iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.70786

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Drug Inventory Supply Chain Management Using Blockchain

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Abstract: ***The Drug Inventory & Supply Chain Management System using Blockchain technology is a novel solution developed to address the serious issues affecting the pharmaceutical supply chain such as counterfeit drugs, lack of transparency, inefficient tracking and data tampering. This can lead to significant adverse effects in the case of patient safety and violations of regulatory requirements. The proposed system utilizesblockchain as a solution to facilitate secure, immutable and decentralized data sharing across all involved parties–rangingfromdrug manufacturersand distributor stopharmaciesandhealthcareproviders.***

In the center of the solution is a blockchain-based ledger which securely stores all transactions and movements of drug inventory. Each drug batch is assigned an unique digital identity using QR codes or RFID tags and their entire journey from production to consumption is documented in real time on the blockchain. This end-to-end traceability provides both verification of accuracy in the supply chain and complete auditability of supply chain for regulators and healthcare organizations.

Smart contracts are used to automatically execute some facets of the supply chain such as drug delivery, inventoryreplenishment,andpaymentsettlement.Smartcontractsenforcecertainconditions(i.e. confirmdeliveryofadrugormaintainaspecifiedtemperature)tocompleteagivenprocess.This improves the speed to market of the supply chain, reduces human intervention, and promotes more trust among supply chain partners through enforceable code.

Also, with the introduction of IoT devices, the system can measure other environmental factors like temperature and humidity during storage and transportation, thereby ensuring the safe handling of highly sensitive medications and immediately putting in place preventive measures if such deviations occur. In addition, with the help of data analytics, the system will be able to predict the demand patterns, helpingusers measure their inventory levels to ensure they remain at their desired level while reducing waste.

Blockchain combines with advanced supply chain management practices and technology to provide significant efficiency and security gains while improving patient safety and public health outcome. Blockchain represents an unprecedented development in pharmaceutical logistics – a new transparent, tamper-proof and efficient tool to manage drug inventory in today's increasingly complex and global healthcare environment.

Keywords: BlockchainTechnology,DrugSupplyChain,SmartContracts,EndtoEndTrackability.

I. INTRODUCTION

The pharmaceutical supply chain is an important component to ensure availability of safe and effective medicines to healthcare providers and patients. There are many challenges faced in conventional drug supply chains such as counterfeit drugs, lack of transparency, inventory re-stocking, delivery delays and even public health risks associated with these issues. Since medical professionals and their patients increasinglydemandefficientandsecure drugdistribution, it'scriticalforallthepartsofthesupply chain to be put into modern technology-driven solutions that can bring transparency, traceability, andtrust to the entire supply chain.

TheproposedDrugInventory/SupplyChainManagementSystemutilizesblockchaintodevelopa reliable digital infrastructure for tracking the progress of drugs; each batch of drugs is assigned a unique identifier, and their progression through the supply chain is recorded in a shared ledger available to manufacturers,distributors, pharmaciesandregulatory bodies;suchrecordsareirrevocable(notsubject to modification or deletion), providing unambiguous and consistent access to the source and destinationof drugs throughout the supply chain.

In addition to blockchain, the system uses IoT (Internet of Things) devices to monitor environmental conditions during drug transportation and storage. Many pharmaceutical products are temperature sensitive and being exposed to unsuitable conditions can make them less effective. IoT sensors capture real-timetemperatureandhumidity levelsanduploadthisdatatotheblockchainprovidingapermanent(andtraceable)recordofproperhandlingofdrugs.Anydeviationfromtherequiredconditionscanresultinalertsbeingsenttousers–sodrugsthatarenotstoredproperlycanbe prevented from being taken to consumers.

Smart contracts thus further automate supply chain processes as these self-executing digital agreements automatically apply predefined rules and actions—for example, a pending shipment will only be released after all strict compliance conditions have been met. Thus paper production is significantly reduced, processing time can be reduced and the possibility of fraud or human error is significantly reduced.

By combining blockchain, Internet of things (IoT) and smart contract technologies the proposed solution not only achieves cost-effective operation, but also a reliable and transparent pharmaceutical ecosystem, enable faster drug recall, enable real-time audits, and enable compliance with global regulatory requirements. By giving everyone with competent and trustworthy information it empowers all stakeholders, while keeping patient safety and supply chain resilience at the forefront.

II. MOTIVATION

The pharmaceutical assiduity faces critical challenges in icing the safe, timely, and authentic delivery of specifics. One of the most intimidating issues is the wide rotation of fake medicines, which not only jeopardizespatienthealthbutalsodamagesthecredibilityofhealthcaresystems.Traditionalforce chains warrant the translucency and traceability needed to effectively cover the movement andauthenticity of medicines. This motivates the need for a secure, tamper- evidence system that can track medicinal across every stage of the force chain.

Conventional force operation systems frequently operate in insulation, leading to poor visibility, data disagreement,andinefficienciessimilarasstockoutsoroverstocking.Theseissuescomeindeedmoresevere during public health extremities when the demand for certain specifics harpoons suddenly. A lack of real- timedatasharingandcollaborationamong manufacturers,distributors,apothecaries,andcontrollers further complicates force chain operation. Addressing these pain points requires a system that ensures real- time collaboration, data delicacy, and translucency among all stakeholders.

Blockchain technology offers a transformative result to these problems by furnishing an inflexible, decentralized tally where all deals are securely recorded and accessible to authorized actors. Coupled with smart contracts and IoT bias, it enables automated, transparent operations and real- time environmental monitoring of medicine storehouse and transportation. This technology- driven approach can drastically reduce fraud, mortal error, and nonsupervisory non-compliance while perfecting patient safety and overall force chain effectiveness.

The provocation behind this design is to harness the power of arising technologies to make a dependable, scalable, and intelligent medicine force operation system. By perfecting traceability, enhancing communication between stakeholders, and icing nonsupervisory compliance, this system aims to contemporize pharmaceutical logistics and eventually contribute to a more secure and effective healthcare structure.

III. OBJECTIVES

The primary ideal of this design is to develop a robust and transparent medicine Inventory Supply Chain Management System that leverages blockchain technology to insure the secure shadowing and authentication of pharmaceutical products. By recording every sale and movement of medicine force on an inflexible tally, the system aims to exclude fake medicines, ameliorate traceability, and foster trust among manufacturers, distributors, apothecaries, and nonsupervisory authorities.

Anothercrucialidealistostreamlineforceoperationbyintroducingreal-timestockshadowing, automated cautions, and demand soothsaying. These features will help issues like overstocking and stockouts, allowing stakeholders to make informed opinions regarding medicine procurement and distribution. The system is also intended to support batch- position shadowing, icing expired or recalled medicines can be snappily located and removed from rotation.

Thesystemalsoseekstointegratesmartcontractstoautomatecriticalforcechainfunctionssimilaras order processing, quality checks, and compliance verification. These contracts can ensure that specific conditions — like storehouse temperature, delivery evidence, or payment concurrence — are met before deals are executed. This robotization reduces homemade crimes, enhances functional effectiveness, and ensures harmonious nonsupervisory compliance.

Eventually, the design aims to enhance safety and quality assurance by incorporating IoT- grounded detectorsforcoveringenvironmentalconditionssimilarastemperatureandmoistureduringstorehouse and transport.

This integration will ensure that sensitive specifics are handled rightly throughout their lifecycle,withalldatasecurelyrecordedontheblockchainforauditingandcompliancepurposes. Together, these objects contribute to erecting a secure, effective, and case- centric pharmaceutical force chain.

IV. METHODOLOGY

The proposed medicine Inventory Supply Chain Management System is erected on a private blockchain network to insure secure, tamper- evidence, and transparent shadowing of pharmaceutical products. Each sale — be it manufacturing, packaging, shipping, or delivery is recorded as a block on the chain, with a uniqueidentifierandtimestamp. Allstakeholders,includingmanufacturers,distributors,apothecaries,andcontrollers,aregrantedcontrolledaccesstothesystemtocoverandcorroboratemedicine movements in real- time.

Smart contracts are enforced to automate crucial force chain operations. These tone- executing contracts contain predefined rules, similar as vindicating temperature logs before payload blessing or icing compliance attestation before restocking. This removes the need for homemade intervention, reducesmortalerror,andenhancesthespeedandtrustability offorce chainprocesses.also,smartcontracts support secure and tentative payments, payload releases, and automatic restocking when force situationsfall below a threshold.

To ensure the safety of temperature-sensitive medicines, IoT- enabled detectors are integrated into storehouse and transportation units. These detectors collect environmental data and push it to theblockchain in real time via secure gateways. Any diversions from specified ranges spark instant cautions, precludingcorruptionandenablingvisionarymeasures.Aweb-groundeddashboardprovides stakeholders with access to force situations, payload shadowing, compliance logs, and medicineverification tools.

V. EXPECTED OUTCOMES

The primary anticipated outgrowth of this system is a significant improvement in the traceability and translucency of pharmaceutical products throughout the force chain. Every sale and movement ofmedicines—frommanufacturingtodelivery—willbeimmutablyrecordedontheblockchain.Thiswillallowstakeholders,includingmanufacturers,distributors,apothecaries,andcontrollers,totrace each batch of medicines in real- time.

Anotherimportantoutgrowthistherobotizationofcriticalforcechainoperationsthroughsmart contracts. These contracts will execute predefined conduct automatically, similar as validating payload conditions, releasing payments, or driving restock cautions. This robotization will reduce reliance on homemade processes, minimize crimes, and ensure that all conduct misbehave with nonsupervisory conditions, leading to briskly and more dependable force chain performance.

The integration of IoT detectors for environmental monitoring will ensure that temperature-sensitive specifics are stored and transported under proper conditions. Real- time data on temperature and moisture, logged directly onto the blockchain, will give irrefragable evidence of compliance with storehouse guidelines.

Overall, the system is anticipated to ameliorate functional effectiveness, ensure patient safety, and make stakeholder trust by delivering a secure, decentralized, and intelligent pharmaceutical force chain. It'll also help in briskly recalls, accurate demand soothsaying, and more effective nonsupervisory oversight,thereby contributing to a safer and further dependable healthcare ecosystem.

VI. CONCLUSION

The medicine Inventory Supply Chain Management System using blockchain technology offers a transformative result to long- standing issues in the pharmaceutical force chain. By icing translucency, traceability, and invariability, the system combats the serious problem of fake medicines and enhances the overall trustability of medicine distribution. Every step in the force chain is securely logged and empirical, promoting responsibility among stakeholders and adding patient safety.

Throughtheintegrationofsmartcontracts,thesystemintroducesrobotizationintocriticaloperations like payload confirmation, force updates, and compliance checks. This not only reduces homemade workload and mortal error but also ensures that deals are executed under predefined, tamper- evidencerules.

The combined use of blockchain, IoT, and robotization leads to a smarter, briskly, and more responsive pharmaceutical force chain. It facilitates better decision- timber, supports nonsupervisory compliance, and improves the capability to snappily recall compromised products when necessary. Overall, this system contributes to erecting a more secure, effective, and case-centric healthcare structure.

In conclusion, this design demonstrates how arising technologies can be effectively exercised to address real-worldchallengesinmedicineforceanddistribution.Itnotonlymodernizesthepharmaceuticalforcechainbutalsolaysthefoundationfor scalableandsecuresystemsinbroaderhealthcare operations.

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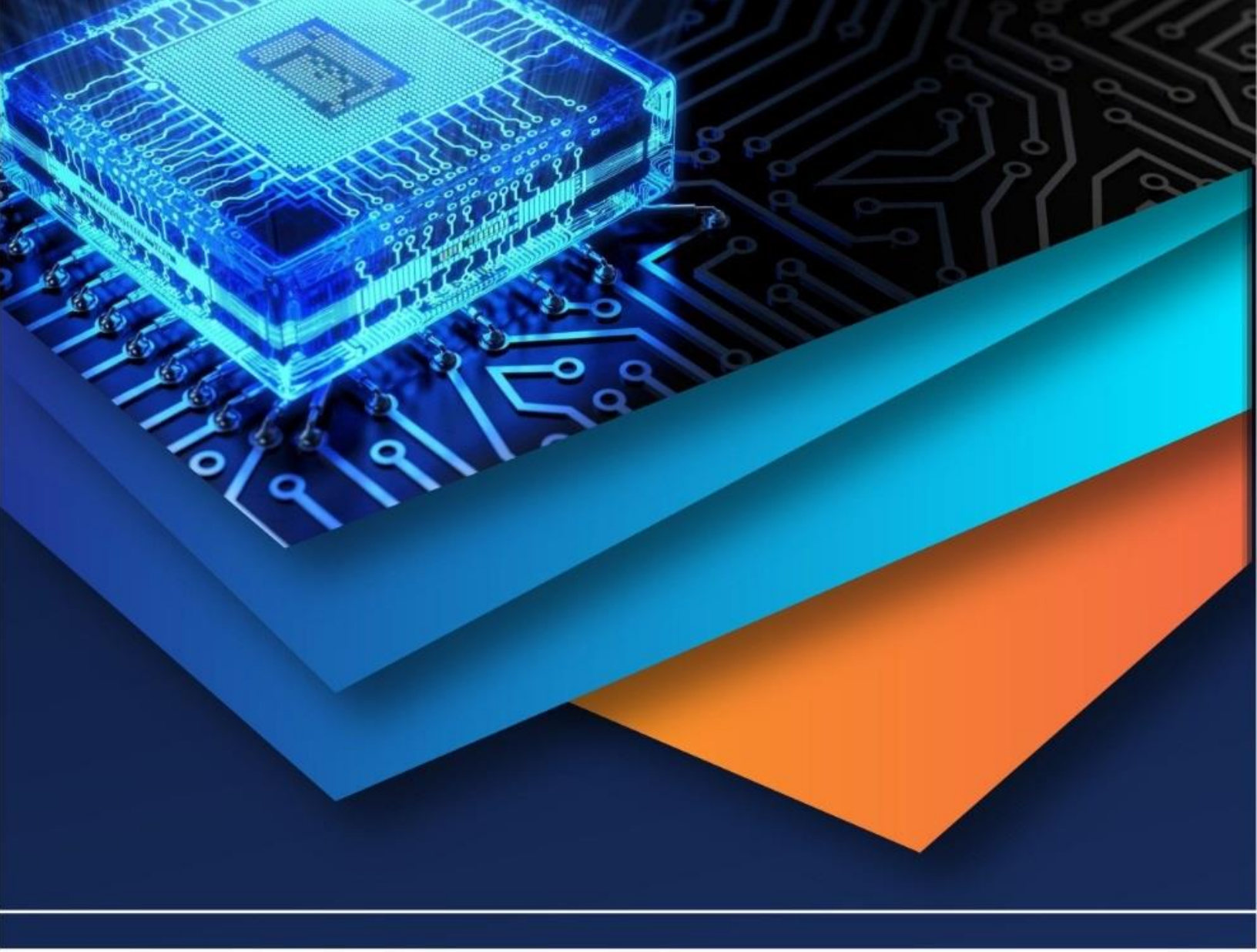

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