European Conference on Information Systems 2018
Enterprise Modelling
Portsmouth, UK, June 23rd – 28th 2018

Decentralized Business Process Modeling and Instance Tracking Secured by a Blockchain

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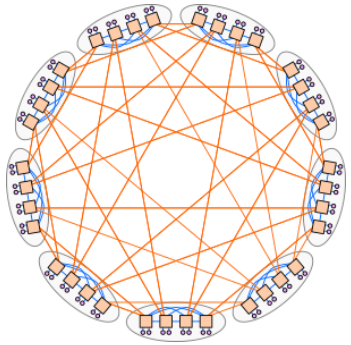
1. Motivation

Public Blockchains Allow for Decentralization

- In 2008, Bitcoin enabled trust-free monetary transfers among decentralized peers
- Peers interact directly as part of a decentralized network, i.e., no central coordinator exists
- Monetary transfers require no intermediaries or prior relationships, since transactions are verifiable by anyone



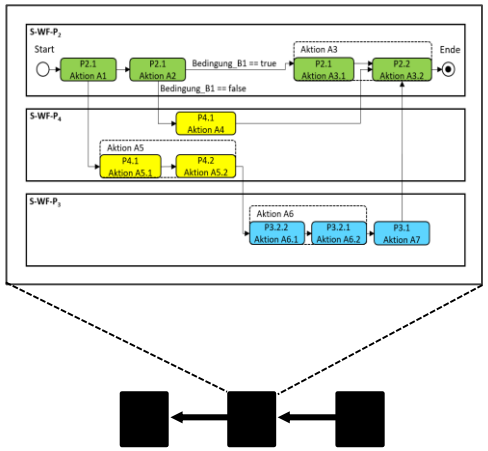
1. Motivation

Decentralized Information Systems Development

- For businesses, peers plan and execute any kind of business transaction
- Process and workflow models define planning and execution of inter-organizational transactions
- A model stored on a blockchain can represent an integrity-secured definition of processes and workflows

→ processes, collaborations, value networks based on models

→ models can become contracts



2. Introduction

Foundations

- Blockchains and Peer-to-Peer
  - Properties: immutable storage, integrity, trust-free transactions between peers (Mendling et al. 2018, Notheisen et al. 2017)
  - Modeling: workflow execution (Weber et al. 2016), storing enterprise models in a permissioned blockchain (Fill and Härer 2018)
- Collaborative Modeling
  - Usually centralized architectures, e.g. using BPMN and ADOxx
  - Synchronous approaches:
    e.g. near-realtime modeling (Derntl et al. 2015, Nicolaescu et al. 2017)
  - Asynchronous approaches:
    e.g. model versioning and version control systems (Brosch et al. 2012)

Fill, H.-G. and F. Härer (2018). "Knowledge Blockchains: Applying Blockchain Technologies to Enterprise Modeling". 51st Hawaii International Conference on System Sciences, HICSS 2018, Hilton Waikoloa Village, Hawaii, USA, January 3-6, 2018.

2. Introduction

Process and Workflow Models

- Multiple process participants collaborate as decentralized peers

  → Requires agreement

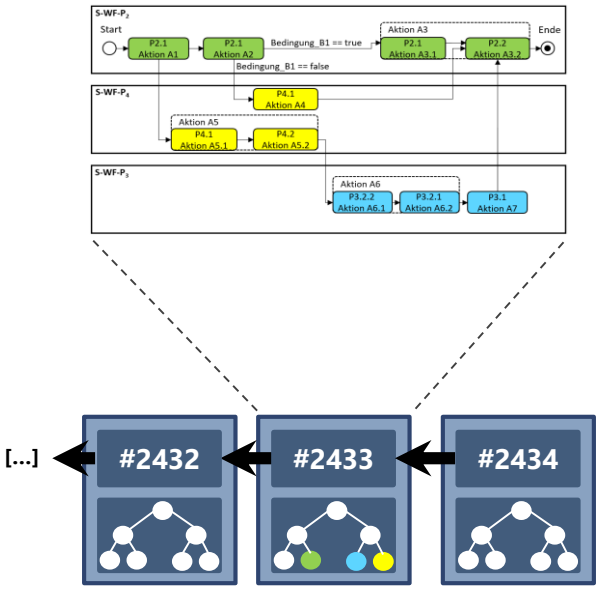
- Multiple inter-organizational processes form a web of inter-connected processes

  → Requires build and run time

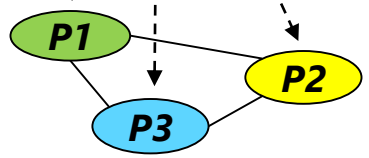
- Evolution of models over time

  → Requires management and storage

Process Definitions



Peer-to-Peer-Network



2. Introduction

Research Questions

1. How can the creation of business process models among decentralized participants be managed providing that participants can collaboratively model and agree on models?
2. How can decentralized participants track instances of agreed-upon models?

3. Decentralized Modeling and Instance Tracking

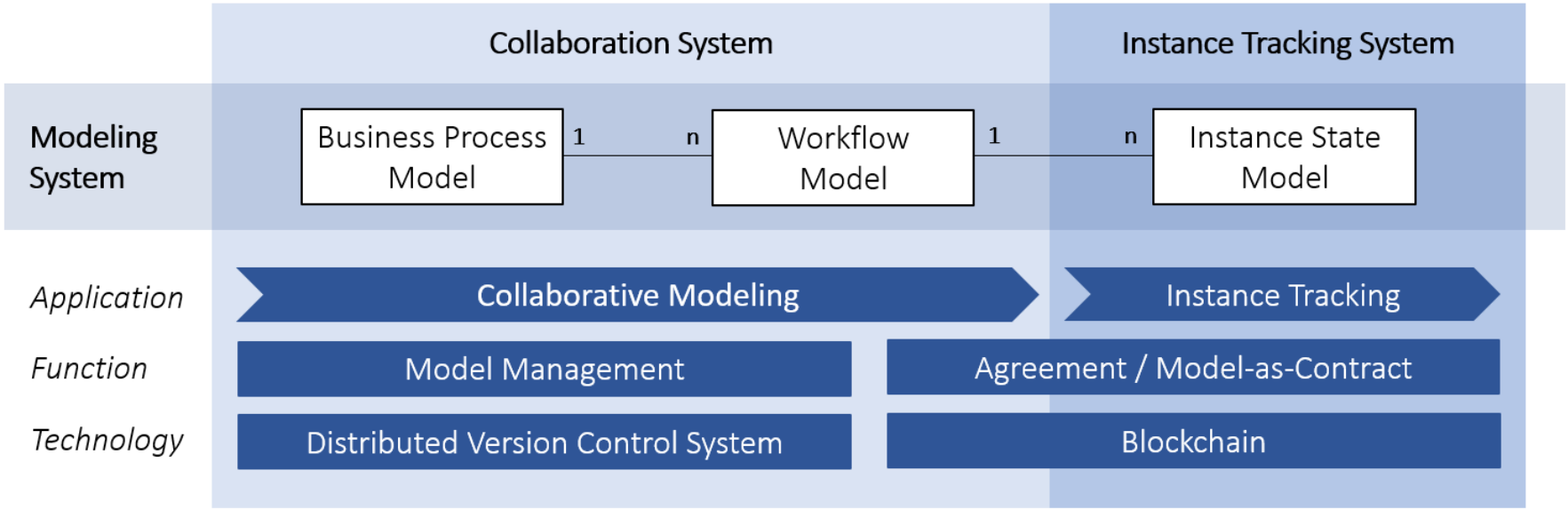
Proposed Strategy

Implement a Decentralized Modeling Approach, based on

- *Public Blockchain for trust-related requirements only*
  - Due to transaction cost, limited block size and rate
  - For securing the integrity of models
  - For agreement procedures (smart contracts)
- *Version Control for collaboration requirements*
  - Off-line storage solved by versioning approaches
  - For asynchronous collaboration
  - For off-chain storage

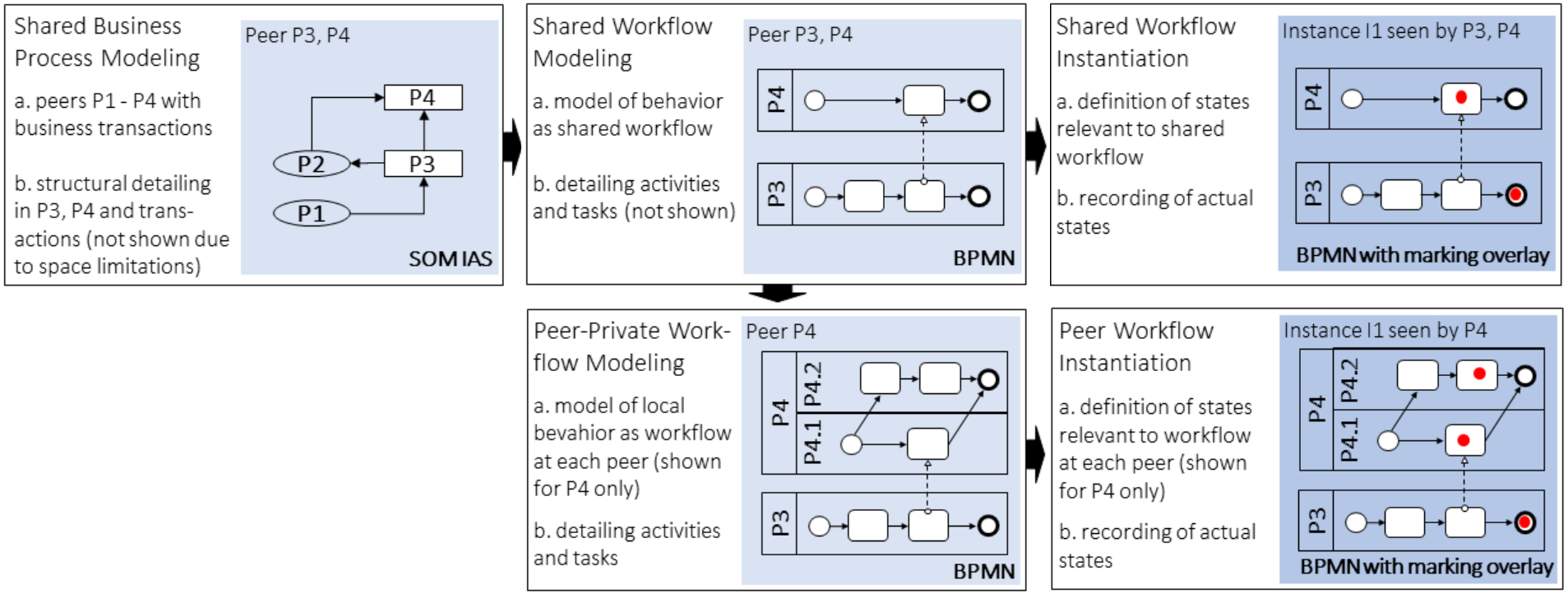
3. Decentralized Modeling and Instance Tracking

Architecture for Approach and Software-Tool



3. Decentralized Modeling and Instance Tracking

Modeling System: System Build / Run Time



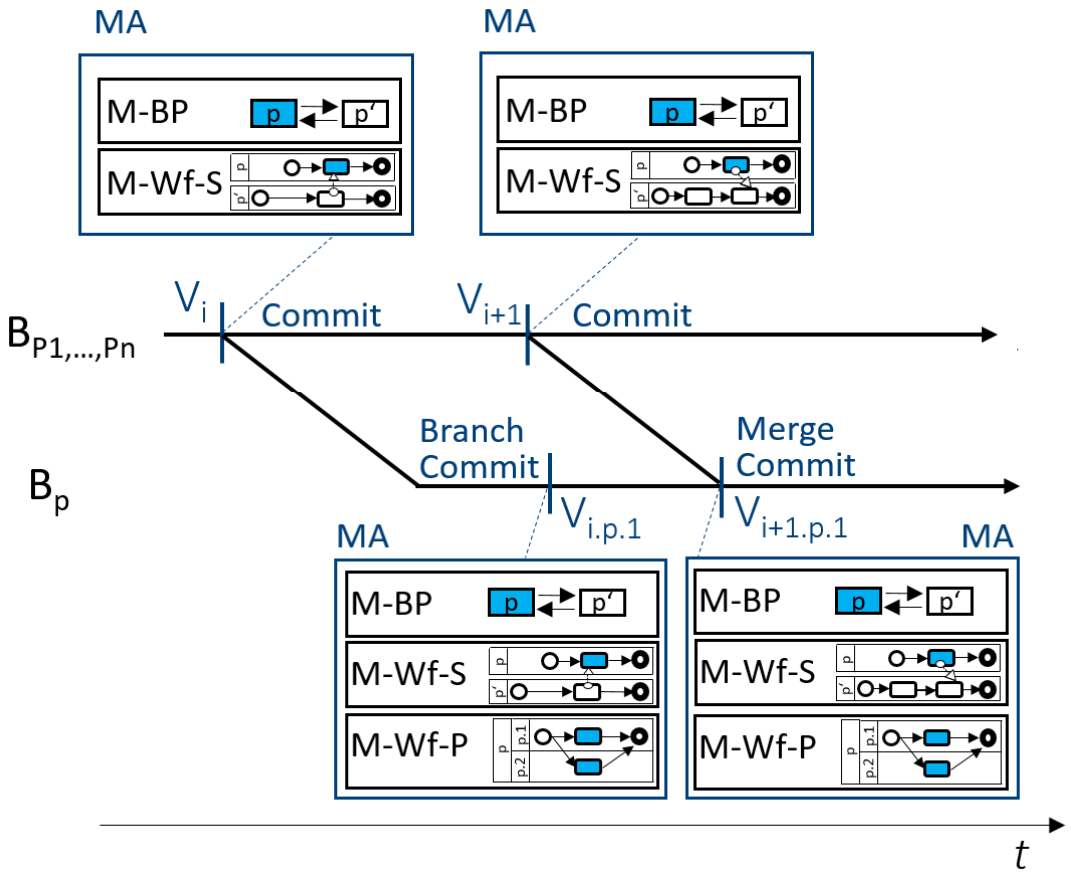
Process Build Time | **Process Run Time**

3. Decentralized Modeling and Instance Tracking

Collaboration System

Transactional Model Creation

- Version Graph
- Operations
  - Commit
  - Branch Commit
  - Merge Commit
- Shared process for collaboration of Peers P1, …, Pn
- Branching for private processes of Peer Pp



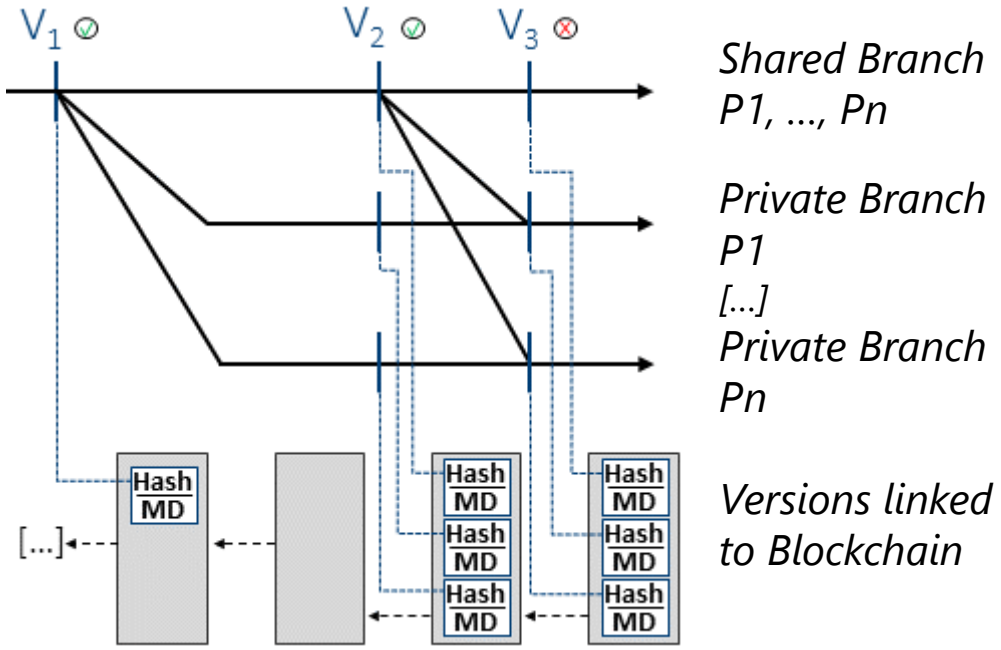
3. Decentralized Modeling and Instance Tracking

Collaboration System

Collaboration on Version Graph

- Each committed version Vi is linked to a Blockchain
  - Calculate Hash_Function(Vi)
- Agreement Problem:
  Which version to use?
- Participants signal agreement by vote using a 2-phase-commit
  - Implemented in Smart Contract

→ Trust-free model agreement



3. Decentralized Modeling and Instance Tracking

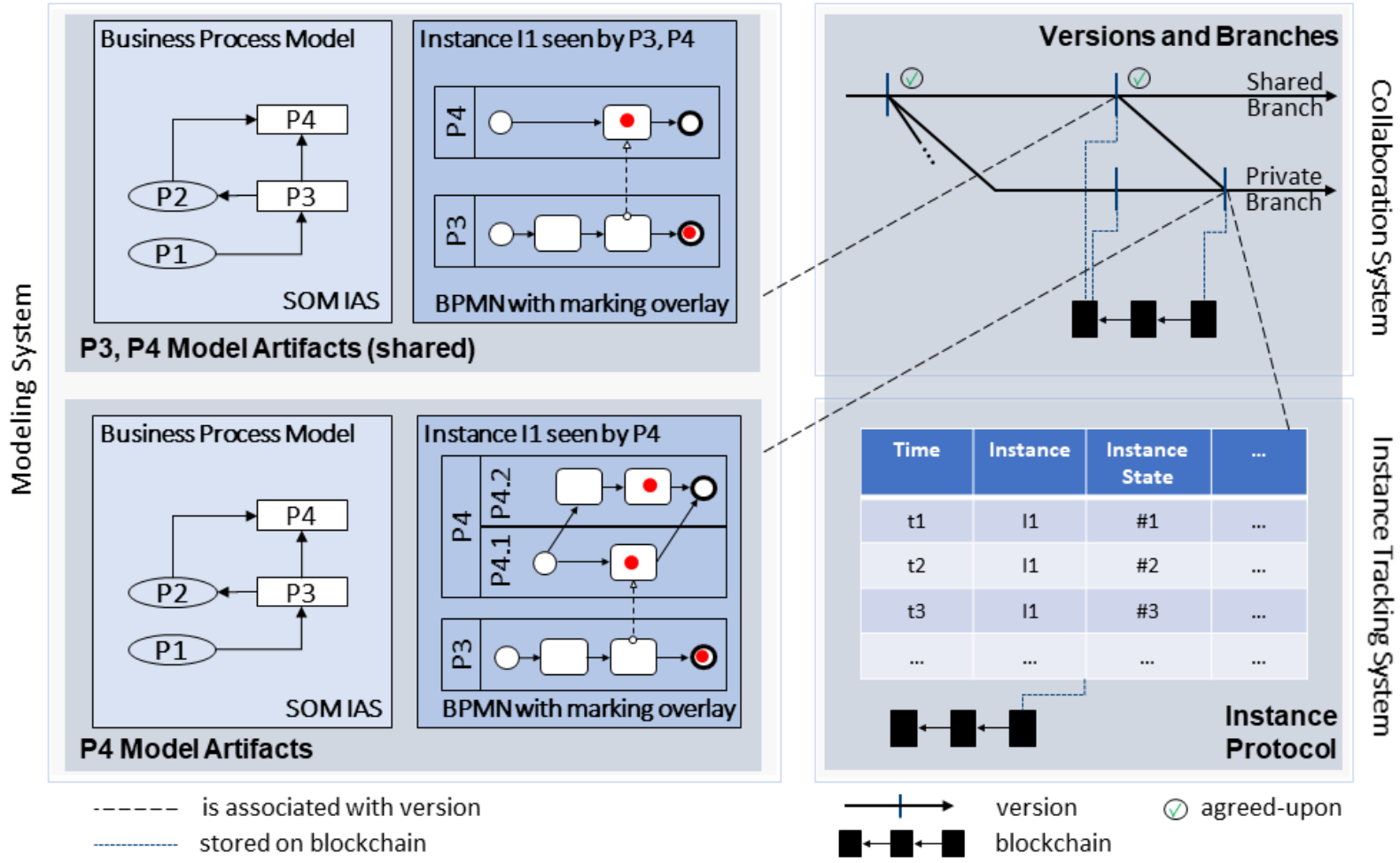
Instance Tracking System

- Participants track workflow instances
- For showing expected states, agreed to by participants
- For showing progression of actual states, occurred during instantiation
- Derivation of Instance Protocols over time

Time	Instance	State ID	CS Hash-Values		AS Hash-Values	
			M-IS-S	M-IS-P	M-IS-S	M-IS-P
t1	I1	#1	(e3b0…, c442…)		(e3b0…)	
t2	I1	#1	(e3b0…, c442…)	(34ca…, 6fb9…)	(e3b0…)	(34ca…)
t4	I1	#2	(e3b0…, c442…)	(34ca…, 6fb9…)	(e3b0…, e464…)	(34ca…)
t6	I1	#2	(e3b0…, c442…)	(34ca…, 6fb9…)	(e3b0…, e464…)	(34ca…, 991b…)

3. Decentralized Modeling and Instance Tracking

Instance Tracking System with Shared and Private Processes

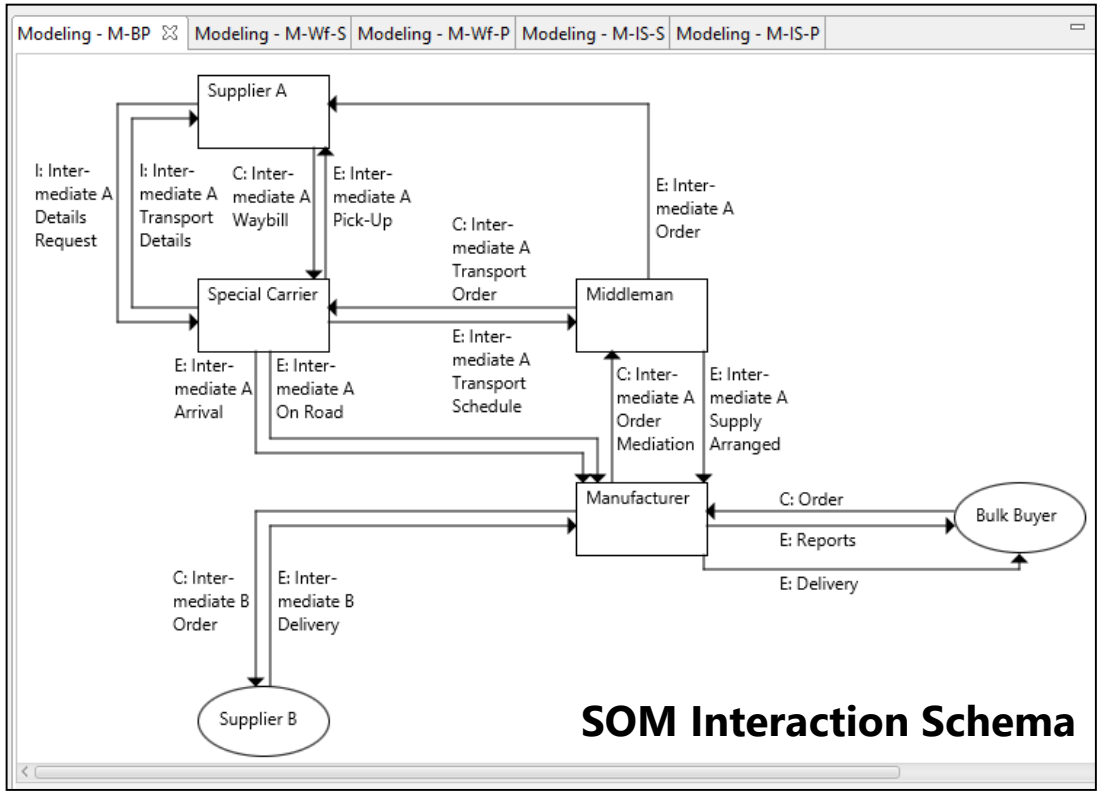


4. Use Case and Software Implementation

Use Case

- Collaborative Business Process based on Fdhila et al. (2015)
- Supply Chain use case
  - Private and public models
  - Change scenario for BPMN model
  - Compliance aspects, not covered by this approach

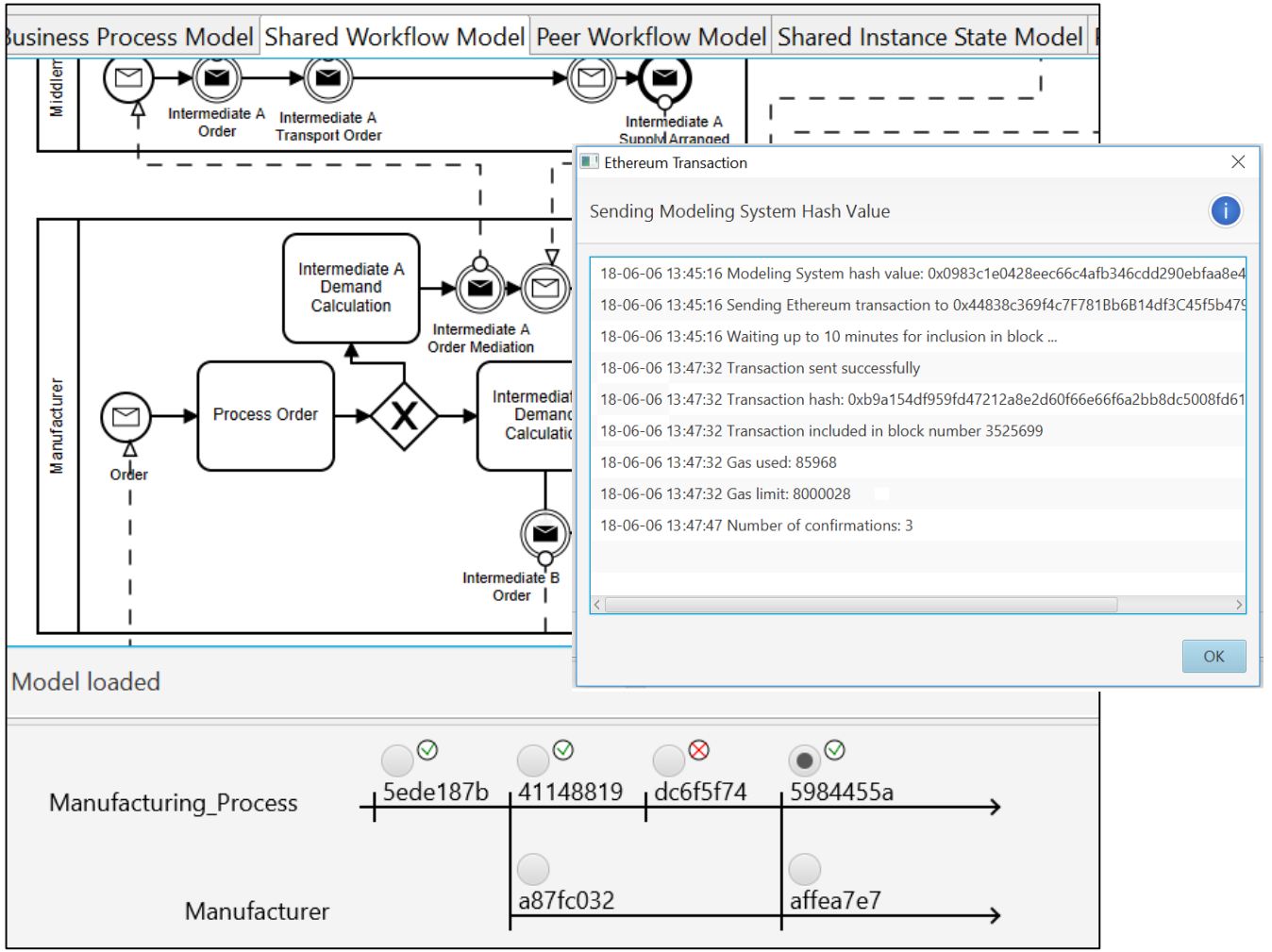
Proof-of-Concept Implementation



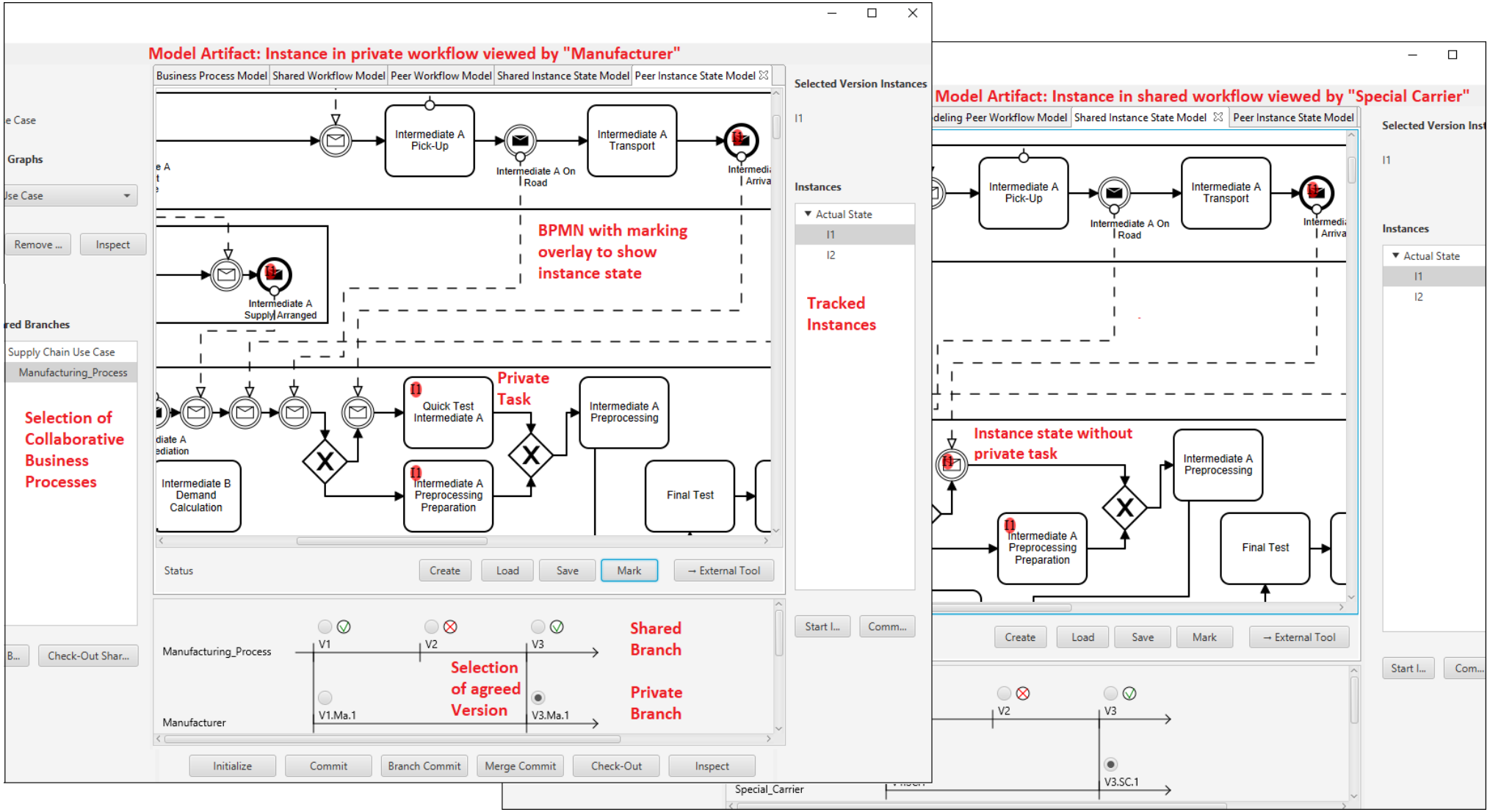
4. Use Case and Software Implementation

Implementation

- Java / JavaFX Platform
- Version Control System
  - Git
- Blockchain
  - Ethereum
  - Solidity Smart Contract for Agreement Procedures
  - Deployed in Test-Net at address 0x44838c369f4c 7F781Bb6B14df3C45f5b4 797Af0d



4. Use Case and Software Implementation



5. Result Discussion

Implementation and Research Questions

- Implementation
  - Collaborative process with change scenario (Fdhila et al. 2015) implementable except for one compliance change
- Research Question 1:
  - System demonstrates collaborative model creation and forming agreements in a decentralized setting
  - Allows trust-free modeling transactions
- Research Question 2:
  - Answered partially
  - Tracking of instances through state models
  - Limitations:
    - Requires manual selection of states
    - Confirmation times
    - Scalability (block size, transaction cost)

5. Result Discussion

Outlook

- Using Blockchains, modeling might become viable …
  - in areas where the integrity of a model is critical for security reasons
  - in cases where an external actor is presented with a model and is required to act on it without a “trusted third party”

- Application areas and future research
  - models of procedures in response to critical infrastructure failures
  - models of manufacturing processes
  - autonomous creation or modification of models by systems

Thank you for your attention!

Future information / Software Tool:
https://haerer.org

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