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DefenseLedger – Blockchain-Powered Ammunition and Supply Chain

Group No. 10

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Project Guide
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Contents

Abstract

DefenseLedger is a blockchain-powered system designed to enhance oversight, traceability, and security across the ammunition lifecycle. It combines a decentralized, tamper-proof ledger with smart contract automation to track ammunition from manufacturing to decommissioning. Key features include real-time monitoring, secure identity management, and automated compliance checks. The system also offers demand forecasting, analytical tools, and data visualizations to support data-driven decision-making and ensure compliance with legal and operational standards.

Introduction

The ammunition supply chain faces challenges in transparency, traceability, and security, which are vital for national security. Traditional manual tracking methods are error-prone and lack real-time visibility. DefenseLedger uses blockchain technology to provide a decentralized, secure solution with real-time monitoring and automated processes through smart contracts, enhancing decision-making and operational efficiency.

Motivation

- Enhanced Security and Accountability: Blockchain secures data and smart contracts enforce accountability, preventing fraud.
- Transparency and Traceability: Immutable ledger ensures transparent, traceable records for compliance and trust.
- Efficiency through Automation: Smart contracts automate tasks, reducing errors and streamlining management.
- Real-Time Monitoring and Decision-Making: Real-time monitoring enables prompt, informed decision-making.
- Decentralization for Resilience: Decentralized blockchain enhances system resilience by eliminating single points of failure.

Objectives

- Develop a Blockchain-Enabled Framework and automate the supply chain using smart contracts for Military Logistics.
- Establish Real-Time Tracking of Ammunition and Supplies.
- Predict Ammunition Requirements Based on Zone-Specific Data Using Time-Series algorithms like ARIMA.
- Enhance Security using Decentralized Data Storage and Enable Secure Access and Authorization for Military Personnel.

Literature Review(1)

Sr.no	Title	Author(s)	Year	Methodology	Drawback
1	Improving Supply Chain Management Processes Using Smart Contracts in the Ethereum Network Written in Solidity	Eren Yigit and Tamer Dag	2024	The methodology involves exploring blockchain and smart contract technologies, analyzing their limitations and advantages, and identifying **potential applications** in supply chain management. It also includes a **comprehensive literature review** of existing implementations and discusses different technological stacks and frameworks for smart contracts in supply chain management.	One drawback is the complexity of introducing **digital technologies** to supply chains, requiring a qualified workforce and robust equipment for IoT data feeds.[1] Another challenge is tailoring the proposed system to meet the **specific needs** of individual supply chains and parties involved, which is essential for effective deployment.
2	Blockchain technology in supply chain management: a comprehensive review	Osato Itohan Oriekhoe , Bankole Ibrahim Ashiwaju, Kelechi Chidiebere Ihemereze, Uneku Ikwue & Chioma Ann Udeh	2024	**Industry-specific solutions**, provide tailored approaches to address challenges unique to sectors like pharmaceuticals, agriculture, and manufacturing. **Hybrid blockchain** models offer flexible solutions by combining the benefits of both public and private blockchains, catering to diverse industry needs.[2] Collaborative frameworks involve regulatory bodies working closely with industry stakeholders to develop comprehensive frameworks that address the specific challenges and opportunities of blockchain in supply chains. Additionally, the integration of AI and IoT enhances real-time data analysis, optimizes logistics, and adds predictive capabilities, boosting supply chain resilience.	**Cost and technical complexity** pose significant challenges due to the need for high initial investments in technology, infrastructure, and personnel training. **Scalability** issues limit blockchain's ability to handle a large number of transactions efficiently. Moreover, regulatory uncertainties complicate widespread adoption, as the legal landscape surrounding blockchain remains unclear. Lastly, privacy concerns arise from blockchain's transparency, which can expose sensitive data that requires protection, especially in industries dealing with confidential information.

Literature Review(2)

Sr.no	Title	Author(s)	Year	Methodology	Drawback
3	Securing Blockchain-Based Supply Chain Management: Textual Data Encryption and Access Control	Imran Khan, Qazi Ejaz Ali, Hassan Jalil Hadi, Naveed Ahmad, Gauhar Ali, Yue Cao and Mohammed Ali Alshara	2024	The proposed approach leverages blockchain technology to improve supply chain management using smart contracts, **Hyperledger and Ethereum** ledgers, and a simple **hash validation algorithm**. It emphasizes **data encryption**, permission-based access control, and converting data into text format for security. The system also focuses on managing data volume and preventing **unauthorized access** through secure event logs.[3]	Key drawbacks include **scalability issues**, as blockchain's design limits transaction processing in large-scale operations. **Integrating existing IT systems**, especially older ones, can be complex and costly. Blockchain's immutability raises privacy concerns, particularly with regulations like GDPR.[3] Additionally, reliance on network consensus for validation can introduce security vulnerabilities if nodes are compromised.
4	Role of Blockchain Technology in Supplychain Management	Gokuleshwaran Narayanan, Ivan Cvitić, Dragan Peraković, and S. P. Raja.	2024	The system integrates blockchain to create a transparent, immutable record of transactions using **NFTs** and a private blockchain for controlled participation.[4] A Supply Chain Consensus (SCC) algorithm balances node validation, enhances efficiency, and incentivizes honest behavior. **RFID** and NFT integration allows real-time tracking and product authenticity verification. Additionally, a dispute resolution mechanism uses a voting system to select neutral arbitrators, ensuring fairness and transparency by leveraging the blockchain's immutable records.	The system's **technical complexity** requires significant expertise and high initial setup costs. **Public acceptance** may be slow due to resistance to new technologies, necessitating educational efforts. **Scalability** concerns could arise with increased transaction volumes, affecting performance.[4] Furthermore, while cost-saving in the long term, the initial investment in technology and infrastructure might deter organizations from adopting the system.

Literature Review(3)

Sr.no	Title	Author(s)	Year	Methodology	Drawback
5	Web3-Based Decentralized Autonomous Organizations and Operations: Architectures, Models, and Mechanisms	Rui Qin, Wenwen Ding, Sangtian Guan	2023	The methodology for developing **DAOs** involves creating a universal intelligent framework that integrates new principles, models, and algorithms. It establishes theoretical models for sustainable DAO development, focusing on **distribution** and **decentralization**.[5] The approach emphasizes advanced technologies, such as natural language processing and smart contract programming, to improve governance and operational efficiency.	A major drawback is the **absence of a unified framework** for all DAOs, causing inconsistencies in operation and governance. Current smart contracts often have limitations, implementing only simple deterministic rules, which can lead to vulnerabilities and inadequate governance.[5] Additionally, risks like **Sybil attacks** threaten the integrity and functionality of DAOs.
6	Blockchain and sustainable supply chain management in developing countries	Nir Kshetri	2021	The methodologies discussed in the excerpts mainly focus on the use of blockchain to enhance **sustainability** in supply chains by ensuring **transparency**, traceability, and verification of **product quality** and environmental impact.[6] This approach allows for the selection of cases that represent full ranges of values, as noted by Seawright & Gerring (2008), and it employs case study analysis to assess the applicability of blockchain in enforcing sustainability in different contexts.	However, a significant drawback highlighted is the inability of small firms in developing countries to **invest in technologies** that track and measure relevant data, which hinders their compliance with sustainability standards.[6] Additionally, the **high costs** associated with implementing systems like grades and standards (G&S) can be prohibitive for smaller players in the market, despite the potential benefits offered by blockchain technology.

Literature Review(4)

Sr. No	Title	Author(s)	Year	Methodology	Drawback
7	Supply chain inventory sharing using Ethereum blockchain and smart contracts	Ilhaam A. Omar, raja jayarman	2021	The methodology involved mapping key stakeholders and components using a sequence diagram. The system includes smart contracts for inventory **sharing**, order processing, and reputation tracking, facilitating inventory sharing.[7] These contracts were deployed and tested on a **simulated** Ethereum network using remix IDE, with thorough validation and transaction logging to ensure functionality and performance.	The methodologies face challenges due to the **lack of trust** among supply chain partners, leading to reluctance to share sensitive information. **High investment costs** and difficulties in deploying new systems further hinder collaboration.[7] Additionally, the absence of standardized data formats and differing KPIs create communication inefficiencies, while concerns over data integrity and security complicate blockchain adoption across the supply chain.
8	Consortium blockchain for military supply chain	Syarifah bahiyah rahayu, sharmelen A/L vasanthan	2021	The research identifies problems in military supply chain management (MSCM) for defense shipments by analyzing previous studies.[8] It gathers secondary data from academic literature and case studies on military blockchains and MSCM operations. The final stage models a new blockchain framework tailored to MSCM procedures in **navy depots**.	MSCM faces issues like **limited visibility** in logistics, **scheduling optimization challenges**, and slow operations due to central authority approvals, reducing agility and speed. These constraints affect military performance, and existing systems are also vulnerable to **cyber threats, risking data integrity and privacy**.[8]

Literature Review(5)

Sr.no	Title	Author(s)	Year	Methodology	Drawback
9	Architecture to Enhance Transparency in Supply Chain Management using Blockchain Technology	Dnyaneshwar J. Ghode, Rakesh Jaina, Gunjan Sonia, Sunil K. Singha, Vinod Yadav	2021	The methodologies discussed include the adoption of blockchain technology in supply chain (SC) management, which enables secure, **decentralized** transactions and enhances **transparency and accountability** within the supply chain.[9] Companies are increasingly utilizing various techniques to improve efficiency and reduce risks, such as implementing smart contracts and facilitating **better traceability** and **information flow** amongst supply chain stakeholders. These methodologies aim to streamline operations, minimize costs, and provide a competitive advantage in a global market.	However, drawbacks include the challenges posed by **traditional centralized architectures** that require **third-party authentication** for transactions, leading to inefficiencies and reliance on intermediaries.[9] Additionally, many organizations face difficulties in **fully integrating** blockchain due to the complexity of existing SC processes and the need for widespread participation from all members. There are also risks associated with data tampering and inaccurate inputs, which can hamper the effectiveness of blockchain in ensuring reliable information management within the SC.
10	A Framework for Exploring Blockchain Technology in Supply Chain Management	Abbas Batwa, Andreas Norrman	2020	The methodology described in the excerpts involves a systematic exploration of blockchain technology (BCT) applications in supply chain management (SCM).[10] It employs a mixed-methods approach **combining literature review, case studies, and interviews to develop a conceptual framework** that encompasses various aspects such as SCM drivers, limitations, success factors, and the impacts of BCT on supply chain objectives. The analysis is conducted through open and axial coding, allowing researchers to derive insights and establish connections across different components of the study.	However, drawbacks of this methodology include the **scattered nature of existing literature** across multiple disciplines, which can complicate the integration of findings into a cohesive framework. Additionally, **reliance on case studies** and interviews **may introduce biases** based on the perspectives of select informants, potentially affecting the generalizability of the results.[10] Furthermore, as BCT is a relatively novel phenomenon, there may be limited empirical evidence available to support claims about its effectiveness in various SCM contexts.

Literature Review(6)

Sr.no	Title	Author(s)	Year	Methodology	Drawback
11	Retail-level Blockchain transformation for product supply chain using truffle development platform	Rana M. Amir Latif, Muhammad Farhan, Osama Rizwan, Majid Hussain, Sohail Jabbar, Shahzad Khalid	2020	The methodologies discussed in the excerpts revolve around integrating blockchain technology within the Internet of Things (**IoT**) and supply chain management. Key aspects include the design and development requirements for a blockchain IoT architecture, focusing on **enhancing data security** and providing **transparent**, immutable **records** for **product traceability** throughout the supply chain.[11] Additionally, methodologies involve various deployment models, assessing the performance of different architectures, such as node-to-system versus gateway implementations.	However, drawbacks include **vulnerabilities** in developing **stable blockchain-IoT** systems due to **privacy concerns** related to **data handling** and the challenges posed by centralized data management, which can undermine trust in supply chains. The **reliance on centralized authority** can lead to inefficiencies and potential security risks, as traditional databases often struggle to provide trusted, tamper-proof records.[11] Moreover, many supply chains are still unable to achieve comprehensive traceability, resulting in significant waste and risk of counterfeiting.
12	Adaptation of IoT with Blockchain in Food Supply Chain Management: An Analysis-Based Review in Development, Benefits and Potential Applications	Amanpreet Kaur, Gurpreet Singh, Vinay Kukreja, Sparsh Sharma, Saurabh Singh and Byungun Yoon	2022	The methodologies described in the excerpts focus on integrating blockchain technology with the Internet of Things (IoT) to enhance the **food supply chain management** (FSCM) system. By utilizing blockchain's traceability features, stakeholders can monitor food safety and quality from farm to table, thereby improving transparency and efficiency in transactions through smart contracts and decentralized data management.[12]	However, some drawbacks include challenges such as **data fragmentation and centralized controls**, which can complicate data modification and management within the supply chain. Additionally, immature technologies, lack of legislation, and **scalability issues** present significant obstacles to the widespread adoption of this integrated approach in the food supply chain.[12]

Literature Review(7)

Sr.no	Title	Author(s)	Year	Methodology	Drawback
13	Agriculture-Food Supply Chain Management Based on Blockchain and IoT: A Narrative on Enterprise Blockchain Interoperability	Showkat Ahmad Bhat, Nen-Fu Huang, Ishfaq Bashir Sofi and Muhammad Sultan	2022	The methodologies discussed include integrating blockchain technology in **agricultural supply chain management** (Agri-SCM). This approach utilizes blockchain for product **traceability**, enhancing **transparency**, and improving the company's image and customer loyalty. The proposed system emphasizes features like audibility and the prevention of tampering with food data, which strengthens food quality assurance.[13] Moreover, the architecture combines elements of **big data analytics and machine learning** to optimize supply chain decision-making and forecasting.	However, drawbacks include the complexity of implementing a decentralized traceability system, especially with multiple tiers of suppliers that **complicate data management and traceability**.[13] Furthermore, the continuous **expansion of blockchain** can impact **system performance**, potentially leading to issues with throughput and storage as the ledger grows. Additionally, despite the benefits of enhanced accountability and transparency, the need for compliance with various regulations and standards can create barriers to widespread adoption.
14	Application of blockchain technology for sustainability development in agricultural supply chain: justification framework	Archana A Mukherjee, Rajesh Kumar S ingh, Ruchi Mishra, Surajit Bag	2021	The methodology highlighted in the excerpts involves the **Analytical Hierarchy Process** (AHP), a structured **multi-criteria decision-making tool** developed by SAATY. AHP allows for the **evaluation of complex problems** by breaking them down into a **hierarchical structure**, utilizing pairwise comparisons to determine weights for different criteria and alternatives, thereby facilitating informed decision-making in assessing sustainability in supply chains.[14]	However, a notable drawback of AHP is the potential for **inconsistency** in the **pairwise comparisons** made by decision-makers, although a consistency ratio is employed to mitigate this issue.[14] Additionally, AHP can be **cumbersome** when dealing with a **large number of criteria,** potentially leading to decision fatigue or biases among participants, which may affect the reliability of the results.

Literature Review(8)

Sr.no	Title	Author(s)	Year	Methodology	Drawback
15	Factors influencing blockchain adoption in supply chain management practices: A study based on the oil industry	Javed Aslama, Aqeela Saleema, Nokhaiz Tariq Khanb, Yun Bae Kim	2021	The methodologies discussed include various supply chain management (SCM) practices such as delayed differentiation, supply chain benchmarking, and the adoption of blockchain technology. Blockchain enhances SCM by enabling **real-time information sharing, improving cybersecurity, and providing transparency, reliability, traceability, and visibility**, which can significantly boost operational performance.[15]	However, a notable drawback is that many SCM practices, including outsourcing and third-party logistics, **require high integration** to maximize their effectiveness.[15] Without this integration, these practices may not **significantly impact operational performance**. Additionally, while blockchain offers robust cybersecurity features, its implementation in web-based information sharing is often hampered by **security concerns** and the **complexities** involved in integrating new technologies.
16	Automating procurement contracts in the healthcare supply chain using blockchain smart contracts	Ilhaam A. Omar, Raja Jayarman, Mazin S. Debe, Khaled Salah, Ibrar Yaqoob, Mohammed Omar	2021	The methodologies outlined in the document focus on leveraging blockchain technology and smart contracts to automate procurement processes in the **healthcare supply chain**. This approach aims to enhance **operational efficiency, reduce transaction costs, and improve traceability** by creating a decentralized ledger that securely tracks the procurement and inventory of medical supplies.[16] The automation of procurement contracts through smart contracts ensures that transactions are executed with **minimal human intervention, thereby streamlining workflows**.	However, drawbacks include the challenges of **integrating blockchain with existing healthcare systems**, which can be complex and require significant investment in both technology and training. There may also be concerns regarding **data privacy,** as **sensitive healthcare information** must be managed within the blockchain framework.[16] Additionally, the necessity for widespread stakeholder adoption is crucial; without participation from all parties in the supply chain, the effectiveness of the blockchain solution could be diminished. Overall, while the proposed methodologies present promising advancements, significant barriers still need to be addressed for full implementation.

Research Gap(Limitations of existing systems)

The issue of transparency and traceability in ammunition management remains unsolved, with blockchain offering potential solutions. Challenges include resistance to new technologies and integration complexities. Smart contracts show promise in automating processes and combining blockchain with big data analytics could enhance decision-making. A blockchain-based system, with stakeholder training, can significantly improve security and accountability by streamlining operations and securing data through immutable ledgers.

Problem Definition

Current ammunition management systems lack sufficient transparency, traceability, and accountability, leading to security risks and unauthorized access. To address these challenges, the proposed solution involves using blockchain technology and smart contracts to automate and secure the entire ammunition lifecycle. This approach aims to prevent unauthorized access, enhance logistical efficiency, and create an immutable, tamper-proof record of every transaction from procurement to disposal.

Scope

- Multi-national Collaboration: Facilitates secure, compliant data sharing across allied nations.
- IoT Monitoring: Tracks environmental conditions to prevent ammunition degradation.
- Predictive Analytics: Forecasts ammunition needs for proactive procurement.
- Quantum-resistant Blockchain: Protects against future quantum computing threats.
- Scalability & Security: Ensures resilience and adaptability to future cybersecurity challenges.

Technological Stack

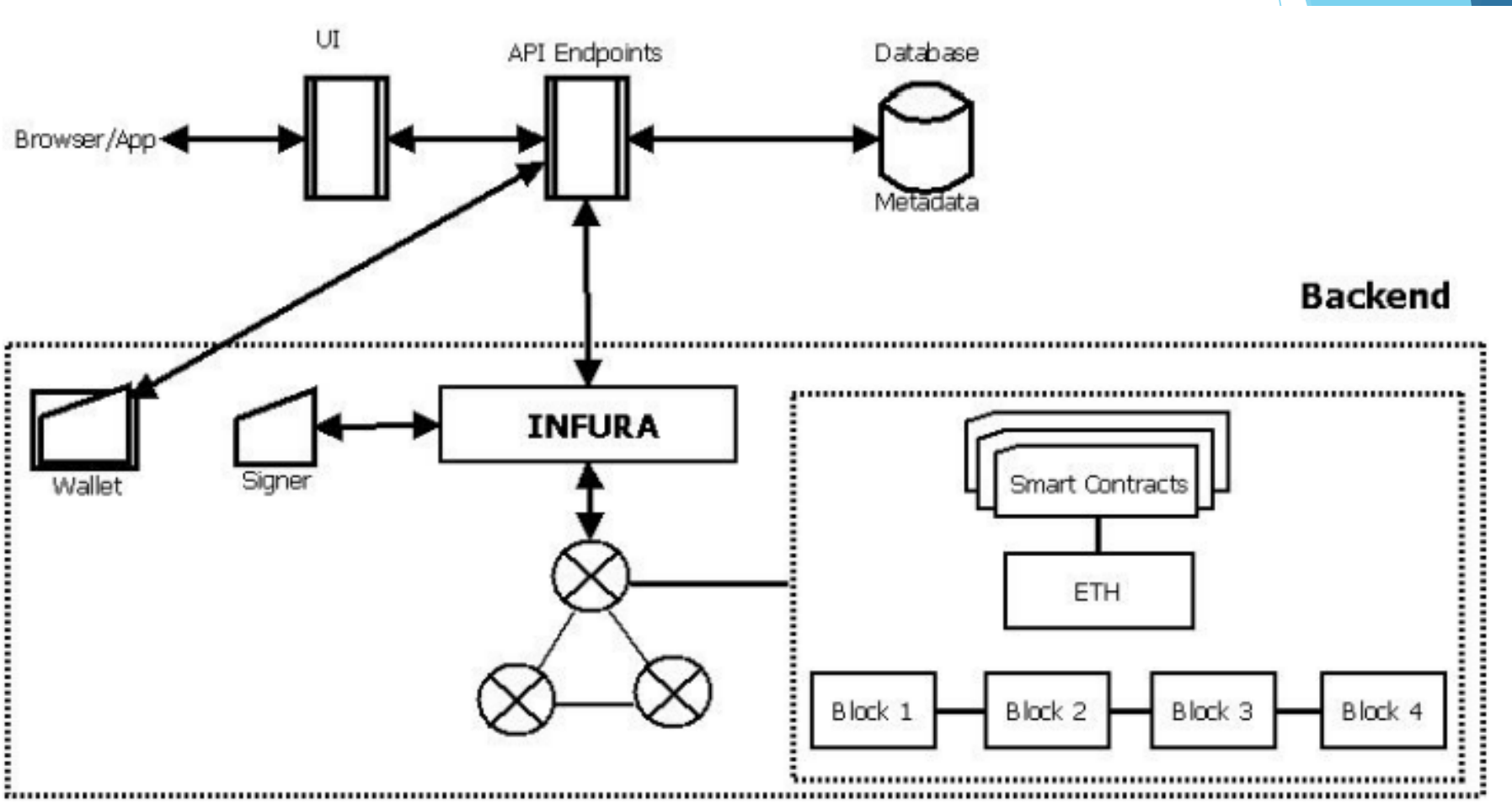
Frontend (Client-Side)

- React.js
- HTML5/Tailwind CSS & Bootstrap
- JavaScript / TypeScript
- Web3.js / Ethers.js
- MetaMask Integration

Backend (Server-Side)

- Next.js / Python
- Express.js / Flask
- Solidity (Smart Contracts)
- Blockchain Platform (Ethereum)
- MongoDB

Proposed system architecture/Working



Proposed system architecture/Working

- **Frontend (UI):**

- **Browser/App**: The user interacts with the dApp via a browser or mobile app, which serves as the user interface (UI). This is where the user inputs information and views output.
- **API Endpoints**: These endpoints act as a middle layer between the UI and the backend services. They handle requests from the user interface and process the data to communicate with the backend components like the database or blockchain network.

- **Backend:**

- **Database (Metadata)**: This store's off-chain data related to the dApp, such as user profiles, app settings, and metadata. Blockchain networks are inefficient at storing large amounts of data, so a regular database complements blockchain storage.

Proposed system architecture/Working

- **INFURA**: INFURA is a service that provides access to Ethereum (ETH) blockchain networks without needing to run a full node. It handles communication between the dApp and the Ethereum blockchain, simplifying interaction with smart contracts and blockchain data.
- **Smart Contracts**: These self-executing contracts reside on the Ethereum blockchain (shown as "ETH"). Smart contracts automatically execute predefined conditions based on the blockchain's logic. They handle token transfers, transactions, and other blockchain-specific actions.
- **Wallet**: The wallet represents the user's private key storage, allowing them to sign transactions and interact with the blockchain. It contains their cryptocurrencies (e.g., ETH).

Proposed system architecture/Working

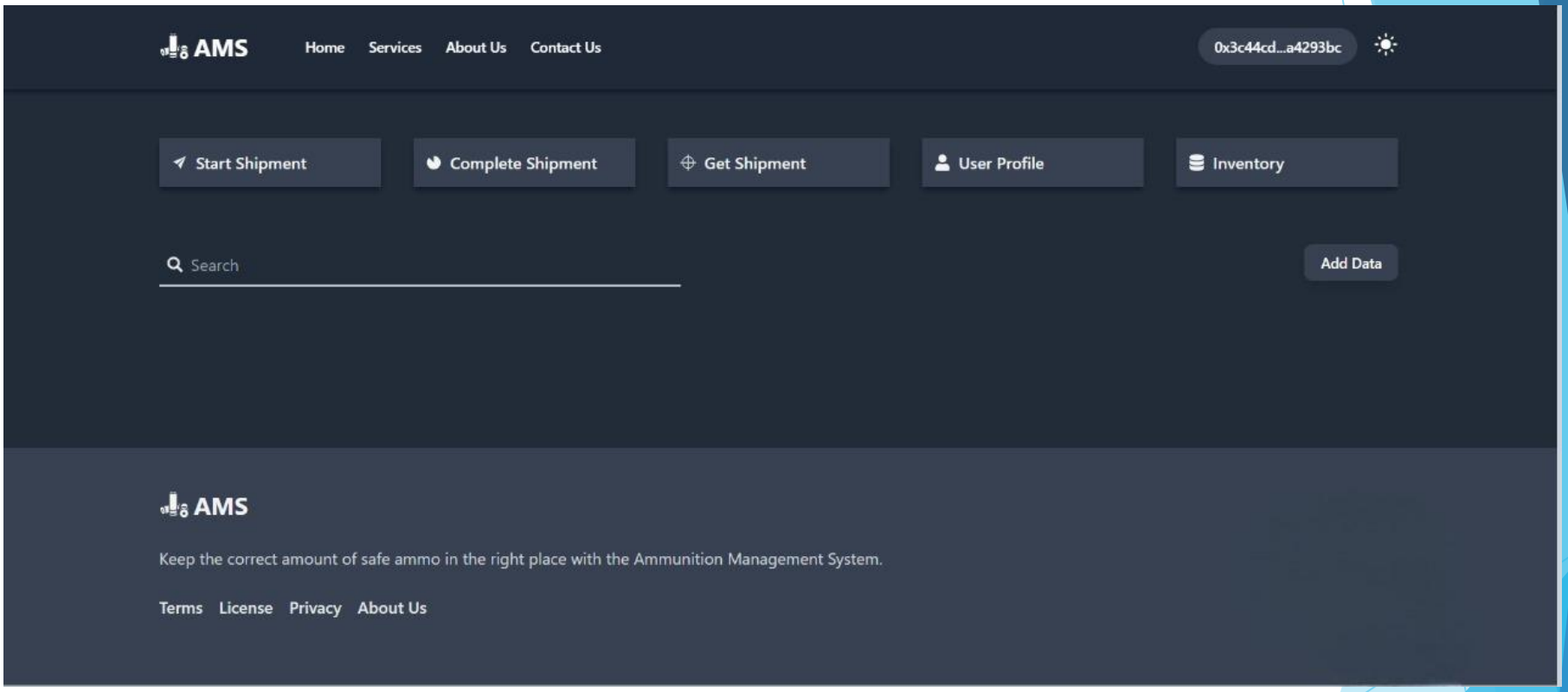
- **Signer**: The signer is a cryptographic function or service that allows users to sign blockchain transactions, typically using the private key stored in the wallet.
- **Blocks (Block 1, Block 2, Block 3, Block 4)**: These represent the blocks in the blockchain, where transactions are grouped, validated, and stored. Each block contains a list of transactions, ensuring the immutability and security of the data.

Proposed system architecture/Working

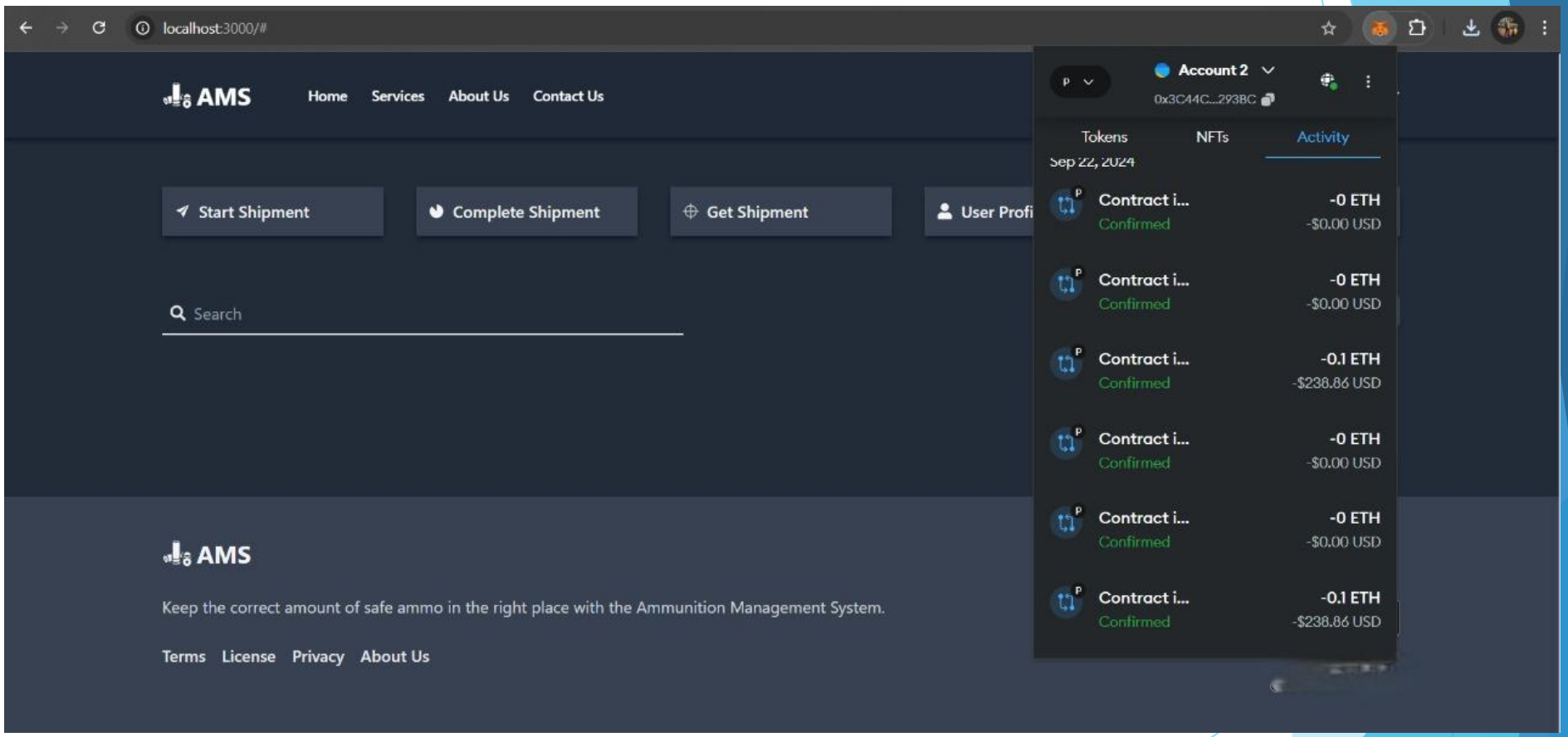
❑ **Flow Summary:**

- The user interacts with the dApp through the browser or app.
- The API endpoints handle communication between the front end and backend.
- INFURA connects the dApp to the Ethereum network, allowing interactions with smart contracts and the blockchain.
- The wallet and signer are responsible for user transaction authorization and signing.
- The smart contracts are executed on the blockchain-based on predefined rules, with each transaction being stored in sequential blocks on the chain.
- Metadata and off-chain data are stored in a traditional database.

Prototype Design Demonstration



Prototype Design Demonstration



Implementation Status

- **UI for the admin side has been implemented.**
- **Blockchain has been implemented for the admin side.**

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Thank You...!!