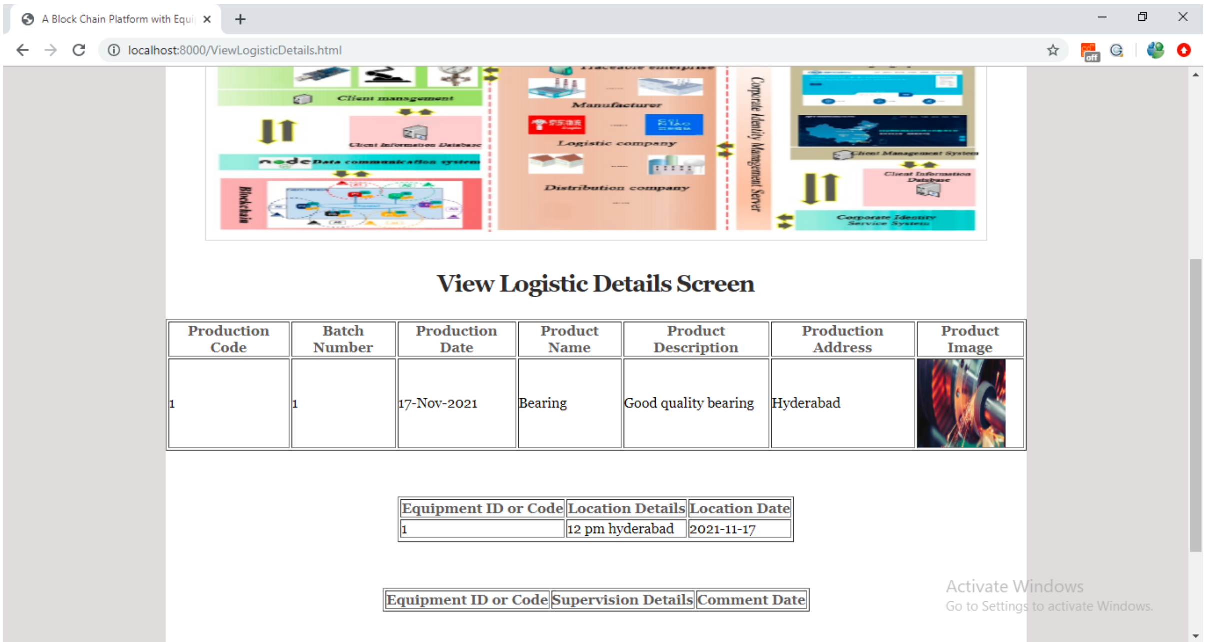


Fig: Output screen 11

In above screen in second table user can view current address of product and to add distribution details, logout and login as Distribution

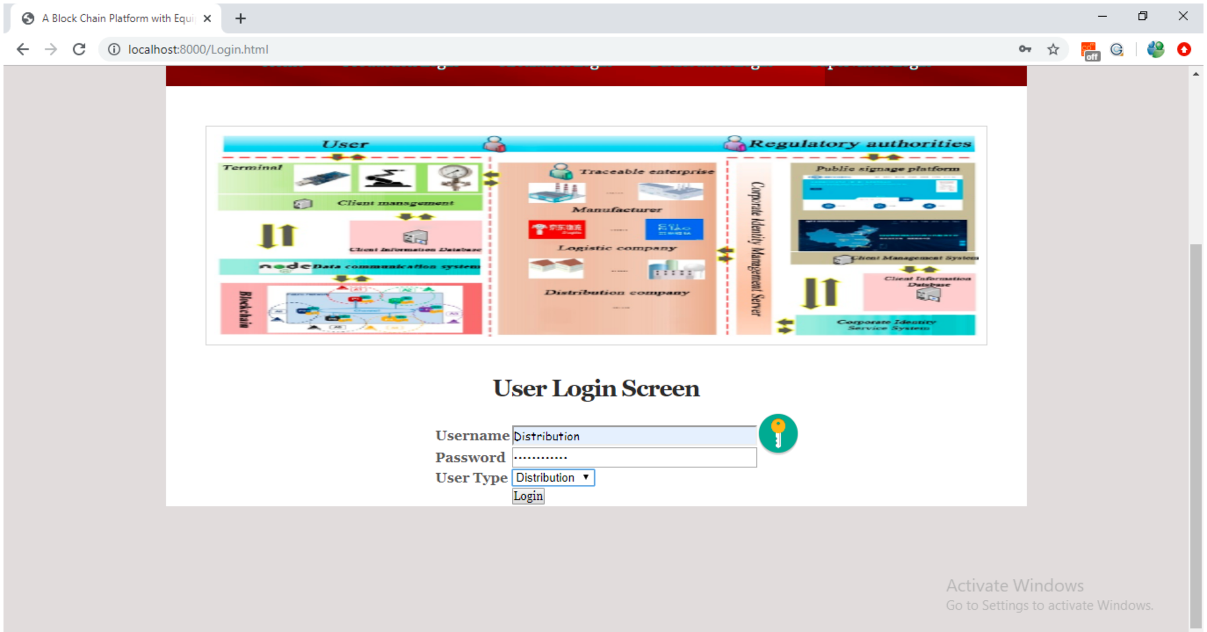


Fig: Output screen 12

In above screen 'Distribution' user is login and after login will get below screen

Fig: Output screen 13

In above screen click on 'Add Distribution Details' link to get below screen

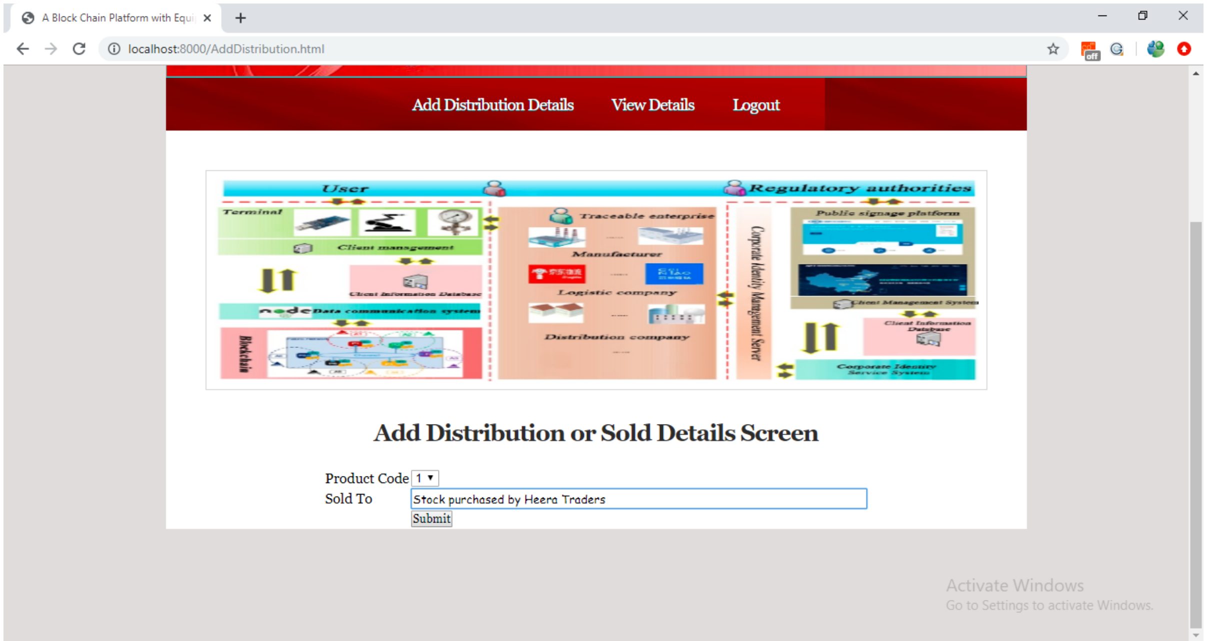


Fig: Output screen 14

In above screen user will add details of purchaser who is purchasing this stock and now click on ‘View Details’ link to view details

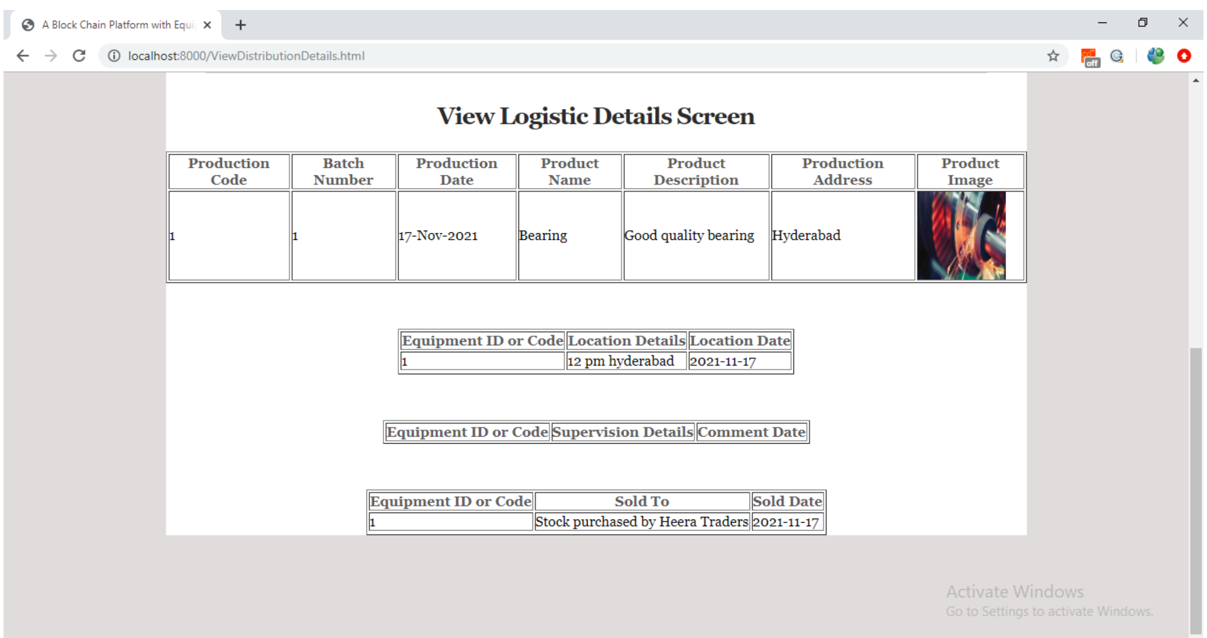


Fig: Output screen 15

In above screen user can see all stock purchased details and similarly to add supervision or defect details logout and login as ‘Supervision’

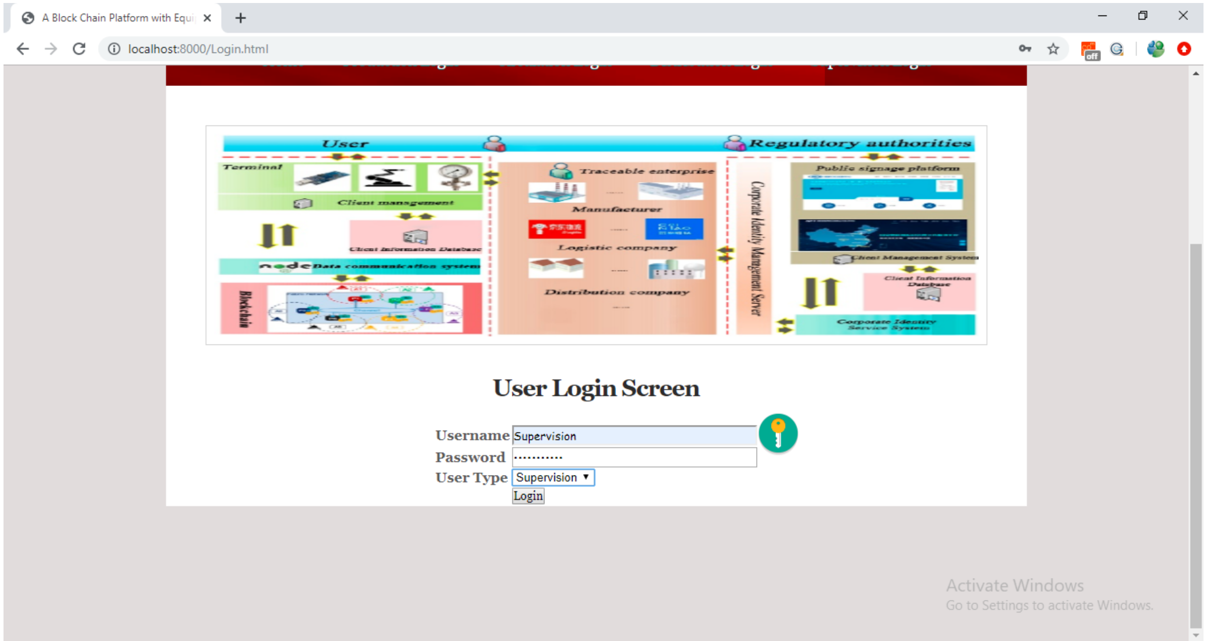


Fig: Output screen 16

In above screen ‘Supervision’ user is login and after login will get below screen

Fig: Output screen 17

In above screen click on ‘Add Supervision Comment’link to get below screen

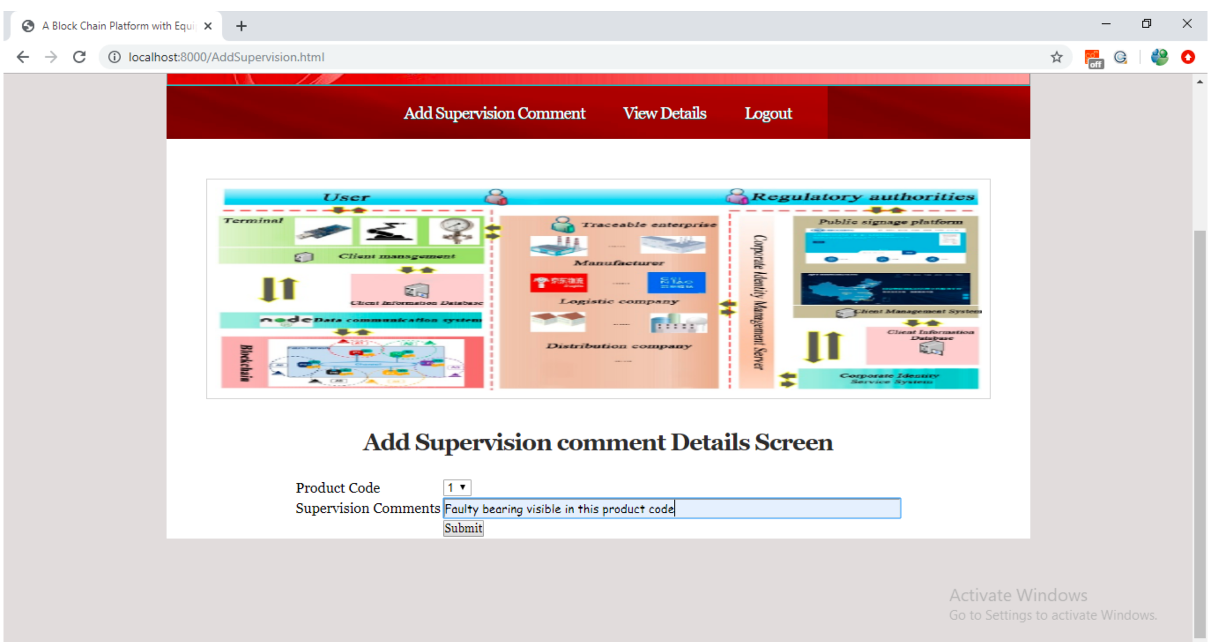


Fig: Output screen 18

In above screen supervision will inspect product and then add any faulty details and all details will saved in Blockchain and then click on 'View Details' link to view all details

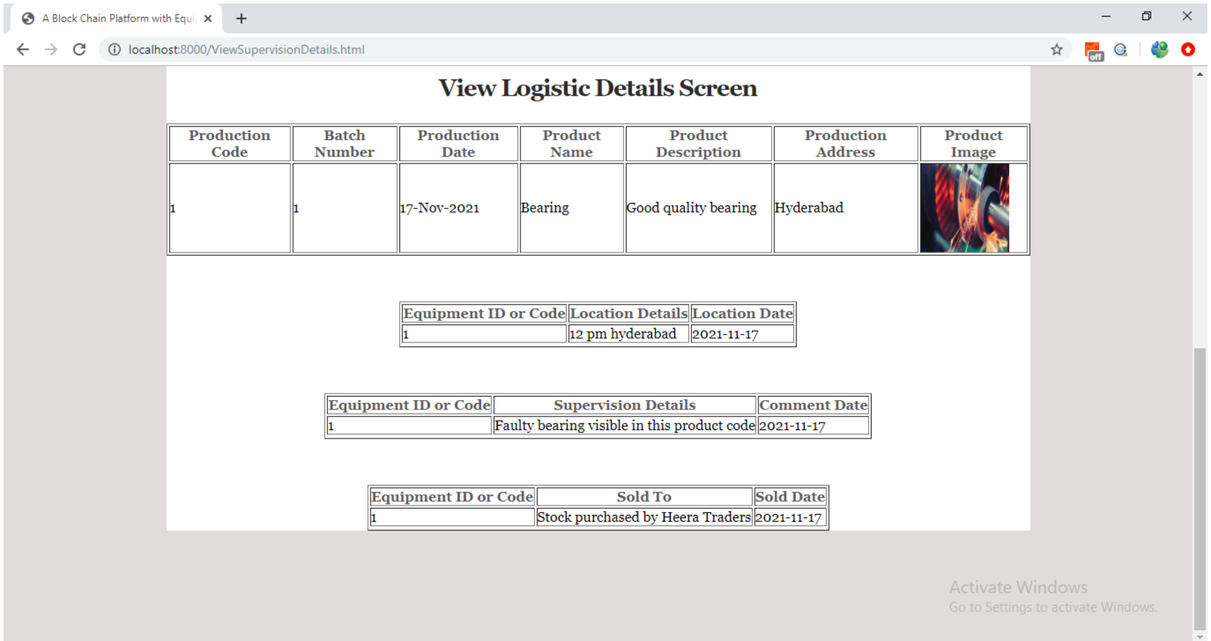


Fig: Output screen 19

In above screen user can fetch all details from Blockchain and view and similarly you can add any number of product details

CONCLUSION

This article focuses on the use of blockchain technology and device identification in the traceability system, as well as how these technologies are applied to it. The overall scheme design and system security design of the traceability system based on blockchain and identity are proposed on the basis of research into these technologies in the traceability system. A blockchain internal traceability solution and a blockchain external traceability solution have been developed as part of the overall plan to address the issue of the explosion of blockchain data and to ensure the tamper-proof and traceability of all information related to consumer electronics products throughout the various supply chain processes. The guarantee of the traceability information's efficacy, the key and authentication method, and the authority management to assure the security of system operation are all included in the system's security design.

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