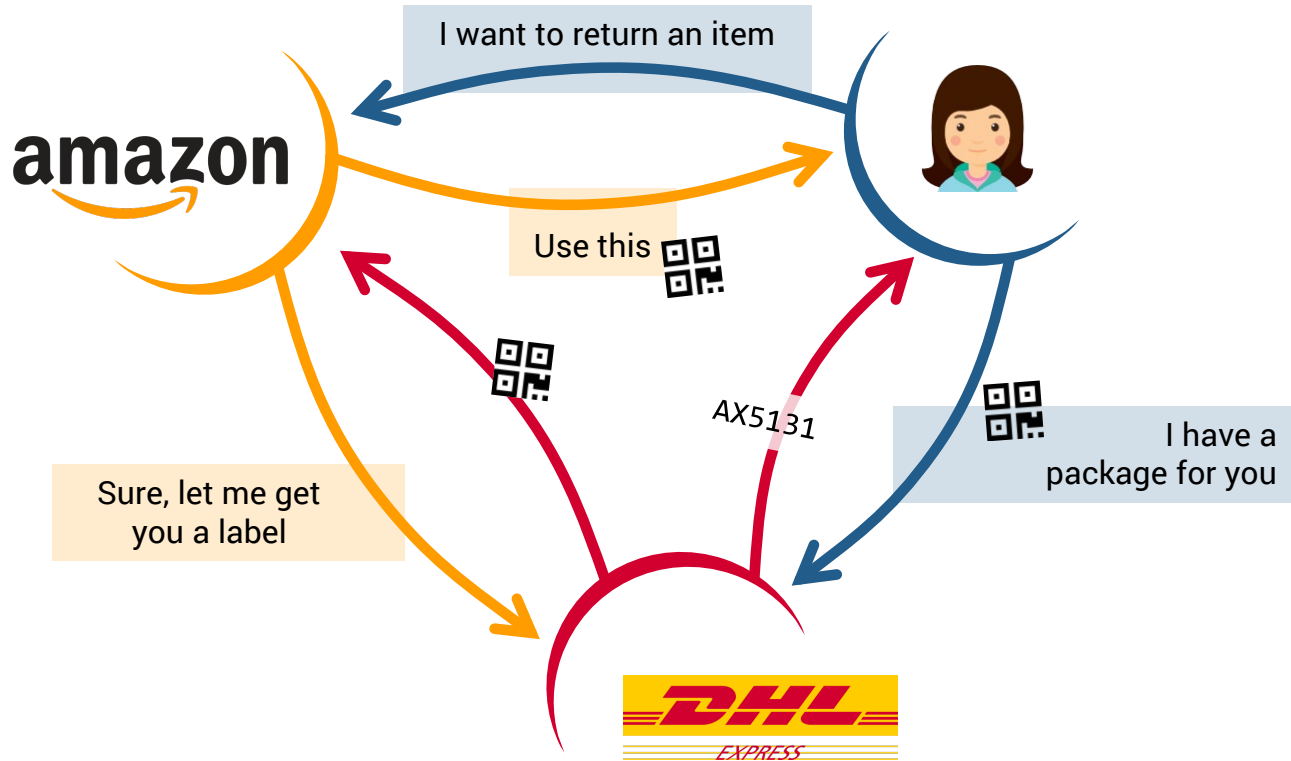


# Process Choreographies on the Blockchain

Master's Seminar, Summer Semester 2019

Prof. Dr. Mathias Weske, Jan Ladleif, Stephan Haarmann  
Business Process Technology @ HPI

# Choreographies



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PhD Candidate  
08.04.2019

Chart 2

# Choreographies are everywhere...

## Amazon

Zustellung heute bis 20h

✓ Bestellt am Samstag, 12. Januar

✓ Versand: Montag, 14. Januar

✓ **In Zustellung**  
Alle Aktualisierungen anzeigen

☐ Ankunft heute

## AirBnB

14 days prior

7 days prior

Check in

Example 48 hours after booking

Fri, Jan 18  
3:00 PM

Fri, Jan 25  
3:00 PM

## Booking.com

[Change dates](#)

[Update credit card](#)

[Add another room](#)

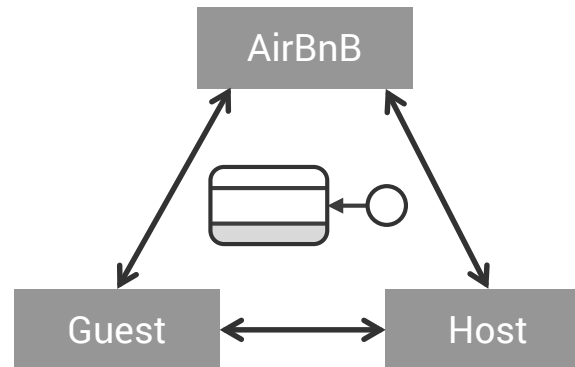
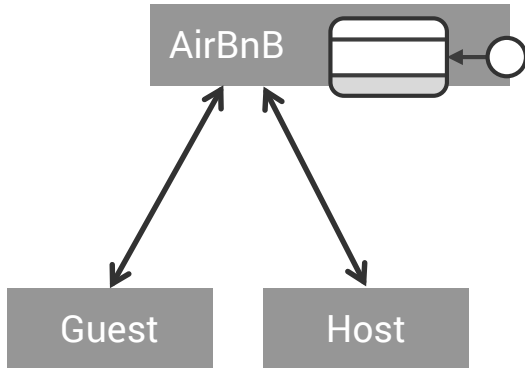
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Chart 3

... but hidden within a single controller.

- All business and choreography logic is hidden within AirBnB
- You have to trust AirBnB
- However, what if we used the blockchain as a central source of truth for data and logic?

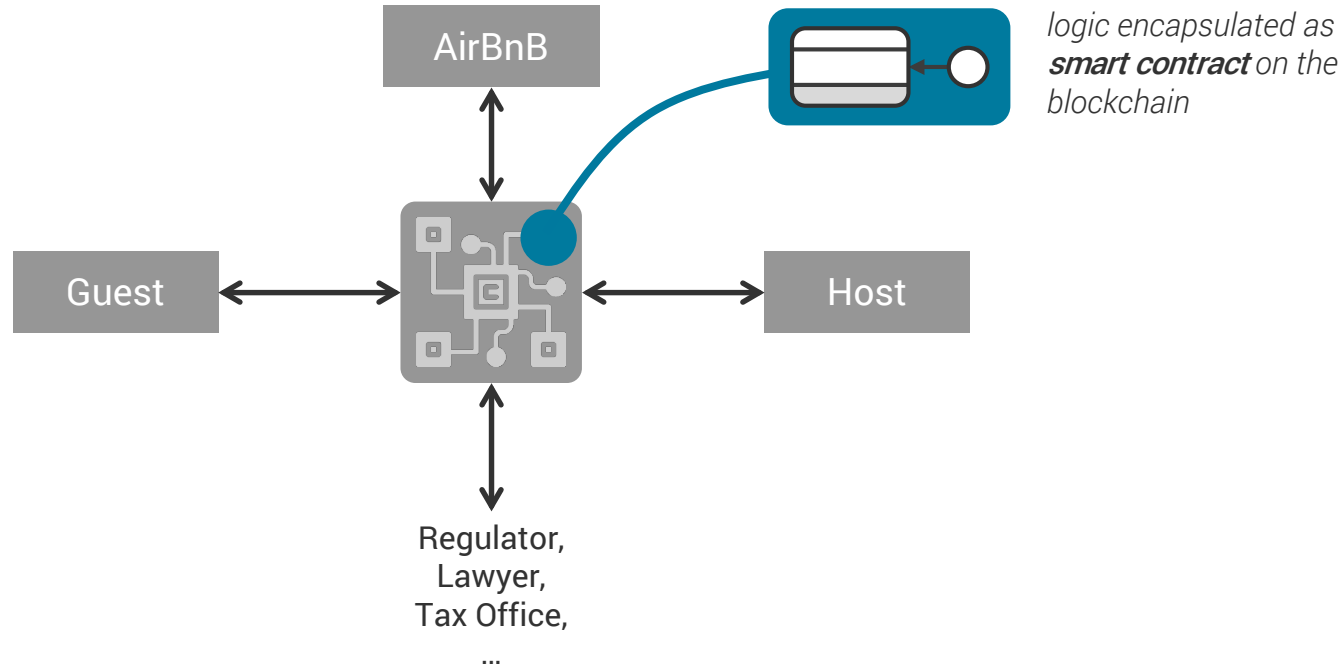


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Chart 4

# Blockchain as a Coordinator



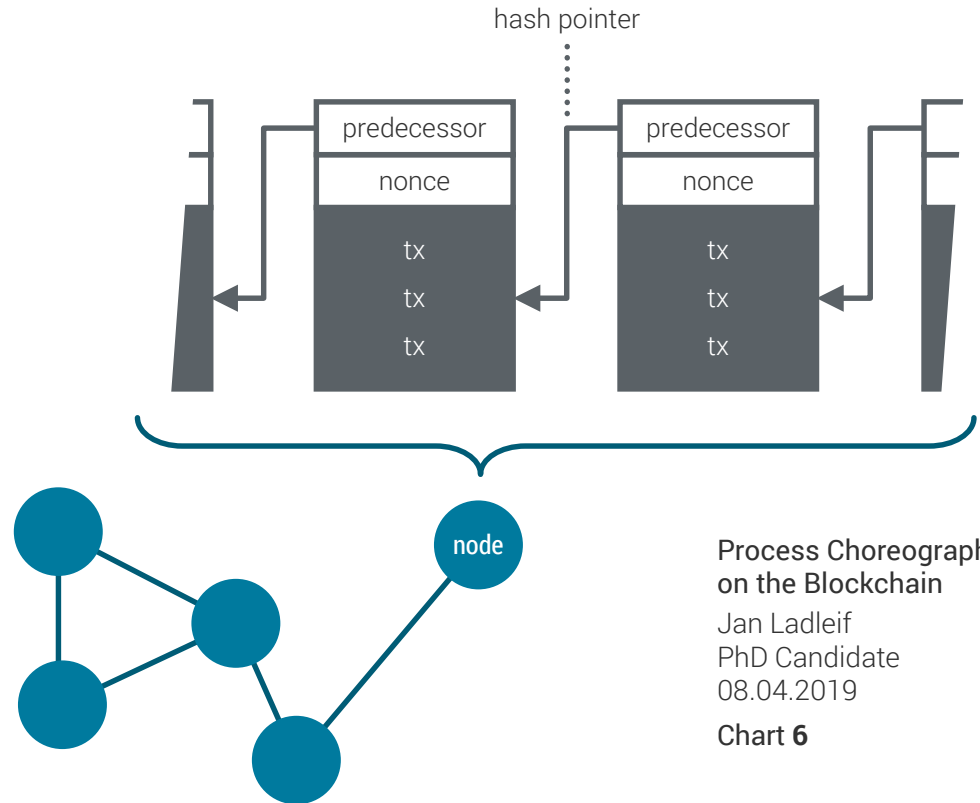
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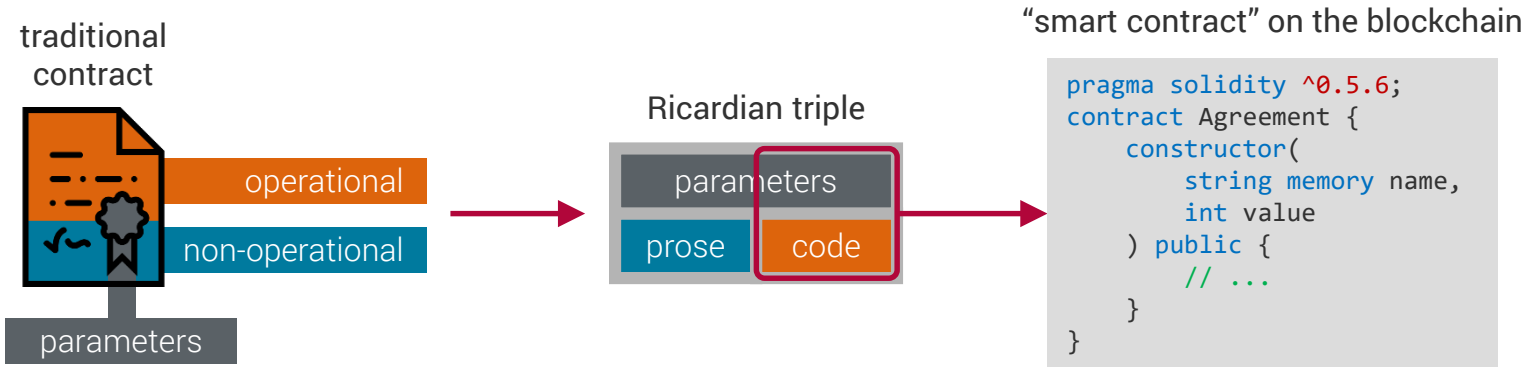
Chart 5

# Blockchain Technology

- cryptographic structure
- relies on hashing and puzzle solving
  
- Properties
  - tamper-proof
  - immutable
  - consensus
  
- This Seminar  
 “append-only distributed database with transaction-based scripting capabilities”



# Smart Contracts



“Smart contracts are programs deployed as data in the blockchain ledger and executed in transactions on the blockchain. [...]”

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

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Chart 7

# Smart Contracts Vulnerabilities

## Digital currency Ethereum is cratering because of a \$50 million hack

Rob Price 17.06.2016, 11:34

FACEBOOK LINKEDIN TWITTER

The value of the digital currency Ethereum has dropped dramatically amid an apparent huge attack targeting an organisation with huge holdings of the currency.



Martin Hunter/Getty Images

The price per unit dropped to \$15 from record highs of \$21.50 in hours, with millions of units of the digital currency worth as much as \$50 million stolen at post-theft valuations.

At a pre-theft valuation, it works out as a staggering \$79.6 million.

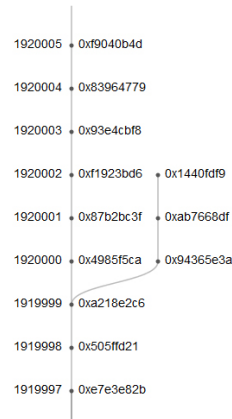
Ethereum developers have proposed a fix that they hope will neutralise



## Hard Fork Completed

Posted by Vitalik Buterin on July 20, 2016

We would like to congratulate the Ethereum community on a successfully completed hard fork. Block 1920000 contained the execution of an irregular state change which transferred ~12 million ETH from the "Dark DAO" and "Whitehat DAO" contracts into the WithdrawDAO recovery contract. The fork itself took place smoothly, with roughly 85% of miners mining on the fork:



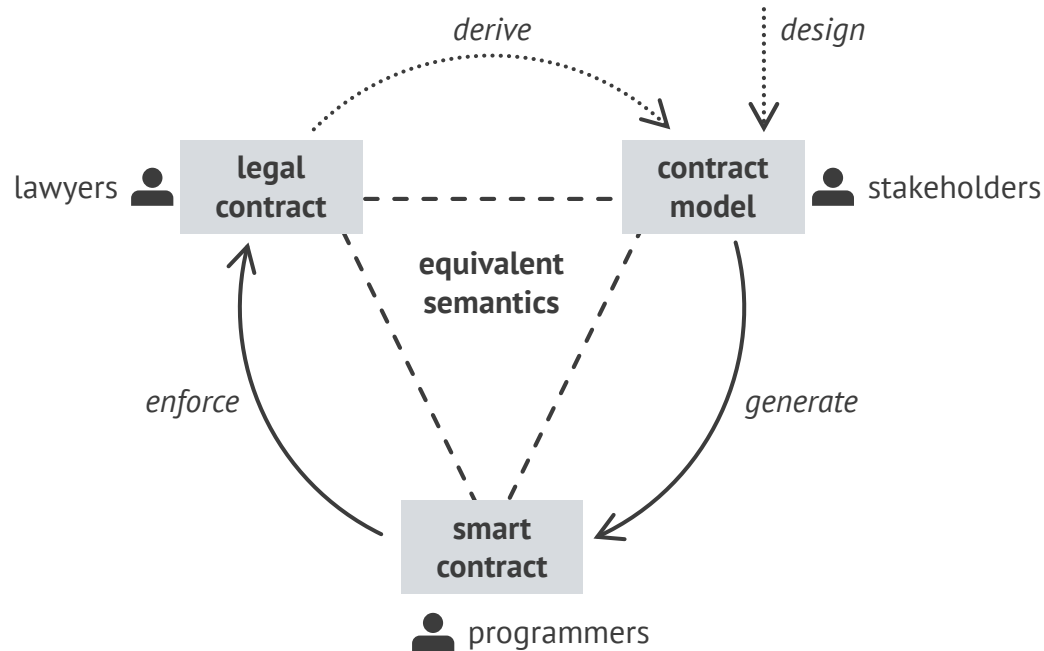
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Chart 8



# Model-Driven Design of Smart Contracts

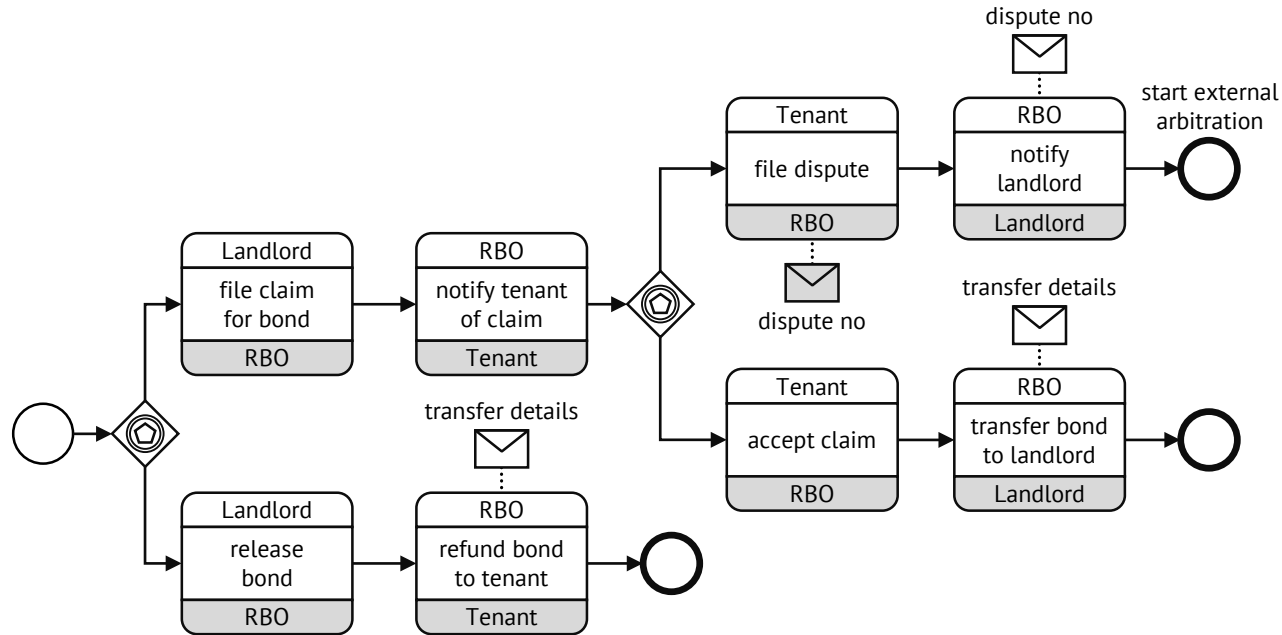


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Chart 9

# BPMN Choreography Diagrams

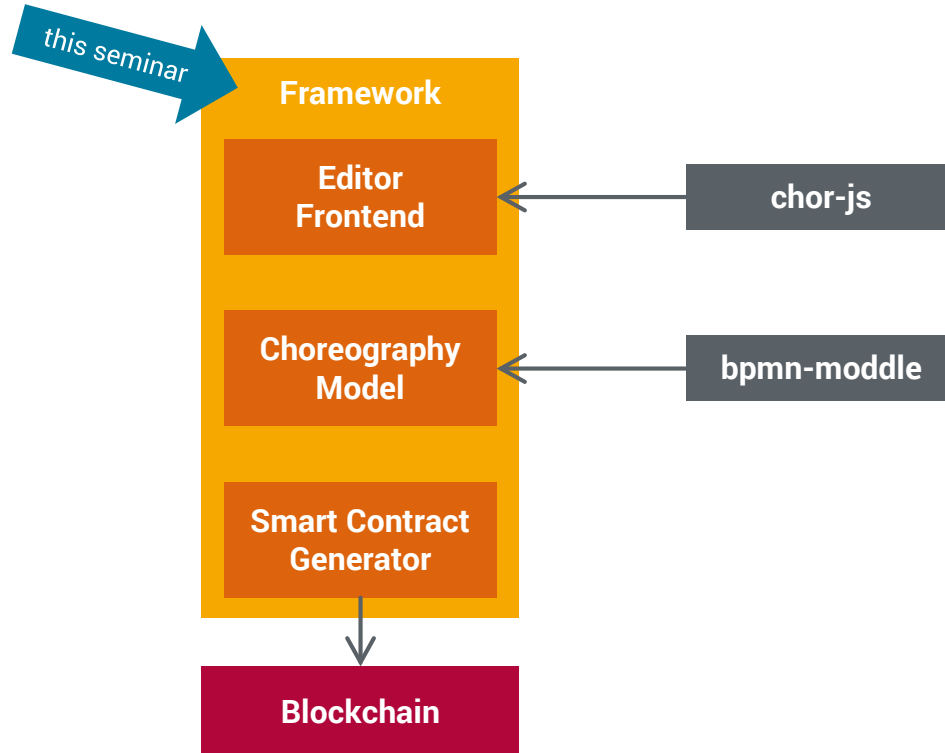


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Chart 10

# A Choreography Framework for Blockchain



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Chart 11



# Seminar Organization & Content

# Organization

---



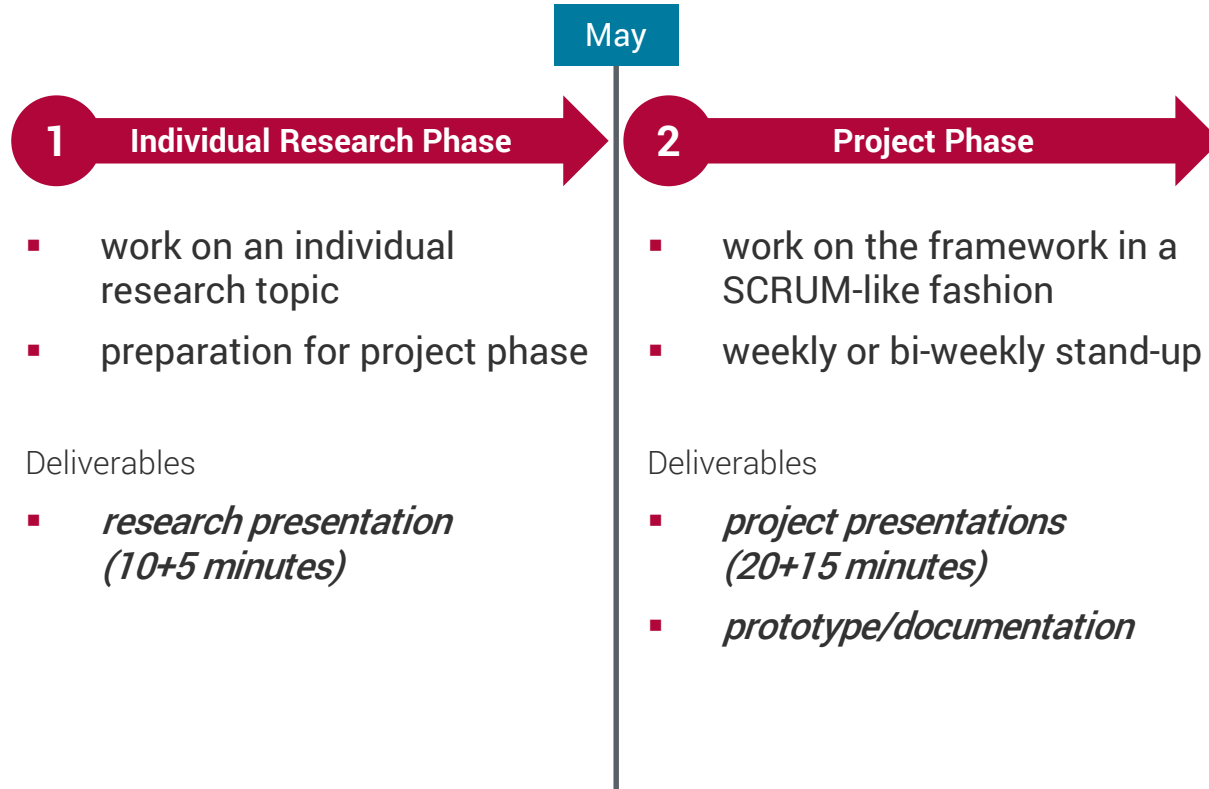
- Teaching Form  
**Project/Seminar**
- Supervisors  
**Jan Ladleif, Stephan Haarmann, Prof. Dr. Mathias Weske**
- ECTS  
**6 (4 presence hours per week per semester)**
- Modules  
ITSE: ITSE, BPET, SAMT  
DE: CODS, DSEC
- Registration Limit  
**8 students**
- Deadlines  
**Application: April 18<sup>th</sup>, 2019**  
**Registration: April 26<sup>th</sup>, 2019**

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**Chart 13**

# Phases & Deliverables



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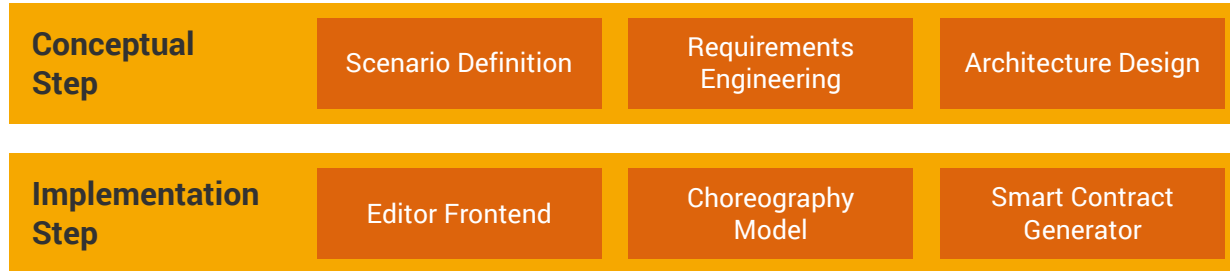
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Chart 14

# Project Phase Overview



- Work in smaller groups on multiple issues in parallel, e.g.,



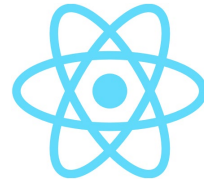
- Permanent coordination between teams
- Everyone should have a rough idea about the global project state
- **All work will be open-source and on GitHub**

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Chart 15

- Node.js with JavaScript/TypeScript
- React-based frontend
- Existing tooling that we will/might use:
  - chor-js <https://github.com/jan-ladleif/chor-js>
  - bpmn-moddle <https://github.com/bpmn-io/bpmn-moddle>
  - blueprint <https://github.com/palantir/blueprint>
- As for the blockchain... let's discuss!
- **We aim for minimality!**





# Research Phase Overview

1. Foundations of Smart Contracts  
Literature
2. Challenges and Opportunities of Blockchain for BPM  
Literature
3. Executing BPMN Collaborations on Ethereum  
Literature
4. Caterpillar  
Technology
- 5.+ Blockchains, Blockchains, Blockchains  
Technology



**HYPERLEDGER**



ethereum



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Chart 17

# Research Topics

## (1) Foundations of Smart Contracts

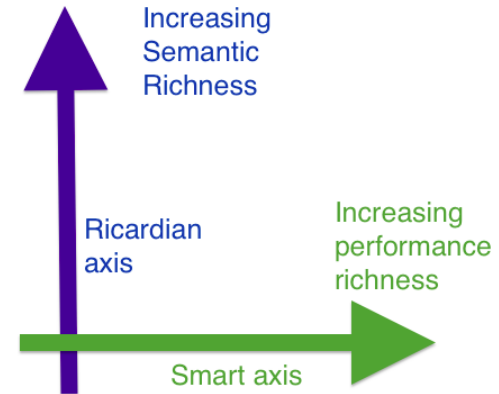
- Smart contracts were not developed “for blockchains”
- There is a long history of smart contracts in law

### Questions

- What was the initial motivation of smart contracts?
- What constitutes “traditional” smart contracts?
- How do they compare to modern ones – are they the same?

### Sources

- [http://iang.org/papers/intersection\\_ricardian\\_smart.html](http://iang.org/papers/intersection_ricardian_smart.html)
- Clack, C. D., Bakshi, V. A., & Braine, L. (2016). Smart contract templates: foundations, design landscape and research directions. arXiv preprint arXiv:1608.00771.



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Chart 18

# Research Topics

## (2) Challenges and Opportunities

- The BPM community recognized blockchains as a promising technology and worked out a seminal paper

### Questions

- What are the challenges and opportunities?
- What still needs to be done?
- What do they think of choreographies?

### Sources

- Mendling, J., Weber, I., Aalst, W. V. D., Brocke, J. V., Cabanillas, C., Daniel, F., ... & Zhu, L. (2018). Blockchains for business process management-challenges and opportunities. *ACM Transactions on Management Information Systems (TMIS)*, 9(1), 4.



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Chart 19

# Research Topics

## (3) Executing BPMN Collaborations

- Weber et al. were the first ones to use blockchain for the execution of processes
- Their prototype has since been used internally for commercial projects

### Questions

- What is their idea and philosophy?
- How do they generate the smart contracts?
- Which limitations does their approach have?

### Sources

- Weber, I., Xu, X., Riveret, R., Governatori, G., Ponomarev, A., & Mendling, J. (2016, September). Untrusted business process monitoring and execution using blockchain. In International Conference on Business Process Management (pp. 329-347). Springer, Cham.
- Tran, A. B., Lu, Q., & Weber, I. (2018). Lorikeet: A model-driven engineering tool for blockchain-based business process execution and asset management. BPM Demo Track.



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Chart 20

# Research Topics

## (4) Caterpillar



- Caterpillar is the first open-source blockchain-based BPMS

### Questions

- How does it work?
- How to set it up?
- What are some outputs?

### Sources

- <https://github.com/orlenyslp/Caterpillar>
- López-Pintado, O., García-Bañuelos, L., Dumas, M., & Weber, I. (2017, September). Caterpillar: A Blockchain-Based Business Process Management System. In BPM (Demos).
- López-Pintado, O., García-Bañuelos, L., Dumas, M., Weber, I., & Ponomarev, A. (2018). CATERPILLAR: A Business Process Execution Engine on the Ethereum Blockchain. arXiv preprint arXiv:1808.03517.

Caterpillar: A BPMN-based BPMS for Ethereum

Commit	Message	Time
Latest commit 782a9b8	Added Policy metadata storage in repository	Dec 20, 2018
v1.0	#7 update 'TestRPC' references to 'ganache-cli'	7 months ago
v2.0	Fixed browser-sync to open: false, and some minor changes	3 months ago
v2.1	Added Policy metadata storage in repository	3 months ago
.gitignore	Initial commit	2 years ago
LICENSE	Update LICENSE	2 years ago
README.md	Update README.md	4 months ago

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Chart 21

# Research Topics

## (5) Blockchains

- Blockchains build the basis of all our efforts
- Look into: Ethereum, Quorum, Corda R3, Hyperledger, Tezos, ...

### Questions

- How easy is the setup?
- How are smart contracts implemented and deployed?
- Support for permissions, private transactions?

### Sources

- Whitepapers, papers, websites, implementations, ...
- Will be distributed once the topics are assigned!



ethereum



Quorum™



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Chart 22

# Research Topics Presentations

---



- Format
  - Around 10+5 minutes
  - Early in the semester
  - Everyone should use this chance to adequately inform the others of their topic
- Selection Procedure
  - Send me an email by **18<sup>th</sup> of April** (a day before Good Friday)
  - Give a **ranked list of 3 out of the 5** topics you would be most interested in
  - This choice does not influence the rest of the seminar, so no worries!

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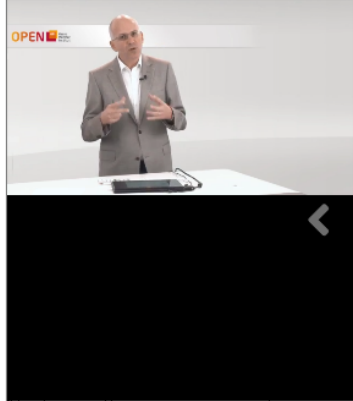
Chart **23**

# In the meantime...

## Choreography MOOC

- Please listen to our 2013 MOOC concerning choreographies
- ~1 lecture worth of content available at <https://open.hpi.de/courses/bpm2013>
- We will discuss the lecture later in class

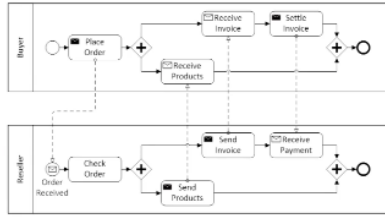
### 6.1 From Orchestrations to Choreographies Time effort approx. 17 minutes



OPEN logo

#### Interacting Business Processes

- Business processes can interact by sending and receiving messages
- Send and receive activities and events connect process orchestrations
  - One way of defining process choreographies



Netmas Website - openM course on Business Process Modeling and Analysis - 2013 6-7

07:53 / 16:02

13x HD



# Selection Procedure

today

April 8	Mon
9	Tue
10	Wed
...	(1 week) ...
18	Thu
19	Fri
20	Sat
21	Sun
22	Mon
23	Tue
24	Wed
25	Thu
26	Fri
27	Sat
28	Sun

decide on a ranked list of 3 research topics

send your list to [jan.ladleif@hpi.de](mailto:jan.ladleif@hpi.de)

notification of participation, topic allocation

registration deadline



(next meeting)

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Chart 25

# Schedule

week	date	
1	Mon, 08.04	introductory lecture 
...		<i>register and hand in topic preferences, watch MOOC on OpenHPI</i>
3	Tue, 23.04	<i>assignment of research topics</i>
	Thu, 25.04	inverted classroom and basic introduction 
4	Mon, 29.04	general steering, planning of the semester
5	Thu, 09.05	research presentations
...		<i>regular meetings</i>
15	Thu, 18.07	project presentations
...		<i>during break: finish implementation &amp; documentation</i>
?	August	final deadline depending on group preferences

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Chart 26

# Grading



weight	deliverable	measure
20%	research presentation	individual
10%	participation during semester	individual
30%	final presentations	parts of the group
40%	result & documentation	group

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Chart 27



generic blockchain background



All **Images** News Videos Shopping More Settings Tools

Collections SafeSearch

block

chain

transaction

ethereum

bitcoin mining

blockchain technology

distributed ledger

futuristic

png

pattern

shutterstock

cryptocurrency



blockchain blue and grey background ...  
alamy.com



Digitization Blue Grey Background ...  
shutterstock.com



Blockchain blue vector background with ...  
alamy.com



blockchain blue and grey background ...  
depositphotos.com



Bitcoin and blockchain blue vector ...  
gograph.com

**Thanks for your attention!**



Blockchain blue vector background ...  
gograph.com



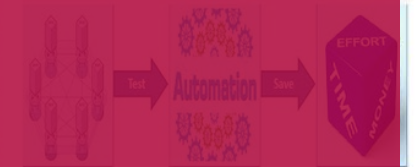
Global Blockchain Ventures Reveals \$100 ...



Virtual Cash Transaction Cryptocurr...



What is Blockchain | History ...



How to develop Automation framework for ...