Business Process Execution and Process Mining on Blockchain

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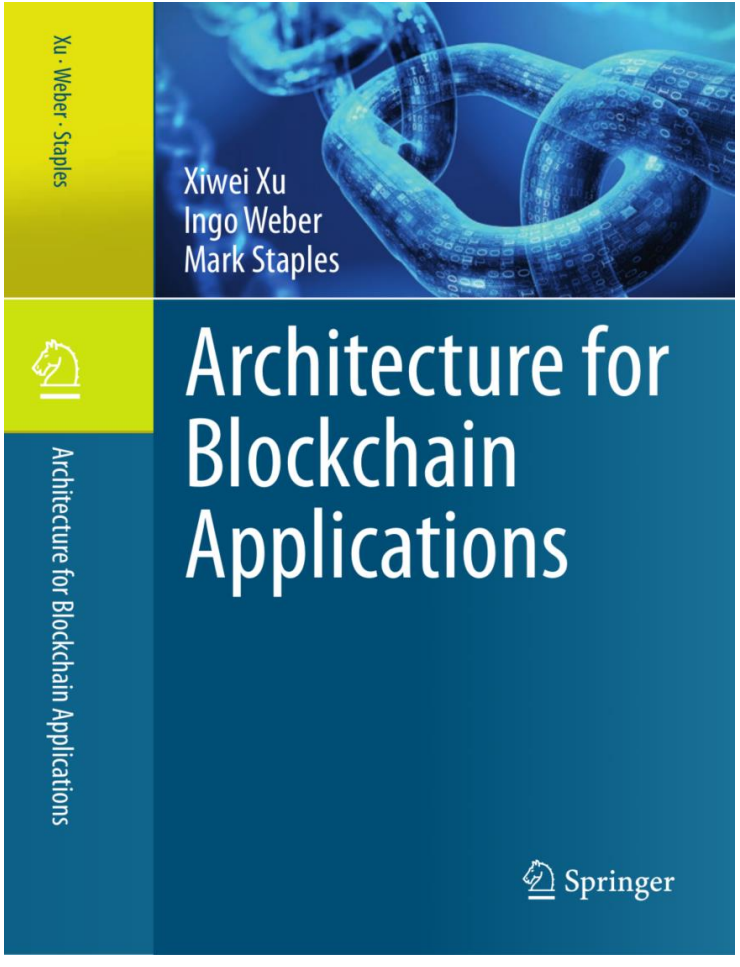


Other blockchain work

Xiwei Xu, Ingo Weber, Mark Staples.
Architecture for Blockchain Applications.
Springer, 2019.

http://dx.doi.org/10.1007/978-3-030-03035-3
→ accessible from the TUM network and many universities

Book website incl. ppt slides of the course:
https://ingo-weber.github.io/blockchain-architecture/

Business Process Enactment on Blockchain

Business Processes on Blockchain – Motivation

Integration of business processes across organizations: a key driver of productivity gains

Collaborative process execution

- Doable when there is trust – supply chains can be tightly integrated
- Problematic when involved organizations have a lack of trust in each other

  → if 3+ parties should collaborate, where to execute the process that ties them together?

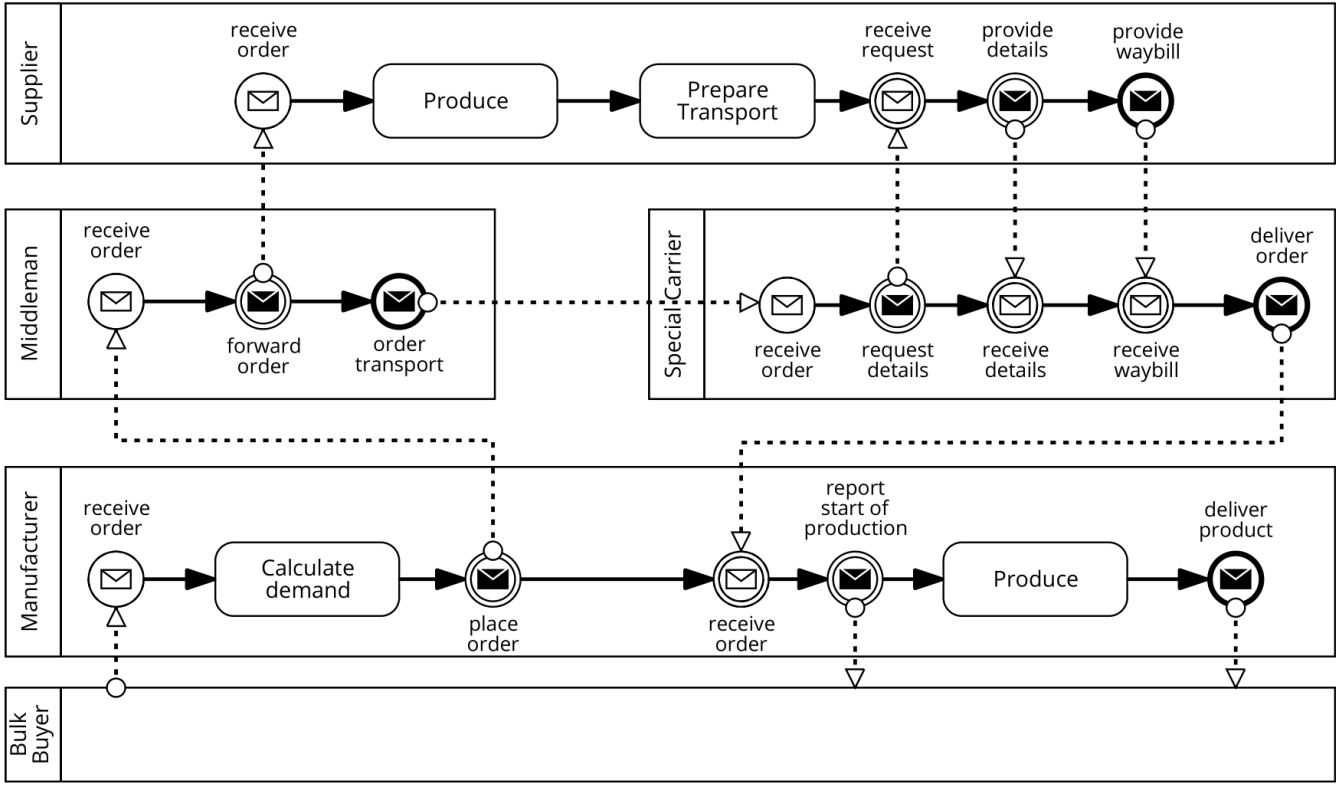
  – Can any participant be trusted with operating an authoritative database?

Cross-organizational processes: by now a common use case for blockchain applications

Motivation: example for collaborative business process

Issues:

- Knowing the status, tracking correct execution
- Handling payments
- Resolving conflicts



Original Approach (BPM 2016) in a Nutshell

Goal: execute collaborative business processes as smart contracts on blockchain

- Translate (enriched) BPMN process models to smart contract code
  → Model-driven engineering (MDE)
- Triggers act as bridge between Enterprise world and blockchain
- Smart contract provides:
  - Independent, global process monitoring
  - Process enforcement: messages are only accepted if they are expected, given the state of the process, and only if sent from the participant playing the respective role
  - Automatic payments & escrow
  - Data transformation

Extensions from the base approach

Optimized execution:
Process reduction based on Petri Net representation, space-optimized encoding using bit vectors

MDE for smart contract-based process implementation: Lorikeet

BPMS execution engine on blockchain: Caterpillar

Code generation vs. interpretation and different modelling styles

Transparency vs. confidentiality: not all-or-nothing
- Off-chain storage + ABE: Attribute-Based Encryption
- “Model commitment”

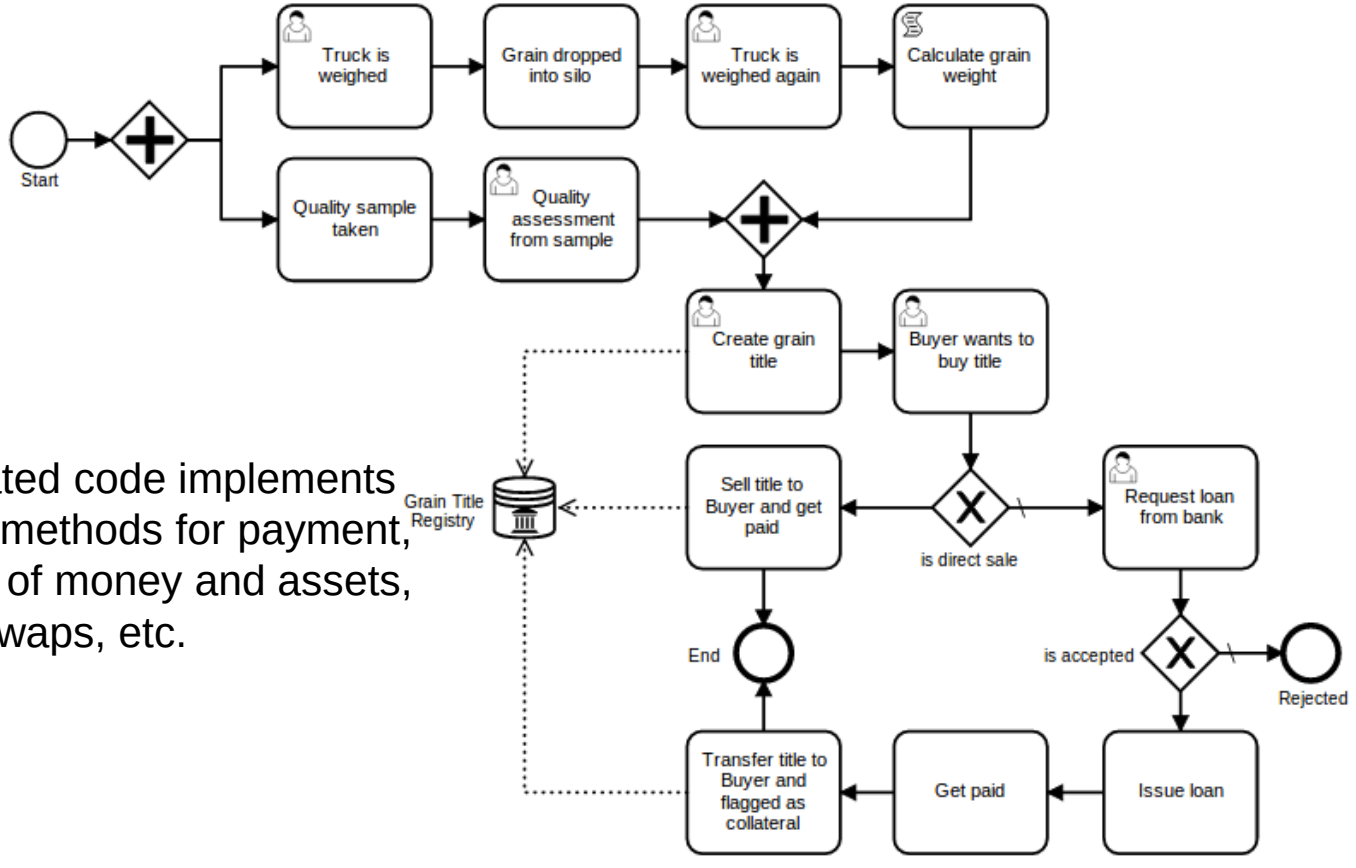
Dynamic role assignment:
- Policies specify who gets to propose changes, who votes on proposals and quora

Controlled flexibility:
- Changes to process implementations, e.g., replacing subprocesses
- Policies as per above

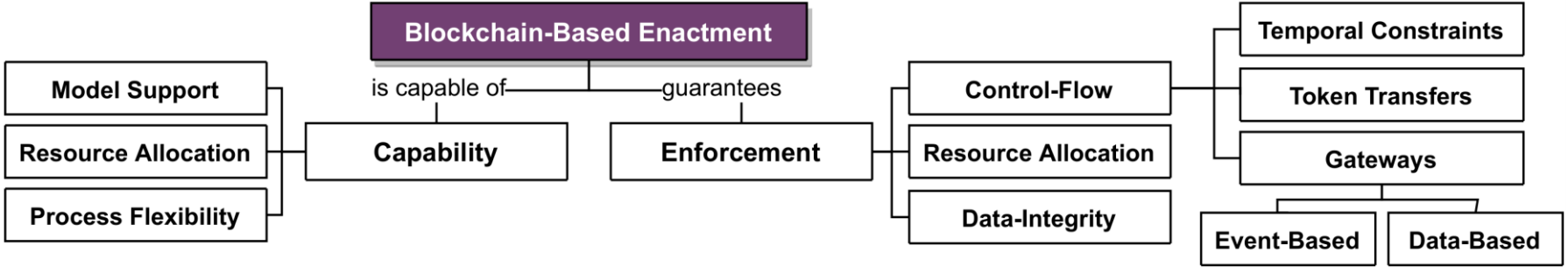
Combining process and data/token models

Combining process and data/token models

Generated code implements secure methods for payment, escrow of money and assets, asset swaps, etc.



SLR & Taxonomy: process execution on blockchain



Cost on Public Ethereum

Execution cost of a single process instance execution at the date of publication and in early 2023. Excluding initial deployment and configuration cost. *Not meant to compare cost-effectiveness of approaches.*

Process mining for blockchain apps

Process Mining / Analytics

Process mining can be used to understand how users / clients and software interact

- Also for blockchain applications

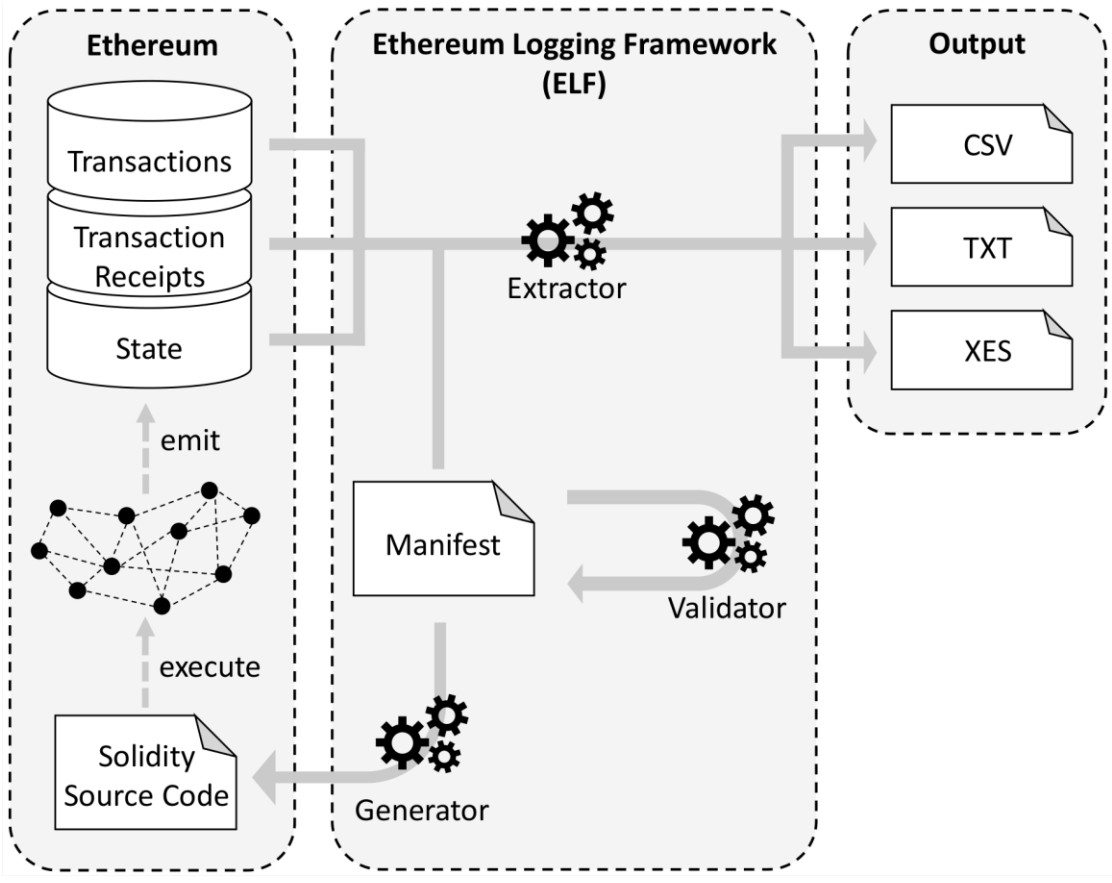
But: understanding log data from blockchain is hard

- Example: which timestamp to use for a given transaction?

Our approach: develop tools (BlockXES / ELF / BLF) to extract
data from blockchain applications, a.o. for process mining

- Can be used on any blockchain application, designed with or without process-awareness
- ELF adds logging capability
- BLF extends the scope to make the tool blockchain-independent; plugins for Ethereum and Hyperledger Fabric implemented, more to come

ELF Overview



For data analytics

Standard log files

For process mining

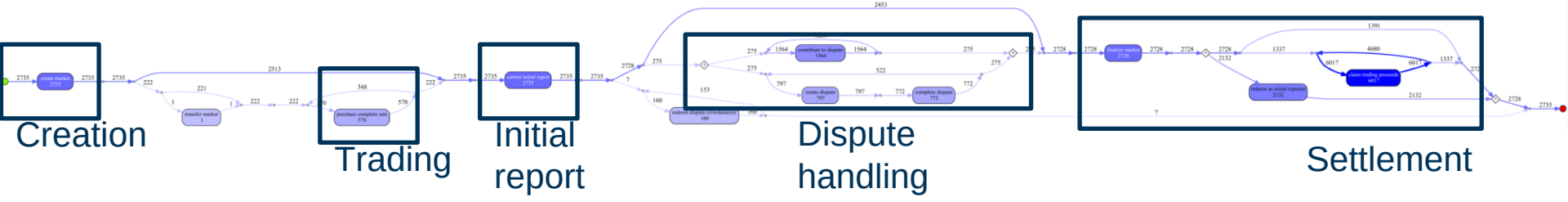
Augur case study [9]

Augur is a prediction and betting marketplace on public Ethereum BC

- Example market: “Will Donald Trump win the presidential election 2020?”

We looked at ~2700 markets (~22k events) created on Augur v1.0

One discovered process model (unfiltered):



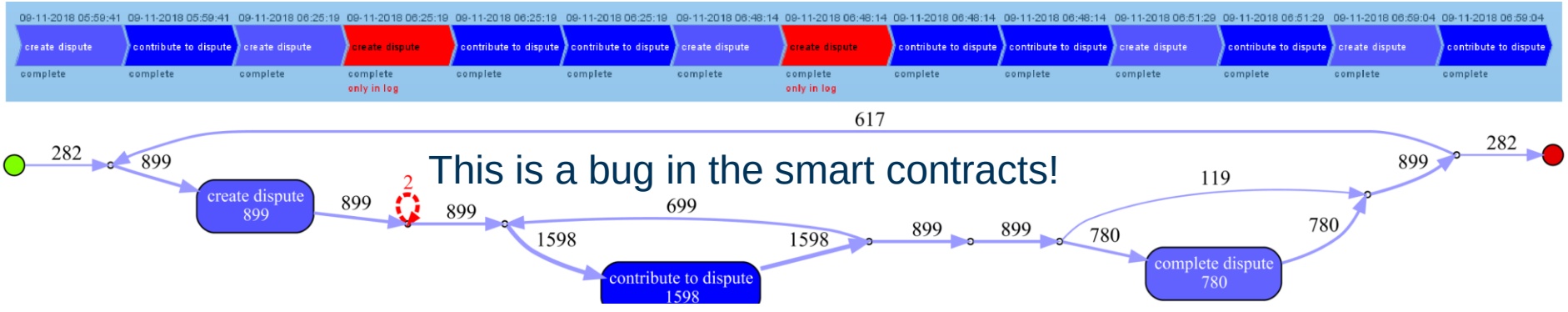
Process Mining analyses we performed:

- Exploration
- Process Discovery
- Conformance Checking

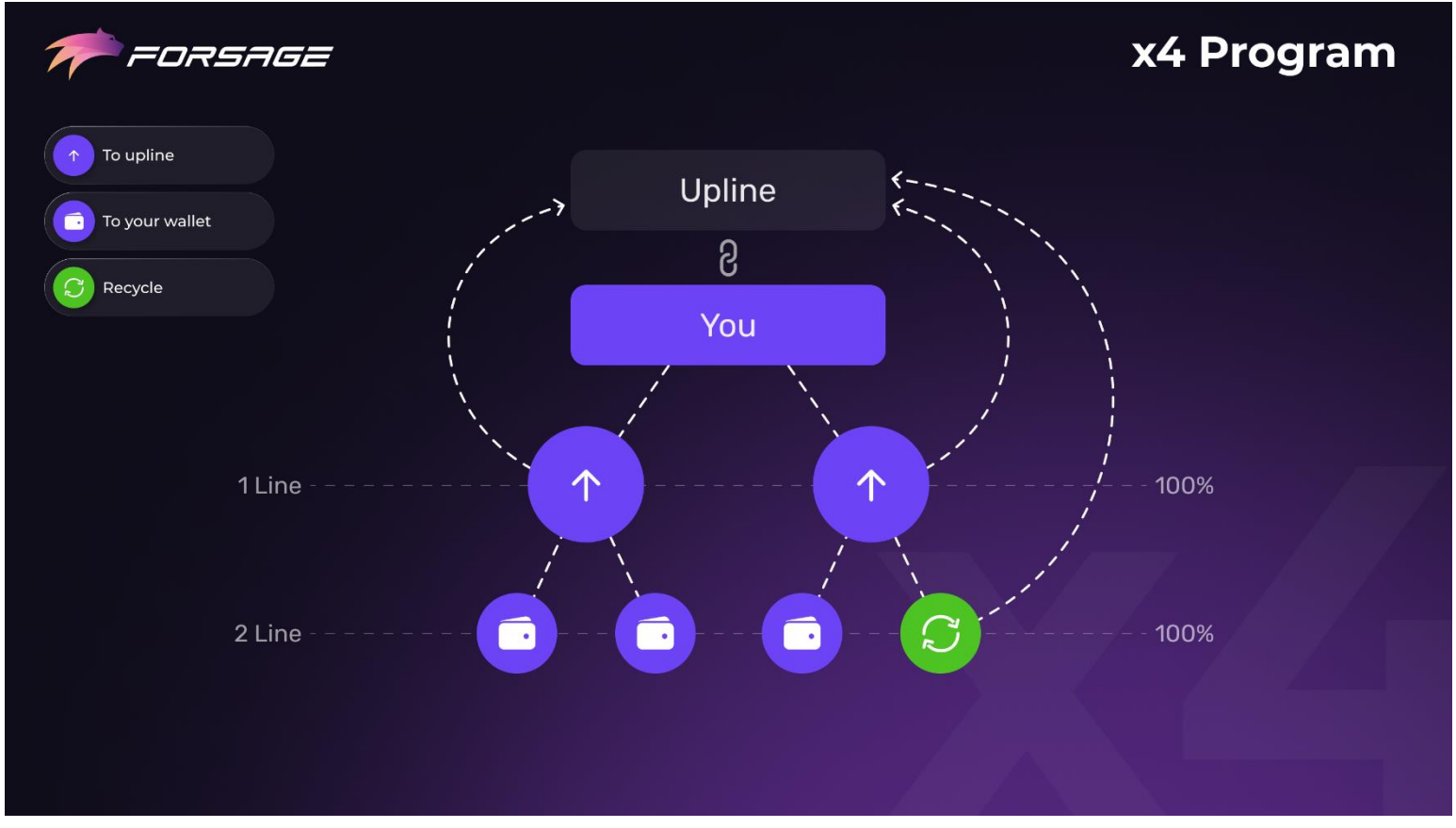

us log imported from log_augur_20201116-disco.xes
Select visualisation ...
Inspector
Info
Legend
Timing patterns
Trace: conceptname
Event: time:timestamp
100 % rendered
in 0.05 sec.

Augur case study [9] continued

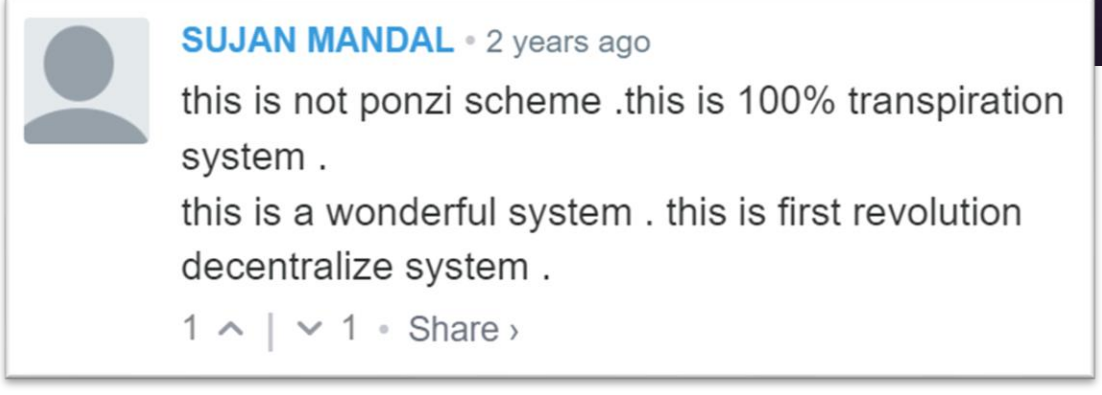
Conformance checking means comparing a normative model against event logs
To obtain the normative model, we relied on the Augur white paper, their UI and further explanations, but filtered activities such that the model only used events present in the log
We also verified and contextualized our findings by interviewing Augur's lead architect
One conformance checking result:

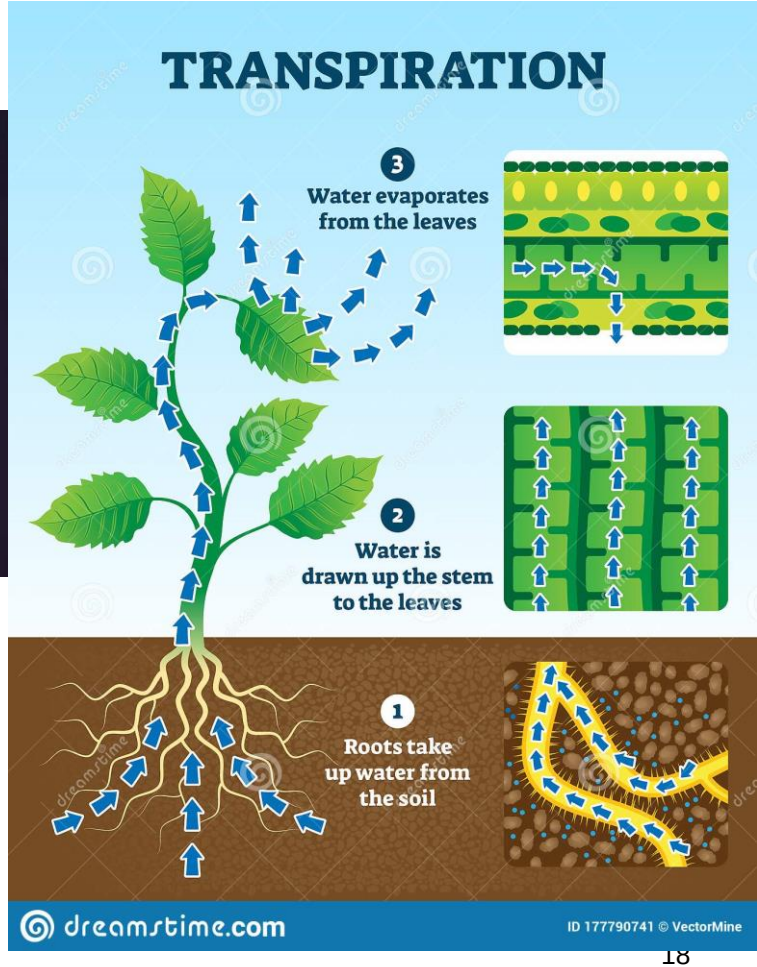


Forsage: a “matrix-based” investment scheme

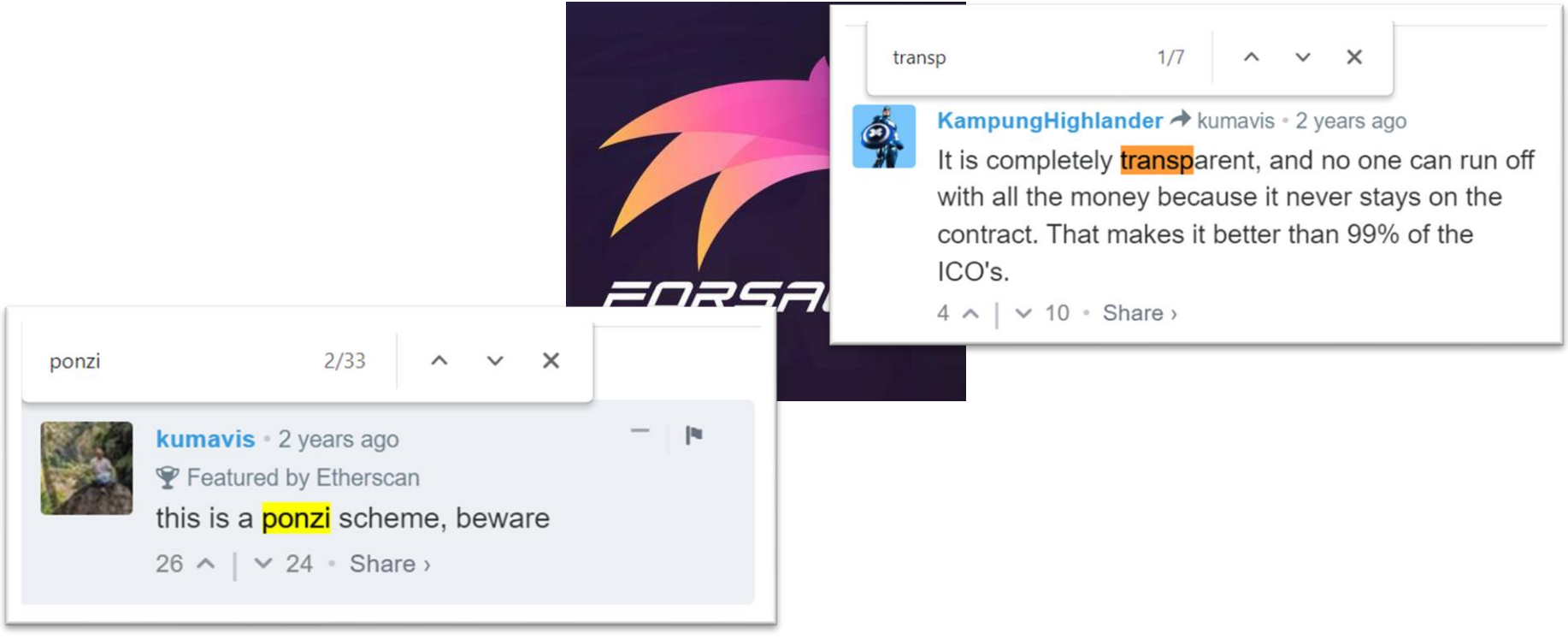


Second case: Forsage





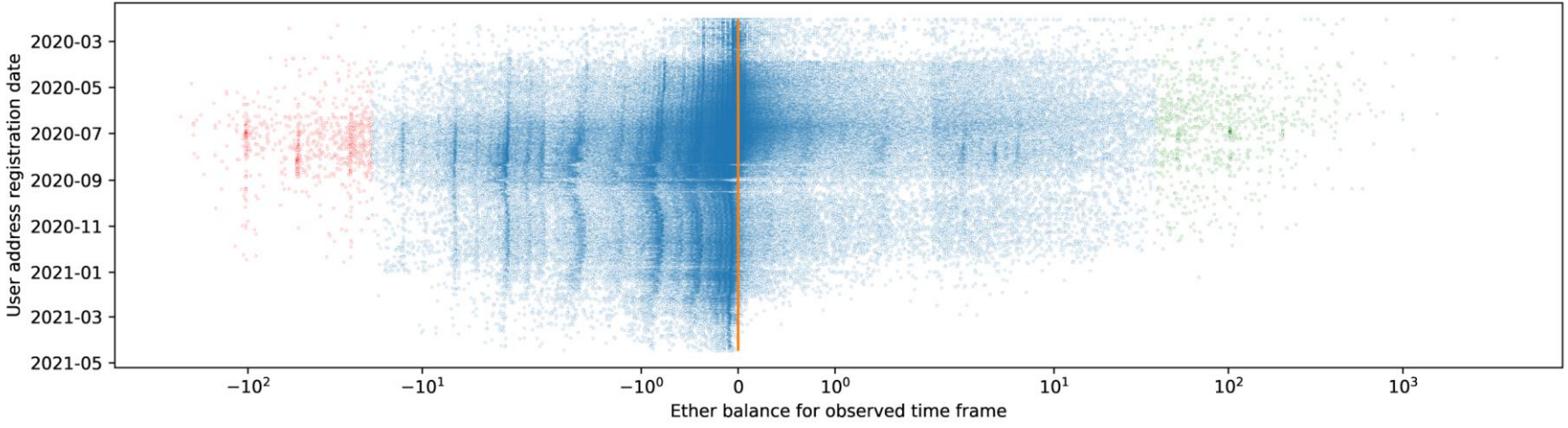
What is Forsage?



Second case study: Forsage

Data: 13.4 M events in 1.06 M traces

Marketing claim: regardless of when you enter, you can always profit



→ Not true, and about 90% of users* made a loss (*simplifying assumption: 1:1 match of users to accounts)

→ 3 of 4 claims debunked through our case study

Conclusion so far

Shed light on **application dynamics** and **money flow**

- Forsage is a Ponzi scheme

The Forsage **documentation** does **not** reflect **code execution** in detail, Augur contained a bug

- We unveiled this through conformance checking and drill-downs
- Forsage: not transparent

Compare **behaviour** of users, e.g. **successful** and **unsuccessful** users

- Recommended strategy for users → how to benefit from a Ponzi scheme ;-)

Is it useful to do process mining on blockchain data?

→ **In two cases** (Augur and Forsage) **we found: yes**

- 4 data sets available, in XES: https://ingo-weber.github.io/dapp-data/

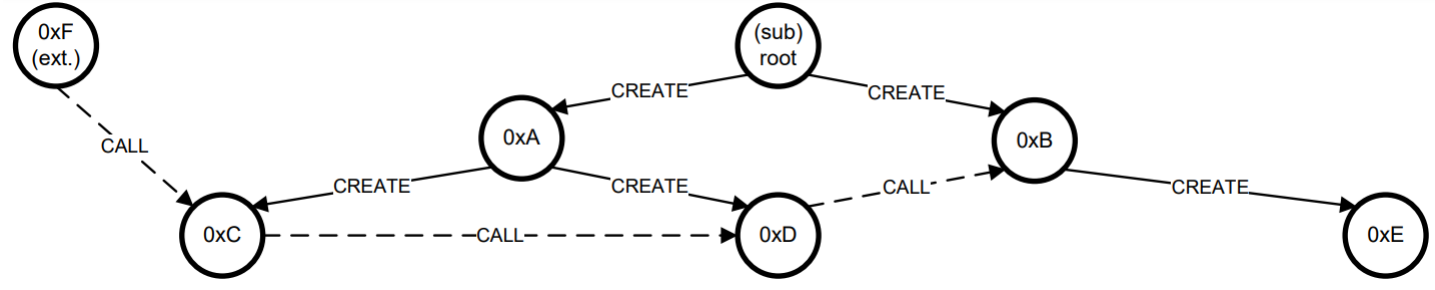
Outlook: Object-centric process mining

Traditional approach:

Single case notion at a time (e.g., user)

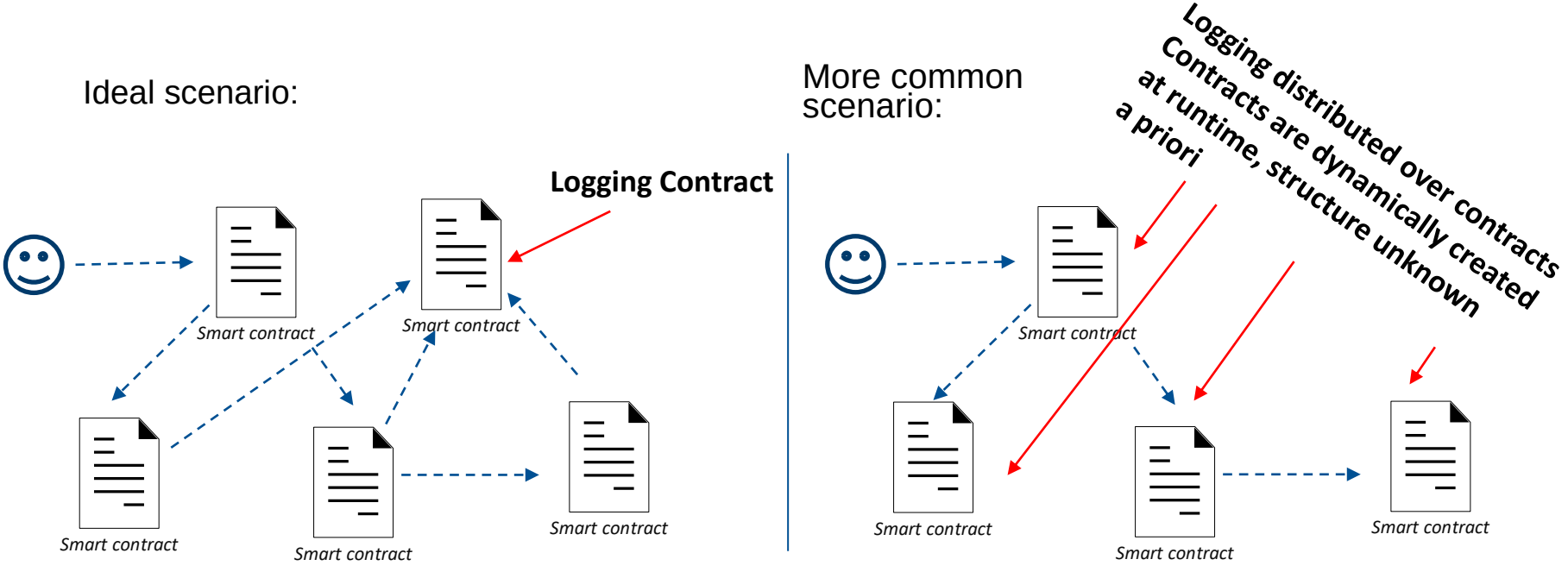
Object-centric approach:

Multiple entities (*objects*) the process can revolve around
(e.g., user, contract type, order, etc.)
→ There might <u>not</u> be one consistent case notion throughout the DApp



Hobeck, R., Weber, I. (2023). Towards Object-Centric Process Mining for Blockchain Applications

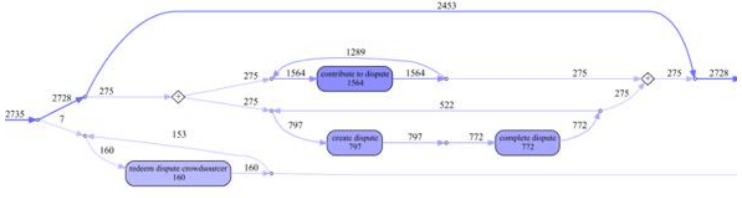
Motivation for object-centric process mining



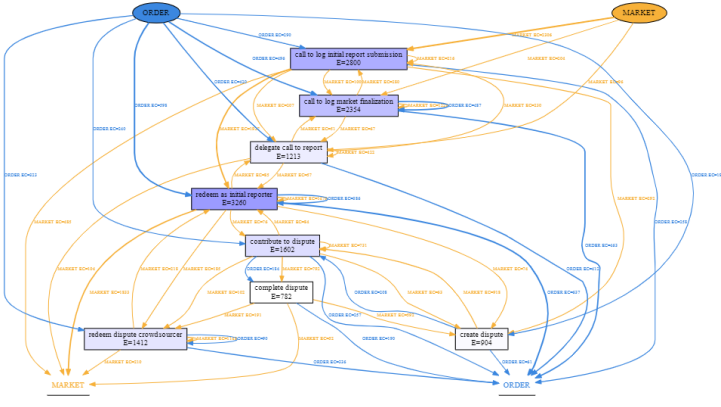
Object-centric process mining

Revisiting the **Augur dispute**:

Single case notion (market)



Object-centric (market and order)



*discovered based on additional data compared to single-case notion example

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