Blockchain-Based Product Authentication

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# 1. Problem Statement

Counterfeit products are a growing threat to consumers and industries, leading to loss of trust and financial damage. There is a need for a secure, tamper-proof solution to authenticate products from production to end-user.

# 2. Objective

To build a blockchain-based system that registers and verifies authentic products using a smart contract deployed on the Ethereum Sepolia testnet. The system ensures that each registered product can be publicly verified as genuine.

# 3. Tools and Technologies

- Ethereum Sepolia Testnet  
- Solidity (Smart Contract Language)  
- Remix IDE  
- MetaMask  
- QR Code for Contract Access

# 4. Smart Contract Details

Contract Address: 0xDb5e9c4D49145b74378dB146E1caBc49eDb54653

Functions: registerProduct, getProduct

Product ID registered: PRD124

Product Name: iPhone 15

# 5. How It Works

1. Manufacturer registers a product with a unique Product ID.  
2. The product data is stored immutably on the blockchain.  
3. Anyone can check authenticity by querying the Product ID.  
4. If found, the product is genuine. If not found, it's unauthentic.

# 6. Demo Steps

1. Deployed the smart contract on Sepolia using Remix + MetaMask.  
2. Registered product PRD124 (iPhone 15).  
3. Used getProduct() to confirm blockchain registration.  
4. Verified authenticity with a frontend and QR code.

## 7. Future Scope

The current implementation demonstrates product authentication using a smart contract deployed on the Ethereum Sepolia testnet. While effective as a prototype, the following enhancements can be considered to make it suitable for real-world deployment:

1. **Frontend Interface (DApp):**  
   Develop a user-friendly web or mobile application using Web3.js or Ethers.js to allow customers to verify products by simply entering or scanning a Product ID.
2. **QR Code Integration:**  
   Generate QR codes for each product’s unique ID, enabling customers or retailers to scan and verify authenticity quickly without manual input.
3. **Role-Based Access Control:**  
   Implement admin-level permissions within the smart contract to restrict product registration to authorized manufacturers only.
4. **Expanded Metadata:**  
   Include more product details such as batch number, manufacture date, expiration date, and product category to enhance traceability.
5. **Scalability via IPFS or Layer 2 Solutions:**  
   Store large or sensitive metadata off-chain using IPFS and link it to the product ID, or migrate the system to a Layer 2 network (e.g., Polygon) for reduced gas costs and higher scalability.
6. **Multi-Stakeholder Interaction:**  
   Enable supply chain stakeholders like distributors, retailers, and consumers to interact with the system (e.g., update delivery status, verify source).
7. **RFID/NFC Integration (Hardware):**  
   Combine blockchain with RFID or NFC tags embedded in physical products for secure and contactless authentication.
8. **Real Mainnet Deployment:**  
   Once fully tested, deploy the contract on Ethereum Mainnet or other production-grade blockchain platforms for actual use in industries.

# 8. Conclusion

This project demonstrates how blockchain can be used for secure product authentication. It prevents tampering and enables public verification. The system can be extended to various industries.