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Using blockchain for Transparent Management of Public Procurements

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Abstract

It's honestly disappointing how much public money gets wasted on poor deals especially in developing countries like Algeria . In some cases, around 20 to 25 percent of government budgets just vanish, mainly due to corruption. While governments are aware of the problem and have taken steps to use public funds more wisely, challenges remain. One popular solution has been e-procurement using digital tools to manage public buying more fairly and efficiently. But even with these systems in place, corruption and human error still manage to sneak in. That's why Blockchain technology is getting so much attention. It's not just a buzzword it actually offers a way to make systems more secure, transparent, and hard to manipulate. Because everything on the Blockchain is traceable and can't be altered, it creates trust. In our research, we looked at how Blockchain could improve government procurement processes, especially in selecting suppliers. The goal is to make everything clearer, more accountable, and harder to exploit. Keywords: public procurement, e-procurement, corruption, blockchain, smart contracts.

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Introduction

Public procurement, the way governments buy goods, services, and infrastructure, is one of the biggest drivers of public spending, often accounting for 12–20% of a country's GDP (**Gross Domestic Product**). But despite its scale and importance, procurement systems are often inefficient, opaque, and prone to corruption. These issues can lead to wasted resources, unfair competition, and a lack of public trust.

Blockchain technology offers a new way forward. Known for powering cryptocurrencies, blockchain has grown into a powerful tool for transparency and accountability. With features like distributed ledgers, smart contracts, and cryptographic security, it's well-suited to solve many of the problems that plague procurement, like hidden decisions, tampered bids, and unreliable audits.

This thesis explores how blockchain can improve public procurement. It proposes a blockchain-based system designed to make procurement processes more trustworthy, auditable, and efficient. The approach combines theory, technical design, and real-world case studies.

The document is structured into four chapters:

- **Chapter 1** lays out the basics of blockchain, how it works, what makes it secure, and how different consensus mechanisms compare.
- **Chapter 2** examines current procurement frameworks, common challenges, and where existing digital platforms fall short.
- **Chapter 3** proposes a blockchain-powered model for handling bids, evaluations, and contract execution with smart contracts and a permissioned ledger.
- **Chapter 4** walks through a working prototype built with Solidity and MetaMask, simulating tender cycles and evaluating the system's performance.

The goal is to show that blockchain isn't just a theoretical fix, it can actually work in practice. With the right design and gradual adoption, it has the potential to make public procurement more transparent, fair, and resilient.

Chapter 1: Blockchain

Introduction

Blockchain is a groundbreaking technology that has transformed the way we think about data, trust, and transactions. At its core, blockchain is a decentralized and distributed digital ledger that records transactions across multiple computers in a secure and transparent manner. Unlike traditional systems, where a central authority manages the data, blockchain operates on a peer-to-peer network, ensuring that no single entity has full control. This decentralized structure, combined with cryptographic security, makes blockchain immutable and tamper-proof, fostering trust among participants without the need for intermediaries.

Why is Blockchain Important?

The significance of blockchain extends far beyond its origins in cryptocurrency. It has become a key enabler of innovation across a wide range of industries:

- **Finance:** Blockchain underpins cryptocurrencies like Bitcoin and Ethereum, enabling fast, borderless, and low-cost financial transactions. It also powers decentralized finance (DeFi) platforms, which provide financial services without intermediaries.
- **Healthcare:** Patient records can be securely stored and shared using blockchain, ensuring data integrity while protecting sensitive information from unauthorized access.
- **Supply Chain and Logistics:** Blockchain enhances transparency by enabling real-time tracking of goods, ensuring authenticity, and reducing fraud.
- **Public Administration:** From digital voting to transparent procurement systems, blockchain has the potential to revolutionize how governments operate, promoting accountability and reducing corruption.
- **Intellectual Property and Entertainment:** Artists, creators, and developers can use blockchain to establish ownership and monetize their work directly, without intermediaries.

This versatility and potential for disruption make blockchain one of the most significant technological advancements of the 21st century.

Chapter Objectives

The goal of this chapter is to provide a comprehensive yet accessible overview of blockchain technology. We will:

1. Explore the origins and evolution of blockchain, from its inception with Bitcoin to its current applications in various sectors.
2. Break down the fundamental principles of blockchain, including its structure, operation, and key features such as decentralization, transparency, and immutability.
3. Examine the different types of blockchains, public, private, and hybrid, and their use cases.

4. Highlight real-world applications of blockchain technology to demonstrate its transformative potential.
5. Address the challenges and limitations of blockchain, setting the stage for a deeper dive into its application in public procurement in subsequent chapters.

By the end of this chapter, readers will have a solid understanding of blockchain's foundational concepts, enabling them to grasp its relevance and its potential to address complex challenges, particularly in the realm of public procurement.

1. History and Evolution of Blockchain

1.1. Origins of Blockchain

The concept of blockchain first emerged in 2008 with the release of the Bitcoin whitepaper^[44], titled *“Bitcoin: A Peer-to-Peer Electronic Cash System”*, authored by the pseudonymous creator Satoshi Nakamoto. This whitepaper introduced the revolutionary idea of a decentralized digital currency system, where transactions could be conducted directly between parties without the need for a trusted intermediary, such as a bank.

At the heart of Bitcoin's success was the blockchain, a distributed and immutable ledger that securely recorded all transactions. The key innovations of this first-generation blockchain included:

- **Decentralization:** Transactions were verified by a network of nodes (computers) rather than a central authority.
- **Consensus mechanism:** Bitcoin utilized Proof of Work (PoW) to validate and secure transactions through a computationally intensive process called mining.
- **Immutability:** Once a transaction was recorded on the blockchain, it could not be altered, ensuring trust and transparency.

This initial application of blockchain focused solely on creating a secure, decentralized currency, but it laid the foundation for broader use cases.

1.2. Evolution to Blockchain 2.0 and 3.0

The limitations of the first-generation blockchain, such as its narrow focus on cryptocurrency, paved the way for the development of more advanced iterations.

Blockchain 2.0: The Rise of Smart Contracts

In 2015, Ethereum, created by Vitalik Buterin ^[45], introduced the concept of smart contracts, self-executing contracts with predefined rules encoded directly into the blockchain. This innovation transformed blockchain from being merely a ledger for transactions to a platform capable of executing programmable agreements. Ethereum opened the door to decentralized applications (DApps) across a wide range of industries, including:

- **Decentralized Finance (DeFi):** Platforms enabling services like lending, borrowing, and trading without intermediaries.
- **Tokenization:** Issuance of tokens representing assets like real estate, art, or shares in a company.

Blockchain 3.0: Towards Scalability and Sustainability

The third generation of blockchain focuses on addressing challenges such as scalability, energy efficiency, and interoperability. Key advancements include:

- **Scalable solutions:** Layer 2 technologies like the Lightning Network and sidechains enable faster and cheaper transactions.
- **Consensus innovations:** Alternatives to Proof of Work, such as Proof of Stake (PoS), significantly reduce energy consumption [1]. Ethereum's transition to Ethereum 2.0 is a prime example of this evolution.
- **New use cases:** Beyond cryptocurrencies and smart contracts, Blockchain 3.0 has spurred innovations in decentralized identity systems, supply chain traceability, and the emerging Metaverse.

This evolution has made blockchain a versatile tool, capable of addressing complex challenges far beyond its original scope. Figure 1 illustrates the progression of blockchain technology through its various versions, highlighting how each phase introduced new capabilities and expanded its potential applications.

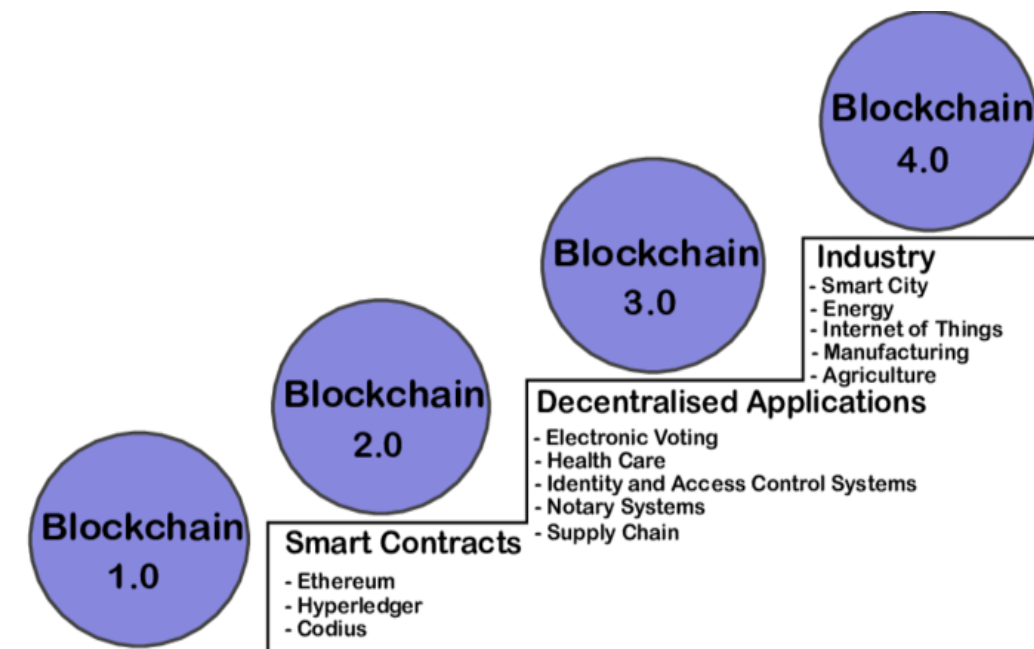


Figure 1: Blockchain versions

1.3. Major Milestones and Current Trends

The history of blockchain is marked by several milestones that highlight its growing adoption and impact:

- **2017: Initial Coin Offerings (ICOs)**
Blockchain technology became a popular fundraising mechanism, with ICOs raising billions of dollars for blockchain-based projects. However, this period also saw significant regulatory scrutiny due to fraud and speculative bubbles.
- **2018-2020: Corporate Adoption**
Companies like IBM, Microsoft, and JPMorgan began exploring private blockchains for enterprise applications, such as supply chain management and cross-border payments.
- **2020-Present: DeFi and NFTs**
The DeFi boom marked a significant milestone for decentralized finance, with billions of dollars locked in smart contracts for lending, borrowing, and staking. Simultaneously, Non-Fungible Tokens (NFTs) revolutionized the way digital art and collectibles are created, traded, and owned.
- **Government Adoption**
Countries are increasingly exploring blockchain for governance. For example:
 - **China:** Development of the Digital Yuan and integration of blockchain into its economic planning.
 - **Estonia:** Pioneering e-governance with blockchain-based digital identity systems.
 - **El Salvador:** Adoption of Bitcoin as legal tender.
- **Emerging Trends**
Blockchain continues to evolve, with trends like:
 - **Green blockchains:** Reducing the environmental impact through energy-efficient consensus mechanisms.
 - **Interoperability:** Creating systems where multiple blockchains can interact seamlessly (e.g., Polkadot, Cosmos).
 - **Decentralized Autonomous Organizations (DAOs):** Democratizing decision-making in organizations through blockchain technology.

These milestones demonstrate how blockchain has progressed from a niche technology to a cornerstone of innovation, shaping the future of industries worldwide.

2. Fundamental Principles of Blockchain

2.1 Structure of a Blockchain

In addition to its historical development, blockchain technology can also be understood through its layered architecture. This model breaks down the system into several functional layers from the foundational data layer to the application layer each responsible for specific tasks such as

data integrity, network communication, consensus, incentives, and execution of smart contracts. The following diagram provides a detailed overview of these layers and their key components.

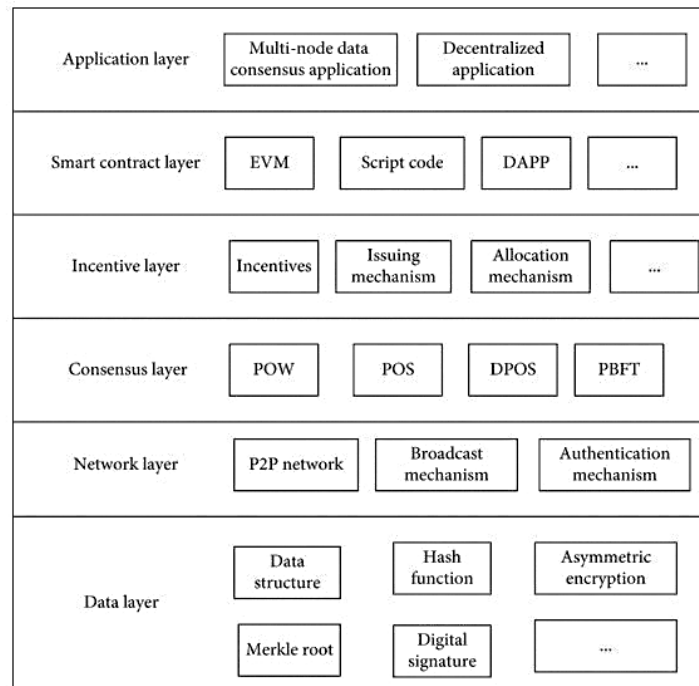


Figure 2 : Schematic diagram of the blockchain technology system

Structure of a Block

Each block in a blockchain comprises three main components:

1. **Header:** Contains metadata about the block, including:
 - **Timestamp:** Records the exact time the block was created.
 - **Previous Block Hash:** A cryptographic link to the hash of the preceding block, ensuring continuity in the chain.
 - **Nonce:** A number used during the mining process to generate the correct hash value.
 - **Merkle Root:** A hash that summarizes all the transactions within the block, enabling efficient and secure verification.
2. **Data/Transactions:** This section includes the actual information being stored in the block, such as transaction details, smart contract execution, or other types of records.
3. **Hash:** A unique identifier (fingerprint) of the block, generated using a cryptographic hash function (e.g., SHA-256 for Bitcoin).

Chaining of Blocks

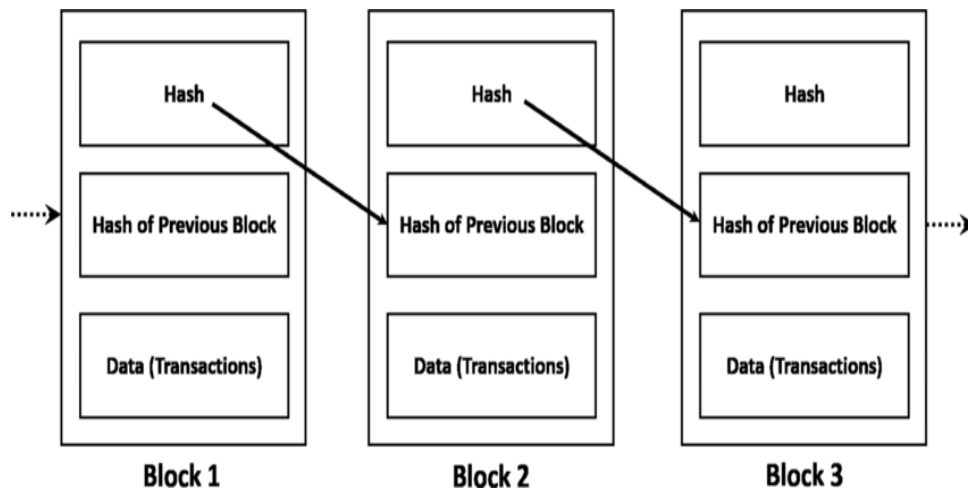


Figure 3 : Simplified-diagram-of-a-blockchain

The blocks are cryptographically linked using their hashes (see figure 3). Each block contains the hash of the previous block in its header. If any data in a block is altered, its hash changes, breaking the chain. This mechanism ensures:

- **Immutability:** Once added, blocks cannot be modified without affecting the entire chain.
- **Integrity:** The chain remains intact as long as the hashes match sequentially.

2.2 How Blockchain Works

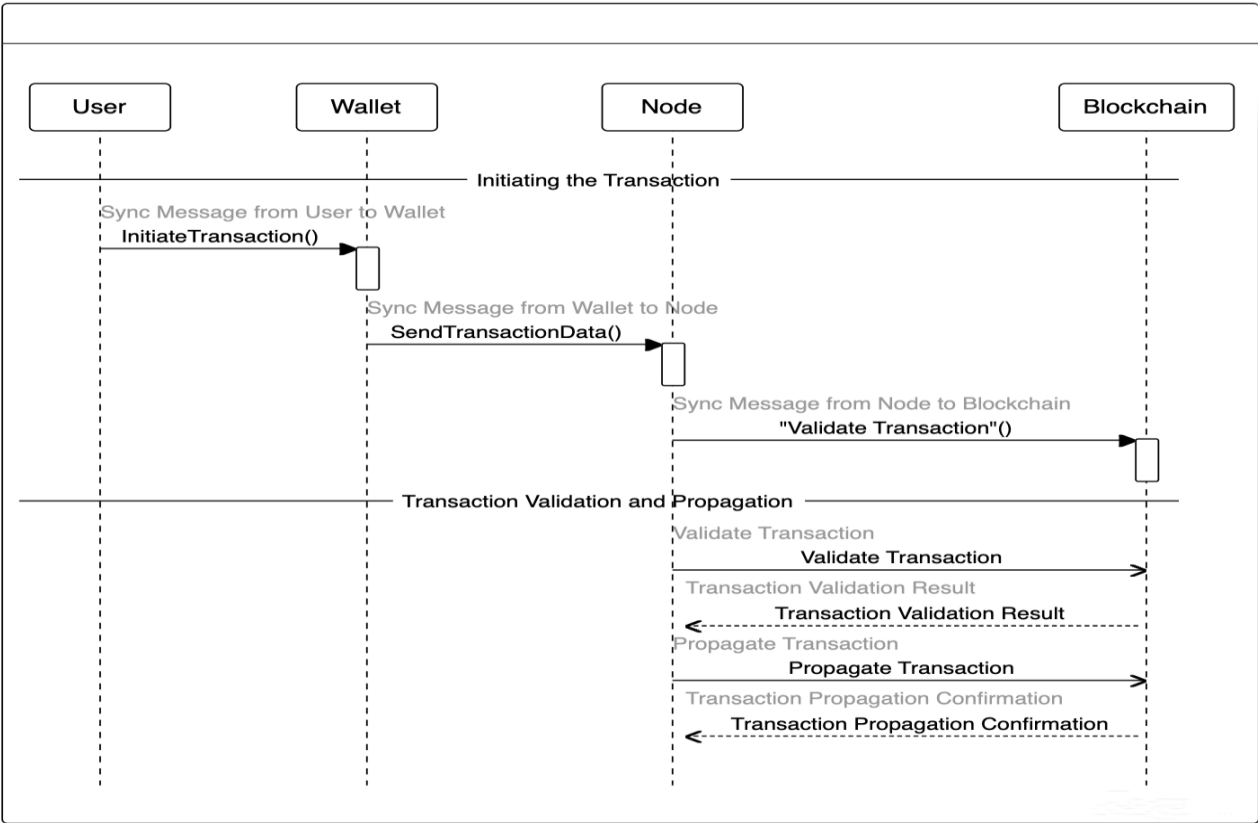


Figure 4 : Sequence Diagram of a Transaction (Validation and Propagation)

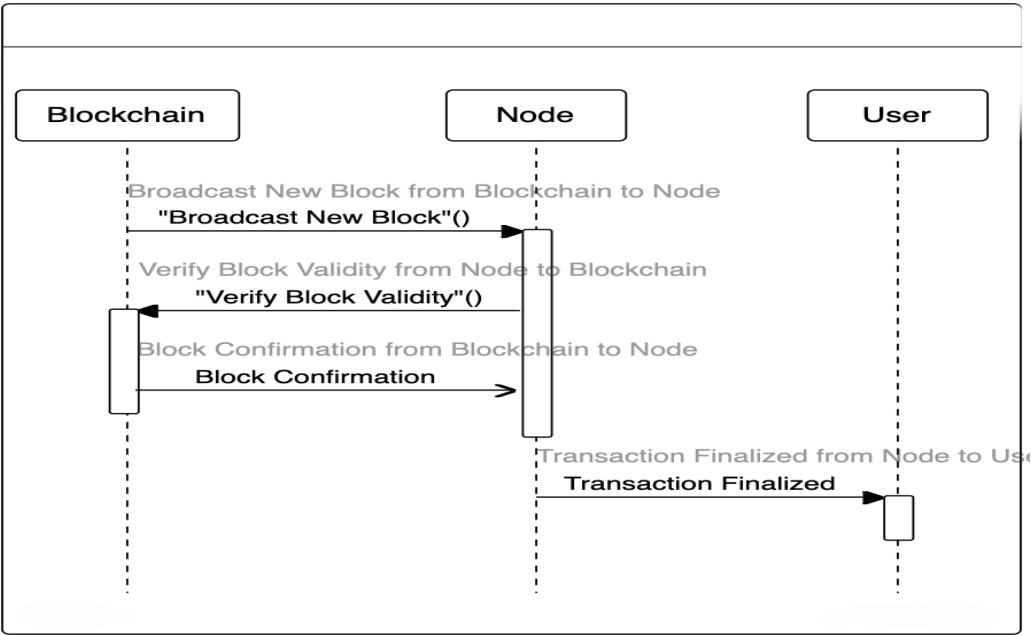


Figure 5 : Sequence Diagram of a Transaction (Confirmation and Finalization)

Decentralized Consensus

In traditional financial systems, a central authority, such as a bank, verifies and records

transactions. Blockchain, however, eliminates the need for a central authority by relying on a decentralized network of participants who work together to validate transactions. This is achieved through **consensus mechanisms**, which ensure that all participants (nodes) in the network agree on a single, consistent version of the ledger.

Different blockchains use various consensus mechanisms depending on their objectives, such as security, transaction speed, energy efficiency, or decentralization. The most widely used mechanisms are as follows:

Proof of Work (PoW)

Proof of Work is the first and most widely recognized consensus mechanism, introduced by Bitcoin in 2009. It relies on **miners**, who are network participants that compete to solve complex cryptographic puzzles. The first miner to solve the puzzle earns the right to add a new block to the blockchain and is rewarded with newly minted cryptocurrency.

Mechanism:

- Miners use computational power to solve a mathematical problem known as a hash puzzle.
- The first miner to find the correct solution broadcasts it to the network.
- Other nodes verify the solution before adding the new block to the chain [2].

Advantages:

- High security, as altering past transactions would require an impractical amount of computing power.
- Fully decentralized, allowing open participation.

Limitations:

- High energy consumption due to the continuous computational effort required.
- Lower transaction throughput compared to alternative consensus mechanisms.

Examples of Use: Bitcoin, Ethereum (before Ethereum 2.0), Litecoin.

Here is a figure that displays this model of consensus algorithm concept :



Figure 6: infographics Proof of Work PoW

Proof of Stake (PoS)

Proof of Stake was introduced as an alternative to PoW to improve energy efficiency. Instead of relying on computational power, PoS selects validators based on the amount of cryptocurrency they hold and are willing to “stake” as collateral.

Mechanism:

- Participants lock up a certain amount of cryptocurrency in a smart contract.
- The network selects a validator at random, with a higher stake increasing the chances of selection [3].
- The chosen validator confirms transactions and adds a new block.

Advantages:

- Lower energy consumption compared to PoW, as it does not require intensive computation.
- Faster transaction validation times and lower transaction fees.

Limitations:

- Greater influence of wealthier participants, as those with larger stakes have a higher probability of being selected.
- Some PoS models may be susceptible to the “nothing-at-stake” problem, where validators attempt to approve multiple conflicting transactions

Here is a figure that displays this model of consensus algorithm concept:

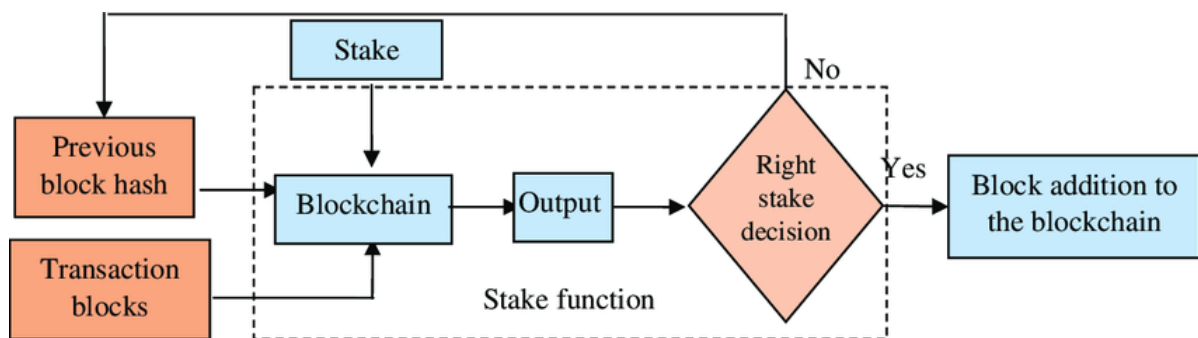


Figure 7: The working mechanism of the proof of stake consensus algorithm

Examples of Use: Ethereum 2.0, Cardano, Polkadot, Solana.

Proof of Authority (PoA)

Proof of Authority is a consensus mechanism that prioritizes **efficiency and speed over decentralization**. Unlike PoW and PoS, where validators are chosen based on computational work or financial stake, PoA relies on **pre-approved validators**. It is commonly used in **private or consortium blockchains** where trust among participants is established [4].

Mechanism:

- A limited number of validators are selected based on their credibility and trustworthiness.
- Validators take turns verifying and adding new blocks.
- Since there is no competition, transactions are processed quickly and efficiently.

Advantages:

- High transaction speed due to the absence of competitive validation.
- Reduced computational and financial costs.

Limitations:

- Increased centralization, as only a small number of entities control block validation.

- Lower resistance to censorship compared to PoW and PoS.

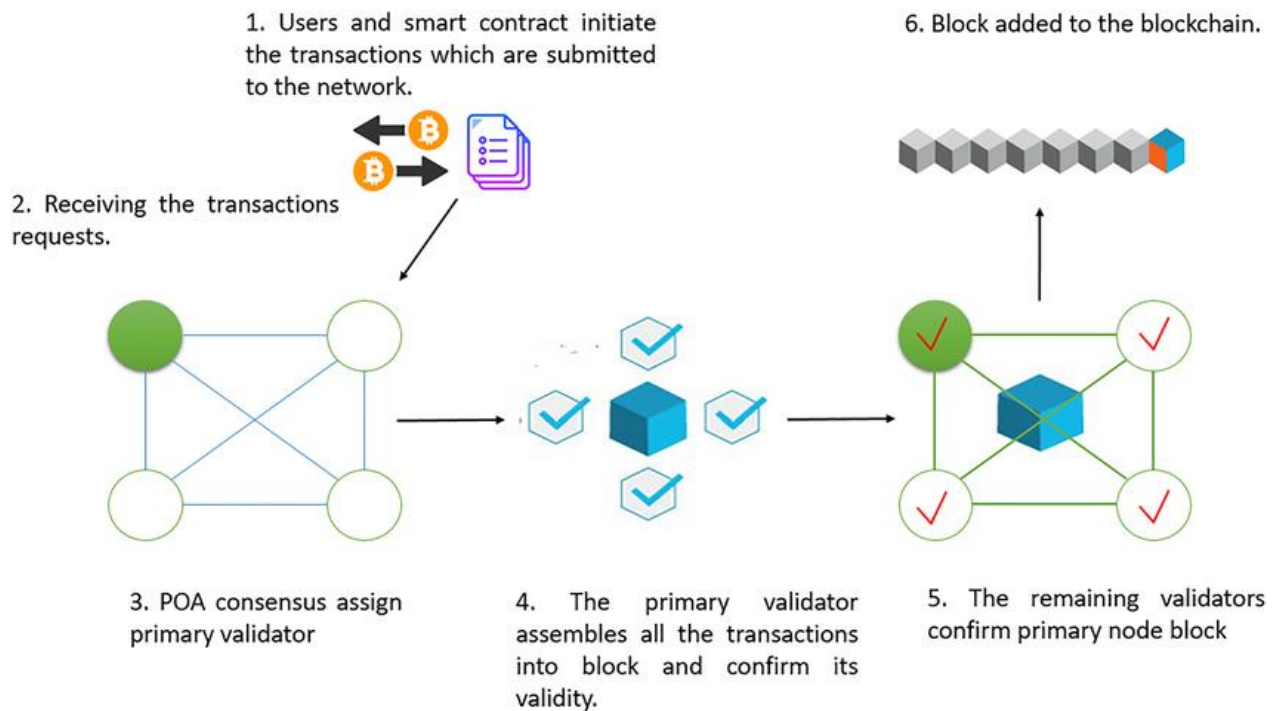


Figure 8: Proof of authority PoA consensus mechanism

Examples of Use: VeChain, Corda, private Ethereum-based blockchains.

Proof of Space-Time (PoST)

Proof of Space-Time, also referred to as Proof of Capacity or Proof of Storage, introduces an alternative approach to transaction validation by leveraging **storage space instead of computational power**. In this model, network participants allocate unused storage capacity to support the blockchain.

Mechanism:

- Users dedicate a portion of their hard drive space to store cryptographic data, which functions as proof of their commitment to the network.
- The probability of being selected as a validator increases with the amount of storage allocated.
- Validation is periodically verified over time to ensure continued participation.

Advantages:

- Significantly lower energy consumption compared to PoW, making it a more sustainable alternative.
- Utilizes existing storage resources, reducing the dependency on specialized mining hardware.

Limitations:

- Requires large amounts of storage space, which may create barriers to entry.
- Potential risk of centralization if a small number of entities control the majority of storage resources.

Here is a figure that displays this model of consensus algorithm concept :

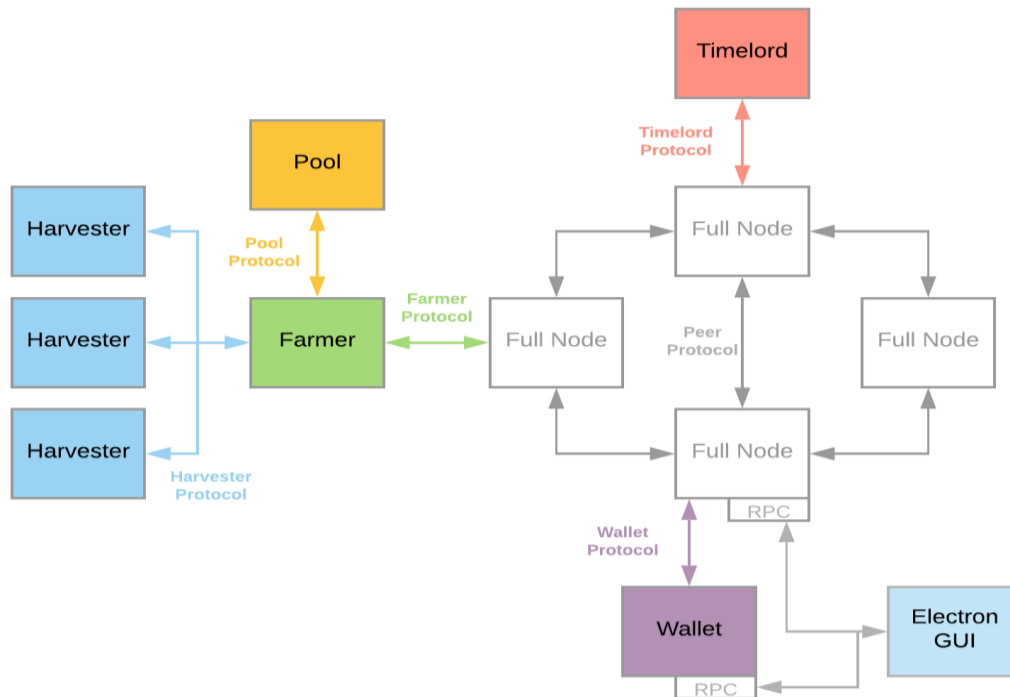


Figure 9: space time PoST

Examples of Use: Chia Network, Filecoin.

Consensus Algorithm	Core Idea	Used In / Examples	Main Advantages	Main Drawbacks
Proof of Work (PoW)	Miners solve puzzles with computational power	Bitcoin, Litecoin	High security, decentralized	High energy use, slow throughput
Proof of Stake (PoS)	Validators are chosen based on staked coins	Ethereum 2.0, Cardano, Solana	Energy efficient, faster than PoW	Wealth-based influence, possible 'nothing at stake' issue
Delegated Proof of Stake (DPoS)	Stakeholders vote for delegates who validate blocks	EOS, TRON, Steem	Fast, scalable	Centralization risk through delegate selection
Proof of Authority (PoA)	A small set of approved validators	VeChain, Corda, private	Fast, low cost	Not decentralized, lower trust in

		Ethereum chains		permissioned environments
Proof of Space (PoSpace)	Validators allocate disk space instead of computing	Burstcoin	Energy-efficient	Requires large disk storage
Proof of Space-Time (PoST)	Builds on PoSpace, verifies continued storage over time	Chia, Filecoin	Very low energy use	Centralization risk via large storage farms
Proof of Elapsed Time (PoET)	Trusted hardware determines block producers	Hyperledger Sawtooth	Energy efficient, fair random selection	Requires trusted hardware, less decentralized
Proof of Burn (PoB)	Coins are 'burned' to gain mining rights	Slimcoin, Counterparty	No need for hardware, incentivizes long-term commitment	Burning assets is wasteful
Proof of Activity (PoA)	Hybrid: PoW then PoS for validation	Decred	Combines PoW security with PoS efficiency	Still needs mining hardware
Proof of Importance (PoI)	Measures a user's network importance	NEM	Promotes active and valuable participation	Complex calculation of importance
Practical Byzantine Fault Tolerance (PBFT)	Agreement through message exchanges	Hyperledger Fabric, Tendermint	Fast, final consensus	Not scalable beyond a certain number of nodes
Federated Byzantine Agreement (FBA)	Nodes choose trusted quorum slices	Stellar, Ripple	High speed, low energy	Relies on trust assumptions, possible cartel risk
Directed Acyclic Graph (DAG)	Transactions confirm previous ones	IOTA (Tangle), Nano	Scalable, fast, no miners	Complex consensus logic, still experimental
Hybrid Consensus	Mix of two or more methods	Decred, Kadena	Flexible, tries to balance trade-offs	Complex to implement and govern

Tableau 1: Overview of Blockchain Consensus Mechanisms

Peer-to-Peer Network

Blockchain operates on a decentralized, peer-to-peer (P2P) network, where nodes (participants) share responsibility for maintaining the ledger.

- **Full Nodes:** Store the entire blockchain and validate transactions and blocks.
- **Light Nodes:** Store only a portion of the blockchain, relying on full nodes for verification.
- **Mining Nodes:** Compete to validate transactions and create new blocks (in PoW systems).

In this distributed system, all nodes communicate to ensure consistency and prevent double-spending or fraudulent transactions.

2.3 Core Advantages of Blockchain

Transparency and Immutability

- **Transparency:** Every transaction is recorded on a public or permissioned ledger, accessible to all participants. This openness fosters trust and accountability, particularly in applications like public procurement and supply chain management.
- **Immutability:** Once a block is validated and added to the chain, its data cannot be altered without consensus from the majority of nodes. This feature prevents fraud and unauthorized changes, making blockchain ideal for applications requiring data integrity, such as healthcare and financial systems.

Security and Cryptography

Blockchain leverages advanced cryptographic techniques to ensure data security and user privacy:

1. **Hash Functions:** Algorithms like SHA-256 create unique and irreversible fingerprints for data. Any change in the input alters the hash, ensuring data integrity.
2. **Public and Private Keys:** These cryptographic tools enable secure communication and authentication:
 - **Public Key:** Shared with others for encrypting data or verifying transactions.
 - **Private Key:** Kept secret by the user to decrypt data or authorize transactions.
3. **Digital Signatures:** A combination of hashing and public/private keys that verify the authenticity and integrity of messages or transactions.

Through these mechanisms, blockchain achieves a level of security that is highly resistant to hacking or unauthorized access, making it a trusted tool for sensitive applications.

2.4 Additional Key Terms in Blockchain

1. Cloud Mining

Cloud mining allows users to rent mining hardware or processing power from data centers instead of owning physical equipment. This approach makes mining more accessible for those who lack the resources or technical expertise to set up and maintain mining rigs. Users typically pay a subscription fee and receive a share of the mining rewards.



2. Exchange

A cryptocurrency exchange is a platform where users can trade digital currencies for other assets, including fiat money (e.g., USD, EUR) or other cryptocurrencies. These platforms often act as intermediaries, facilitating the buying, selling, and storage of crypto assets.



3. Mining Farm

A mining farm is a large-scale facility dedicated to cryptocurrency mining, housing numerous mining rigs (specialized computers) that work together to solve complex algorithms. These facilities require significant resources, such as electricity and cooling systems, to operate efficiently.



4. Mining Hardware

This refers to the physical equipment used for mining cryptocurrencies. It includes general-purpose devices like GPUs (Graphics Processing Units) and specialized hardware like ASICs (Application-Specific Integrated Circuits) designed specifically for mining.



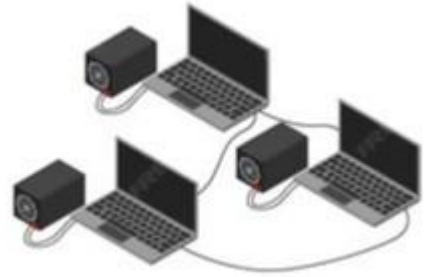
5. ASIC (Application-Specific Integrated Circuit)

ASICs are highly specialized hardware devices optimized for performing a single task, such as mining specific cryptocurrencies. They are much more efficient than GPUs but are limited to mining specific algorithms (e.g., Bitcoin's SHA-256).



6. Pool

A mining pool is a collective group of miners who combine their computational resources to solve blocks more quickly. Rewards are distributed proportionally based on each participant's contribution to the mining effort. Pools make mining accessible to individual miners with limited resources.



7. Halving

Halving refers to the programmed reduction in mining rewards that occurs in certain cryptocurrencies, such as Bitcoin, roughly every four years. For example, if the reward for mining a block was 12.5 BTC, it would reduce to 6.25 BTC after a halving event. This mechanism is designed to control inflation and limit the total supply of coins.



8. Crypto Wallet

A crypto wallet is a digital tool that allows users to securely store, send, and receive cryptocurrencies. Wallets can be:

- **Hot wallets:** Connected to the internet, such as mobile apps or web wallets.
- **Cold wallets:** Offline storage devices like hardware wallets or paper wallets, offering enhanced security.



9. Analysis

Blockchain analysis involves examining blockchain data to gain insights into transaction patterns, network activity, or trends. It is widely used for forensic purposes, compliance, and optimizing blockchain applications.



3. Types of Blockchains

Blockchain technology can be categorized into three main types based on the level of accessibility and control: public, private, and hybrid/consortium blockchains. Each type has unique characteristics, making it suitable for different use cases.

3.1 Public Blockchains

A public blockchain is a decentralized and open network accessible to anyone. It operates without a central authority, relying on consensus mechanisms to validate transactions.

Examples:

- **Bitcoin:** The first and most well-known public blockchain, designed for peer-to-peer digital currency transactions.
- **Ethereum:** A versatile platform for deploying decentralized applications (DApps) and smart contracts.

Advantages:

- **Transparency:** Transactions are visible to all participants, ensuring trust and accountability.
- **Decentralization:** No single entity controls the network, reducing the risk of censorship.
- **Security:** Robust consensus mechanisms (e.g., Proof of Work or Proof of Stake) and cryptographic techniques make public blockchains highly secure.

Disadvantages:

- **Scalability Issues:** High transaction volumes can lead to slower processing times and increased fees.
- **Energy Consumption:** Proof of Work systems consume significant energy, raising environmental concerns.

3.2 Private Blockchains

A private blockchain is a restricted network where access is limited to authorized participants. It is typically managed by a single organization or group.

Examples:

- **Hyperledger:** An open-source blockchain framework designed for enterprise use cases, such as supply chain management and financial services [5].
- **Corda:** A blockchain platform tailored for businesses, with a focus on privacy and interoperability.

Advantages:

- **Control:** Organizations maintain full control over the network and its participants.
- **Efficiency:** Fewer participants and a controlled environment allow for faster transaction processing.
- **Privacy:** Sensitive data is protected, as access is restricted to trusted entities.

Disadvantages:

- **Limited Decentralization:** Since control is centralized, it may not provide the same level of trust and transparency as public blockchains.
- **Trust Dependency:** Participants must trust the central authority managing the network.

3.3 Hybrid/Consortium Blockchains

Hybrid or consortium blockchains combine features of both public and private blockchains. They allow for customizable levels of decentralization and access control.

Examples:

- **Ripple:** A blockchain designed for financial institutions, facilitating cross-border payments with high efficiency and security.
- **Energy Web Chain:** A blockchain tailored for the energy sector, combining public transparency with private access for energy companies.

Advantages:

- **Flexibility:** Organizations can define which data is public and which is private.
- **Scalability and Efficiency:** Combines the speed of private blockchains with the trust of public ones.
- **Collaboration:** Facilitates cooperation among multiple entities in a secure and transparent manner.

Disadvantages:

- **Complexity:** Setting up and maintaining a hybrid blockchain can be more challenging.
- **Centralization Risks:** In some cases, certain aspects may still depend on centralized control.

3.4 Comparison of Blockchain Types

The following table highlights the key differences between public, private, and hybrid/consortium blockchains:

Feature	Public Blockchain	Private Blockchain	Hybrid/Consortium Blockchain
Accessibility	Open to anyone	Restricted to authorized participants	Combination of public and private access
Decentralization	Fully decentralized	Centralized	Partially decentralized
Transaction Speed	Slower due to high network activity	Faster due to fewer participants	Moderate, depending on configuration
Transparency	Fully transparent	Limited transparency	Customizable transparency
Security	High, secured by consensus mechanisms	High, controlled by the central authority	Balanced, with flexible security configurations

Use Cases	Cryptocurrencies, public services	Enterprise solutions, supply chains	Inter-organizational collaboration, financial networks
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Tableau 2: Comparison of Blockchain Types

4. Applications of Blockchain

Blockchain technology has evolved beyond its initial use in cryptocurrencies and is now being applied across various domains, addressing challenges and offering innovative solutions. This section highlights existing applications and explores its potential in public procurement, transitioning into the core topic of this thesis.

4.1 Existing Applications

1. Finance

Blockchain has revolutionized the financial sector, providing secure, transparent, and decentralized systems for managing money and transactions.

- **Cryptocurrencies:** Digital currencies like Bitcoin and Ethereum allow for peer-to-peer transactions without intermediaries.
- **Cross-border Payments:** Blockchain reduces the cost and time required for international money transfers. Platforms like Ripple and Stellar excel in this domain.
- **Decentralized Finance (DeFi):** DeFi platforms provide financial services (lending, borrowing, trading) without relying on traditional banks, democratizing access to financial tools.

2. Healthcare

Blockchain enhances data management and security in the healthcare sector:

- **Patient Data Management:** Ensures secure and interoperable sharing of medical records while maintaining patient privacy. Projects like MedRec aim to improve healthcare efficiency.
- **Drug Traceability:** Tracks the production and distribution of pharmaceuticals to combat counterfeit drugs.

3. Logistics

In supply chain management, blockchain provides transparency and traceability:

- **Product Tracking:** Each step in a product's journey, from raw material to final delivery, can be recorded on the blockchain. Companies like IBM and Maersk have implemented blockchain-based solutions for global shipping [6].
- **Fraud Prevention:** Verifies the authenticity of products, reducing counterfeiting in industries such as luxury goods and food production.

4. Governance and Administration

Blockchain is being used to enhance transparency and efficiency in government operations:

- **Electronic Voting:** Provides secure and tamper-proof voting systems, ensuring trust in electoral processes [7].
- **Land Registry:** Digitizes and secures land ownership records, reducing disputes and corruption. For example, the government of Georgia has adopted blockchain for property registration.

4.2 Potential in Public Procurement

Public procurement, the process by which governments acquire goods and services, is often plagued by inefficiency, corruption, and lack of transparency. Blockchain technology has the potential to address these challenges and transform the sector in several ways:

1. Transparency

Blockchain's immutable ledger ensures that every transaction and decision made in the procurement process is recorded and visible to all stakeholders. This transparency reduces opportunities for corruption, favoritism, or mismanagement.

2. Accountability

Smart contracts can automate and enforce procurement rules, ensuring compliance with regulations. For instance:

- Contracts can release payments automatically once conditions are met.
- Deadlines and deliverables are tracked without manual intervention, minimizing delays.

3. Auditability

Blockchain's traceability enables real-time auditing of procurement processes. Authorities can track the flow of funds, monitor contract execution, and identify irregularities early.

4. Combatting Corruption

Blockchain can significantly reduce corruption by:

- Eliminating middlemen and manual record-keeping, which are common sources of fraud.
- Providing a tamper-proof record of bids, awards, and transactions, ensuring fair competition.

5. Inclusive Participation

Blockchain-based procurement platforms can open opportunities for smaller businesses by creating a level playing field. Transparent bidding processes and reduced administrative barriers encourage wider participation.

Conclusion

The integration of blockchain into public procurement systems could lead to significant improvements in efficiency, fairness, and trust. By addressing key challenges such as corruption and inefficiency, blockchain offers a transformative solution that aligns with the goals of modern

governance. This concept will be further explored in subsequent chapters, focusing on the design and implementation of a blockchain-based solution for transparent public procurement.

5. Challenges and Limitations of Blockchain

Despite its transformative potential, blockchain technology faces several challenges and limitations that hinder its widespread adoption. This section highlights the key issues associated with scalability, energy consumption, regulatory barriers, and centralization risks.

5.1 Scalability

One of the most significant challenges for blockchain technology is scalability, or the ability to handle an increasing number of transactions efficiently.

- **Issue:**
Public blockchains like Bitcoin and Ethereum (prior to Ethereum 2.0) often experience congestion during periods of high activity. For example, Bitcoin can process approximately 7 transactions per second (TPS), while Ethereum averages 15-30 TPS, compared to traditional payment systems like Visa, which can handle over 24,000 TPS [8].
- **Impacts:**
 - Slower transaction speeds lead to delays in processing payments or executing smart contracts.
 - Higher transaction fees discourage smaller participants from using the network.
- **Solutions:**
 - **Layer 2 Solutions:** Technologies like the Lightning Network (Bitcoin) or Optimistic Rollups (Ethereum) aim to process transactions off-chain to reduce network congestion.
 - **Sharding:** Implemented in Ethereum 2.0, sharding splits the blockchain into smaller, manageable pieces to distribute transaction processing.

5.2 Energy Consumption

Blockchain networks that rely on Proof of Work (PoW) consensus mechanisms are criticized for their high energy requirements.

- **Issue:**
Mining Bitcoin, for instance, consumes more energy annually than many small countries. The vast computational power required for PoW leads to environmental concerns.
- **Impacts:**
 - Increases the carbon footprint of blockchain operations.

- Makes blockchain unsustainable in the long term if alternative solutions are not adopted.
- **Solutions:**
 - **Transition to Proof of Stake (PoS):** PoS drastically reduces energy consumption by replacing computational work with stake-based validation. Ethereum's shift to PoS has cut its energy use by over 99% [9].
 - **Green Blockchains:** Emerging blockchains like Algorand and Tezos focus on eco-friendly operations by minimizing energy requirements.

5.3 Regulatory and Legislative Adoption

The integration of blockchain into existing legal and regulatory frameworks is complex and inconsistent across regions.

- **Issue:**
Governments and institutions face challenges in adapting laws to accommodate blockchain technology, especially in areas like cryptocurrencies and smart contracts.
- **Impacts:**
 - Slows down innovation and adoption of blockchain-based solutions.
 - Creates uncertainty for businesses and investors operating in the blockchain space.
- **Solutions:**
 - **Clear Regulations:** Countries like Switzerland and Singapore have developed blockchain-friendly regulations, fostering innovation.
 - **International Collaboration:** Coordinated efforts between nations can create standardized frameworks for blockchain adoption.

5.4 Risks of Centralization

Although blockchain is designed to be decentralized, certain practices can lead to partial centralization.

- **Issue:**
 - **Mining Pools:** In PoW blockchains, mining pools that control significant hash power can dominate the network, creating potential risks of 51% attacks.
 - **Private Blockchains:** Centralized control in private blockchains undermines the core principle of decentralization, making them susceptible to manipulation.
- **Impacts:**
 - Reduces trust in the network, particularly for public blockchains.

- Concentrates decision-making power in the hands of a few entities.
- **Solutions:**
 - Encourage the use of decentralized mining techniques and distributed validation.
 - Promote hybrid blockchains that balance decentralization with operational control.

Conclusion

In this chapter, we explored the foundational aspects of blockchain technology, starting with its definition and historical evolution. We examined the basic principles that govern blockchain, including its structure, functioning, and fundamental advantages such as transparency, security, and immutability. The various types of blockchains, public, private, and hybrid, were detailed, along with their unique characteristics and use cases. Additionally, we delved into the wide-ranging applications of blockchain across finance, healthcare, logistics, and governance, setting the stage for understanding its transformative potential. Finally, we discussed the challenges and limitations that must be addressed to maximize the technology's effectiveness.

Understanding blockchain is crucial not only to appreciate its current impact but also to innovate solutions tailored to specific problems. In the context of this thesis, this knowledge forms the foundation for envisioning a transparent and efficient system for managing public procurement. By leveraging blockchain's features, it becomes possible to address critical issues such as corruption, inefficiency, and lack of accountability in this domain.

In the next chapter, we will focus on the subject of this thesis, public procurement management, and explore the existing challenges within this field. This discussion will highlight the opportunities for blockchain integration, laying the groundwork for proposing and modeling a blockchain-based solution.

Chapter 2: Using Blockchain for Transparent Management of Public Procurements

Introduction

Public procurement refers to the process by which governments and public institutions acquire goods, services, and infrastructure necessary to fulfill their responsibilities. It plays a central role in national economies and public service delivery. On a global scale, public procurement accounts for nearly **13 trillion dollars annually**, making it one of the largest areas of public sector expenditure[10]. In **OECD (Organisation for Economic Co-operation and Development) countries**, it represents around **13% of GDP (Gross Domestic Product)** and roughly a **third of total government spending**[11]. In **Africa**, governments spend more than **50 billion dollars each year** on public contracts, which amounts to nearly **half of the continent's imports**[12].

In **Algeria**, the public procurement sector is just as crucial, contributing to more than **20% of the national GDP** [46]. It funds essential projects in infrastructure, healthcare, education, and more. However, like many countries, Algeria faces recurring issues such as **cumbersome administrative processes, opaque procedures, and a general lack of transparency**. These factors often lead to delays, increased costs, and erosion of public trust in the system.

Across the globe, corruption in public procurement continues to be a widespread concern. The **OECD** estimates that up to **25% of procurement budgets** may be lost to fraud, bribery, or favoritism[13]. Even in relatively transparent environments, inefficiencies persist due to manual procedures and outdated digital infrastructures, which limit accountability and make oversight more difficult.

In this chapter, we examine how public procurement systems operate, explore the challenges they face, and investigate how blockchain could bring transparency, trust, and efficiency into the process. This foundation sets the stage for designing and implementing a blockchain-based solution adapted to the needs of modern procurement systems, especially in developing contexts.

1. Understanding Public Procurement

1.1. Definition of Public Procurement

Public procurement refers to the process by which governments and public institutions acquire goods, services, and infrastructure to fulfill their responsibilities and serve the public. It includes everything from purchasing office supplies to constructing roads, schools, and hospitals. According to the World Bank, public procurement can account for up to 20% of a country's GDP, making it one of the most significant areas of public expenditure [14].

1.2 Stakeholders in Public Procurement

Public procurement involves a wide range of stakeholders, each playing a specific role throughout the procurement lifecycle:

- **Government Entities:** Ministries, municipalities, and public agencies initiate and manage procurement processes.
- **Suppliers and Contractors:** These are private sector businesses that provide goods, services, or execute public works.
- **Regulatory Bodies:** Institutions like national audit offices or procurement authorities oversee compliance with legal and ethical standards.
- **Civil Society and Citizens:** As end-beneficiaries, the public has a stake in ensuring that procurement is fair, efficient, and delivers value for money.
- **International Organizations:** Entities such as the World Bank, OECD, and UNDP (**United Nations Development Programme**) often fund or support procurement projects, especially in developing countries, and promote good practices.

1.3 Objectives and Principles

The core objectives of public procurement are to:

- **Ensure value for money:** Getting the best possible outcome for public funds.
- **Promote fair competition:** Creating equal opportunities for suppliers through transparent and non-discriminatory processes.
- **Foster integrity and accountability:** Preventing corruption and misuse of public resources.
- **Encourage efficiency and innovation:** Streamlining procedures to reduce costs and improve quality.
- **Support social and environmental goals:** Including sustainability, local development, and gender inclusion.

These objectives are reinforced by guiding principles widely recognized in international frameworks, such as the OECD Recommendation on Public Procurement [15], which emphasizes transparency, integrity, efficiency, accountability, and accessibility as pillars of a sound procurement system.

2. Procurement Mechanisms and Frameworks

2.1 Procurement Forms

Public procurement can take multiple forms depending on the nature of the acquisition, urgency, and the policy environment. These forms define how goods, services, or works are obtained and help determine the level of competition, transparency, and efficiency within a system. The main procurement forms include:

- - **Open Procurement:** The most transparent form, where tenders are publicly advertised and all eligible suppliers can participate.
- - **Restricted Procurement:** Used when the buyer limits participation to a pre-qualified list of suppliers.
- - **Direct Procurement (Sole Sourcing):** Involves awarding contracts without a competitive process, usually in emergencies.
- - **Two-stage Procurement:** Common in large infrastructure projects involving initial conceptual proposals followed by final offers.

To better understand how these forms play out in practice, the following diagram illustrates a typical **AS-IS public procurement process**. It captures the conventional workflow that many public institutions follow, highlighting the decision points, document exchanges, and stakeholder interactions.

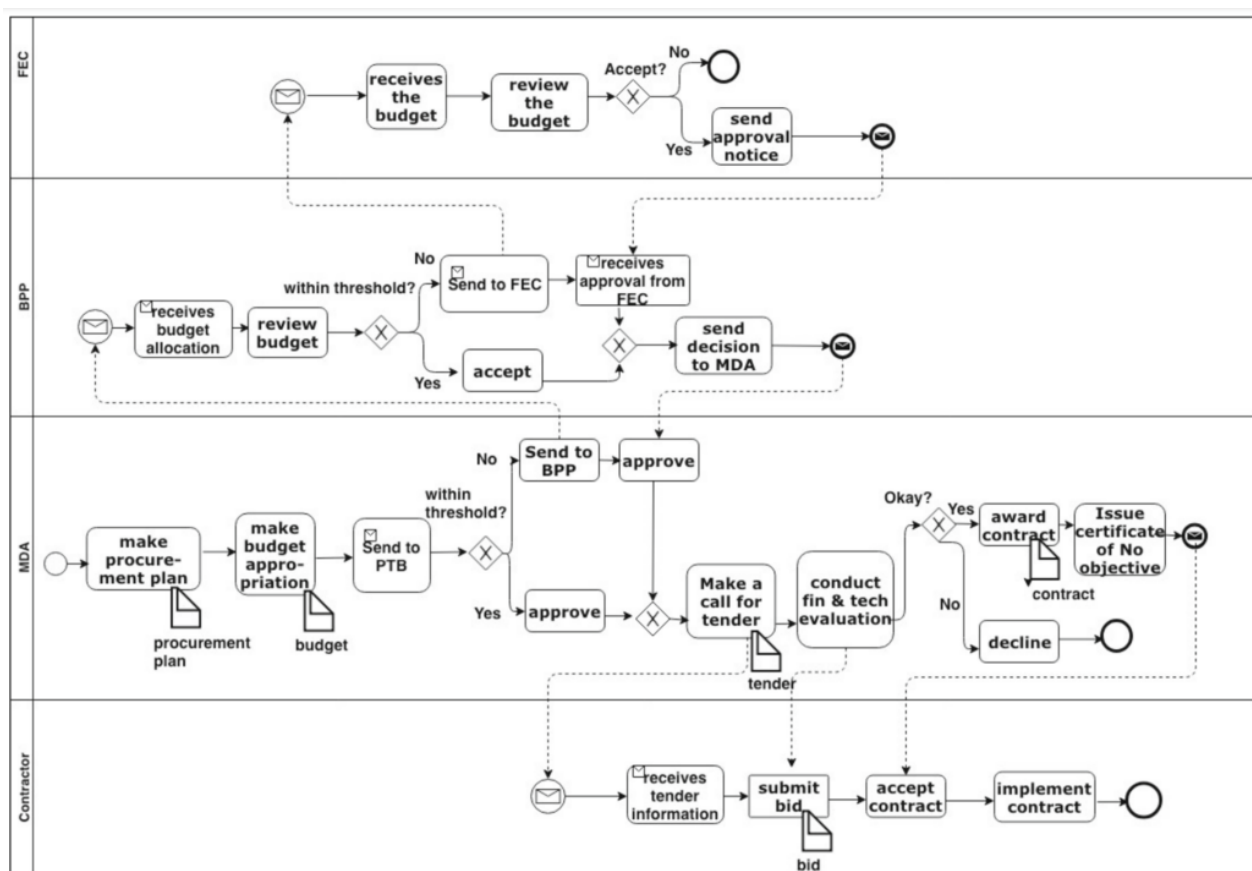


Figure 10 : AS-IS Model (Current State) Public Procurement Process

This current model, while structured, often suffers from fragmentation, manual paperwork, and a lack of transparency across steps. These pain points will be explored further in Section 3 ([Types of Blockchains](#)).

2.2 Tender Types

Tendering is a core component of procurement. The type of tendering used greatly influences efficiency, fairness, and the overall value obtained by public institutions. Common tender types include:

- **Open Tender:** The most inclusive method, ensuring maximum competition and transparency.
- **Selective Tender:** Only invited or pre-qualified suppliers may submit bids.
- **Negotiated Tender:** The authority negotiates directly with suppliers, often in urgent or complex cases.
- **Competitive Dialogue:** Suppliers engage in structured dialogue before submitting offers.
- **Request for Proposals (RFP):** Focuses on both technical merit and price, common in IT and consulting.
- **Framework Agreements:** Establish long-term vendor relationships with simplified future contracts.

2.3 Frameworks and Standards

To ensure procurement systems operate with integrity, many governments and institutions rely on standardized frameworks that define best practices, guidelines, and regulatory principles. Key examples include:

- **UNCITRAL Model Law on Public Procurement:** Promotes transparency, efficiency, and fairness[16].
- **OECD Principles for Integrity in Public Procurement:** Focuses on transparency, participation, and accountability[17].
- **World Bank and EU Procurement Guidelines:** Comprehensive rules for donor-funded projects[18].
- **ISO 20400 (Sustainable Procurement):** Guidance on integrating sustainability into procurement[19].

2.4 Concurrency in Procurement

Concurrency refers to the ability of procurement systems to handle multiple overlapping or simultaneous processes efficiently and securely. It's especially critical in large-scale operations involving:

- **Parallel Tendering Processes:** Running multiple tenders concurrently.
- **Multi-stakeholder Review and Approval:** Involves multiple departments reviewing in parallel.
- **Cross-border or Multi-tiered Projects:** Requires coordination between national and international bodies.

Blockchain technology naturally supports concurrency through distributed ledgers and smart contracts that enforce parallel workflows without data inconsistency or manipulation risks.

3. Challenges in Public Procurement

Public procurement, despite being one of the most important functions of modern governance, often struggles with deeply rooted challenges that undermine its efficiency, fairness, and public legitimacy. These issues are particularly critical in developing countries, but they also persist globally, even in systems that are considered relatively well-established. This section outlines the four major challenges in public procurement: transparency issues, inefficiency and bureaucracy, corruption and fraud, and limited accountability.

3.1 Transparency Issues

Transparency is the cornerstone of trust in public procurement. It ensures that processes are open, information is accessible, and decisions can be scrutinized by both citizens and oversight bodies. Unfortunately, procurement systems around the world frequently fall short in this area.

According to the Open Contracting Partnership, only 10% of countries publish complete and timely data on government contracts[20]. A 2022 study by the World Bank found that nearly 40% of procurement data in low and middle-income countries is either inaccessible or incomplete, creating room for manipulation or unfair favoritism[21].

The absence of transparency leads to information asymmetry, where only a small circle of insiders is aware of tenders, eligibility criteria, or evaluation methods. This discourages competition, reduces value for money, and enables backroom deals that can go undetected.

3.2 Inefficiency and Bureaucracy

Public procurement processes are often hindered by rigid administrative procedures, outdated systems, and a lack of automation. These inefficiencies contribute to long lead times, delays in project execution, and wasted resources.

For example, in Sub-Saharan Africa, procurement processes can take up to 200 days from tender announcement to contract award, compared to less than 60 days in OECD countries. Even in Europe, procurement delays cost taxpayers an estimated €5 billion annually, as reported by the European Commission [22], [23].

Much of this inefficiency stems from manual processes, excessive documentation, and inconsistent procedures across agencies. Without digitization and streamlined workflows, even basic tasks such as bid evaluation or contract monitoring can become cumbersome and error-prone.

3.3 Corruption and Fraud

Corruption is one of the most pervasive and damaging issues in public procurement. Because procurement involves large financial flows and discretionary decisions, it is a prime target for fraud, bribery, and collusion.

According to the OECD, between 20% to 25% of public procurement budgets globally are lost to

corruption[24]. In 2021 alone, the United Nations Office on Drugs and Crime (UNODC) estimated that procurement fraud accounted for \$2 trillion in losses worldwide [25].

Some of the most common fraudulent practices include:

- **Manipulating bids** so that a specific company wins (also known as bid rigging).
- **Bribes or secret payments** to officials in exchange for contracts (kickbacks).
- **Giving contracts to friends or preferred companies**, regardless of merit (favoritism).
- **Charging much higher prices than necessary** for goods or services (inflated pricing).
- **Creating fake companies** to receive payments without delivering anything (ghost suppliers).

These practices not only waste public resources but also result in substandard infrastructure, reduced service quality, and growing public disillusionment.

3.4 Limited Accountability

Without strong accountability mechanisms, procurement officials may act without consequences, even in the face of irregularities or inefficiencies. Accountability gaps arise when there is a lack of monitoring, weak audit trails, or limited access to real-time data on procurement activities.

In many countries, procurement audits are carried out manually and retroactively, often missing critical red flags or taking too long to prevent fraud. The Transparency International Global Corruption Report highlighted that only 38% of countries systematically audit public procurement data [26].

Moreover, in the absence of citizen engagement or independent oversight, procurement outcomes can deviate significantly from the public interest. When no one is clearly responsible or answerable for poor decisions, systemic problems persist.

4. Barriers to Blockchain Adoption

4.1 Technical Challenges

Blockchain technology, while promising, faces significant technical hurdles that impact its adoption in public procurement systems. These challenges include:

- **Scalability:** Blockchain networks, especially those using Proof of Work, can experience slow transaction processing times as the network grows. This makes them less suitable for high-volume procurement transactions [27].
- **Integration with Existing Systems:** Public procurement systems often rely on outdated software and manual processes. Integrating blockchain with these legacy systems can be complex, requiring significant resources and technical expertise [28].

- **Infrastructure and Expertise:** Blockchain implementation requires specialized infrastructure and skilled professionals. Many governments and institutions may not have the necessary technical capabilities to manage and deploy blockchain solutions [28].

4.2 Regulatory and Legal Constraints

The adoption of blockchain in public procurement is hindered by several legal and regulatory barriers:

- **Lack of Clear Legal Frameworks:** Blockchain operates in a largely unregulated space. Without clear legal frameworks, there are concerns about how blockchain solutions will comply with existing laws and procurement regulations [29].
- **Alignment with Public Procurement Laws:** Traditional procurement processes often involve complex legal requirements and established procedures. Adapting blockchain to fit within these frameworks while ensuring compliance with national and international laws can be a significant challenge [29].
- **Data Privacy Concerns:** Governments must ensure that blockchain-based procurement systems comply with data protection regulations (e.g., GDPR in Europe). Blockchain's transparency and immutability could conflict with privacy laws, especially regarding sensitive contract details [30].

4.3 Adoption and Cultural Resistance

One of the main barriers to blockchain adoption in public procurement is resistance to change:

- **Stakeholder Resistance:** Government officials, procurement professionals, and contractors may be skeptical of blockchain technology. Familiarity with traditional systems and fear of disruption can prevent stakeholders from embracing blockchain solutions [31].
- **Cultural Resistance:** Bureaucratic and institutional cultures may prioritize the status quo. Introducing new technologies like blockchain requires not only technical changes but also shifts in mindset and workflow, which can be difficult to achieve [31].
- **Trust in Technology:** Blockchain, being relatively new, still lacks widespread trust among public procurement officials, who may question its reliability and robustness for handling sensitive procurement data [31].

4.4 Combatting Corruption

While blockchain has the potential to combat corruption, its implementation faces obstacles that may limit its effectiveness:

- **Resistance from Corrupt Actors:** In countries where corruption is prevalent, individuals or entities benefiting from the current procurement system may actively resist adopting blockchain due to its transparency and ability to expose fraudulent activities [32].
- **Weak Enforcement Mechanisms:** While blockchain can make processes more transparent, the enforcement of anti-corruption measures still requires robust oversight and monitoring systems. Without complementary reforms, blockchain alone may not be enough to combat corruption effectively [32].

5. Case Studies and Related Searches

5.1 Review of Academic and Industry Research

Over the past decade, interest in applying blockchain technology to public procurement has significantly increased across both academic and industry fields. Research has mainly explored

how blockchain can enhance transparency, traceability, and trust in procurement operations, especially in environments affected by corruption or inefficiencies.

Academic literature has proposed various frameworks and proof-of-concept models. For instance, Hunhevicz and Hall (2021) examined how blockchain can record procurement transactions on tamper-proof ledgers to prevent retroactive changes or hidden negotiations. Wüst and Gervais (2018) offered a decision-making framework to evaluate when blockchain is appropriate in procurement, highlighting its value in decentralization, auditability, and disintermediation [33][34].

Industry research echoes this momentum, with numerous organizations launching pilot projects. The World Economic Forum and the Inter-American Development Bank have promoted blockchain-based platforms aimed at curbing corruption in Latin America’s procurement systems [35]. Similarly, the European Union’s “OpenTender” initiative focused on increasing transparency and citizen engagement through distributed ledgers [36].

Aspect	Hyperledger Fabric (India)	Ethereum (Smart Contracts)	Oracle Blockchain (Enterprise Procurement)	BIoT (Blockchain + IoT)	CBDCs (Blockchain-Based Digital Currencies)
Type	Permissioned	Public	Permissioned	Hybrid (Public + IoT)	Centralized Blockchain
Transparency	High (for stakeholders)	Fully Public	Medium (Enterprise-focused)	High (Sensor-driven tracking)	Central Bank-Controlled
Smart Contracts	Yes (Restricted to approved users)	Yes (Decentralized)	Yes (Regulated execution)	Yes (Automates compliance monitoring)	Yes (For milestone-based payments)
Privacy	High (Permissioned access)	Low (Public ledger)	High (Enterprise-controlled)	Moderate	Low (Govt-controlled transactions)
Adoption	Government pilot projects	Used in DeFi & GovTech	Used in enterprise procurement	Emerging in logistics & public projects	Under development in many central banks
Weaknesses	Limited scalability	High gas fees	Requires corporate buy-in	High infrastructure costs	Privacy concerns

Table 2 : Comparison of Blockchain Models for Procurement

This growing body of research reflects a shared belief in blockchain’s potential to reshape procurement systems, though many projects remain in early phases or limited to small-scale trials.

5.2 Comparative Analysis of Implemented Solutions

Governments and institutions across the globe have begun to implement blockchain-based solutions in their procurement systems. These implementations differ in technological approach and maturity but offer meaningful insights into real-world challenges and outcomes.

- **Colombia’s SECOP II Extension:** In collaboration with the Inter-American Development Bank, Colombia piloted blockchain enhancements to its national e-procurement platform. The goal was to secure contract records with immutable timestamps and enable smart contract-based workflows. Early evaluations reported improved oversight and decreased risks of data manipulation [35].

- **Ukraine’s ProZorro:** Though not fully blockchain-based, ProZorro integrates open data and transparency tools that align with blockchain principles. It serves as an effective benchmark for understanding the impact of digital transparency on public trust and procurement outcomes [37].

- **Brazil’s bSMART:** This project used Ethereum smart contracts to manage procurement workflows, aiming to automate deadlines, milestones, and payments. It highlighted the need for supportive legal frameworks before blockchain-based solutions can operate at scale [38].

- **Georgia’s Blockchain Land Registry:** While not a procurement platform, this case demonstrated successful government blockchain adoption. It serves as an indirect model for blockchain-based infrastructure procurement and transparent ownership verification [39].

Country	Use Case	Blockchain Model Used	Results
India	E-procurement via Hyperledger	Hyperledger Fabric	Improved transparency, reduced delays
Brazil	Road work procurement tracking	Public Blockchain	Enhanced contract compliance monitoring
Nigeria	Smart contract-based procurement	Ethereum	Increased competition, reduced bid manipulation
Ecuador	Pilot blockchain project	Hybrid (Hyperledger + Smart Contracts)	Early-stage results, legal challenges

European Union	Blockchain-enabled cross-border procurement	Permissioned Blockchain	Ensured fair vendor selection
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Tableau 3: Case Studies of Blockchain-Based Procurement

These case studies demonstrate that successful implementation depends not only on technology but also on institutional readiness, legal compatibility, and stakeholder involvement. They also reveal a recurring pattern, where pilot programs validate technical feasibility, broader adoption hinges on regulatory clarity and cultural openness to change.

6. Real-World Implementations and Use Cases

6.1 Real-World Examples

6.1.1. DZtenders.com – Algeria’s Public Tendering Portal

DZtenders.com is a national platform in Algeria designed to centralize and publish public procurement opportunities. While it is not blockchain-native, it plays a crucial role in digitalizing the procurement landscape and is a prime candidate for blockchain enhancement. The platform allows citizens, suppliers, and foreign investors to:

- Access daily updates on public tenders from over 1000 government agencies.
- Download official documents such as tender notices, specifications, and award results.
- Track procurement timelines and contact contracting authorities.

Although the system increases information accessibility, it remains centralized and vulnerable to opacity in the post-award phases, such as bid evaluation and contract execution. This illustrates the need for a blockchain layer that provides:

- Immutable logging of tender publications and bid submissions.
- Smart contract-based bid evaluation for fairness and auditability.
- Public traceability of funds and project milestones.

If integrated with a permissioned blockchain (e.g., Hyperledger Fabric), DZtenders.com could evolve into a fully traceable procurement system for Algeria, offering a case study for broader MENA-region adoption [40].

6.1.2. Colombia’s SECOP II with Blockchain Pilots

Colombia’s e-procurement system, SECOP II, was among the first in Latin America to explore blockchain for procurement. In partnership with the Inter-American Development Bank (IDB), the Colombian government tested a blockchain-based pilot where:

- Smart contracts were used to automate the supplier registration and prequalification process.
- Bids were timestamped and stored on a public Ethereum testnet for transparency.
- The results were auditable by external civil society organizations.

The pilot revealed significant benefits: the average supplier registration time dropped from 17 to

5 days, and over 90% of participants reported increased trust in the bidding process. However, full implementation remains on hold pending legal and regulatory alignment [41].

6.1.3. Ukraine's ProZorro System

ProZorro is one of the most cited blockchain-inspired procurement systems, designed to promote radical transparency in Ukraine's public sector. Although it uses a hybrid centralized-blockchain model, its core principles include:

- Open access to all procurement documents and actions.
- A decentralized architecture where third parties (NGOs, watchdogs, journalists) can audit transactions in real time.
- Integration of e-auctions with smart contract logic (in future roadmaps).

From 2015 to 2021, ProZorro saved the Ukrainian government over USD 6 billion by eliminating inflated contract awards and fostering competition. The project proves that public trust and cost efficiency can coexist in digital procurement transformation [42].

6.1.4. Peru's Blockchain Project with IDB

The Peruvian government, in cooperation with the IDB, piloted a blockchain-based procurement framework in 2019 focused on public infrastructure tenders. This included:

- Decentralized document verification for all submitted bids.
- Smart contract automation of milestone-based payments.
- Public dashboards for real-time tracking of project execution.

The project received international attention but has yet to be institutionalized due to interagency coordination challenges and resistance from traditional stakeholders [43].

6.2 Insights and Lessons from Existing Initiatives

6.2.1. Partial Digitalization is Not Enough

Systems like DZtenders.com demonstrate that while digital portals increase information access, they do not inherently guarantee transparency. Without blockchain-backed mechanisms to track bid submissions, evaluations, and payments, there remains room for manipulation, especially in post-tender phases.

6.2.2. Legal Alignment is Critical

As seen in Colombia and Peru, regulatory uncertainty can delay or derail blockchain initiatives, even when technical success is evident. Governments must work toward legal frameworks that formally recognize blockchain records and smart contracts as enforceable evidence and decision-making tools.

6.2.3. Public Engagement Enhances Trust

ProZorro's success is partially attributed to active civil society participation. Allowing public audits, citizen feedback, and real-time monitoring strengthens trust and discourages misconduct. Blockchain facilitates this by making procurement logs immutable and publicly accessible.

6.2.4. Infrastructure and Capacity Matter

Blockchain implementation must be supported by robust infrastructure, including cloud services, secure identity management, and internet connectivity. Training procurement officials and IT staff is also vital; lack of technical capacity was a common bottleneck in all case studies.

6.2.5. Gradual, Modular Rollouts Work Best

Rather than overhauling entire procurement systems, the most successful projects started with pilot modules (e.g., supplier registration, e-auctions). This incremental adoption strategy helps identify challenges early and build stakeholder confidence.

Discussion:

The real-world use cases show that blockchain adoption in public procurement is no longer theoretical, but a growing global trend. However, successful implementation hinges on clear legal frameworks, institutional cooperation, and scalable architecture. Platforms like DZtenders.com highlight the untapped potential in regions like North Africa, where digital systems are in place but not yet thrustless or tamper-proof. The experiences of Colombia, Ukraine, and Peru offer replicable models and warnings that should inform the next generation of blockchain-based procurement reforms.

Conclusion

Public procurement plays a pivotal role in economic development and governance, yet it is often plagued by challenges such as corruption, inefficiency, lack of transparency, and limited accountability. These issues not only undermine public trust but also lead to financial losses and hinder the effective delivery of services.

Blockchain technology offers a transformative solution to these challenges. Its decentralized, transparent, and tamper-proof nature ensures that procurement processes are accessible and verifiable by all stakeholders. By leveraging features such as immutable ledgers, smart contracts, and traceable transactions, blockchain can enhance transparency, improve efficiency, combat corruption, and enforce accountability.

Adopting blockchain in public procurement is not just about embracing a new technology, it is a necessary step toward achieving modern governance standards that prioritize fairness, cost-efficiency, and trust. While technical, regulatory, and cultural barriers exist, they can be overcome through education, legal reforms, and pilot projects that demonstrate blockchain's potential.

This chapter has provided a comprehensive overview of public procurement challenges and the role of blockchain in addressing them. The next chapter will focus on developing a model for a

blockchain-based solution tailored to public procurement. This model will bridge the theoretical possibilities discussed here with practical implementation strategies, paving the way for a transparent and efficient procurement system.

Chapter 3: Conception of the Blockchain Tenders System

Introduction

The BlockBid platform is designed as a comprehensive blockchain-based tender management system that ensures transparency, security, and efficiency throughout the entire tender lifecycle. The system architecture is composed of several interconnected components that work together to provide a seamless experience for all stakeholders involved in the tendering process.

1. System Architecture Overview

1.1. Component Architecture

The system is built on a modular architecture that separates concerns and allows for scalability and maintainability. As illustrated in the component diagram, the system consists of the following main components:

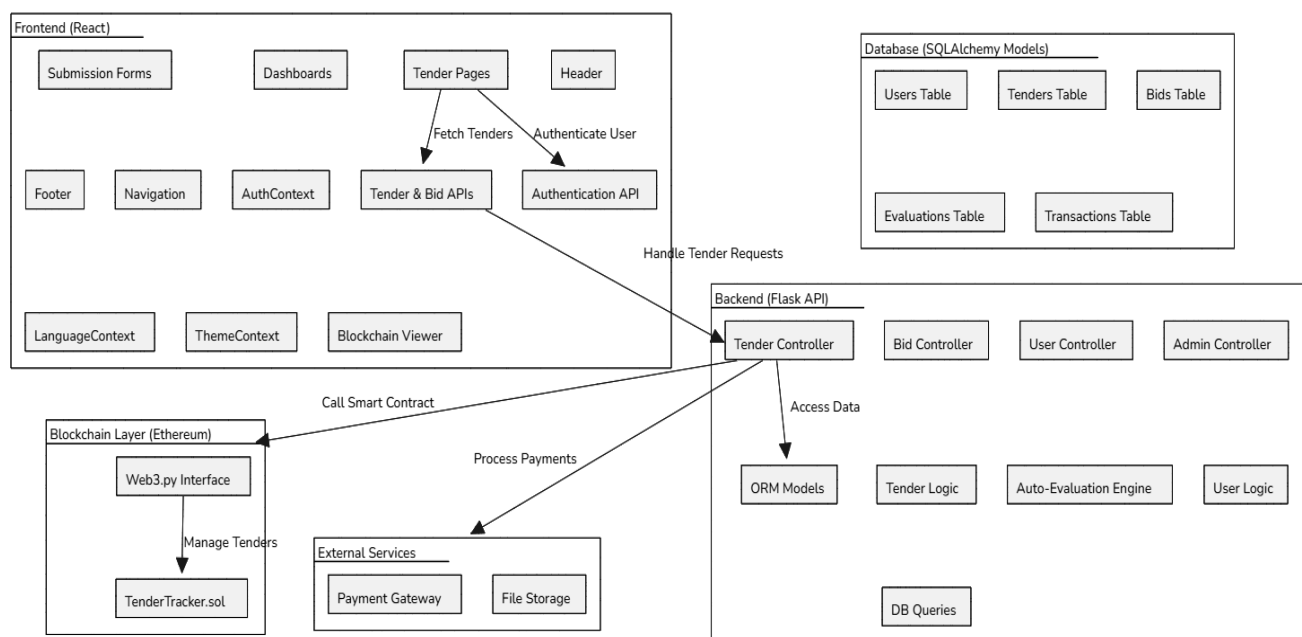


Figure 11: Component Architecture Diagram

Frontend Application: A responsive web interface built with React that provides user-friendly access to all system features.

Backend API: A RESTful API service that handles business logic and data processing

Blockchain Interface: A middleware layer that connects the application to the underlying blockchain network.

Smart Contracts: Self-executing contracts deployed on the blockchain that enforce rules and manage tender-related transactions.

Database: A relational database that stores non-blockchain data and metadata

This modular approach allows each component to be developed, tested, and scaled independently while maintaining clear interfaces between them.

1.2 Entity Relationships

The system's data model is designed to capture all relevant information about tenders, bids, users, and their interactions. The entity relationship diagram illustrates the complex relationships between these entities:

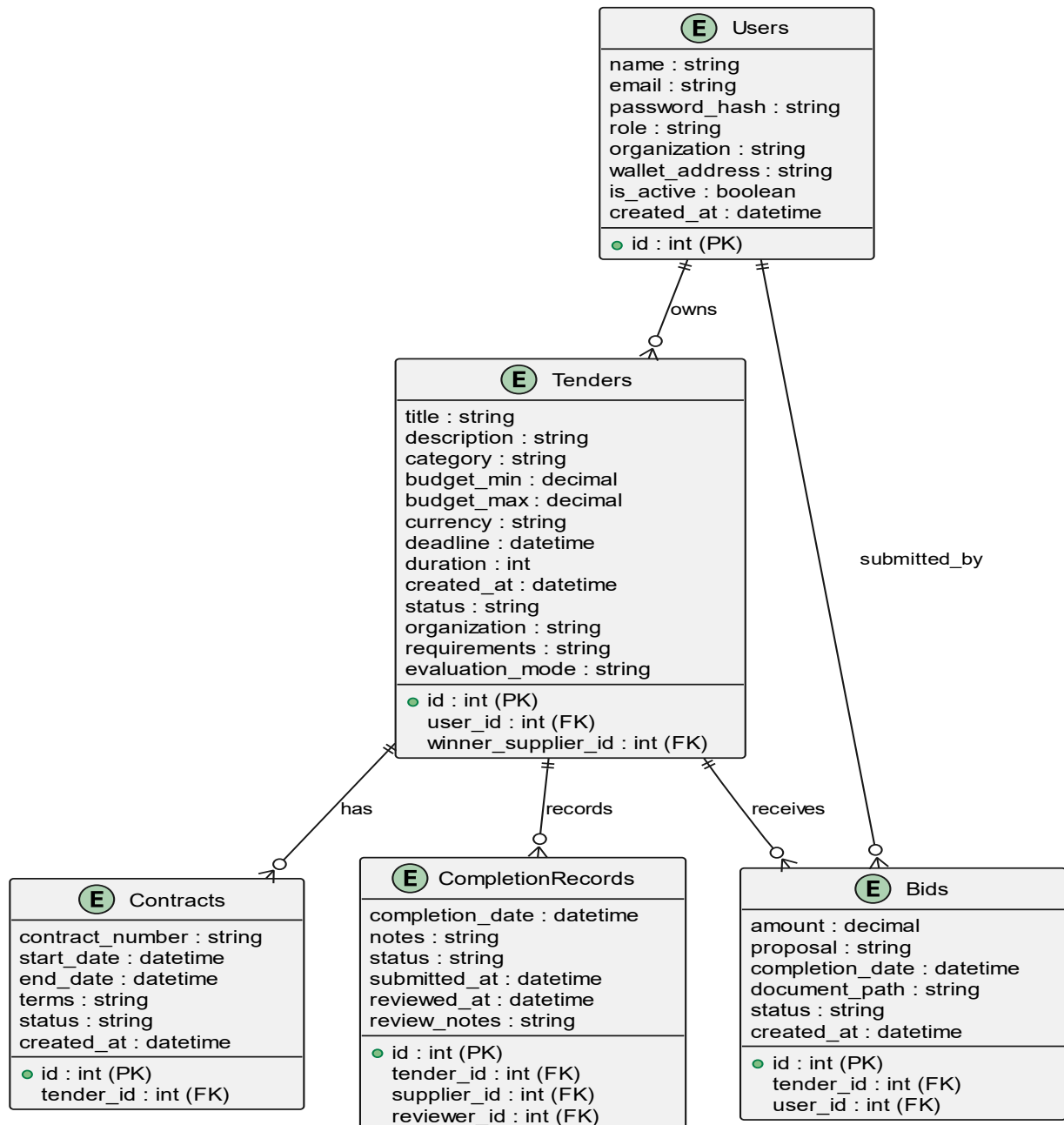


Figure 12: Entity Relationship Diagram

Users: Represent the various stakeholders in the system (tender issuers, suppliers, evaluators)

Tenders: The core entity that contains all information about a tender opportunity

Bids: Proposals submitted by suppliers in response to tenders

Evaluations: Assessments of bids based on predefined criteria

Transactions: Records of all blockchain interactions for audit and transparency.

These entities and their relationships form the foundation of the system's data structure, ensuring that all necessary information is properly captured and linked.

1.3 Class Structure

The object-oriented design of the system is represented in the class diagram, which shows the classes, their attributes, methods, and relationships. Key classes include:

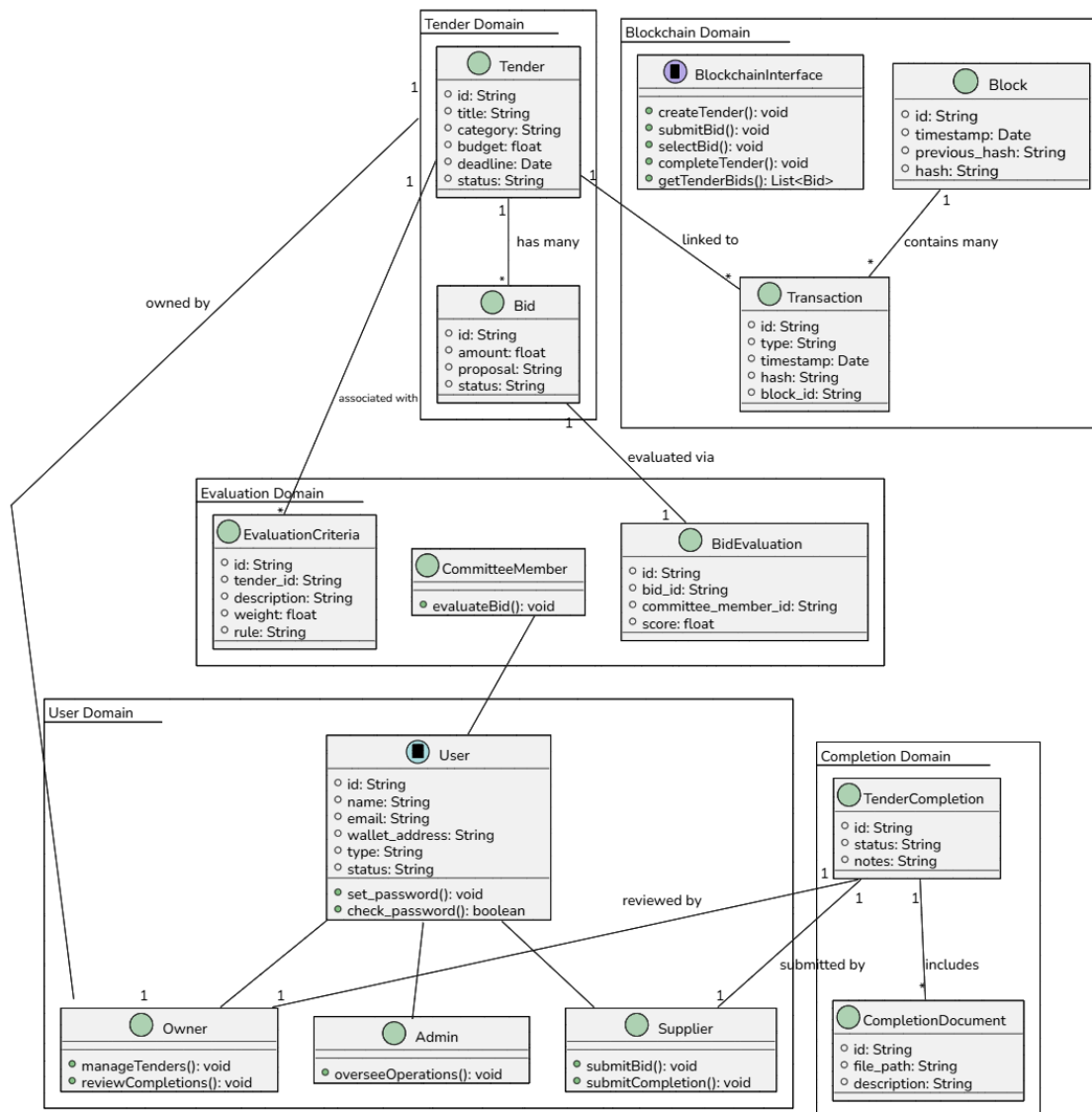


Figure 13: Class Diagram

User: Manages user authentication, profiles, and roles

Tender: Encapsulates all tender-related data and operations

Bid: Handles bid submission, storage, and retrieval

Evaluation: Implements both automatic and committee-based evaluation logic

Blockchain Interface: Provides methods for interacting with the blockchain

This class structure provides a clear blueprint for implementation while ensuring proper encapsulation and separation of concerns.

2. Process Flows

The system implements several key processes that guide users through the tender lifecycle. These processes are designed to be intuitive, secure, and compliant with tendering best practices.

2.1 Tender Lifecycle

The tender lifecycle is the core process flow in the system, as illustrated in the activity diagram. This process includes:



Figure 14: Tender Lifecycle Activity Diagram

1. **Tender Creation:** Issuers define tender requirements, budget, deadline, and evaluation criteria
2. **Publication:** Tenders are published on the platform and recorded on the blockchain
3. **Bid Submission:** Suppliers submit their proposals before the deadline

4. **Evaluation:** Bids are evaluated either automatically or by a committee

5. **Award:** The winning bid is selected and the tender is awarded

6. **Execution:** The awarded supplier completes the work.

Completion: The tender is marked as completed after verification

Each stage in this lifecycle is tracked on the blockchain, ensuring transparency and immutability of the process.

2.2 Bid Submission and Evaluation

The bid submission and evaluation processes are critical to ensuring fair competition and objective selection. The sequence diagrams detail the interactions between system components during these processes:

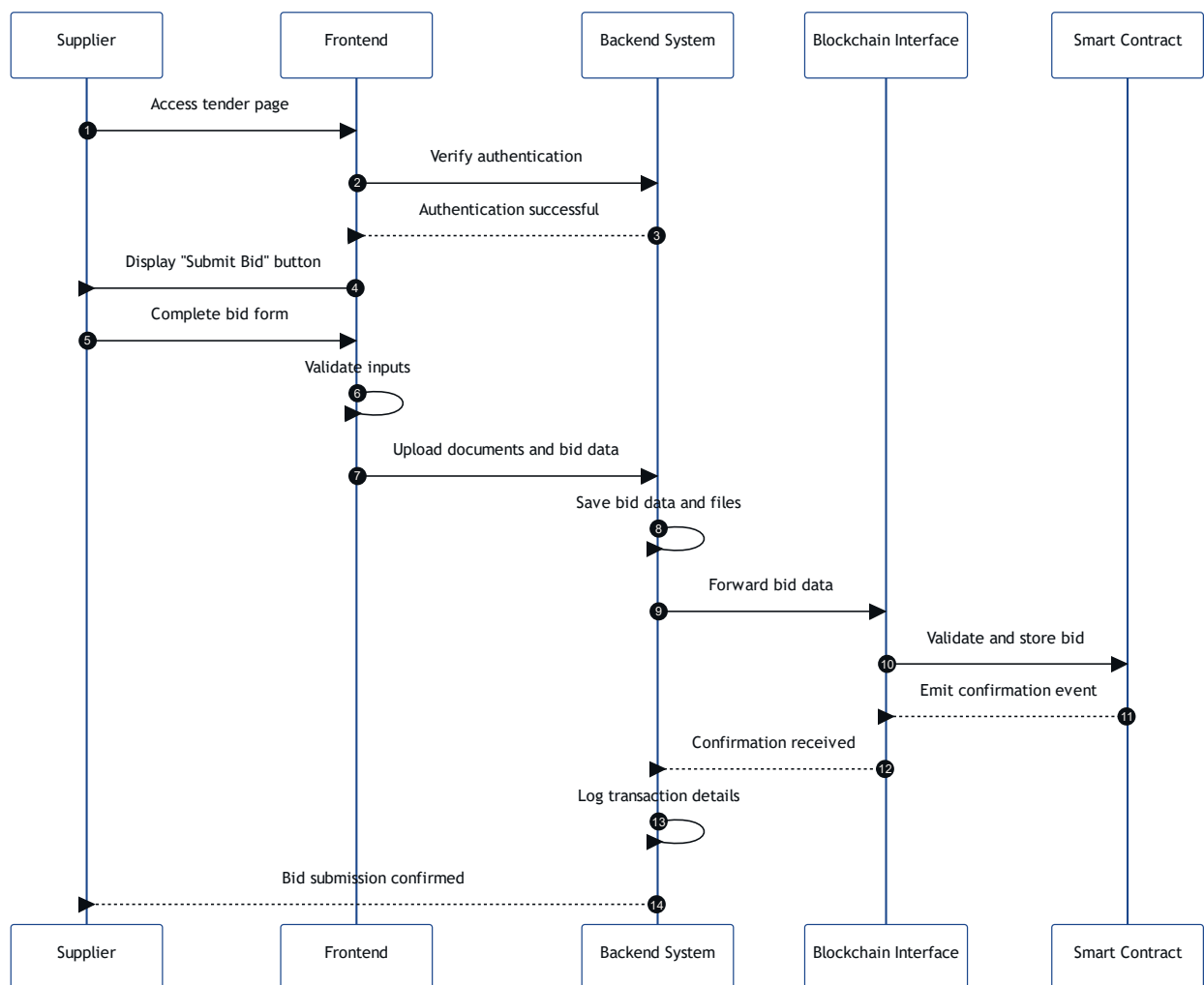


Figure 3.5: Bid Submission Sequence Diagram

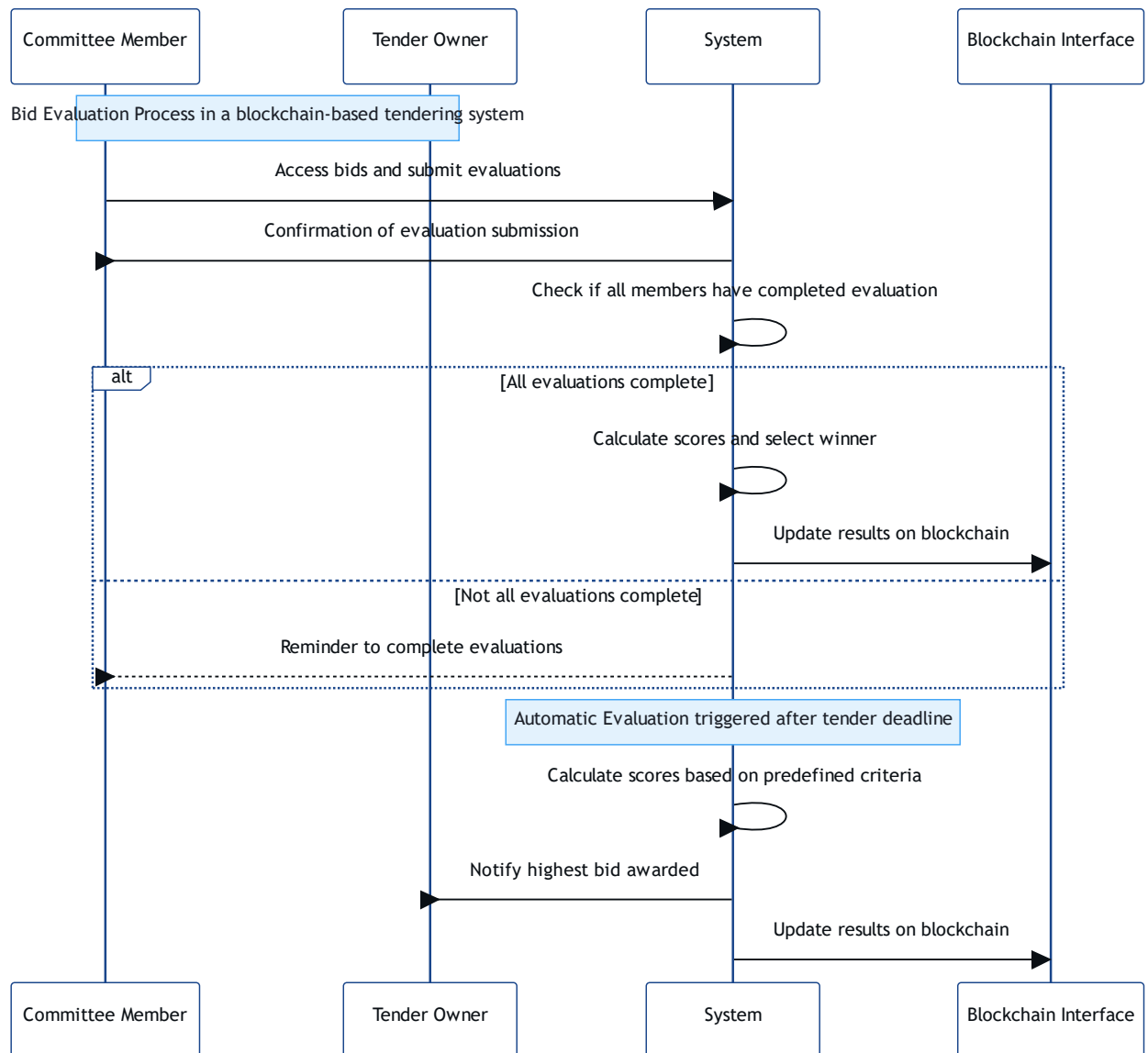


Figure 15: Bid Evaluation Sequence Diagram

Bid Submission: Suppliers prepare and submit their proposals, which are encrypted and stored securely

Bid Evaluation: Depending on the tender configuration, bids are evaluated either: Automatically based on predefined weighted criteria

By a committee of evaluators who independently assess each bid

The evaluation results are recorded on the blockchain to ensure transparency and prevent manipulation.

2.3 Tender Completion

The tender completion process, as shown in the sequence diagram, involves:

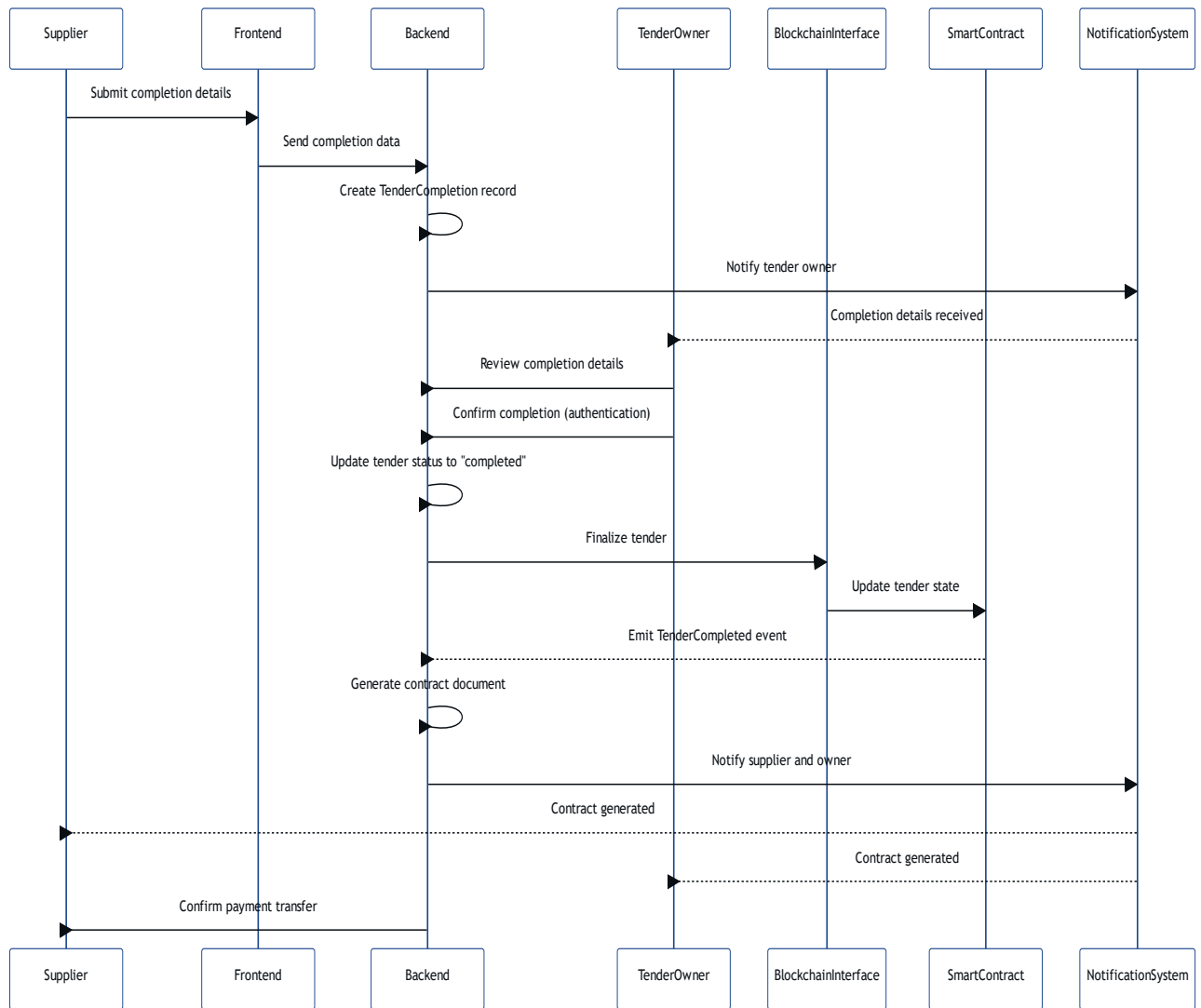


Figure 16: Tender Completion Sequence Diagram

1. Supplier submitting completion evidence
2. Issuer verifying the completed work
3. System recording the completion on the blockchain
4. Updating the tender status to 'completed'

This process ensures proper closure of the tender lifecycle and maintains a complete record of the tender's execution.

3. State Transitions

The system tracks the state of tenders and bids throughout their lifecycle, ensuring that all actions occur in the proper sequence and under the right conditions.

3.1 Tender States

As illustrated in the state diagram, a tender can exist in several states:

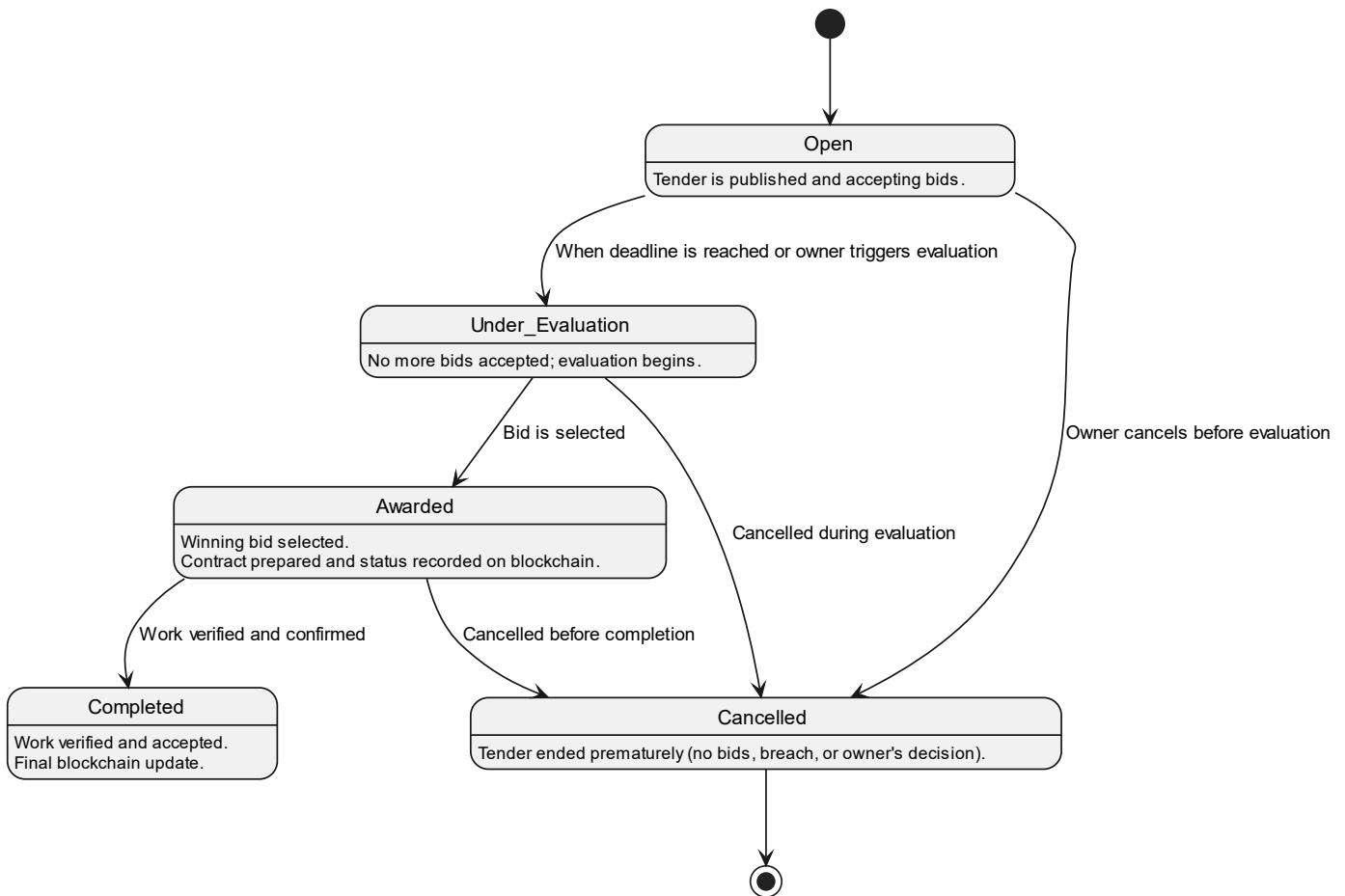


Figure 17: Tender Lifecycle State Diagram

Draft: Initial state during tender creation

Open: Published and accepting bids

Closed: Bid submission deadline has passed

Evaluation: Bids are being evaluated

Awarded: A winning bid has been selected

Execution: Work is being performed by the awarded supplier

Completed: The tender has been successfully fulfilled

Cancelled: The tender has been cancelled before completion

Transitions between these states are triggered by specific events and may require authorization from appropriate users.

3.2 Bid States

Similarly, bids go through their own lifecycle as shown in the state diagram:

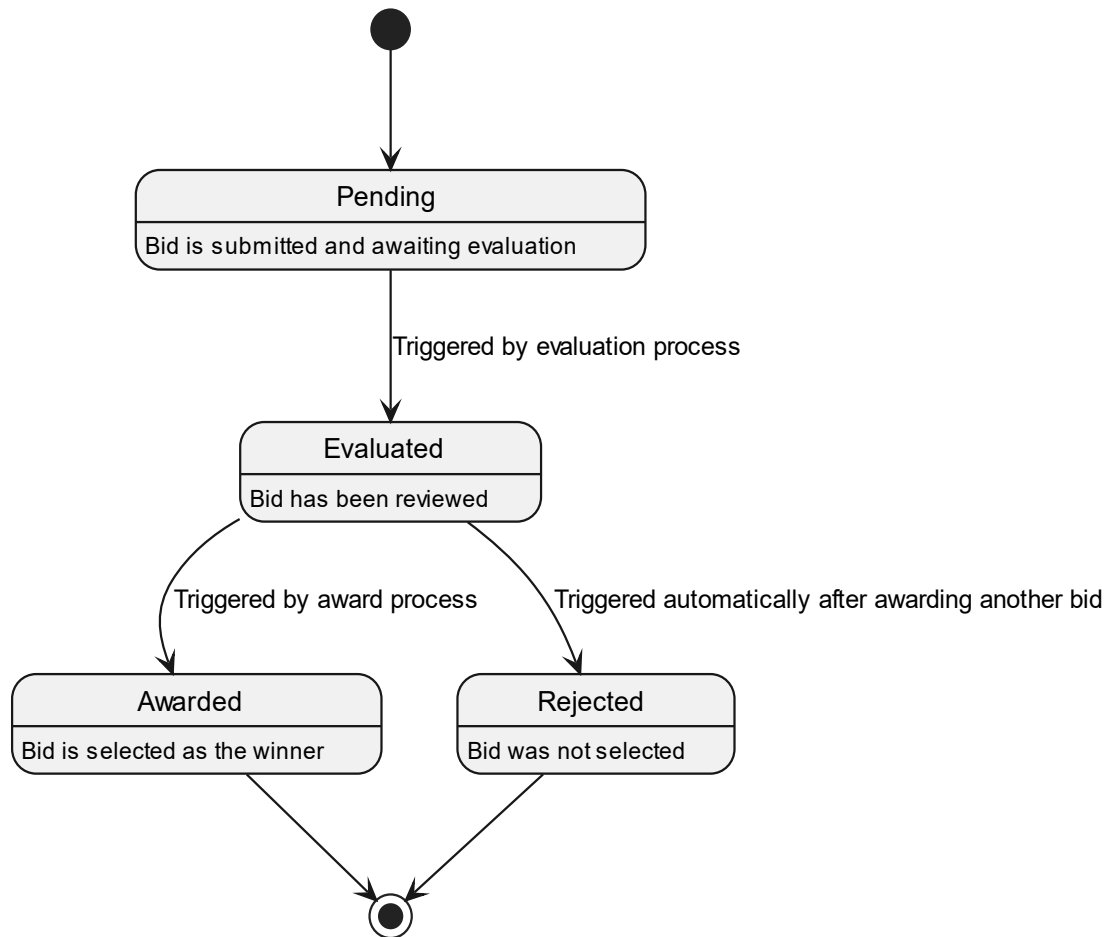


Figure 18: Bid Lifecycle State Diagram

Draft: Bid is being prepared by the supplier

Submitted: Bid has been submitted to the system

Under Review: Bid is being evaluated

Accepted: Bid has been selected as the winner

Rejected: Bid was not selected

Withdrawn: Bid was withdrawn by the supplier before the deadline

These state transitions ensure that bids are processed in a consistent and transparent manner.

4. Use Cases

The system supports various use cases for different stakeholders, as depicted in the use case diagram. Key use cases include:

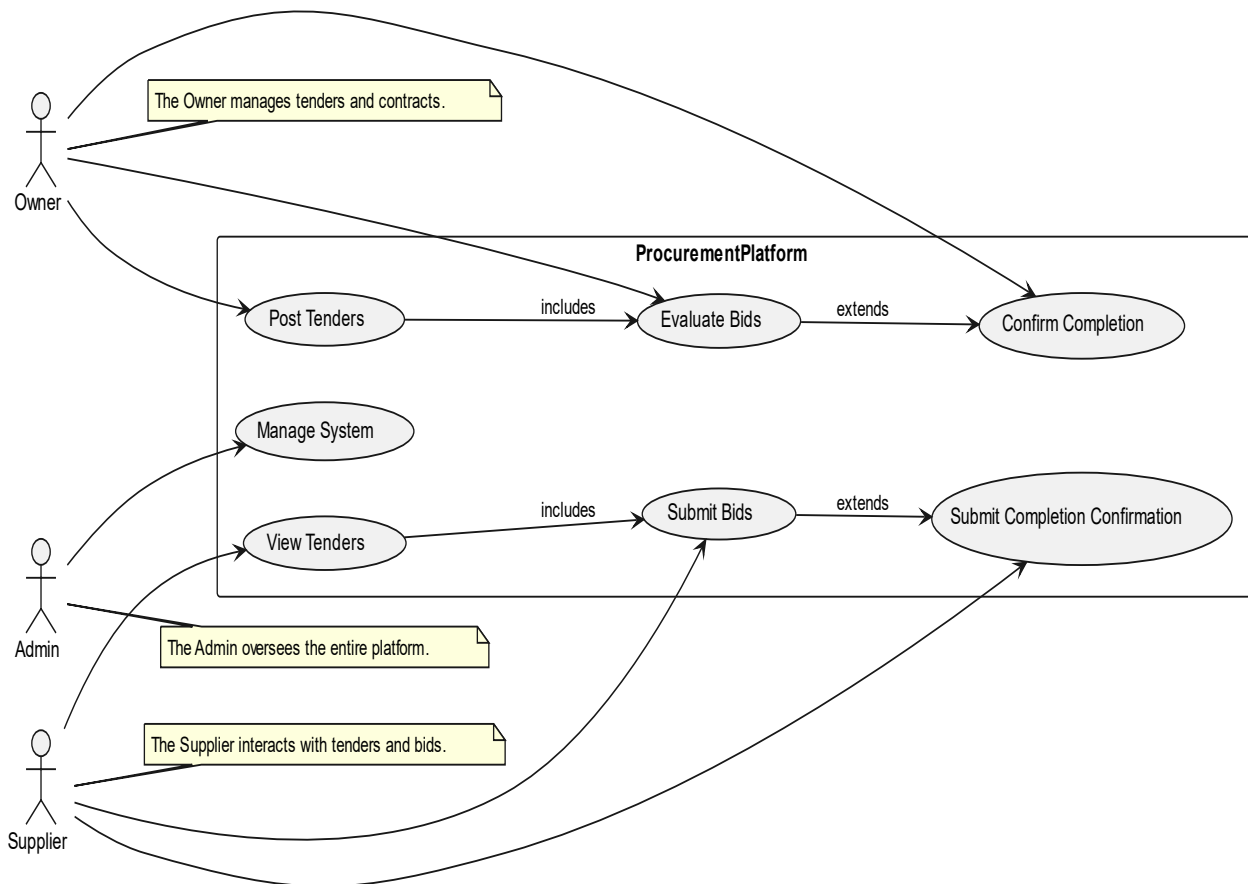


Figure 19: Main Use Case Diagram

4.1 For Tender Issuers

- Create and publish tenders
- Review and evaluate submitted bids Award tenders to winning bids
- Verify completed work
- Access tender analytics and reports

4.2 For Suppliers

- Browse available tenders
- Submit bids for open tenders Track bid status
- Submit completion evidence
- Manage supplier profile and credentials

4.3 For Evaluators

- Review assigned bids
- Score bids based on evaluation criteria Submit evaluation results

- Participate in committee discussions

4.4 For Administrators

- Manage user accounts and permissions Monitor system performance
- Generate system-wide reports
- Configure system parameters

These use cases guide the development of user interfaces and ensure that the system meets the needs of all stakeholders.

5. Blockchain Integration

The integration of blockchain technology is a core aspect of the system's design, providing transparency, security, and immutability to the tendering process.

5.1 Smart Contract Design

The system utilizes smart contracts deployed on the blockchain to enforce rules and manage tender- related transactions. The main smart contract, TenderTracker, implements the following functionality:

- Tender creation and management Bid submission and storage
- Evaluation result recording
- Award and completion verification

These smart contracts ensure that all critical tender operations are executed according to predefined rules and are permanently recorded on the blockchain.

5.2 Blockchain Transactions

Key events in the tender lifecycle trigger blockchain transactions that are recorded immutably. These include:

- Tender publication Bid submission
- Evaluation results
- Tender award
- Completion verification

Each transaction contains relevant metadata and is linked to the corresponding entities in the system, creating a complete audit trail.

5.3 Transparency and Verification

The system provides mechanisms for stakeholders to verify the integrity of the tendering process through blockchain exploration. Users can:

- View transaction details for any tender or bid
- Verify the timestamp and content of submissions
- Confirm that evaluation results match the recorded criteria
- Trace the complete history of a tender from creation to completion
- This transparency builds trust in the system and ensures accountability for all participants.

6. Security Considerations

Security is a paramount concern in the design of the blockchain tenders system, with multiple layers of protection implemented:

6.1 User Authentication and Authorization

- Multi-factor authentication for user accounts Role-based access control to system features
- Fine-grained permissions for tender operations
- Secure credential management

6.2 Data Protection

- Encryption of sensitive bid information
- Secure storage of documents and attachments Privacy-preserving evaluation processes
- Compliance with data protection regulations

6.3 Blockchain Security

- Secure key management for blockchain transactions Protection against smart contract vulnerabilities
- Consensus mechanisms to prevent tampering
- Immutable audit trails for all operations
- These security measures ensure that the system protects the integrity of the tendering process and the confidentiality of sensitive information.

Conclusion

The conception of the blockchain tenders system represents a comprehensive approach to modernizing the tendering process through technology. By leveraging blockchain for transparency and security, implementing robust process flows, and designing intuitive user experiences, the system aims to address the common challenges in traditional tendering processes.

The architectural decisions, process designs, and security considerations outlined in this chapter provide a solid foundation for the implementation phase, ensuring that the resulting system will meet the needs of all stakeholders while maintaining the highest standards of integrity and efficiency.

With the conceptual and architectural groundwork firmly established, the next step focuses on bringing the system to life. Chapter 4 details the implementation phase, beginning with the design and development of the web application interface that serves as the primary user interaction point for the blockchain-based tender management system.

Chapter 4: Implementation

1. Web Application Interface

The following sections showcase the implemented user interface of the blockchain-based tender management system:

1.1. Authentication Pages

Login Page :

This screen presents the user with a clean and secure login interface. The primary goal here is for registered users to access their accounts by entering their email and password. For a streamlined, secure alternative, the interface prominently features a “Connect Wallet” option, allowing users to log in using their cryptocurrency wallet, which simplifies access and enhances security by leveraging blockchain-based identity.

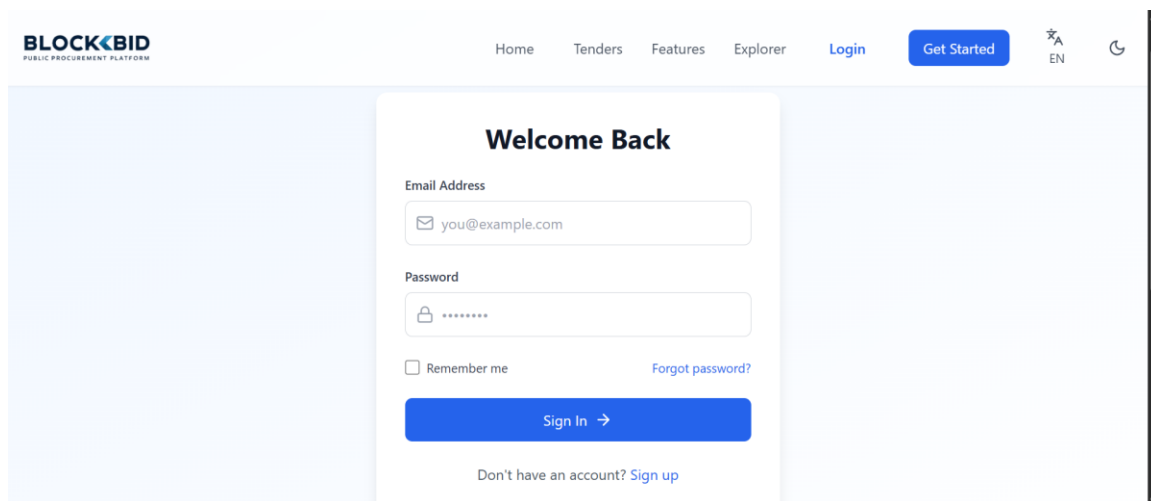


Figure 20: User Login Interface Screenshot

Registration Page :

This interface is the first step in the user registration journey, focusing on connecting a digital wallet. The user is prompted to connect their wallet (e.g., MetaMask), which serves as their unique, secure identity within the application. This wallet-first approach simplifies the registration process by automatically fetching the user's public address, reducing manual input and tying their profile directly to the blockchain from the start.

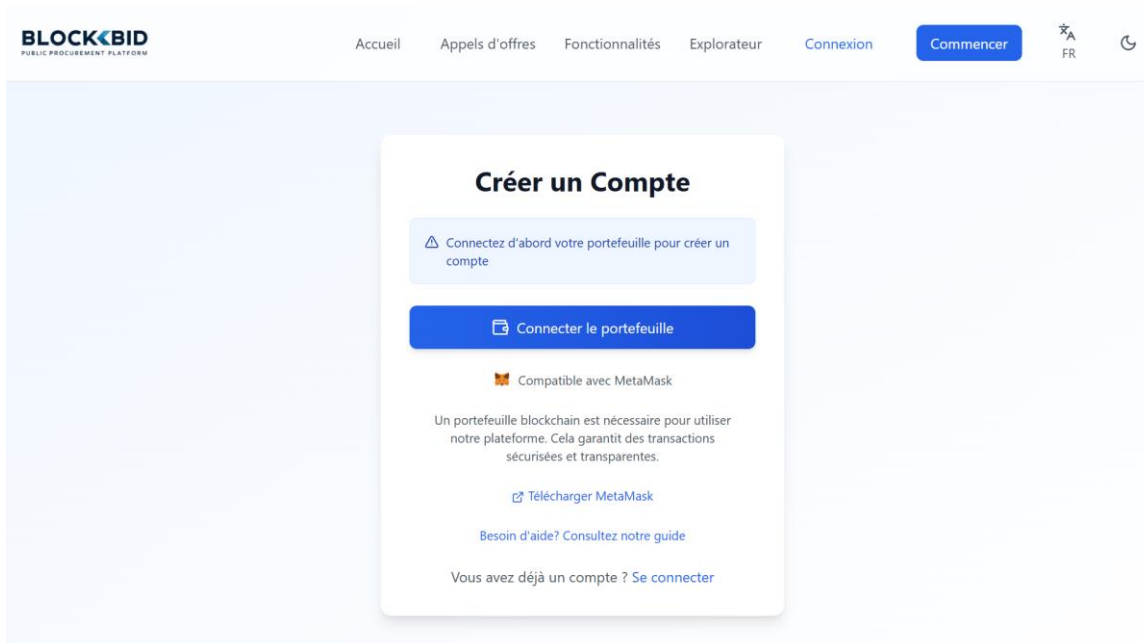


Figure 21: Registration Wallet Connect Interface Screenshot

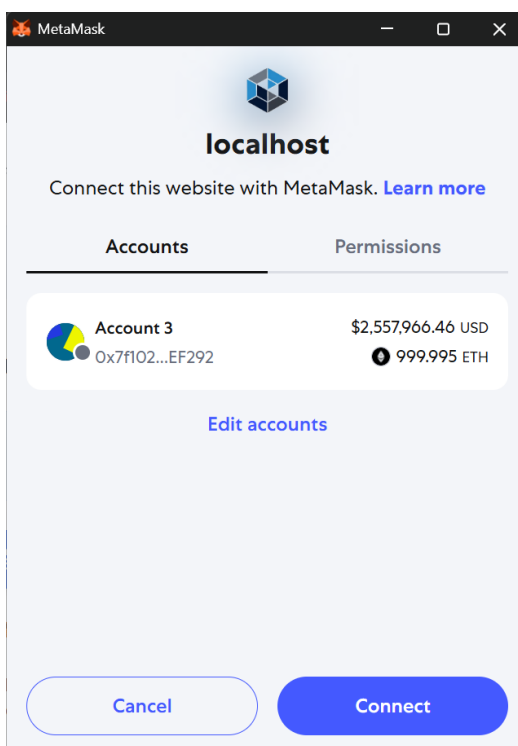


Figure 23: Wallet Account Selection

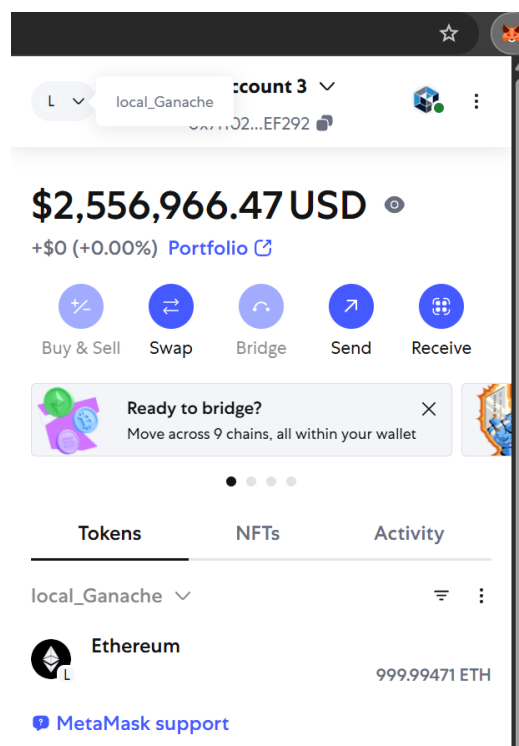


Figure 22: Blockbid Blockchain Account

This page serves as a helpful guide for users who may be new to blockchain applications and do not yet have a digital wallet. It provides clear, step-by-step instructions on how to download, install, and set up a compatible wallet like MetaMask. This thoughtful inclusion lowers the barrier to entry, ensuring even non-crypto-native users feel supported and can successfully navigate the initial setup.

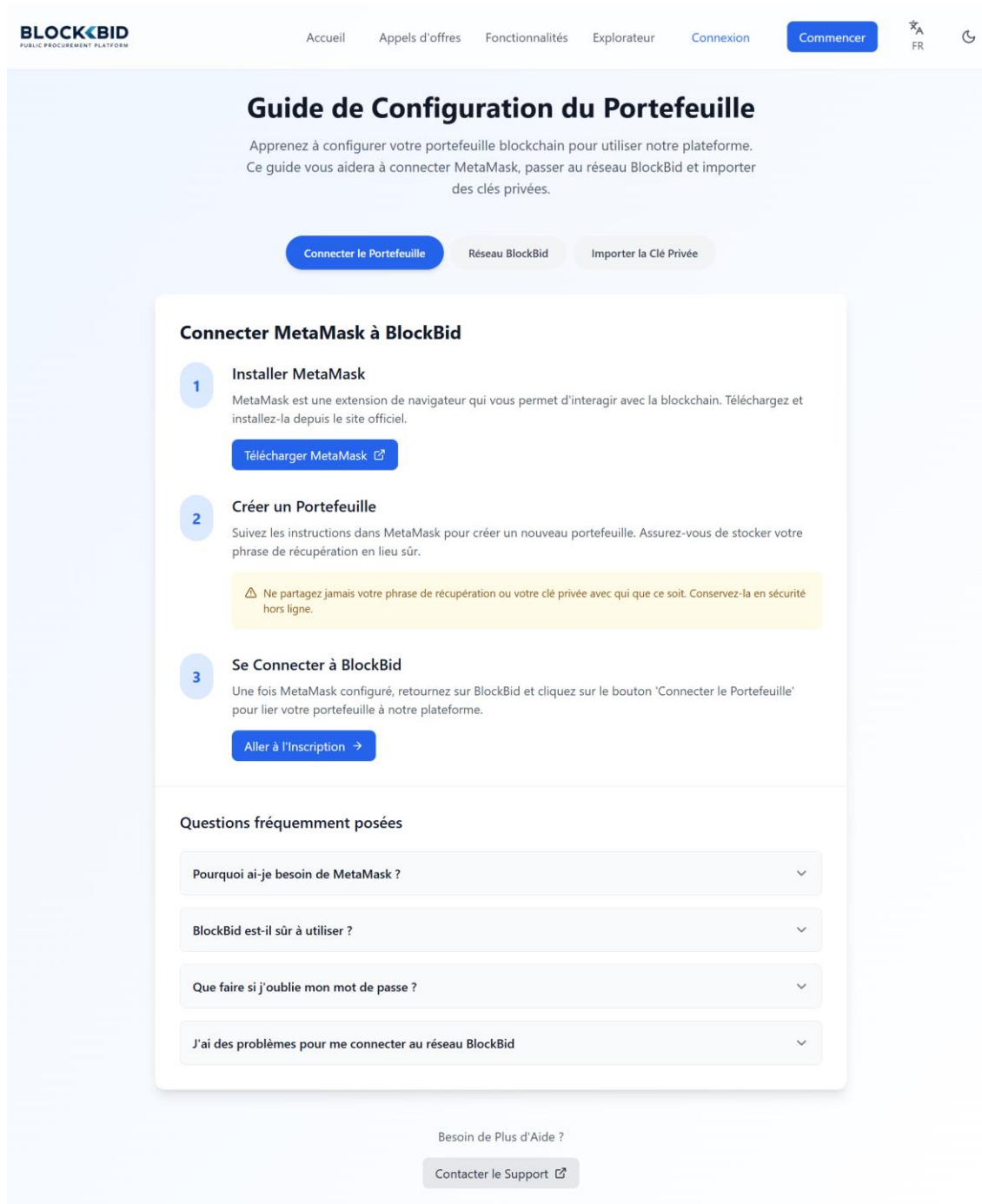


Figure 24: Wallet Guide Interface Screenshot

This page serves as a helpful guide for users who may be new to blockchain applications and do not yet have a digital wallet. It provides clear, step-by-step instructions on how to download, install, and set up a compatible wallet like MetaMask. This thoughtful inclusion lowers the barrier to entry, ensuring even non-crypto-native users feel supported and can successfully navigate the initial setup.

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Créer un Compte

✓ Portefeuille connecté au réseau:
BlockBid Testnet

[Besoin d'aide? Consultez notre guide](#)

Type de Compte

Nom Complet

Adresse Email

Nom de l'Entreprise

Description de l'Entreprise

Mot de Passe

Confirmer le Mot de Passe

[Vous avez déjà un compte ? Se connecter](#)

Figure 25: User Registration Interface Screenshot

This screen represents the final confirmation step in the wallet setup and registration process. It typically asks the user to sign a message with their wallet to cryptographically verify ownership of the address, a standard and secure practice. This action finalizes the link between their wallet and their application profile, providing a secure and tamper-proof foundation for all future interactions.

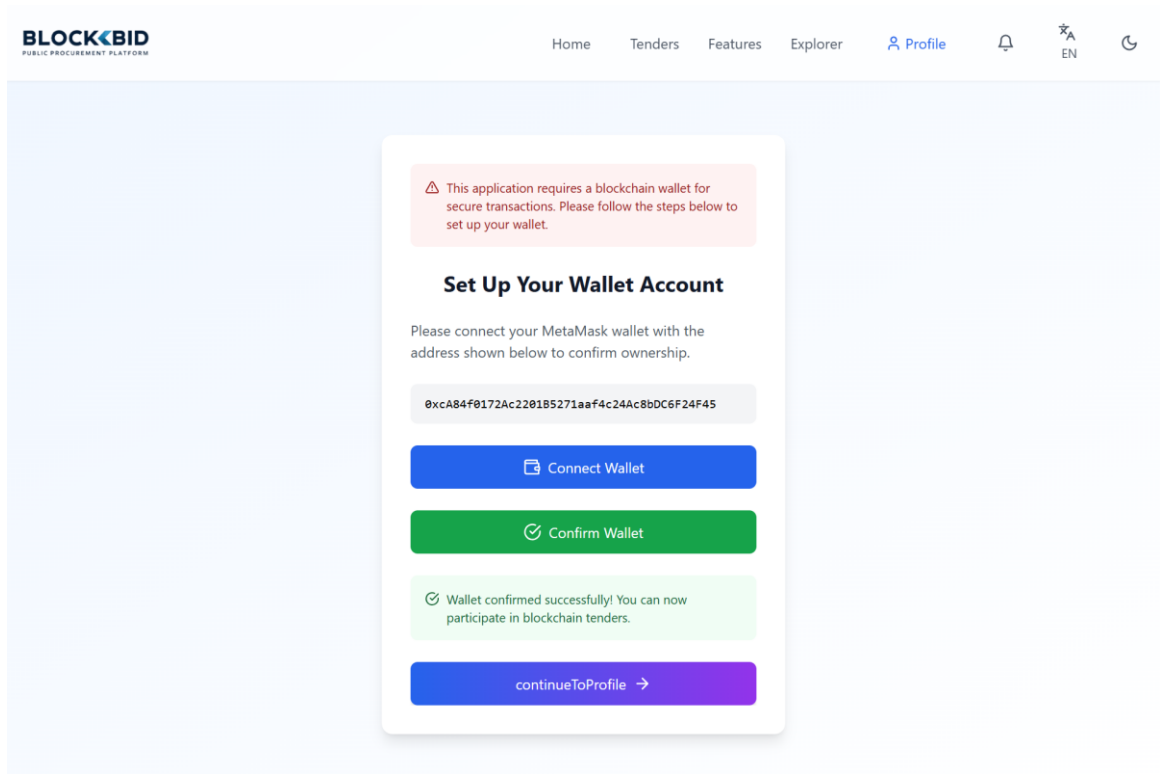


Figure 26: Wallet Setup Final Step Interface Screenshot

1.2 Main Application Pages

Home Page:

This is the central hub or main dashboard that users see after logging in. It provides a high-level overview of their status and quick access to the most relevant actions based on their role—such as viewing active tenders, tracking submitted bids, or creating new tenders. The design aims to give users an immediate, personalized snapshot of their activities, helping them navigate to key tasks efficiently.

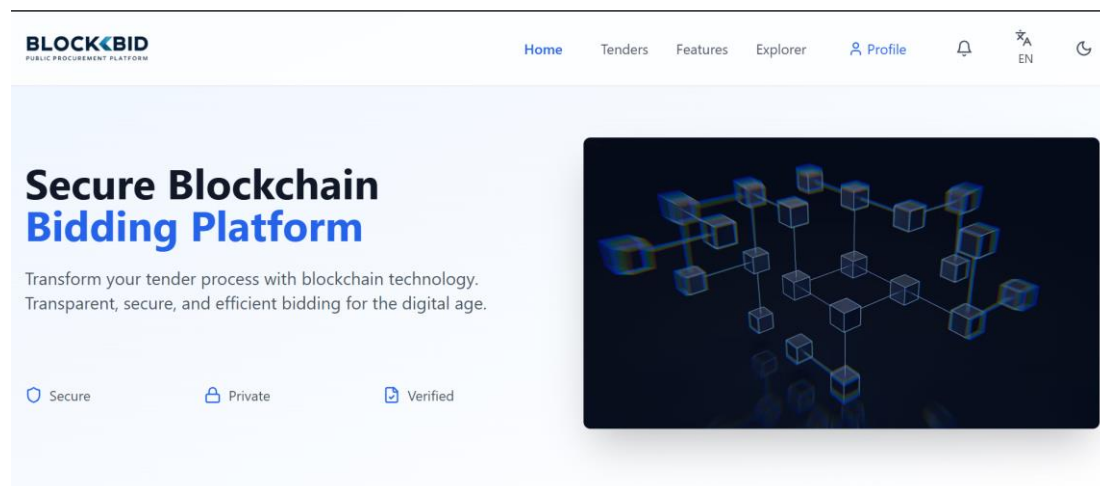


Figure 27: Home Page

Tenders Listing Page:

This interface displays a comprehensive list of all available tenders on the platform. Users can browse, search, and filter through opportunities based on various criteria like category, deadline, or budget. For suppliers, this page is their primary gateway to finding new business, designed to make discovering relevant tenders as easy as possible.

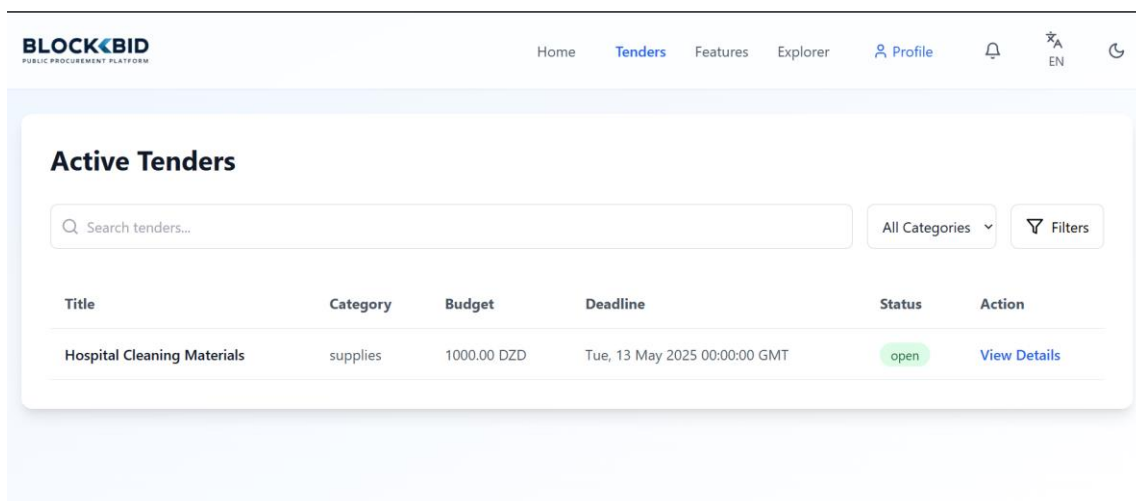


Figure 28: Tenders Listing Interface Screenshot

Tender Details Page:

This page provides an in-depth view of a single tender selected from the listing. It contains all critical information, including the project description, requirements, timeline, and supporting documents. From here, an interested supplier can initiate the bidding process, making this screen the crucial decision-point for participation.

Hospital Cleaning Materials

📅 Mostaganem Hospital

Download Details

📅 Deadline

13/05/2025

\$ Budget Range

DZD 1000.00 - 1500.00

⌚ Duration

2 months

👤 Status

Open

Project Description

We need cleaning materials for the hospital

Requirements

- new materials
- guarantee of durability

Evaluation Method

🔍 Automatic Evaluation

Evaluation Criteria:

☑ price

Weight: 50%

☑ timeline

Weight: 50%

Tender Documents

📄 sample.pdf

Tender Owner

Mansour Owner
mansour@example.com

Bid Information

0 bids submitted

Project Images



Blockchain Information

📖 Blockchain Transaction

📄 Block Number

6 🔗

🕒 Timestamp

21/01/1970 06:15:07

🔍 From

0x7f10219c2674f5af180f9b02e7764ebcAcEF292

➡ To

0xE5E1e896d48d38B7be88FC80654963A3e3115B20

Transaction Hash

a5099555c5329d898764694b8a8e0071f318f288af3ef936be90ffe481431e1d

Action

Transfer or Interaction

This tender is recorded on the blockchain for transparency and immutability.

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Transforming the future of digital

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t

i

o

Figure 29: Tender Details and Bidding

Post New Tender Page:

This interface is a structured form designed for tender owners to create and publish new tenders. It guides the owner through inputting all necessary details, such as the tender title, scope, evaluation criteria, and deadlines. The user-friendly layout simplifies the complex process of defining a tender, ensuring all required information is captured accurately before it's posted.

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Post a New Tender

Project Title

Enter project title

Organization

Enter organization name

Project Description

Describe your project requirements

Project Requirements

Add a requirement

Bid Evaluation Method

Committee-Based Evaluation

Select committee members who will review and score bids after the deadline.

Automatic Evaluation

Define scoring criteria and weights for automatic bid selection.

Committee Members

Mansour Owner (mansour@example.com)

Submission Deadline

jj/mm/aaaa

Budget Range

\$ e.g., \$10,000 - \$15,000

Project Category

Construction

Project Duration

e.g., 3 months

Currency

DZD

Project Files

Documents

Click to upload or drag and drop

PDF, DOC, DOCX, XLS, XLSX (MAX. 10MB)

Images

Click to upload or drag and drop

PNG, JPG, JPEG, GIF (MAX. 5MB)

Post Tender

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Figure 30: Tender Creation Interface Screenshot

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Post New Bid Page:

This screen provides a secure portal for suppliers to submit their bids. Users can fill in their proposed price, upload required documents, and provide other relevant information. The interface is designed to ensure the submission is complete and accurate before the user confirms it, which triggers a transaction to record the bid securely on the blockchain.

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Explorer

Profile

EN

Submit Your Bid

Tender Details

Tender ID: 1

Bid Amount

\$

Enter your bid amount

Technical Proposal

Describe your approach and methodology

Expected Completion Date

jj/mm/aaaa

Supporting Documents

Upload company profile, certifications, and other relevant documents

Submit Bid →

BlockBid

Quick Links

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Figure 31: Tender Bid Submission Interface Screenshot

Auto Evaluation Bids State View :

This interface provides feedback on the status of the automated evaluation phase. After bids are submitted, the system performs a preliminary check against predefined, objective criteria (e.g., completeness, budget compliance). This screen keeps users informed about whether their bid has passed this initial, transparent screening, adding a layer of efficiency to the evaluation process.

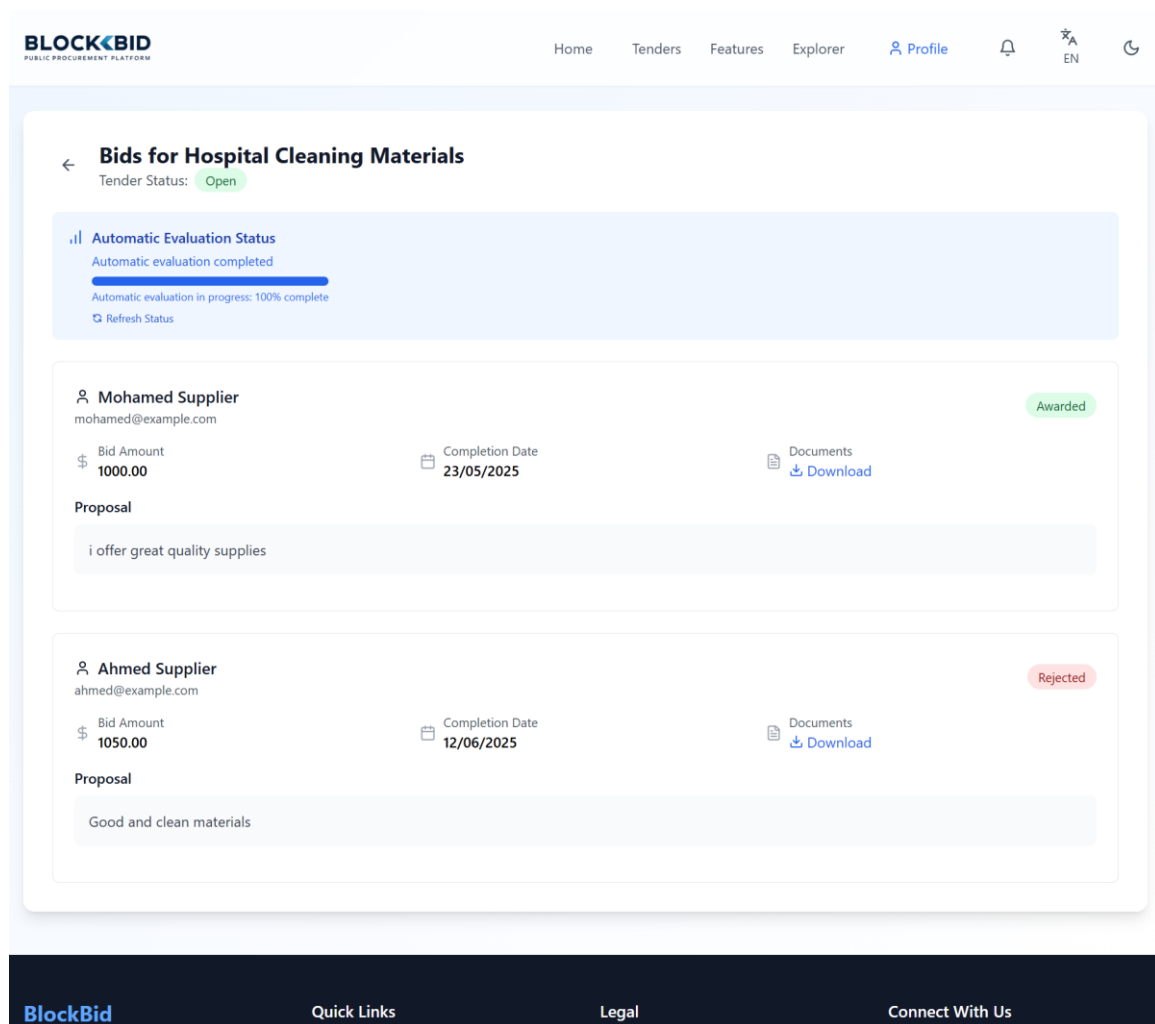


Figure 32: AutoEvaluation Bid State Submission Interface Screenshot

AutoEvaluation Bids Results Page :

This page displays the transparent results of the automated evaluation stage. It clearly shows which bids have met the mandatory pre-qualification criteria and which have not, often with reasons for disqualification. This feature provides immediate, unbiased feedback and helps narrow down the pool of candidates for the manual review, saving time for all parties.

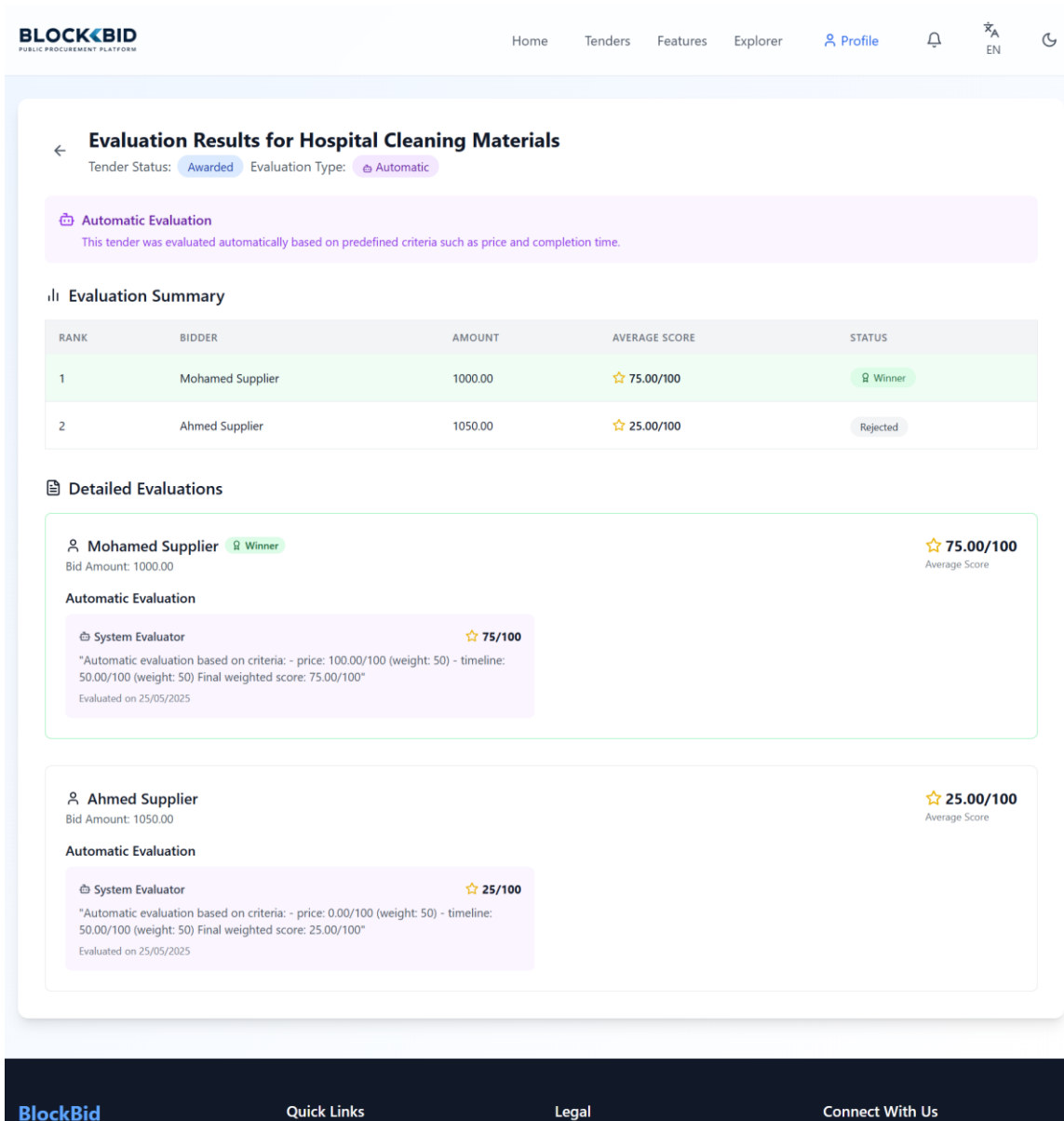


Figure 33: Auto Evaluations Results Interface Screenshot

Comittee Evaluation Bids State View :

These screens present the detailed results from the manual evaluation conducted by a committee. They typically show a breakdown of scores and qualitative feedback from each evaluator for the remaining bids. This transparency is key to building trust, as it allows all participants to understand the rationale behind the final selection.

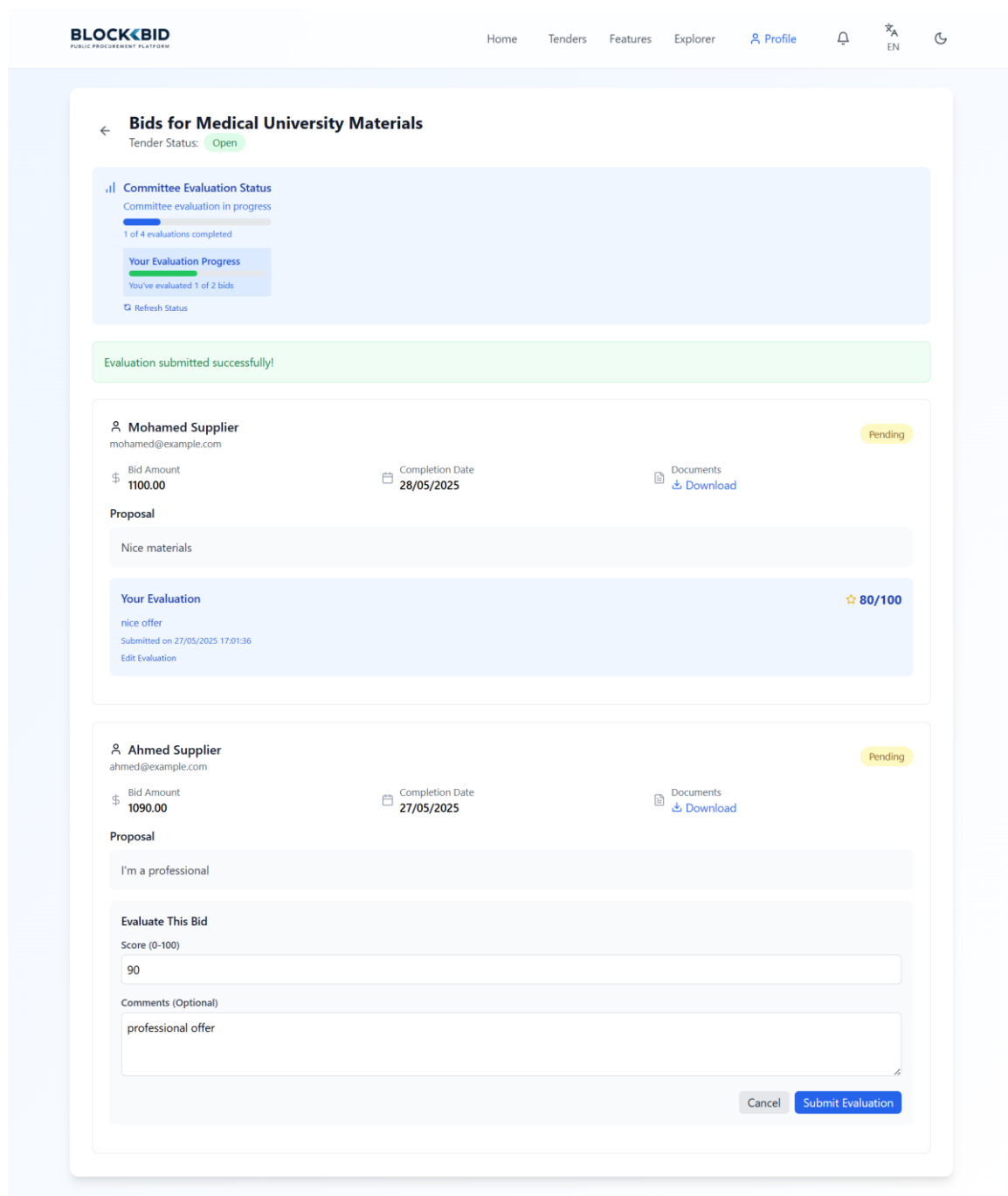


Figure 34: Committee Evaluations Results Interface Screenshot

Comittee Evaluation Bids Results Page:

This screenshot captures the moment a user—such as a winning supplier or a committee member—receives a payment or reward. The interface shows a clear notification confirming that funds have been successfully transferred directly to their connected digital wallet. This demonstrates the power of the integrated blockchain payment system, which ensures fast, secure, and transparent financial transactions.

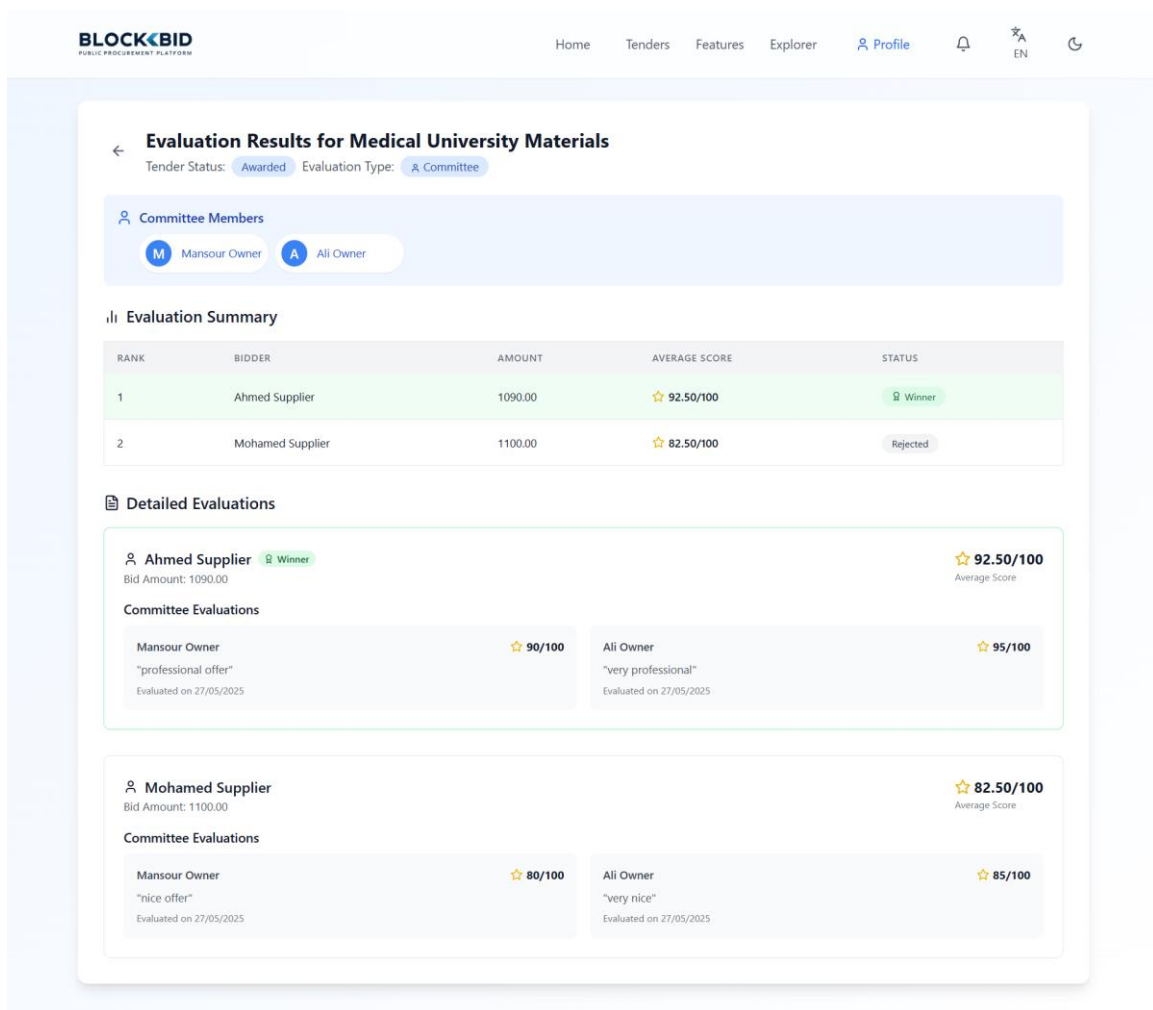


Figure 35: Committee Evaluations Results Interface Screenshot

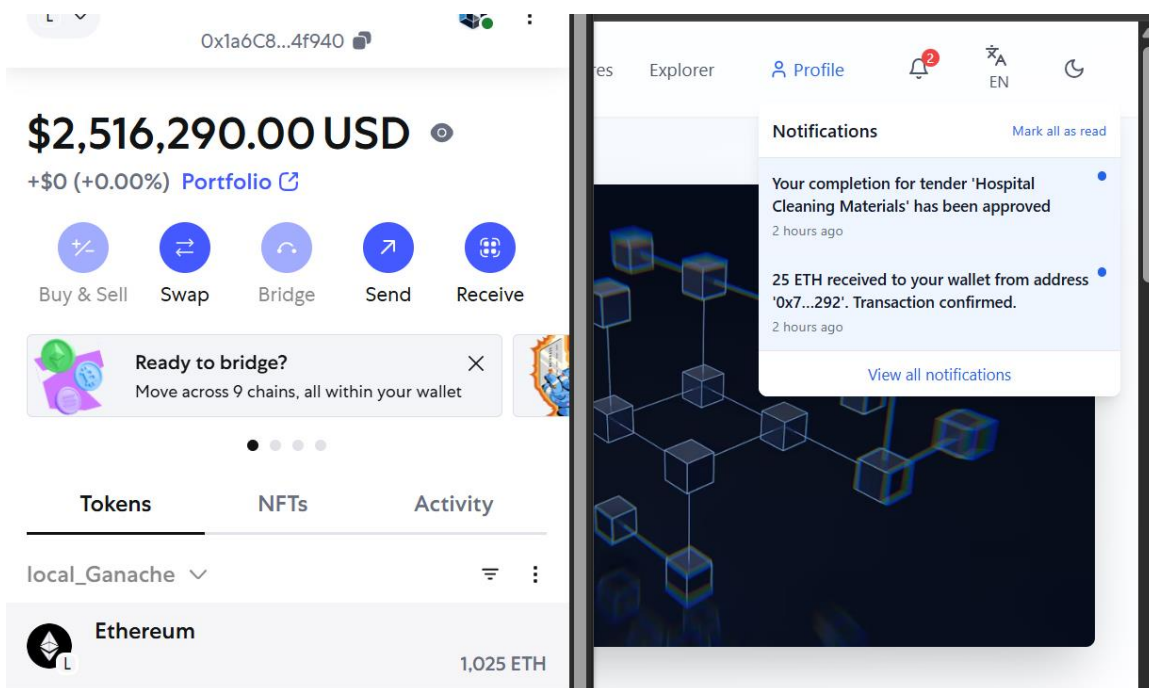


Figure 36: Reward Reception into Wallet and Notification

Tender Completion Submission:

Once the work for a tender is finished, the winning supplier uses this interface to formally mark the project as complete. This typically involves uploading final deliverables or providing proof of completion. The interface provides a clear, final step in the tender lifecycle, creating an official record of project fulfillment.

The screenshot displays a web application interface for 'Tender Completion Inspection'. A modal dialog titled 'Confirm Completion' is centered on the screen, prompting the user to enter their password to confirm the completion of a tender. The dialog includes a yellow shield icon, a warning message, a password input field, and 'Cancel' and 'Confirm' buttons. The background interface shows details for a tender titled 'Hospital' with a status of 'Waiting' and a budget of 'DZD'. It also lists a supplier 'Mohamed' and includes a 'Confirm Completion' button at the bottom.

Tender Completion Inspection [X]

Tender Info

Title: Hospital
Status: Waiting
Budget: DZD

Supplier Confirmation

Supplier: Mohamed
Email: mohamed@sample.je
Completion Status: Pending
Notes: I had prepared the final deliverables for the project.
Submitted: 2023-10-27 10:30 AM
📎 sample.jpg

Confirm Completion [X]

Please enter your password to confirm the completion of this tender. This action cannot be undone.

Password

Enter your password

Cancel Confirm

Confirm Completion

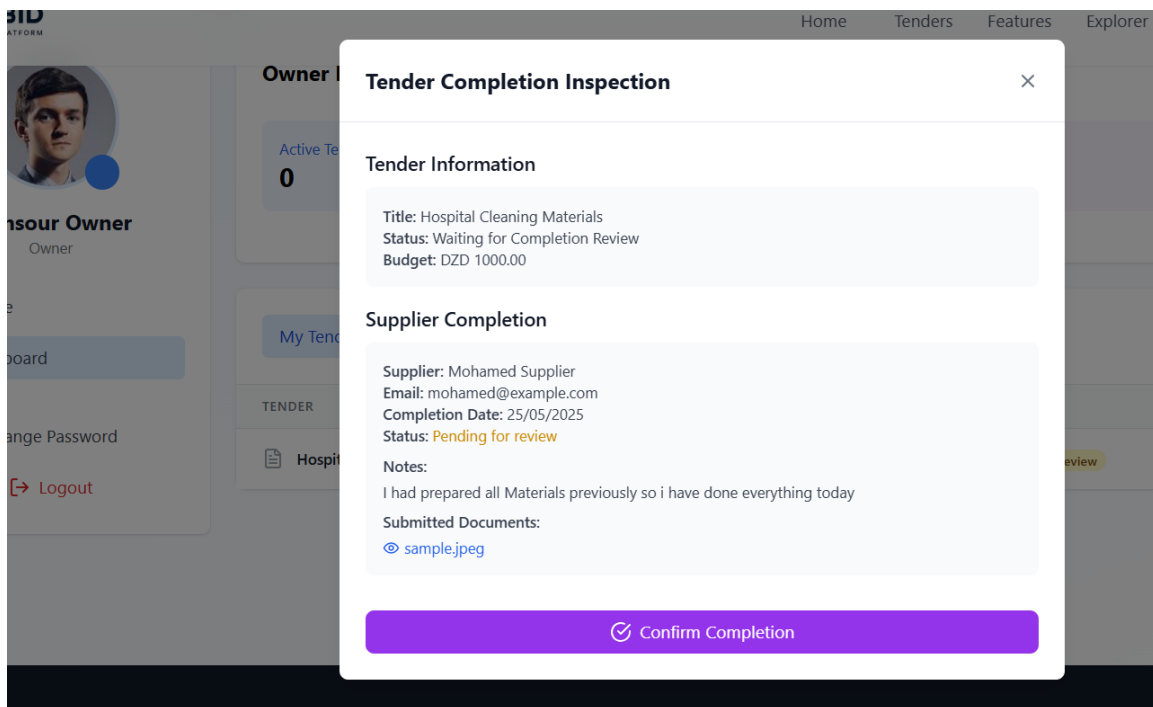


Figure 37: Tender Completion Submission

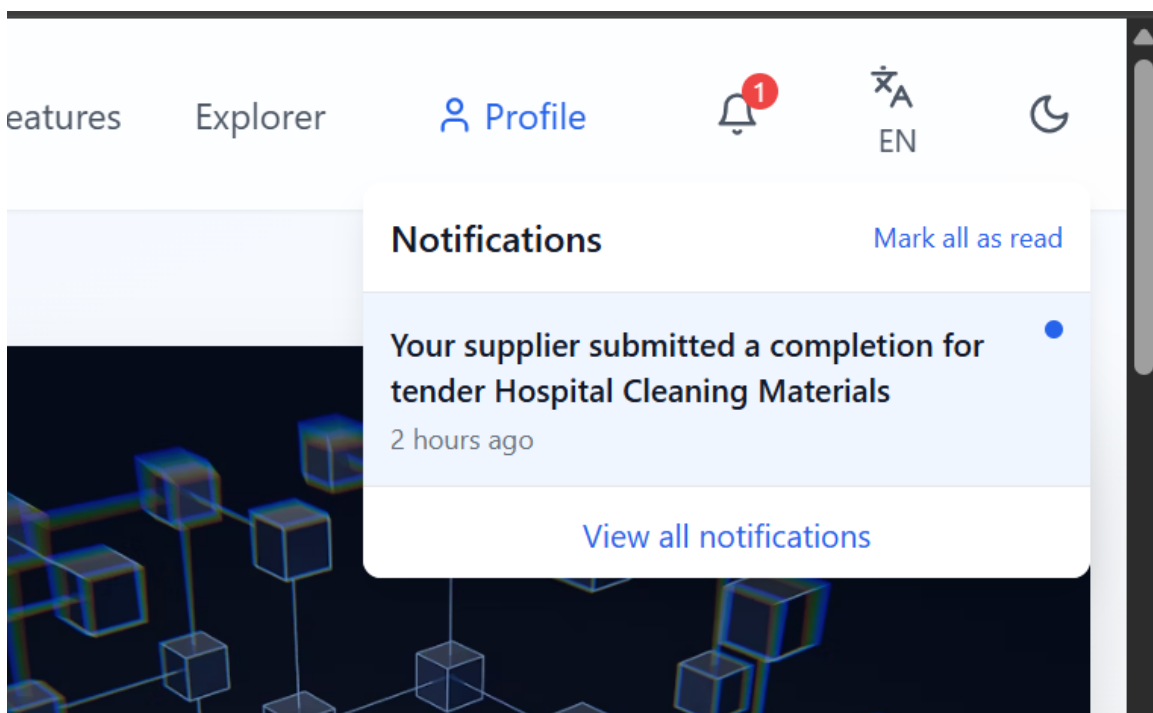


Figure 38: Completion Submission Notification

1.3 User Profile and Dashboard

User Profile Page:

This page allows users to manage their personal account settings. Here, they can update their contact information, change their password, and view their connected wallet address. It serves as a personal control panel, giving users the autonomy to keep their profile information current and secure.

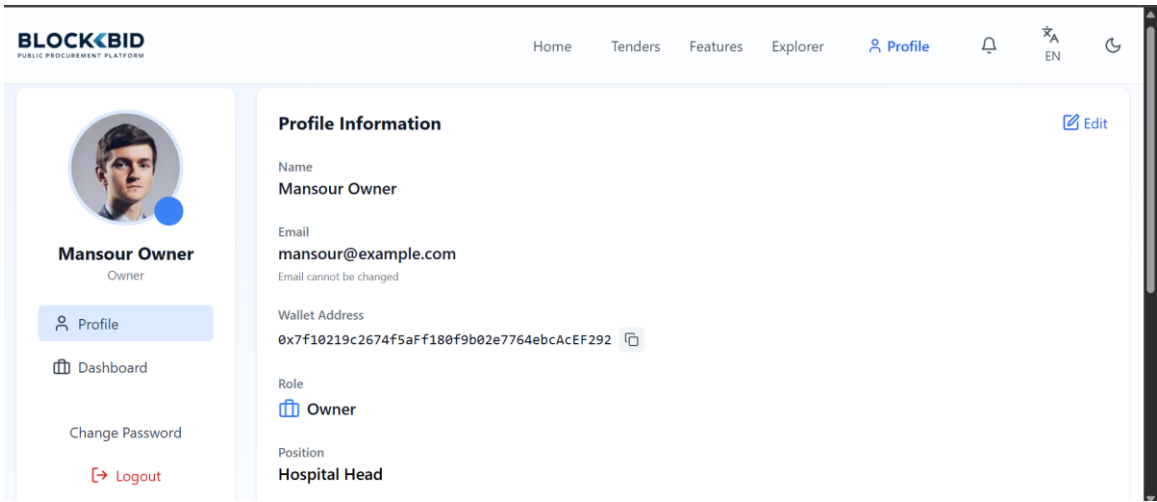


Figure 39: User Profile Management

Owner Dashboard:

This is a specialized dashboard tailored for users with the "owner" role. It provides a consolidated view of all tenders they have created, showing their current status (e.g., open for bidding, under evaluation, awarded). This role-specific view helps owners efficiently manage their procurement lifecycle from a single, organized screen.

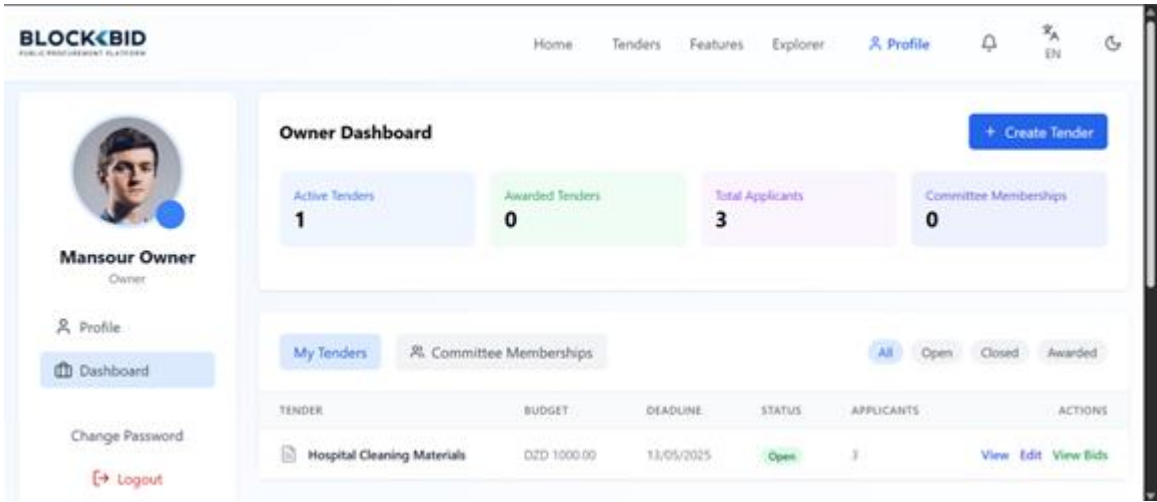


Figure 40: Owner Dashboard Interface Screenshot

Supplier Dashboard:

This dashboard is designed specifically for suppliers, offering a personalized overview of their bidding activities. It summarizes the status of all their submitted bids, tracks tenders they are participating in, and highlights any contracts they have won. This helps suppliers stay organized and informed about their opportunities and ongoing projects.

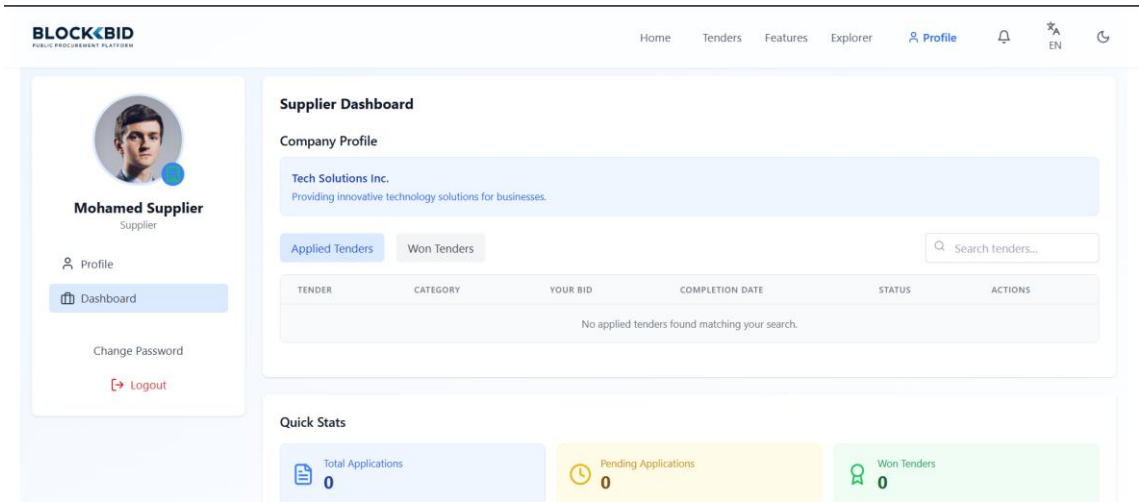


Figure 41: Supplier Dashboard Interface Screenshot

Admin Dashboard:

This powerful interface is the central command center for system administrators. It provides a comprehensive overview of the entire platform, including user management, system-wide tender monitoring, transaction logs, and platform settings. This dashboard is essential for maintaining the health, integrity, and smooth operation of the application.

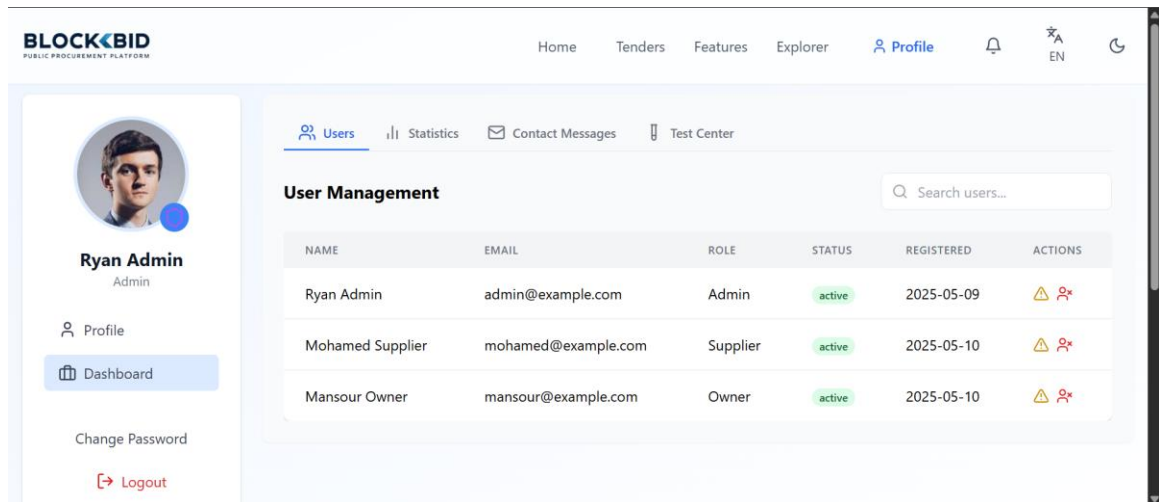


Figure 42: Admin Dashboard Interface Screenshot

1.4 UI Behavior

Multi-language Support:

This screenshot showcases the application's multi-language capabilities, displaying the user interface in English, French, and Arabic. This feature demonstrates a commitment to accessibility and inclusivity, allowing users from different regions to interact with the platform in their native language. It significantly broadens the application's reach and improves the user experience for a global audience.

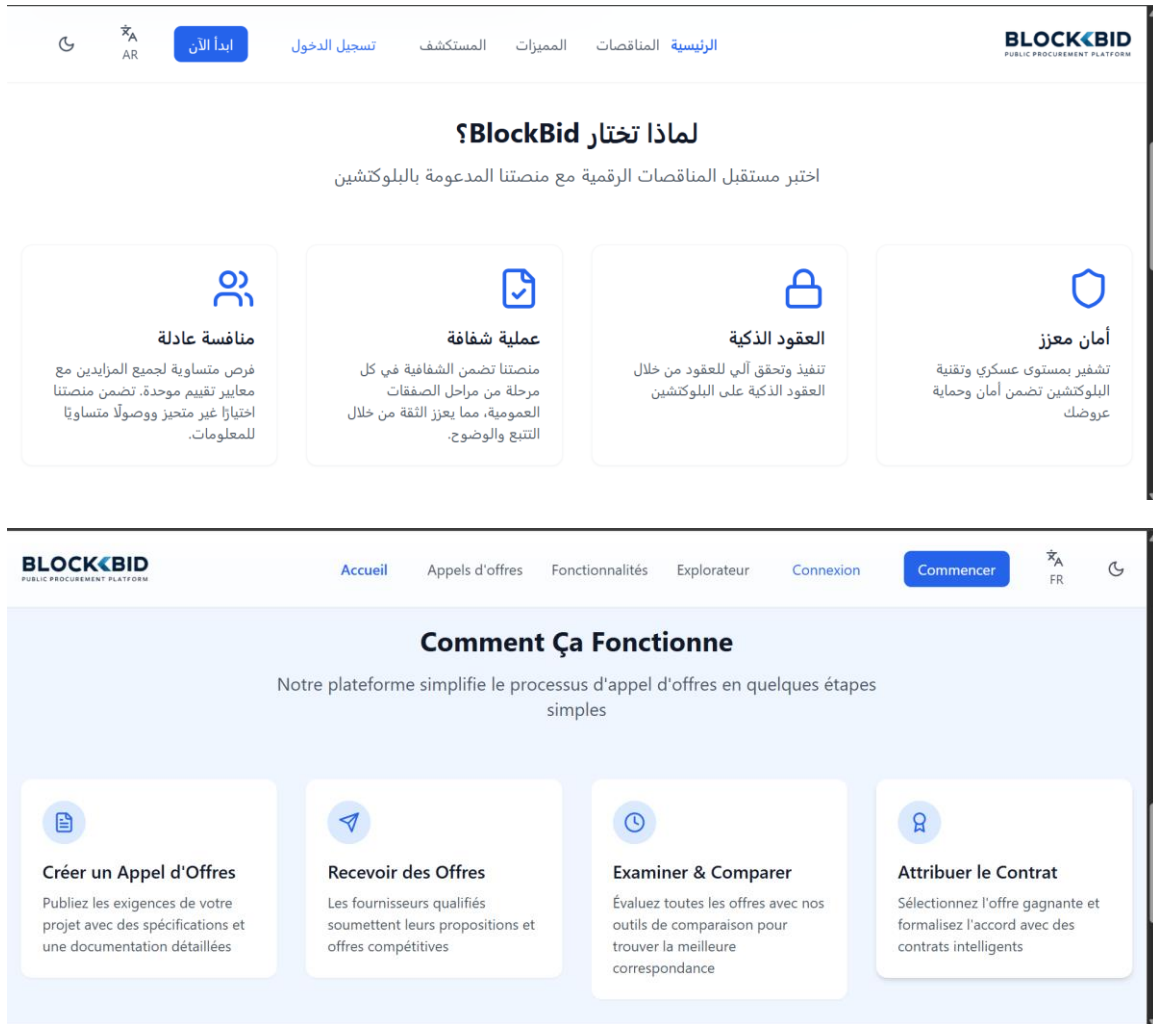


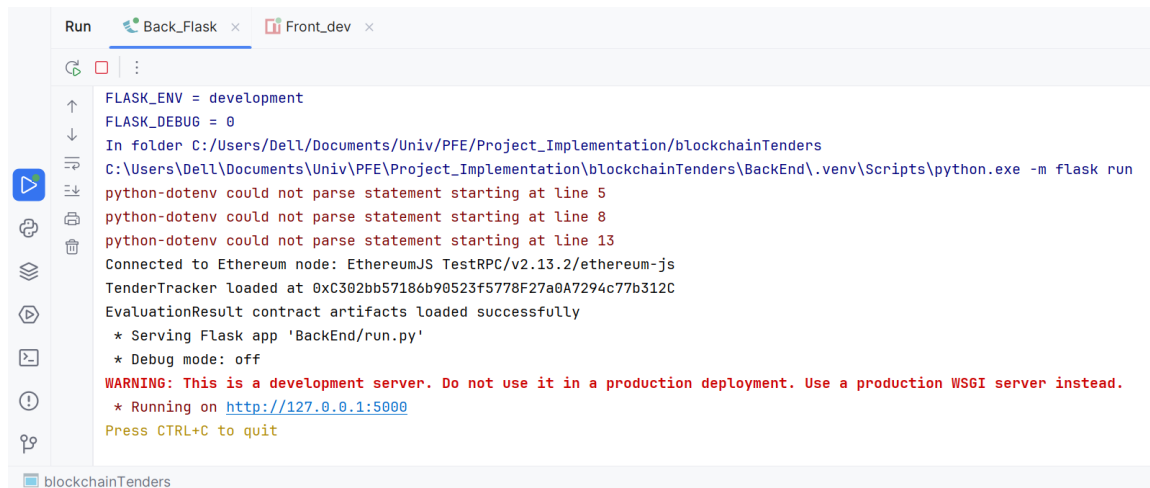
Figure 43: Multi-language Support (English/French/Arabic)

2. Backend Implementation

The backend system is implemented using Flask framework with SQLAlchemy ORM for database management and JWT for authentication.

2.1 Flask Server

Server Console:

A screenshot of the Pycharm IDE's Run console. The top bar shows two tabs: 'Back_Flask' and 'Front_dev'. The console output shows the execution of a Flask application. It starts with environment variables 'FLASK_ENV = development' and 'FLASK_DEBUG = 0'. The working directory is set to 'C:/Users/Dell/Documents/Univ/PFE/Project_Implementation/blockchainTenders'. The command executed is 'python-dotenv could not parse statement starting at line 5', 'python-dotenv could not parse statement starting at line 8', and 'python-dotenv could not parse statement starting at line 13'. The application connects to an Ethereum node (EthereumJS TestRPC/v2.13.2/ethereum-js) and loads TenderTracker. It then serves the Flask app 'BackEnd/run.py' in debug mode. A warning message states: 'WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.' The application is running on 'http://127.0.0.1:5000'. The prompt 'Press CTRL+C to quit' is shown at the bottom.

```
Run Back_Flask Front_dev
FLASK_ENV = development
FLASK_DEBUG = 0
In folder C:/Users/Dell/Documents/Univ/PFE/Project_Implementation/blockchainTenders
C:/Users/Dell/Documents/Univ/PFE/Project_Implementation/blockchainTenders/BackEnd/.venv/Scripts/python.exe -m flask run
python-dotenv could not parse statement starting at line 5
python-dotenv could not parse statement starting at line 8
python-dotenv could not parse statement starting at line 13
Connected to Ethereum node: EthereumJS TestRPC/v2.13.2/ethereum-js
TenderTracker loaded at 0xc302bb57186b90523f5778f27a0A7294c77b312C
EvaluationResult contract artifacts loaded successfully
* Serving Flask app 'BackEnd/run.py'
* Debug mode: off
WARNING: This is a development server. Do not use it in a production deployment. Use a production WSGI server instead.
* Running on http://127.0.0.1:5000
Press CTRL+C to quit
```

Figure 44: Pycharm Flask Console

2.2 Database Structure

Database Schema:

This figure shows a technical diagram of the application's database structure, known as an Entity-Relationship Diagram (ERD). It visually maps out the database tables (e.g., Users , Tenders , Bids) and the relationships between them. This schema is the blueprint for how data is organized, stored, and accessed, and is fundamental to the application's architecture.

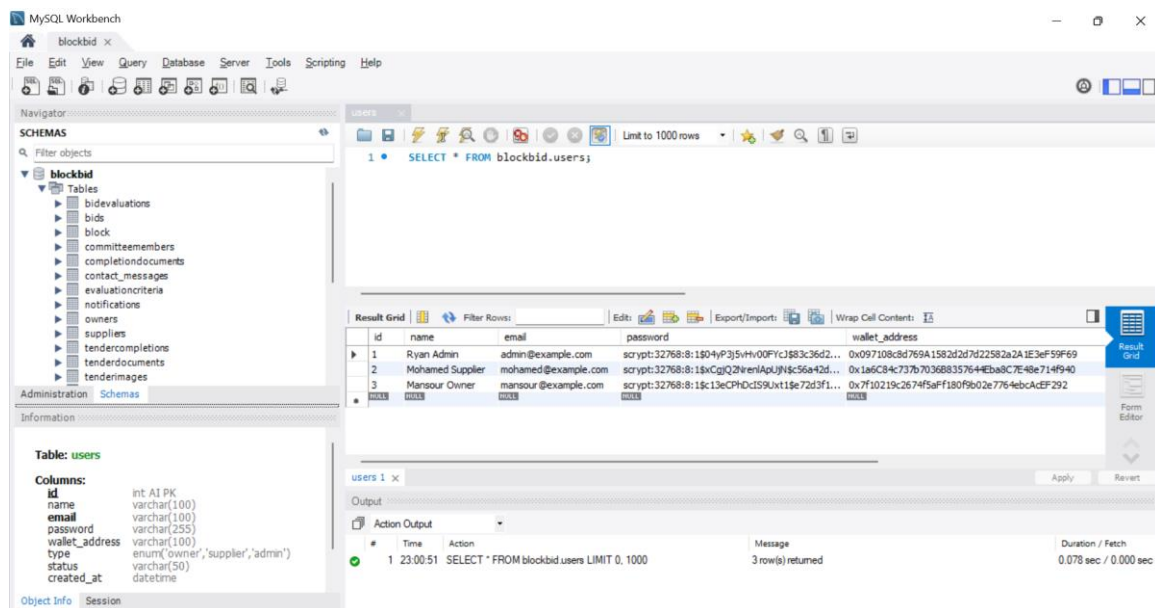


Figure 45: Database Schema and Entity Relationships

3. Blockchain Integration

The system integrates with Ethereum blockchain using Hardhat development environment and Ganache for local testing.

3.1 Ganache Development Environment

Ganache Interface :

This screenshot shows the Ganache interface, a personal blockchain for local development and testing. It displays a list of simulated Ethereum accounts, each with a balance of test Ether, along with a log of transactions and deployed smart contracts. This tool is essential for developers to build and test blockchain interactions in a controlled environment without incurring real-world costs.

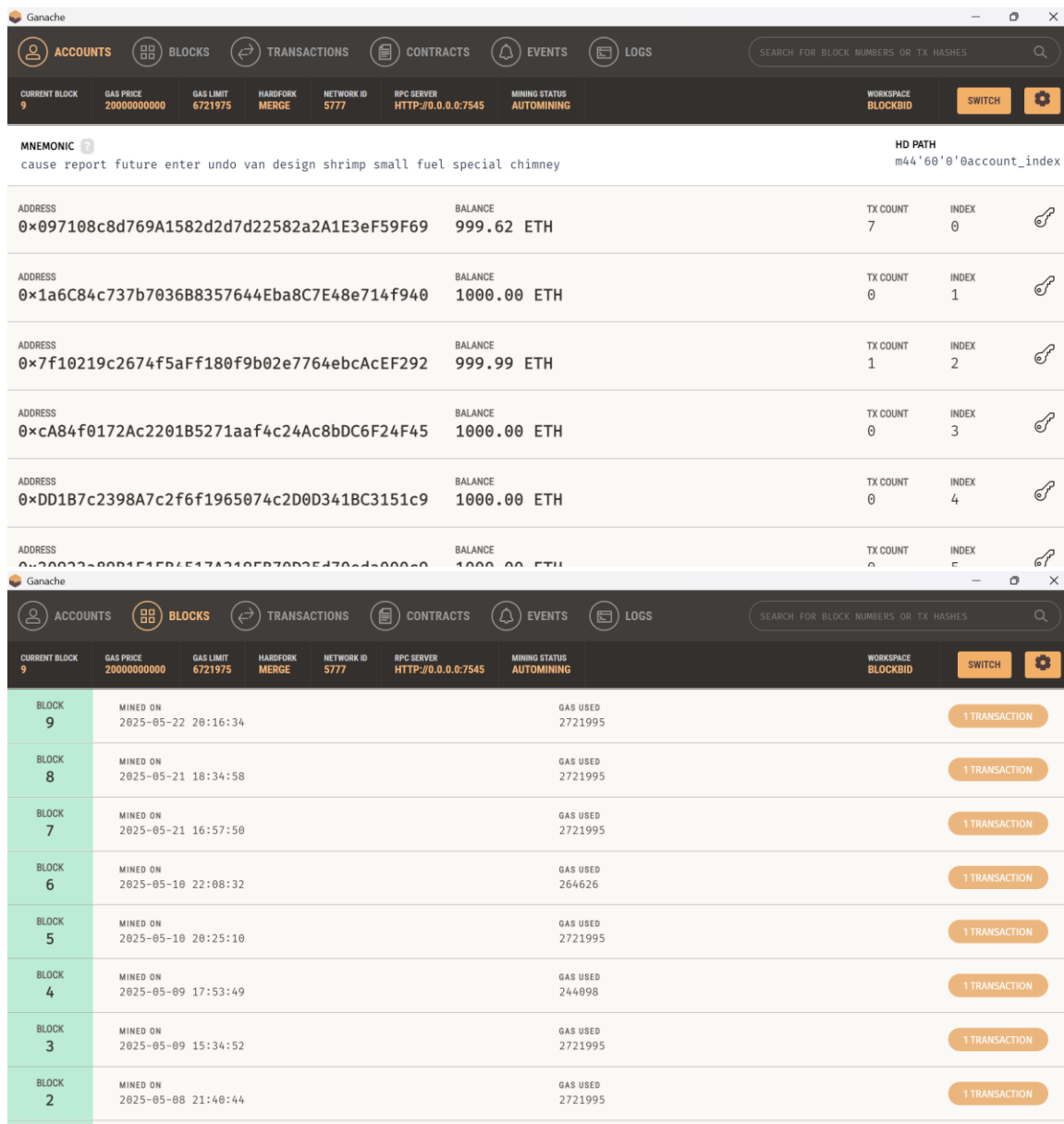
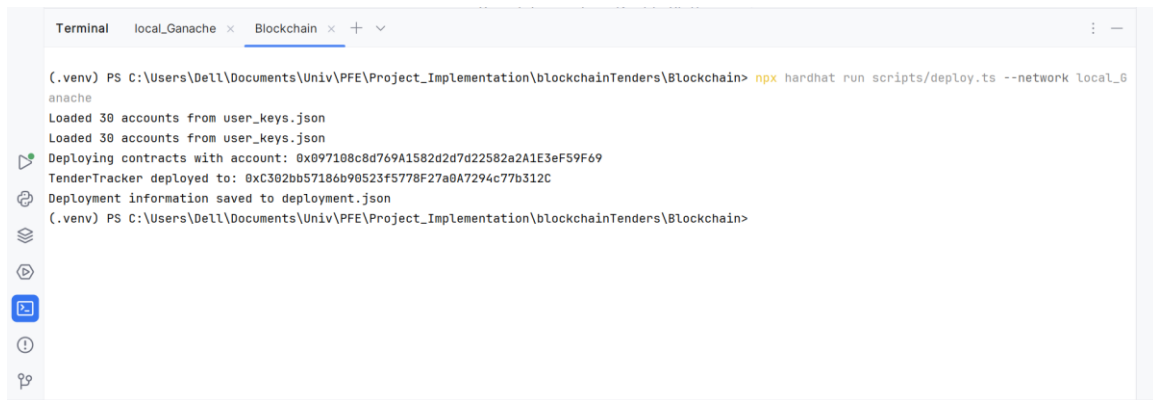


Figure 46: Ganache Blockchain Development Environment Interface Screenshot

Smart Contracts Deployment:

This interface shows the status of contract deployments to the blockchain and provides a UI to call contract functions directly. This is where the on-chain business logic is managed, tested, and finalized before being pushed to a live environment.



```
Terminal local_Ganache x Blockchain x + v
(.venv) PS C:\Users\Dell\Documents\Univ\PFE\Project_Implementation\blockchainTenders\Blockchain> npx hardhat run scripts/deploy.ts --network local_ganache
Loaded 30 accounts from user_keys.json
Loaded 30 accounts from user_keys.json
Deploying contracts with account: 0x097108c8d769A1582d2d7d22582a2A1E3eF59F69
TenderTracker deployed to: 0xC302bb57186b90523f5778F27a0A7294c77b312C
Deployment information saved to deployment.json
(.venv) PS C:\Users\Dell\Documents\Univ\PFE\Project_Implementation\blockchainTenders\Blockchain>
```

Figure 47: Smart Contract Deployment and Interaction Interface Screenshot

3.2 Implementation Summary

The implementation demonstrates a complete blockchain-based tender management system with the following key features:

- Multi-role user authentication (Owner, Supplier, Admin)
- Comprehensive tender lifecycle management
- Blockchain integration for transparency and security
- Real-time notifications and document management
- Multi-language support (English, French, Arabic)
- Responsive design with dark/light theme support
- Automated evaluation system with committee-based review
- Secure file upload and contract generation
- Transaction tracking and blockchain explorer functionality

The system successfully integrates traditional web application features with blockchain technology to create a transparent, secure, and efficient tender management platform.

Conclusion:

This chapter demonstrated the practical implementation of the proposed blockchain-based public procurement system. By deploying smart contracts on a local Ethereum testnet and integrating tools like MetaMask, the prototype showcases how decentralized technologies can automate and secure key procurement processes. While the system proves technically viable, challenges remain in scaling, legal alignment, and user adoption. Nonetheless, this implementation serves as a concrete step toward more transparent, accountable, and tamper-proof public procurement systems.

Conclusion:

During this study we explored how blockchain might actually help fix some of the major issues in public procurement. At first we discussed how blockchain works and why concepts like decentralization and transparency make it such a strong technology. especially when it comes to trust and preventing corruption.

Then we focused on public procurement itself we noticed that current systems even the digital ones still have problems they're slow and sometimes unfair not to mention vulnerable to manipulation. It became obvious that change is needed and blockchain seems like a good path forward.

So we came up with our own solution. we identified the roles of the different actors and used smart contracts to automate everything from the start to the end of the process. Every step is saved on the blockchain which makes it difficult to manipulate or conceal information.

We also developed a working prototype using tools such as React, MetaMask, and Hardhat. This demonstrated that the system is not merely a concept but a viable and functional solution.

To summarize, this work showed that blockchain could really improve the way public procurement is managed. it's a real step toward more transparency and trust. Smart contracts could still be improved and made more flexible, But what we built already provides a solid basis.

References

- [1] "Ethereum Finally Completes The Merge," *Investopedia*, Sep. 15, 2022. [[Online](#)].
- [2] "What Is Proof of Work (PoW) in Blockchain?" *Investopedia*. [[Online](#)].
- [3] "What Is Proof Of Stake? The Benefits Explained," *PlasBit*. [[Online](#)].
- [4] G. Wood, "Proof-of-Authority," *Ethereum.org*, 2017. [[Online](#)].
- [5] The Linux Foundation, "Hyperledger", *Hyperledger.org*, 2020.
- [6] A.P. Moller - Maersk and IBM, "TradeLens," *Maersk.com*, 2021.
- [7] M. Swan, "Blockchain: Blueprint for a New Economy," O'Reilly Media, 2015.
- [8] "Bitcoin scalability problem," *Wikipedia*. [[Online](#)].
- [9] A. Chen, "Ethereum's Transition to Proof-of-Stake," *WalletInvestor*. [[Online](#)].
- [10] World Bank, "A Global Procurement Partnership for Sustainable Development," 2022. [[Online](#)].
- [11] OECD, "Public procurement performance: A framework for measuring," 2023. [[Online](#)].
- [12] African Union, "Report of the High Level Panel on Illicit Financial Flows from Africa," 2015. [[Online](#)].
- [13] OECD, "Implementing the OECD Principles for Integrity in Public Procurement," 2013. [[Online](#)].
- [14] World Bank, "Public Procurement," 2020. [[Online](#)].
- [15] OECD, "OECD Recommendation on Public Procurement," 2015. [[Online](#)].
- [16] UNCITRAL, 'UNCITRAL Model Law on Public Procurement,' United Nations Commission on International Trade Law, 2011.
- [17] OECD, 'Principles for Integrity in Public Procurement,' Organisation for Economic Co-operation and Development, 2009.
- [18] World Bank, 'Procurement Regulations for IPF Borrowers,' The World Bank, 2020.
- [19] ISO, 'ISO 20400:2017 - Sustainable procurement - Guidance,' International Organization for Standardization, 2017.
- [20] Open Contracting Partnership, "Global Data Barometer: Public Procurement," 2022.
- [21] World Bank, *Benchmarking Public Procurement 2022: Assessing Public Procurement Regulatory Systems in 180 Economies*.
- [22] European Commission, "Public Procurement Performance Indicators," 2021.
- [23] OECD, *Government at a Glance 2021*, OECD Publishing, Paris.
- [24] OECD, *Preventing Corruption in Public Procurement*, OECD Publishing, 2016.
- [25] UNODC, "Combating Procurement Fraud: Global Estimates and Best Practices," 2021.
- [26] Transparency International, *Global Corruption Report 2021*.
- [27] "Public vs Private Blockchains: Challenges and Gaps," *Investopedia*, Mar. 3, 2018. [[Online](#)].

- [28] "What Is Sharding? Purpose, How It Works, Security, and Benefits," Investopedia, May 3, 2018. [\[Online\]](#).
- [29] C. Mulligan, "This is how politicians should regulate the blockchain," Wired, Jun. 14, 2018. [\[Online\]](#).
- [30] R. Belen-Saglam et al., "A Systematic Literature Review of the Tension between the GDPR and Public Blockchain Systems," arXiv preprint arXiv:2210.04541, Oct. 10, 2022. [\[Online\]](#).
- [31] "The Trump Administration Wants USAID on the Blockchain," Wired, Mar. 20, 2025. [\[Online\]](#).
- [32] "We need to address Libra's privacy problems before it's too late," Wired, Dec. 6, 2019. [\[Online\]](#).
- [33] Hunhevicz, J. J., & Hall, D. M. (2021). Decentralized project delivery on the crypto commons. *Journal of Construction Engineering and Management*, 147(9), 04021089. [\[ScienceDirect\]](#).
- [34] Wüst, K., & Gervais, A. (2018). Do you need a blockchain? In *2018 Crypto Valley Conference on Blockchain Technology (CVCBT)* (pp. 45-54). IEEE.
- [35] World Economic Forum. (2018). Exploring Blockchain Technology for Government Transparency: Blockchain-Based Public Procurement to Reduce Corruption. [\[Online\]](#).
- [36] European Commission. (2023). European Blockchain Sandbox announces the selected projects for the first cohort. [\[Online\]](#).
- [37] Harvard Kennedy School. (2023). Overcoming Corruption and War: Lessons from Ukraine's ProZorro Procurement System. [\[Online\]](#).
- [38] Luane Silva Nascimento & David Gabriel Dutra Martins, ResearchGate. (2023). Smart Contracts: Security Issues and Further Development in Brazil. [\[Online\]](#).
- [39] Eurasianet. (2017). Georgia: Authorities Use Blockchain Technology for Developing Land Registry. [\[Online\]](#).
- [40] DZtenders. "Explore Algeria Tenders and Bids Online." [\[Online\]](#).
- [41] Inter-American Development Bank. "IDB Group and Davivienda Bank Issue Colombia's First Blockchain Bond." [\[Online\]](#).
- [42] ProZorro. "ProZorro Official Website." [\[Online\]](#).
- [43] Inter-American Development Bank. "Blockchain Integration for Custody of Nature by Rural Residents of Peru." [\[Online\]](#).
- [44] Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. Retrieved from [\[Online\]](#).
- [45] V. Buterin, *A Next-Generation Smart Contract and Decentralized Application Platform*, 2015. [\[Online\]](#).
- [46] "Algeria embarks on procurement reforms to tackle corruption," *The Africa Report*, Sep. 6, 2023. [\[Online\]](#).

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي والبحث العلمي

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كلية العلوم الدقيقة والإعلام الآلي

تصريح شرفي خاص بالالتزام بقواعد النزاهة العلمية
لإنجاز البحث

أنا الممضي أدناه،

الطالب(ة): دردور محمد رقم التسجيل الجامعي: 201937029520
الحامل لبطاقة التعريف الوطنية رقم: 100010963032990009 والصادرة بتاريخ:
08/05/2024

عن بلدية مستغانم
المسجل ب: كلية العلوم الدقيقة والإعلام الآلي / قسم : رياضيات وإعلام الآلي
شعبة : الإعلام الآلي / التخصص : شبكات و أنظمة

والمكلف بإنجاز مذكرة ماستر بعنوان:

Using blockchain for Transparent Management of Public Procurements

أصرح بشرفي أنني ألتزم بمراعاة المعايير العلمية والمنهجية ومعايير الأخلاقيات العلمية والنزاهة الأكاديمية المطلوبة في إنجاز البحث ، وأتحمل المسؤولية الشخصية عن كل المحتوى المتضمن في البحث المذكور أعلاه .

التاريخ: 24/06/2025

إمضاء المعني



* ملحق القرار الوزاري رقم 933 المؤرخ في 28 جويلية 2016 الذي يحدد القواعد المتعلقة بالوقاية من السرقة العلمية ومكافحتها.

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي والبحث العلمي

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كلية العلوم الدقيقة والإعلام الآلي

تصريح شرفي خاص بالالتزام بقواعد النزاهة العلمية
لإنجاز البحث

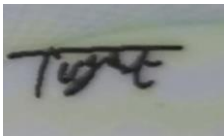
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الطالب(ة): ترقانت رشيد ريان..... رقم التسجيل الجامعي:....
.....202031009528
الحامل لبطاقة التعريف الوطنية رقم: 40640800..... والصادرة بتاريخ:
.....2023.07.16.....
عن بلدية ذراع الميزان-تيزي وزو.....
المسجل ب: كلية العلوم الدقيقة والإعلام الآلي / قسم : رياضيات وعلوم الإعلام الآلي.
.....
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التاريخ: 16/07/2025

إمضاء المعني



* ملحق القرار الوزاري رقم 933 المؤرخ في 28 جويلية 2016 الذي يحدد القواعد المتعلقة بالوقاية من السرقة العلمية ومكافحتها.