

A simulation-based and data-driven framework for enabling the analysis and design of business processes based on blockchain and smart contracts solutions

Francesco Pasqua(2), Luciano Argento(2), Sabrina Graziano(2), Alfredo Garro(1), Antonella Guzzo(1) and Domenico Saccà(1)

- (1) Department of Computer Engineering, Modeling Science, Electronics and Systems,
University of Calabria, Italy
- (2) OKT Open Knowledge Technologies, Rende Italy

Outline

- Aims
- Overview of the Methodology
- Principles and Distinctive features
 - Platform Independent Model
- Case study: Biomass production chain
- Conclusions

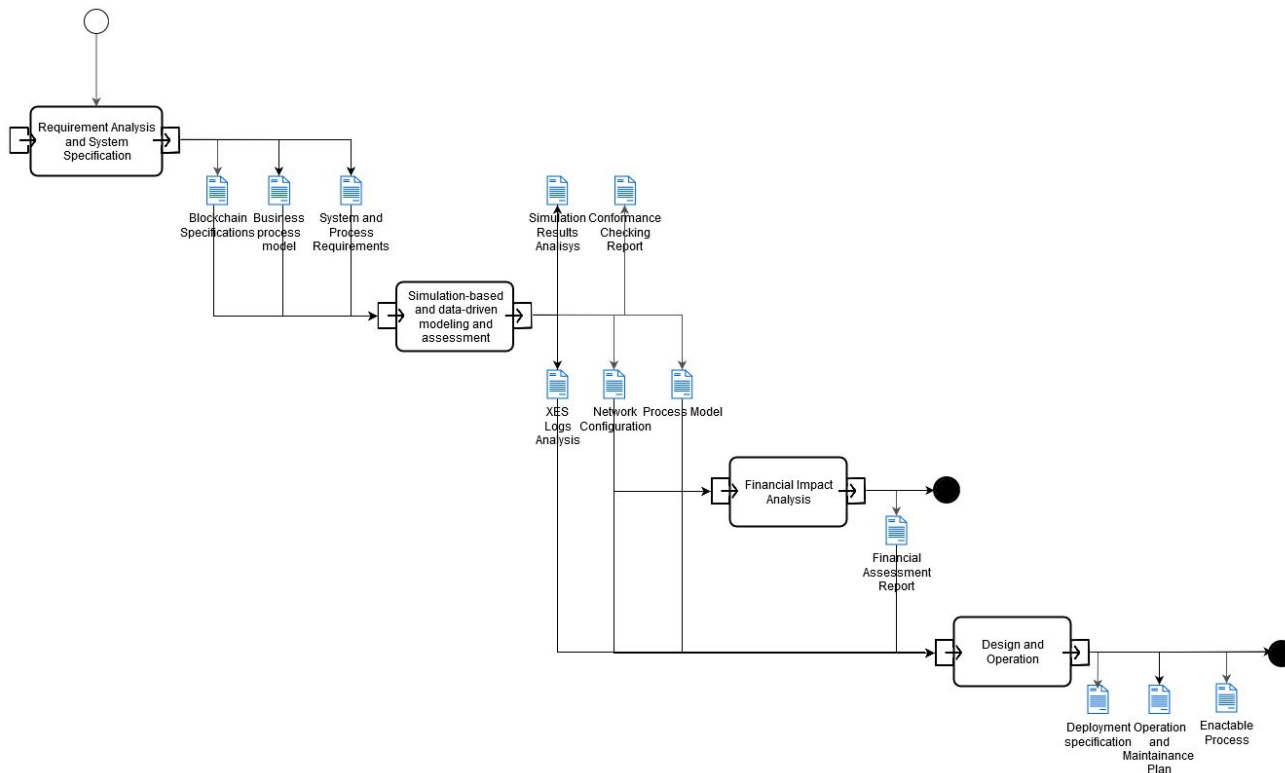
Aims

A methodology aimed at supporting interested businesses (henceforth, clients) in mitigating risks while implementing blockchain technology, in order to enhance and protect their, already set, business processes.



- Formalizing AS-IS Business Processes
- Performing what-if analysis
- Obtaining prescriptive technological Analysis
- Assessing Performance and Costs
- Establishing a monitoring framework in order to check business process conformance over time

Overview of the Methodology



Overview of the Methodology

Requirement Analysis and System Specification

Simulation-based and data-driven modeling and assessment

Financial Impact Analysis

Design and Operation

- Business process model
- System and Process Requirements
- Blockchain Specifications

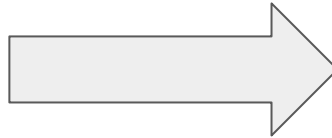
- XES logs Analysis
- Network Configuration
- Process Model
- Simulation Results Analysis
- Conformance Checking Report

- Financial Assessment Report

- Deployment specification
- Operation and Maintenance Plan
- Enactable Process

Principles and distinctive features

- Combining model-based and data driven approaches
- Taking into account financial aspects as well as technical ones
- Model continuity
- Reusability of models across different technologies



- Platform Independent Model, assuring reusability and model continuity
- Agent based simulation, to model scenarios and obtain data
- Conformance checking via process mining on data obtained both from simulation and from the enacted process

Distinctive features

- Platform Independent Model (*PIM*)
- Agent based simulation
- Process Mining

Methodology Phases and workproducts

1. **Requirement Analysis and System Specification**
 - a. Blockchain Specifications
 - b. Business Process Model
 - c. System and Process Requirements
2. **Simulation-based and Data-driven Modeling and Assessment**
 - a. Simulation Final Report
 - b. Conformance Checking Report
 - c. XES Logs Analysis
 - d. Network Configuration
 - e. Simulation Data Exchange Model
3. **Financial Impact Analysis**
 - a. Financial Assessment Report
4. **Design and Operation**
 - a. Deployment Specification
 - b. Operation and Maintenance Plan
 - c. Enactable Process

Requirement Analysis and System Specification

This preliminary work phase assesses the AS-IS situation, by using:

- Domain Specific Analysis
- Requirements Engineering Techniques

Results come in the form of:

- Standard **BPMN document**, enhanced with expected performance indicators.
- **Blockchain Specification** document, describing what distinctive blockchain features are needed in order to meet the client's needs.
- **System and Process Requirements**, quickly capturing domain specific requirements (I.E. Law and regulatory ones etc..)

Simulation-based and Data-driven Modeling and Assessment

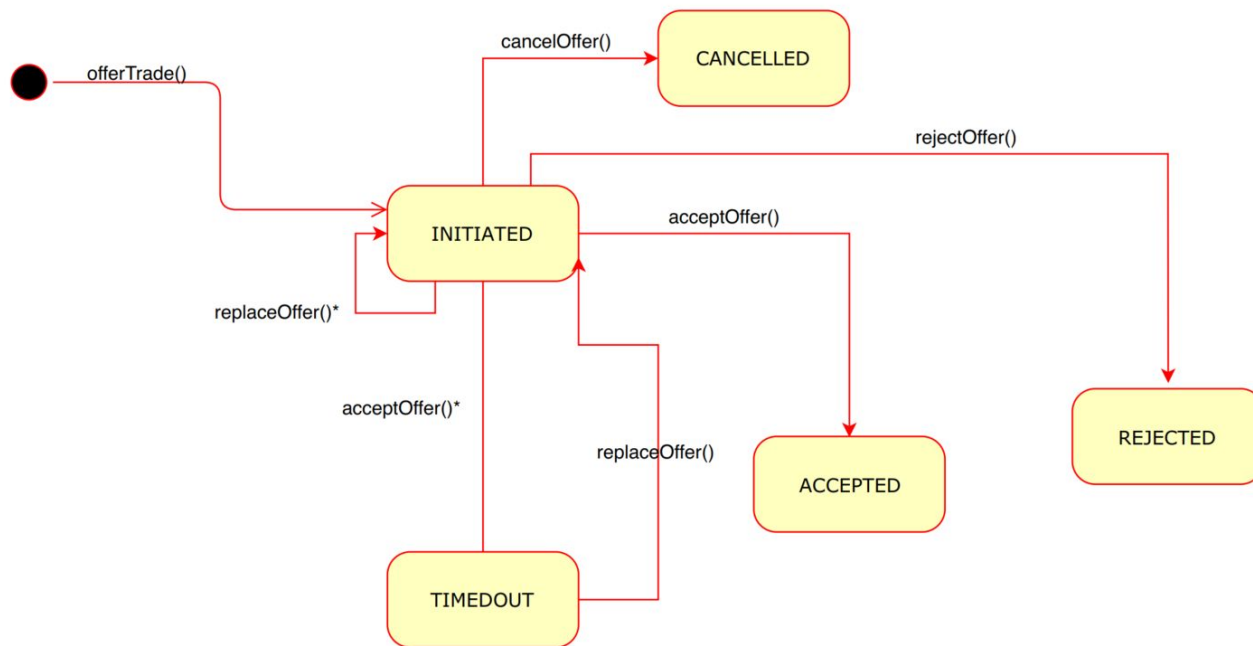
By using the work products obtained in the previous phase as a starting point, a series of activities are carried out:

- A test blockchain network is readied, along with smart contracts compliant with our *Platform Independent Model (PIM)*.
- A virtual environment simulation is primed, modeled according to the BPMN document.
- A blockchain log extraction and XES-format transformation layer is implemented

The simulation run results are taken into account in tuning the test blockchain network topology, in order to satisfy performance requirements.

XES logs are analysed in order to assess the implemented smart contracts adherence to the client's business process.

Platform Independent Model



- FSM based
- Easy to implement in multiple blockchain technologies (platform agnostic)
- Captures BPMN activities as information exchanges between actors
- General and flexible: no need to infuse Business Process specific ontology (business process agnostic)

Agent Based Simulation

- Development of dynamic and complex scenarios for the assessment
- Simulation as a means for reproducing the scenarios
- Agent-based simulation was chosen

Agents:

- Represent entities that live inside an environment to simulate
- Are able to reproduce complex behaviours
- Bring a scenario to life when interacting with each other and the environment
- Form a society (*model*) that can be altered in order to explore different dynamics and scenarios

Process Mining

- Log analysis
- Standard and widespread XES format
- Main focus : Model Conformance Checking
- Supports model continuity
- Many visual tools available



Financial Impact Analysis

By following both the *Blockchain Specification* and the *Network Configuration*, a financial impact analysis is carried out, in order to evaluate the financial feasibility of the blockchain implementation.

Different options are put forward for the client to peruse, mainly according to:

- Technology chosen
- Current blockchain as a service offerings in the market
- Performance desiderata

At this point the client can clearly see how much a future blockchain implementation shall impact financially, and has the power to carry on towards the Design and Operation work phase, if the perceived value is adequate.

Design and Operation

Simulation models and data obtained in the previous work phase can be used to support monitoring, corrective and evolutionary maintenance services, such as:

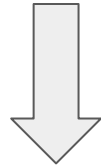
- Enacting a refined simulation model (*Enactable Process*) in a BPMN based environment
- Using process mining algorithms, tested beforehand on simulation data, on real data, incoming from the business process, for monitoring purposes.
- Defining a *Deployment Specification* for the blockchain and supporting network
- For said deployment, also devise a *Operation and Maintenance Plan*

Case Study : Biomass Production Chain



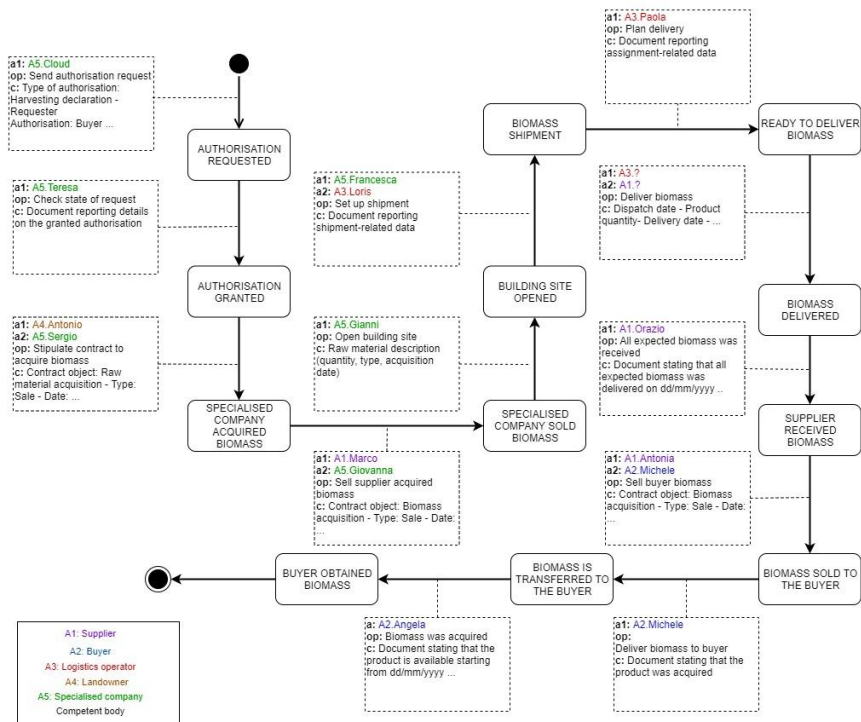
Case Study : Biomass Production Chain

- Involves different organizations
- Must cooperate to pursue a common goal
- Presence of Accountability and Traceability issues



All prime use cases for a blockchain implementation!

Case Study : Biomass Production Chain



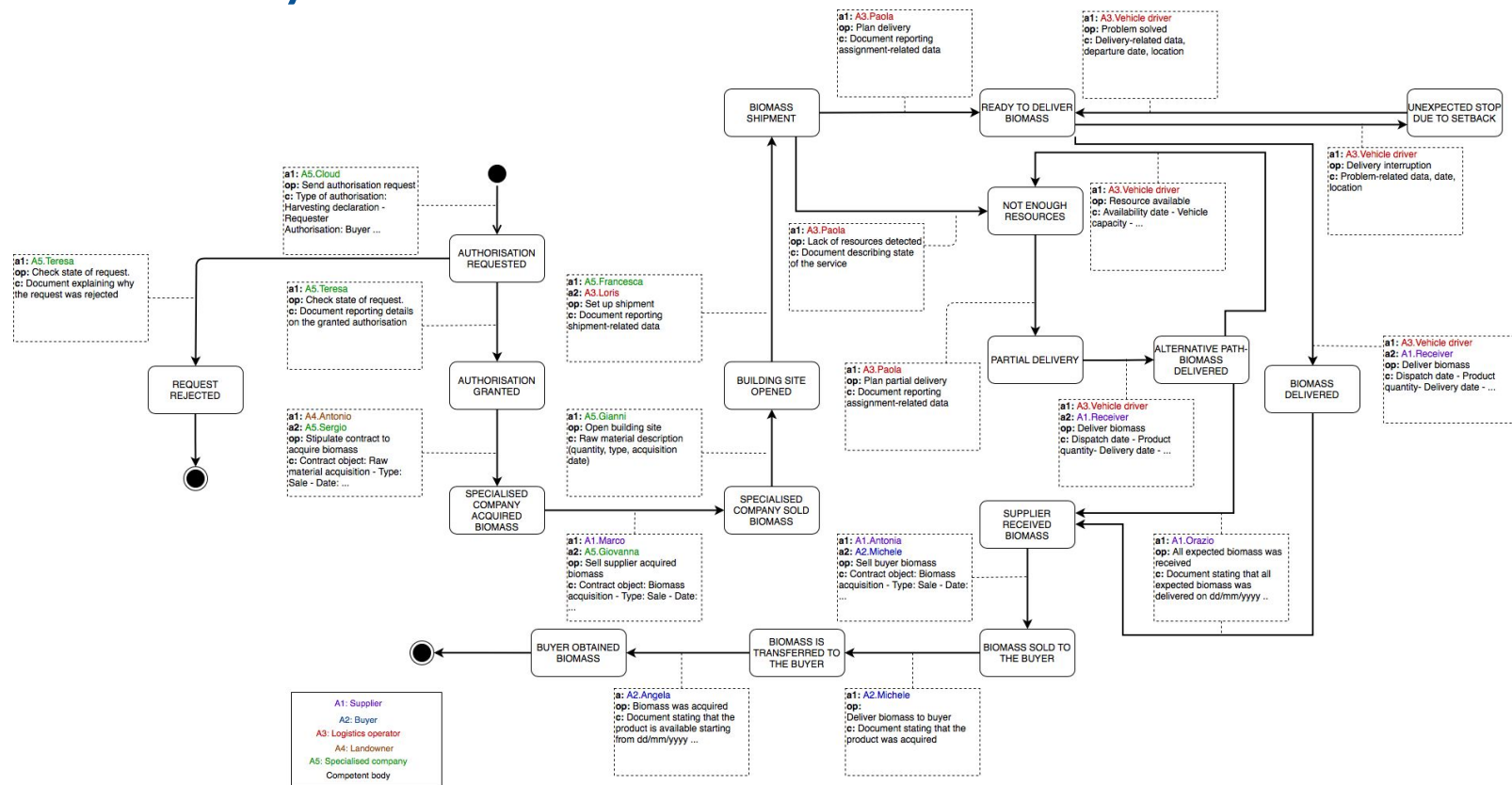
Business process involving multiple stakeholders

- Buyer
- Supplier
- Logistics Operator
- Landowner
- Specialized company

Each of them pursues slightly different needs, and may or may not belong to different organizations.

The main objective is to achieve a higher level of accountability across the entire process.

Case Study : Biomass Production Chain



Case Study : Blockchain Specification

The resulting *Blockchain Specification* document, obtained from the Requirement Analysis and System Specification phase pointed towards a platform with the following features:

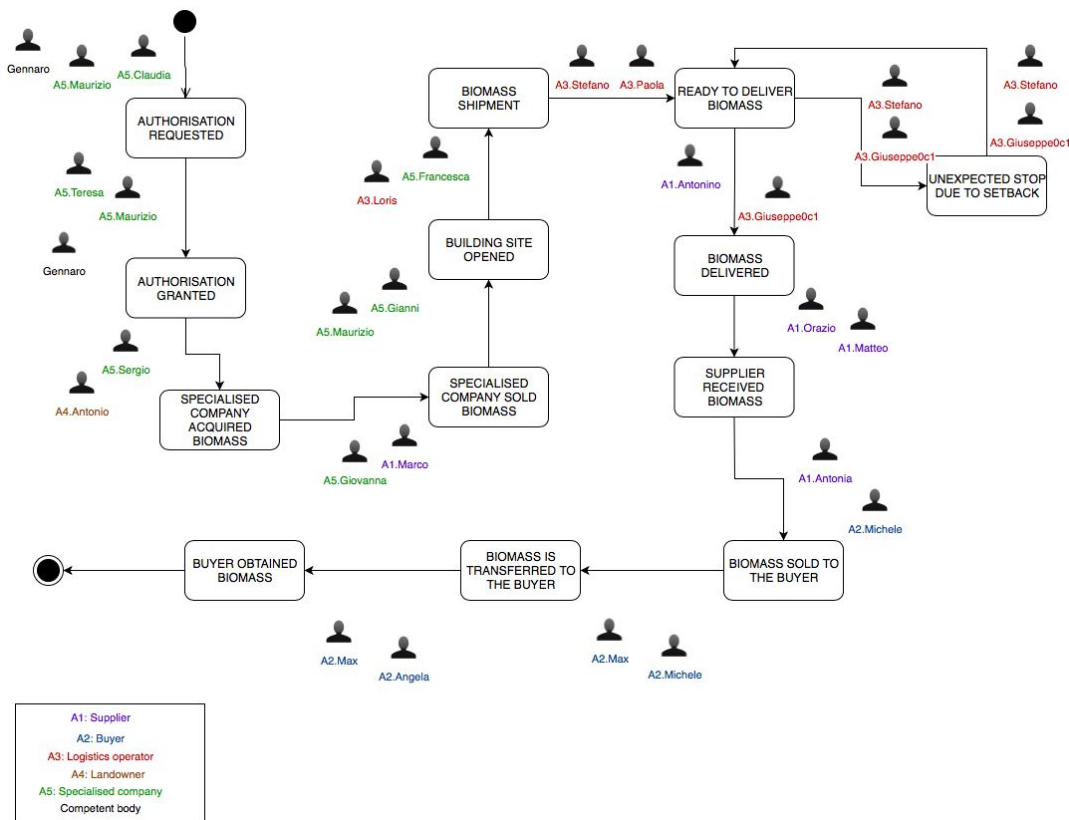
- Permitted Ethereum test blockchain
- Service Provider-Accountability nodes acting as master nodes
 - Employing tokens as collateral payment, in order to obtain the AN title
- Identity services obtained from already established Identity Providers chosen by the client (SPID for example)
- No user personal data stored on blockchain, just generated IDs

Case Study : Testbed Blockchain Network

- Solidity
 - Check-Effects-Interactions pattern
 - CRUD pattern
 - Events emitted in order to track each FSM evolution
- Easy to obtain a fitting PIM implementation, while respecting the platform's unique features (Gas)
- Code obtained from the PIM implementation is reusable, thoroughly testable and Gas efficient

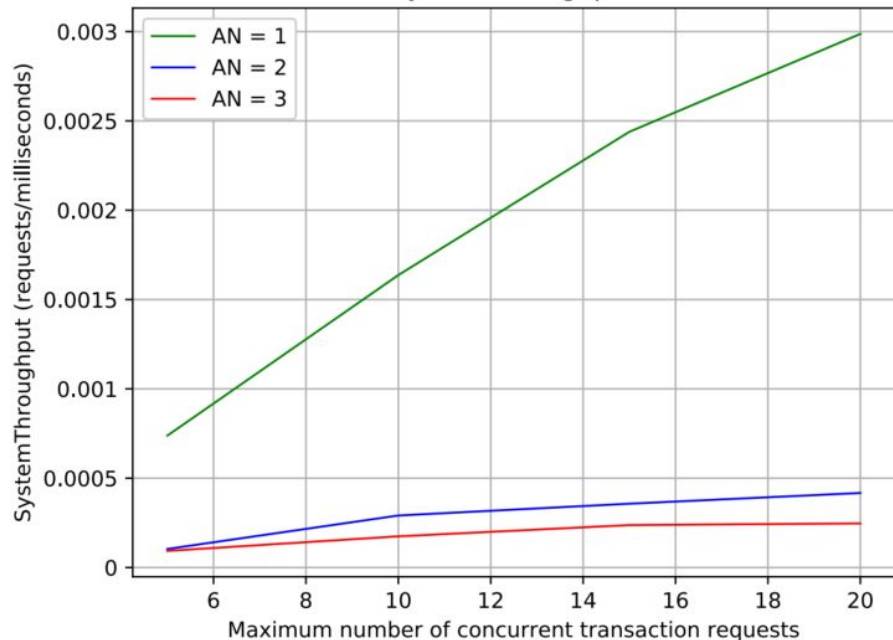
```
function offerTradeSigned(bytes32 _sender, bytes32 _receiver, bytes32
    _valueHash, uint _tmout,
    uint8 sigV, bytes32 sigR, bytes32 sigS) returns (bool success) public {}
```

Case Study : Simulation-based Modelling and Assessment

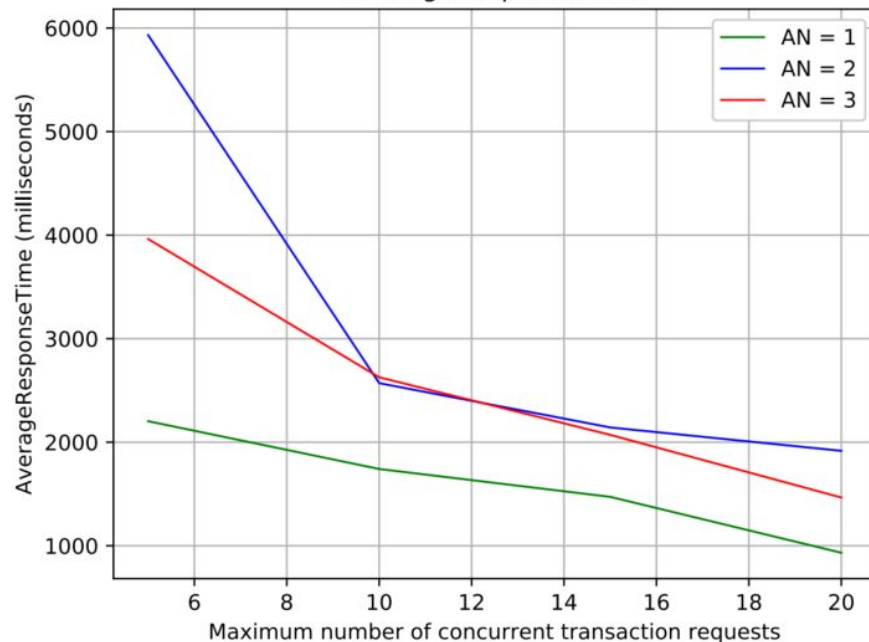


Case Study : Performance Assessment

SystemThroughput



AverageResponseTime



Case Study : Process Mining

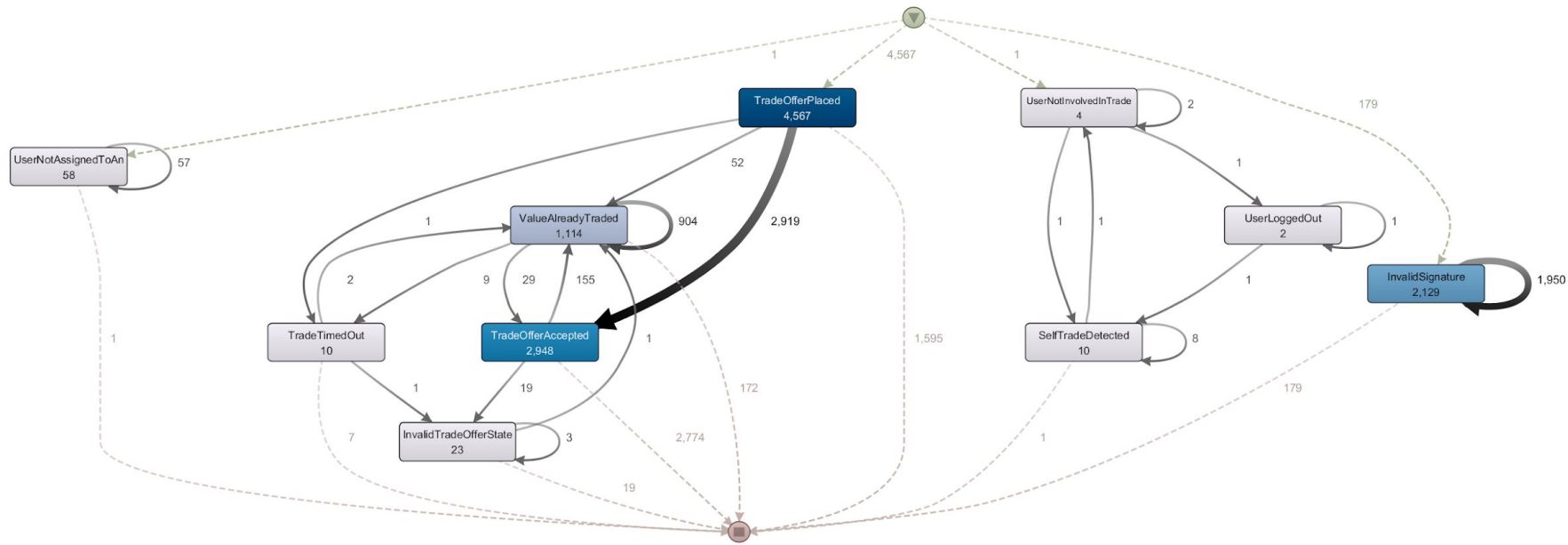
By tuning process mining algorithms on XES transformed simulation data (10865 events over 5236 blocks), we obtained a full trace graph using Disco.

Such graph serves as a conformance check for the intended Business process at hand.

- Intended behaviours are strictly followed towards their conclusion
- Unintended, potentially malicious behaviors lock down the trace, while generating distinctive error events.

Such analysis is useful in both testing the smart contract and simulation implementations, and subsequent deployment and enactment time monitoring.

Case Study : Process Mining



Conclusion

- Supporting businesses in integrating DLTs
- By leveraging descriptive (AS IS), predictive (WHAT IF) and prescriptive analysis
- Building a model and data driven framework upon such analysis
- We have successfully tested our methodology on two different case studies, one of which has been presented, with simulation and process mining results

Future Work

- Enhancing operational support
- Improving process mining in order to support operational conformance checking
- Testing and tuning the methodology on novel case studies

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Thank you for your attention!