Blockchain-Based Ammunition Supply Chain Traceability

1. Project Overview

The project aims to enhance the security, transparency, and accountability of the ammunition supply chain by leveraging blockchain technology. Using Hyperledger Fabric, the system records and manages ammunition lifecycle events—ranging from manufacturing to deployment—ensuring end-to-end traceability while preserving data privacy.

2. Problem Statement

The ammunition supply chain faces several critical challenges:

- **Lack of End-to-End Visibility:** There is no seamless tracking from production facilities to deployment sites.
- **Manual Record-Keeping:** Reliance on manual logs exposes data to tampering, errors, and delays.
- **Counterfeiting and Misplacement Risks:** Without real-time tracking, counterfeit or misplaced batches go undetected for extended periods.
- **Inadequate Oversight:** Headquarters lacks detailed insight into who handled batches, when, and where without exposing classified data.

3. Proposed Solution

This project implements a blockchain-powered solution using **Hyperledger Fabric** to:

- **Record Every Transaction:** Every movement, storage, or status change of ammunition batches is securely logged on the ledger.
- **Track Batches:** Batches are traced from manufacturing, transportation, storage, to deployment.
- **Use Private Data Collections (PDCs):** Sensitive information is shared only between authorized organizations while maintaining the integrity of audit logs.
- **Enable HQ Oversight:** Defense headquarters can audit the entire lifecycle without revealing confidential operational details.

4. System Architecture

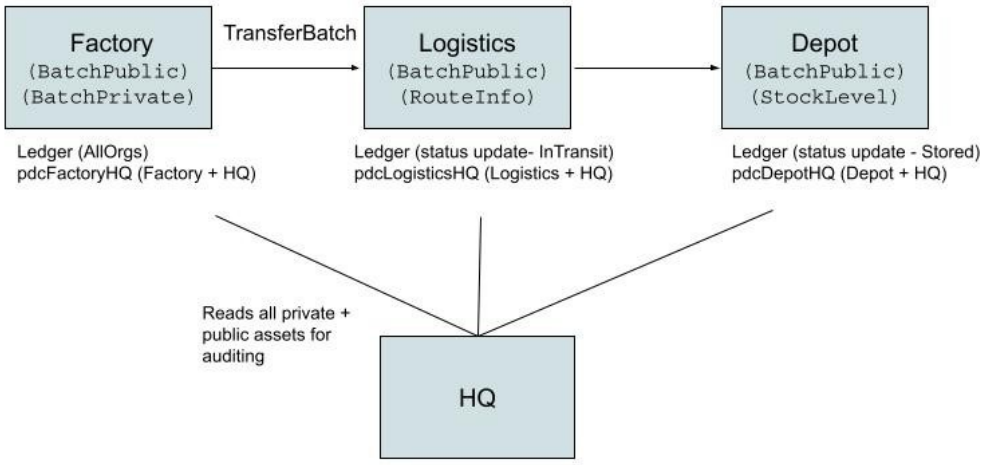
Participating Organizations

Organization	Role
Ordnance Factory (Org1)	Manufactures ammunition batches
Logistics Division (Org2)	Handles transport operations
Army Depot (Org3)	Stores and issues ammunition
Defense HQ (Org4 - Auditor)	Monitors and audits supply chain activities

Assets

1. **BatchPublic**
    - **Visibility:** All organizations
    - **Purpose:** General batch tracking, shipment planning, lifecycle status
2. **BatchPrivate**
    - **Visibility:** Factory and HQ (stored in PDC)
    - **Purpose:** Confidential batch details, HQ audit, factory tracking
3. **RouteInfo**
    - **Visibility:** Logistics and HQ (stored in PDC)
    - **Purpose:** Transport route information for auditing purposes
4. **StockLevel**
    - **Visibility:** Depot and HQ (stored in PDC)
    - **Purpose:** Tracks stock levels without exposing unnecessary data

5. Information Flow



Factory (Org1)

- Creates **BatchPublic**, visible to all organizations
- Creates **BatchPrivate**, visible only to HQ

Logistics (Org2)

- Updates **BatchPublic** to reflect transit status
- Stores **RouteInfo** privately, visible only to HQ

Army Depot (Org3)

- Updates **BatchPublic** when stored at the depot

- Stores **StockLevel** privately, visible only to HQ

Defense HQ (Org4)

- Accesses both public and private assets for auditing and oversight while preserving data confidentiality

6. Benefits

- **Complete Traceability:** Tracks ammunition throughout its lifecycle.
- **Tamper Prevention:** Immutable ledger prevents data manipulation.
- **Counterfeit Detection:** Quick identification of misplaced or fake batches.
- **Controlled Data Sharing:** Sensitive data is accessible only to authorized parties.
- **Efficient Auditing:** HQ can monitor operations without compromising security.
- **Operational Transparency:** Real-time updates reduce communication gaps.

7. Technologies Used

- **Hyperledger Fabric:** For permissioned blockchain operations and private data sharing.
- **Private Data Collections (PDCs):** To ensure restricted data visibility.
- **Smart Contracts:** For defining rules and automating batch updates.
- **Role-Based Access Control:** To enforce permissions and audit rights.

8. Example Workflow

1. **Batch Creation:**
   The factory creates a batch with Batch Id **Batch-001** containing 1000 shells with an expiry date of 2030. General information is recorded as BatchPublic, while sensitive data is stored as BatchPrivate.
2. **Transportation:**
   The logistics division picks up the batch. The status is updated to "In-Transit" in BatchPublic. Transport routes are stored in RouteInfo, visible only to logistics and HQ.
3. **Depot Storage:**
   The batch is delivered to the army depot and the status of Batch is marked as "Received". Stock levels are updated in StockLevel, visible only to the depot and HQ.
4. **Audit:**
   HQ reviews the entire transaction history, confirming that the chain of custody is intact without any tampering or unauthorized access.

9. Future Scope

- Integration with IoT sensors for automated tracking.
- Real-time alerts for supply chain anomalies.
- Enhanced analytics and reporting for decision-making.
- Expansion to other defense and critical supply chain sectors.