Blockchain Energy Market Place Evaluation: an Agent-Based Approach

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Introduction
  • Context and Motivation
  • Related works

Proposed solution

Experimental Study

Conclusion
CONTEXT AND MOTIVATION (1/3)

Context

• Socio-Political Context:
  • Growing interest toward decentralized production and green energies
  • Emergence of Smart Cities
• Economical Context: Increasing utility rates for consumers, decreasing rates for producers
• Evolution of Legislation: In France, people can exchange energy on local grids
  ➔ New needs of decentralized energy trading system

Goals

• Validate the technical feasibility of a blockchain based Energy Market Place
• Study the economical impact of such system
• With different real world scenarios

Challenges

• Multi-agent simulation tools
• System performance and scalability
• Real world data integration
• Pricing and bills
Prosumers can sell their energy to their neighbours

Billing done by the representative

Consumers pay the prosumers manually

Legal representative is designated

Centralized trust, implies: costs and opacity

Risk of payment delay and conflicts

Lack of openness to other services

Pain point 1
Centralized financial system for decentralized energy exchange

Pain point 2
Lack of auditability and transparency

Pain point 3
Lack of trustable, automated and secure system

Pain Point 4
Closed system, no possible evolution
Our proposal

- **Auditability, transparency**
- **No Intermediary for fixing prices**
- **Autonomy of the locality**
- **Collaboration with other services**

**Energy Market Place on a Local Blockchain**

**Related Works**
- **Renault** (Blockchain with only one stakeholder)
- **Car Vertical, VinChain** (currently ongoing, no implementation yet)
Introduction

Proposed solution
  • Overall Solution
  • Overall Architecture
  • Agent Behavior and Market Place Smart Contract

Experimental Study

Conclusion
Overview

Blockchain and Smart Contracts (financial transfers)

Locality composed of households

Power infrastructure (energy transfers)
**Inputs:** Data provided by EDF (French energy provider)
- Consumption and production profiles
- Of 200 households of two cities (one in north other in southern France) during 1 week in winter and 1 week in summer

**Asynchronous Multi-Agent Simulation Platform**
- 1 house = 1 agent = 1 blockchain node and his Wallet contract
- Bid/ask behavior depending on his consumption/production (profile in database)

**Smart Contracts**
- Wallet: contains token of a house
- MarketPlace: double auction allocation algorithm (auctioneer)

**Outputs**
- Local bids and asks volumes
- Prices evolutions
- Local vs utility energy ratio
- Economical gain (with vs without the market place)
Each agent, at each market turn
- Retrieves its consumption/production volumes
- Proposes an ask or a bid through his Wallet (ZI prices)
- The Wallet transmits the order to the MarketPlace contract
- Waits for the notification of the MarketPlace that contains the results (lost/won, if won, actually traded volume and price)
- Writes the results into the database (output)

The MarketPlace contract
- Gathers the proposals
- At the end of the turn (turn duration is fixed)
  - Runs the double auction mechanism
  - Transfers tokens between Wallets and notifies them
Introduction

Proposed solution

Experimenental Study
  - Blockchain deployment tool
  - Technical Performance Analysis
  - Use case KPI

Conclusion
**Algorithm 1: Assessment workflow**

*Input*: Number of nodes $n$,
- Number of validators $v$,
- Topology of the network $t$,
- Assessment duration $d$
- Number of transactions per second (frequency $f$)

*Output*: Performance indicators (average transaction validation time, average block size, number of transactions validated per second, etc)

```plaintext
1 begin
   // BlockChain Deployment
   buildBlockChain($n,v,t$)
   waitForBlockChainToBeReady()
   // Send Transactions
   while duration < $d$ do
      for $i = 0; i < f; i++$ do
         tx ← PrepareTransaction()
         send($tx$)
      end
      sleep($ls$)
   end
   // Extract performance indicators
   ComputeAverageValidationTime()
   ComputeAverageBlockSize()
   ComputeAverageTransactionsPerSecond()
end
```

**Automated Blockchain nodes deployment**
- Ethermint/Tendermint technology
- NodeJS web service
- 1 Docker container = 1 node
- 1 node = 1 Ethermint + 1 Tendermint
- Configurable Blockchain parameters
- Dynamic KPI computation (outputs)
Average Tx per second
Network Topology Impact
Evolution of Blockchain Folders Size

Blockchain Data Size
Use Case Definition

- 200 households
- Location: near Marseille (southern France)
- Period: Summer and Winter
- Duration 1 week
- Producers/Consumers ratio: variable

Goal

- Estimate the economical gain of the proposed solution (with respect to a classical system)
Offer quantity and price of the Double auction for different times of the day - 100% producers scenario

Hour of the day

Quantity of electricity in kWh

Difference in Tokens between EDF prices and Marketplace prices

- Quantity of electricity traded on the Marketplace
- Buyer - price gain of energy in token per kWh
- Seller - price gain of energy in token per kWh
**Evaluation**

**Use Case Analysis – Economical Gains**

<table>
<thead>
<tr>
<th>Percentage of Producers</th>
<th>Gains in Euro per day</th>
<th>Percentage of Overproduction Sold in the MarketPlace</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summer</td>
<td>Winter</td>
</tr>
<tr>
<td>25%</td>
<td>0.54</td>
<td>0.08</td>
</tr>
<tr>
<td>50%</td>
<td>1.10</td>
<td>0.12</td>
</tr>
<tr>
<td>75%</td>
<td>2.14</td>
<td>0.29</td>
</tr>
<tr>
<td>100%</td>
<td>2.80</td>
<td>0.48</td>
</tr>
</tbody>
</table>

**Table 1**

**Weekly Gains in Euros and the Percentage of Overproduction sold in the MarketPlace in the proposed scenarios.**
PLAN

- Introduction
- Proposed solution
- Experimental Study

**Conclusion**

- Contributions
- Perspectives
CONCLUSIONS - CONTRIBUTIONS

- **Multi-agent Platform to**
  - Simulate realistic behavior of households
  - Test multiple scenarios
  - Asynchronous transactions on the Blockchain

- **Market Place Contract**
  - Decentralized trust
  - Market turn interval handled on-chain using a state machine

- **Performance evaluation**
  - Blockchain performance (tx throughput and energy consumption of raspberry pies)
  - Use case KPI
CONCLUSIONS - PERSPECTIVE

- **Already tested in real world**
  - 7 real houses during 1 week
  - Using Raspberry Pies
  - Good results but needs more tests

- **Privacy issues**
  - Avoid offers traceability → Untraceability
  - Avoid linkability of offers to one pseudonym (i.e. blockchain identity) → Unlinkability

- **Commitment Scheme**
  - Proposals are in clear, one can wait others before proposing his unbeatable proposal
  - Apply Commitment Scheme (on-chain)
Thank you for your attention