GridTokenX

Blockchain Performance Analysis for P2P Energy Trading

Master's Thesis Defense

December 2024

Research Motivation

- Renewable energy adoption accelerating
- Prosumers need peer-to-peer trading capability
- Blockchain provides decentralized trust
- **Challenge**: Can blockchain meet performance requirements?

Research Questions

1. Can blockchain achieve **production-level** performance for energy trading?
2. What is the **Trust Premium** (cost of decentralization)?
3. How does GridTokenX compare to **existing platforms**?

Methodology

TPC Benchmark Adaptation

TPC-C Transaction	Energy Trading Operation
New Order (45%)	Create Energy Order
Payment (43%)	Token Transfer
Order Status (4%)	Query Order
Delivery (4%)	Execute Trade
Stock Level (4%)	Balance Check

Platform Architecture

GridTokenX Technology Stack

- **Blockchain**: Solana-based
- **Consensus**: Proof of Authority (PoA)
- **Framework**: Anchor 0.32.1
- **Smart Contracts**: 5 programs (Energy Token, Trading, Oracle, Registry, Governance)

Benchmark Results

TPC-C Performance

Metric	Value
tpmC	21,378 tx/min
Avg Latency	11.34 ms
p99 Latency	20 ms
Success Rate	99.9%

Benchmark Results

All Benchmarks Summary

Benchmark	Primary Metric	p99 Latency
TPC-C	21,378 tpmC	20ms
Smallbank	1,741 TPS	10ms
TPC-E	307 tpsE	17ms
TPC-H	246,938 QphH	147ms

Comparative Analysis

Platform Comparison

Platform	TPS	Latency	Trust Premium
GridTokenX	356	11ms	5.67x
Hyperledger Fabric	200	350ms	175x
Ethereum	30	12,000ms	6,000x
PostgreSQL (baseline)	5,000	2ms	1x

Trust Premium Analysis

> **Trust Premium** = Blockchain Latency / Centralized Baseline Latency

- GridTokenX: **5.67x** (acceptable for decentralization benefits)
- Hyperledger Fabric: 175x
- Ethereum: 6,000x

GridTokenX achieves lowest Trust Premium among blockchain platforms

Scalability

Linear Scaling Demonstrated

- Tested: 5 to 200 concurrent users
- TPS maintained at ~545 TPS
- Latency stable at ~1.8ms average
- **Efficiency**: 103% at 200 users

Key Contributions

1. **TPC Benchmark Adaptation** for blockchain
2. **Trust Premium Metric** quantification
3. **Production-level Performance** demonstration
4. **Scalability Validation** to 200 users

Limitations

- Simulated network conditions
- Single-validator PoA configuration
- No real smart meter integration
- Limited geographic distribution

Future Work

- Multi-validator PoA network deployment
- Smart meter IoT integration
- Cross-chain interoperability
- Zero-knowledge privacy extensions

Conclusion

- GridTokenX achieves **21,378 tpmC** (production-level)
- **Sub-20ms latency** meets real-time requirements
- **Trust Premium of 5.67x** is acceptable trade-off
- **PoA consensus** provides speed + security balance

Blockchain is viable for P2P energy trading

Thank You

Questions?

📊 All data available at:

`test-results/csv/`

📄 LaTeX chapters at:

`test-results/thesis/`