



UNIVERSITY OF TARTU



Towards Developing a Blockchain Selection Toolkit for Smart Cities

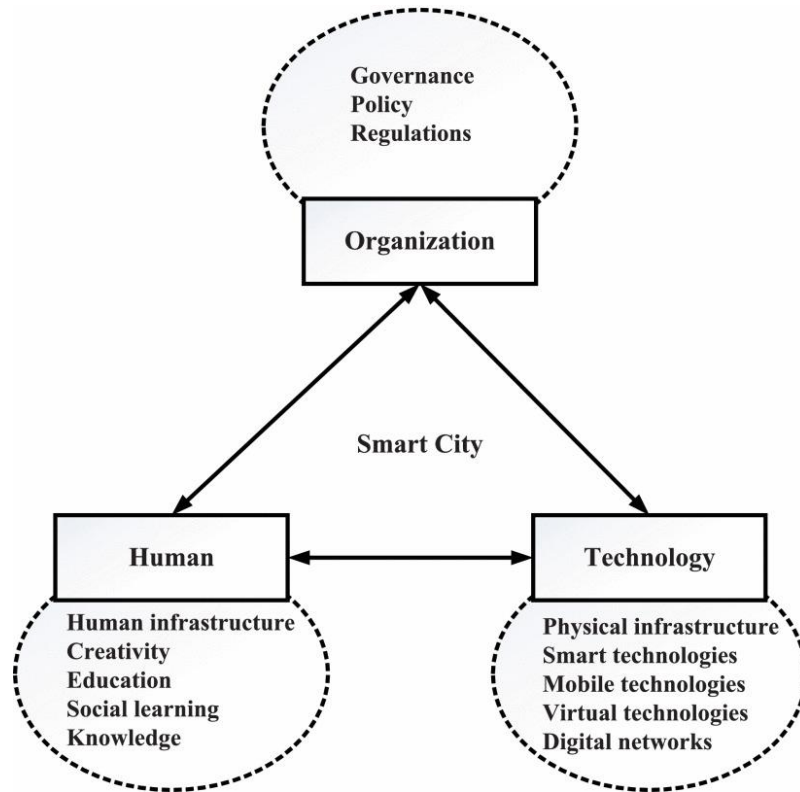
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Smart Cities



- Institutional Infrastructure
- Physical Infrastructure
- Social Infrastructure
- Economic Infrastructure

Problem Statement

- Rapid smart city growth creates challenges in resource management & data security.
- Real-world risks: e.g., 2021 Colonial pipeline ransomware, 2023 Lisbon smart meter data breach.
- Research gaps: Lack of cross-domain integration (tech + urban planning).

Contribution

Design and implement a blockchain selection toolkit tailored for smart city contexts.

Based on multi-criteria decision analysis, enables policymakers and system designers to match blockchain solutions with project-specific requirements, bridging the gap between theory and practice.

Research Questions

1. What are the existing blockchain-based applications in smart city domains?
2. How are different blockchain solutions being compared in smart city infrastructure?
3. How can we build a tool to optimize the selection of blockchain technology for smart cities?

Systematic Literature Review

Research question 'What are the existing blockchain-based applications in smart city domains?' and 'How are different blockchain solutions being compared in smart city infrastructure?' are answered in SLR.

Public Blockchain: Kratos in Education

Purpose:

Secure, transparent educational data management using blockchain.

Blockchain platforms:

Stellar + Ethereum

Smart contracts:

Define and enforce data access rules between schools and edtech providers.

Architecture:

Combines blockchain + InterPlanetary File System + PostgreSQL

Private Blockchain: NAPR Land Registry

Purpose: Secure and transparent land title registration.

Platform: Private blockchain built on Exonum framework.

Consensus: PBFT-like mechanism

Performance: High throughput (up to 5,000 TPS).

Public trust: Reduces fraud and improves efficiency.

Future plans: Smart contracts for leasing & mortgage automation.

Consortium Blockchain: Brooklyn Microgrid

Purpose: Enable decentralized P2P energy trading.

Platform: Consortium blockchain using Tendermint consensus

Smart contracts: Automate energy trade and payment

Efficiency: Low energy cost, low latency, high throughput; Proof-of-Identity used

Privacy: Encrypted, permissioned, and supports anonymous transactions

Challenges of Blockchain Integration in Smart Cities

Security & Privacy

- Public blockchains reveal user data
- Solutions: Temp addresses, zero-knowledge proofs, encryption
- Trade-off: More privacy = Higher latency

Latency & Throughput

- Slow processing & network delays
- Forking causes chain inconsistencies
- Solutions: Nearest-neighbor, acknowledgment-based forks

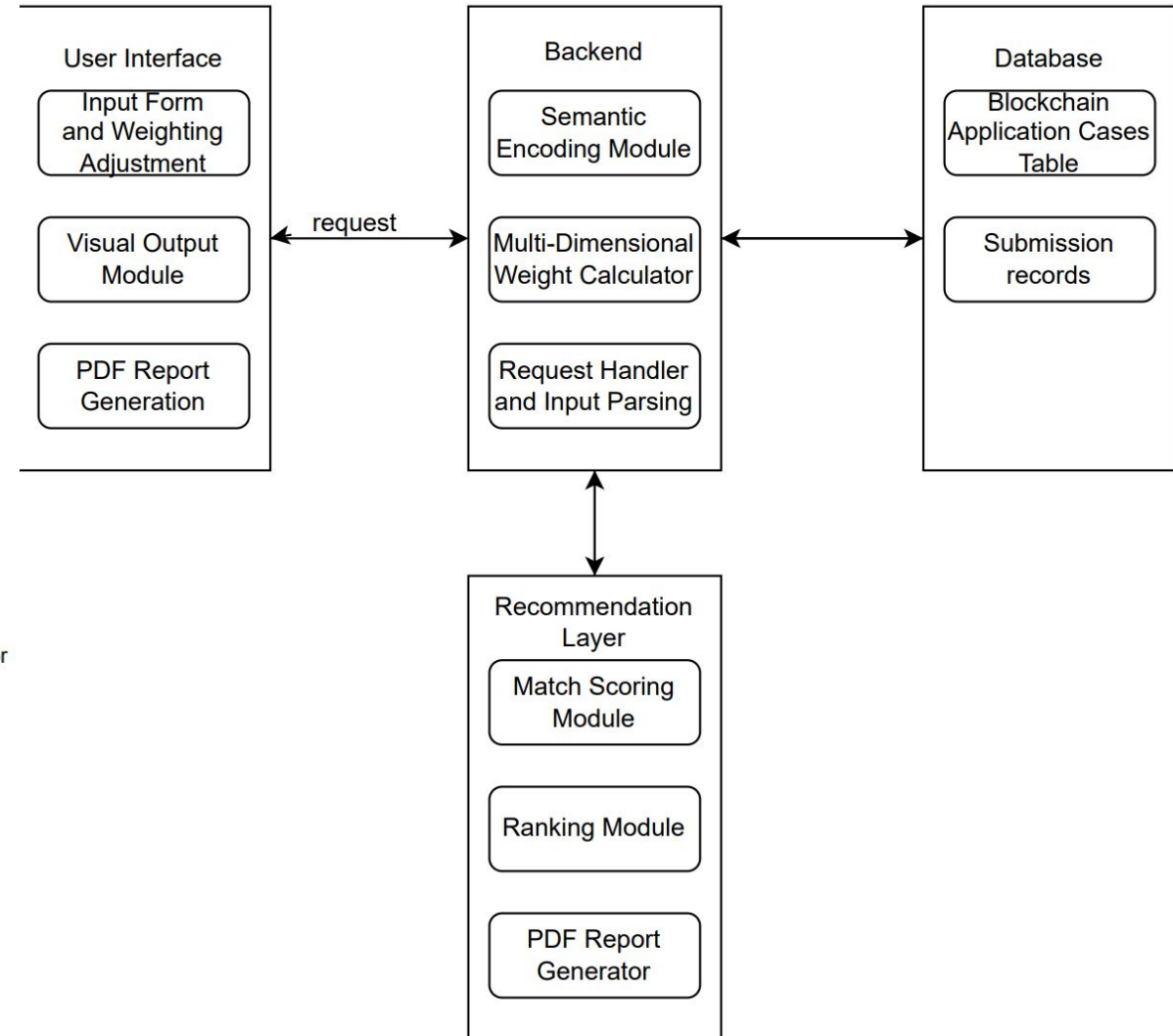
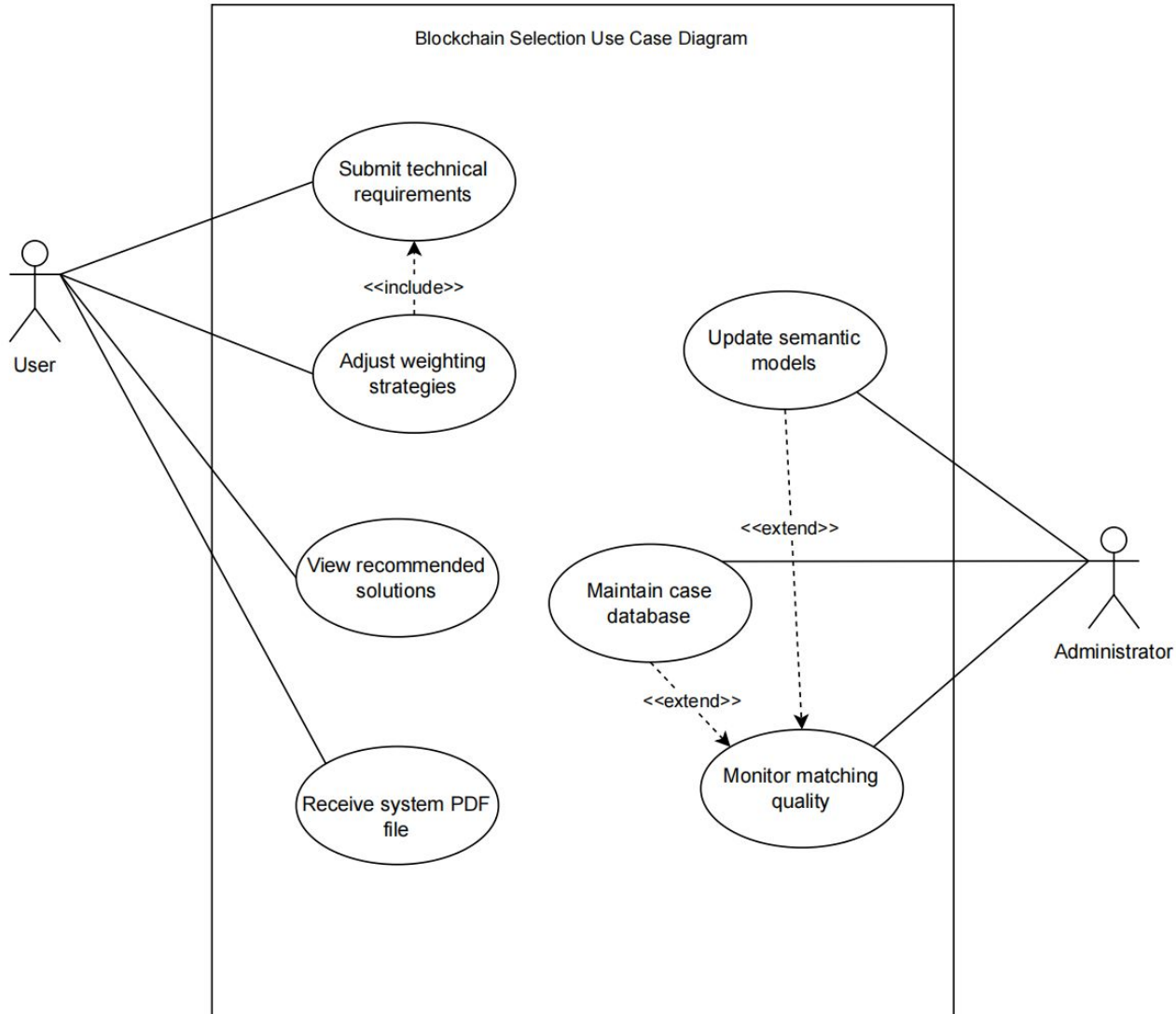
Energy Efficiency

- PoW consumes too much energy
- Alternatives: PoS, DPoS, BFT algorithms
- Emerging: Proof of Trust (early stage)

Toolkit Design & Implementation

Answer research question 3: How can we build a tool to optimize the selection of blockchain technology for smart cities?

System Design



Implementation

- Built with FastAPI for multi-step decision logic
- NLP module encodes user input into semantic vectors
- Multi-dimensional fuzzy logic handles numeric and qualitative data
- Jaccard distance enables partial and vague input matching
- Ranked results based on similarity scores
- Generates PDF report with explanation of recommendations

CityChain Advisor

Application Scenarios

Energy Grid Insurance Healthcare Tourism Supply Chain Logistics

Smart Traffic Land Registry

Describe your application scenarios...

TPS Latency (ms)

1000 200

Security Level

High

Technology Stack City Size

Hyperledger, IPFS Large

Budget Range

[500000, 1000000]

Adjust Match Weights

scenario

Weight: 0.20

tech_req

Weight: 0.20

tech_stack

Weight: 0.20

city_size

Weight: 0.20

budget

Weight: 0.20

Start Analysis

Evaluation: Small-Scale Energy Grid

User input:
1000 TPS and 200ms latency
High security
Ethereum
Small city size
Budget from \$500,000 to \$1 million

CityChain Advisor

Application Scenarios

Energy Grid

Insurance

Healthcare

Tourism

Supply Chain

Logistics

Smart Traffic

Land Registry

Energy Grid

TPS1000Latency (ms)200

Security LevelHigh

Technology StackEthereumCity SizeSmall

Budget Range[500000, 1000000]

Adjust Match Weights

scenario

Weight: 0.20

tech_req

Weight: 0.20

tech_stack

Weight: 0.20

city_size

Weight: 0.20

budget

Weight: 0.20

Start Analysis

Recommendations

Quartierstrom

Score: 0.85

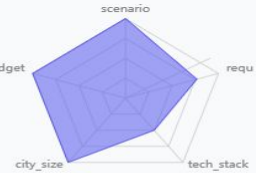
Energy Grid

City Size: small

Budget: \$500,000 - \$1,000,000

Technologies: Ethereum, Smart Meters

City size match • Budget range compatible • Common technologies: Ethereum



ME SOLShare

Score: 0.50


Energy Grid

City Size: medium

Budget: \$300,000 - \$700,000

Technologies: SOLBox, Blockchain, IoT

Budget range compatible



Brooklyn Microgrid

Score: 0.41


Energy Grid

City Size: large

Budget: \$8,000,000 - \$12,000,000

Technologies: TransactiveGrid, IoT, Smart Meters

Security level match



Evaluation: Large-Scale Supply Chain

User input:

1000 TPS and 200ms latency

High security

IoT Devices

Large city size

Budget from \$ 1 million to \$ 6 million

CityChain Advisor

Application Scenarios

Energy Grid Insurance Healthcare Tourism **Supply Chain** Logistics

Smart Traffic Land Registry

Supply Chain

TPS: 1000 Latency (ms): 200

Security Level: High

Technology Stack: IoT Devices City Size: Large

Budget Range: [1000000,6000000]

Adjust Match Weights

scenario Weight: 0.20

tech_req Weight: 0.20

tech_stack Weight: 0.20

city_size Weight: 0.20

budget Weight: 0.20


Start Analysis

Recommendations

BMW VerifyCar Score: 0.78

Supply Chain

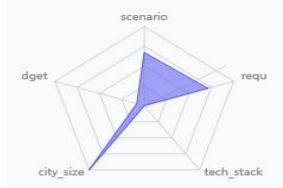
- City Size: large
- Budget: \$4,000,000 - \$6,000,000
- Technologies: VeChainThor, IoT Devices
- City size match • Budget range compatible • Common technologies: IoT Devices



Port of Los Angeles Blockchain Cargo Tracking Score: 0.49

Logistics


- City Size: large
- Budget: \$10,000,000 - \$15,000,000
- Technologies: Blockchain, IoT Sensors
- City size match • Security level match



Port of Valencia Smart Port Project Score: 0.47

Logistics

- City Size: large
- Budget: \$12,000,000 - \$18,000,000
- Technologies: Hyperledger Fabric, IBM Blockchain
- City size match • Security level match



Evaluation: Secure Healthcare

User input:

500 TPS and 200ms latency

High security

Hyperledger Fabric

Medium city size

Budget from \$ 1 million to \$4million

CityChain Advisor

Application Scenarios

Energy Grid Insurance **Healthcare** Tourism Supply Chain Logistics

Smart Traffic Land Registry

Healthcare

TPS: 500 Latency (ms): 200

Security Level: High

Technology Stack: Hyperledger Fabric City Size: Medium

Budget Range: [1000000,4000000]

Adjust Match Weights

scenario Weight: 0.20

tech_req Weight: 0.20

tech_stack Weight: 0.20

city_size Weight: 0.20

budget Weight: 0.20

Start Analysis

Recommendations

Guardtime Score: 0.70

Healthcare

- City Size: medium
- Budget: \$2,000,000 - \$4,000,000
- Technologies: Alphasight Public Chain, Smart Contracts

City size match • Budget range compatible • Security level match

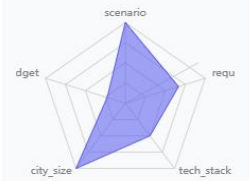


Singapore Medical Records Score: 0.68

Healthcare

- City Size: medium
- Budget: \$3,500,000 - \$6,000,000
- Technologies: Hyperledger Fabric, CouchDB

City size match • Budget range compatible • Common technologies: Hyperledger Fabric



MedRec Score: 0.66

Healthcare

- City Size: medium
- Budget: \$1,500,000 - \$2,500,000
- Technologies: Ethereum, Smart Contracts

City size match • Budget range compatible



Conclusion

- Design and implement a blockchain selection toolkit for smart city contexts
- A comprehensive and up-to-date systematic survey of blockchain applications in smart cities

Limitations

- Limited case coverage (to expand case diversity)
- Policy compliance not yet quantitatively assessed

Thanks!

