

Emerging Technologies for the Circular Economy

Lecture 12: The Machine-to-Everything (M2X) Economy - A step towards the Circular Economy 2.0?

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M.Sc. Anant Sujatanagarjuna
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- Updated versions of these slides will be available in our [Github repository](#).

NEWS

Smart Metal Piece Sorting Using AI Technology

A HiWi position (30-60 hr per month) is now available at the Institute for Software and Systems Engineering at Clausthal University of Technology.

In this project, we aim to upgrade a machine by using artificial intelligence to make it smarter. The machine's main task is to identify and sort different metal pieces based on their characteristics, such as size, color, density and etc. By incorporating AI technology, the machine becomes capable of analyzing and categorizing the metal pieces more efficiently and without the presence of manpower.

Your main tasks will be:

- Helping us in the development of the AI model
- Helping us in test and evaluation of the model

Requirements:

- You are passionate about learning new algorithms
- You are able to work independently and in a very structured manner, and you quickly grasp new concepts
- Your proficiency level in English is at least B2 in spoken and written form

Experience in the following areas is desirable:

- Proficiency in python language
- Basic understanding of machine/deep learning
- Basic Knowledge of sensor setup, camera configuration, Raspberry Pi, and IoT technologies.

How to Apply: Please send your resume, along with a brief cover letter outlining your relevant experience and interest, to → Benjamin.leiding@tu-clausthal.de

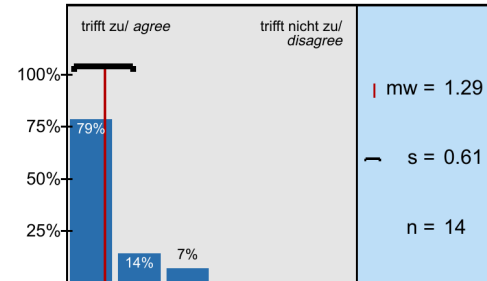
Note: The HiWi position is open to students currently enrolled at TU Clausthal University or any other universities.

The project duration and working hours are flexible to accommodate your academic commitments.

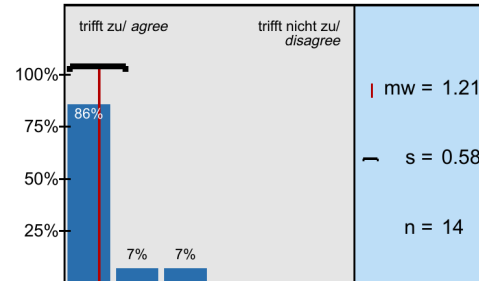
Course Evaluation Results

Feedback

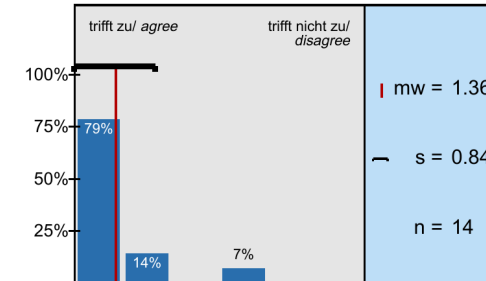
Der inhaltliche Aufbau der Lehrveranstaltung ist logisch und nachvollziehbar.



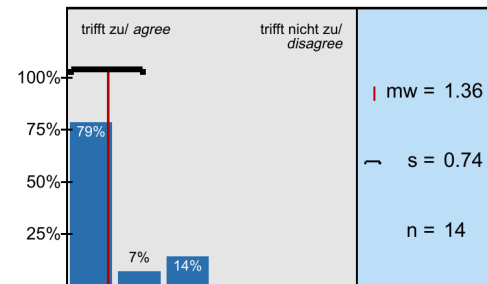
Der / dem Lehrenden ist es wichtig, dass die Studierenden etwas in der Lehrveranstaltung lernen



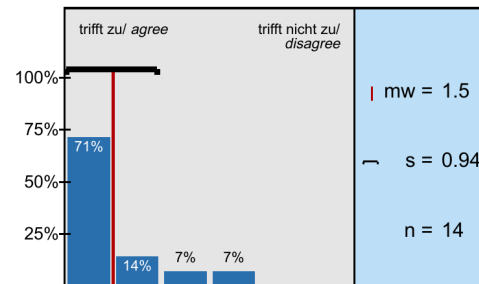
Die / der Lehrende vermittelt den Stoff anschaulich und verständlich.



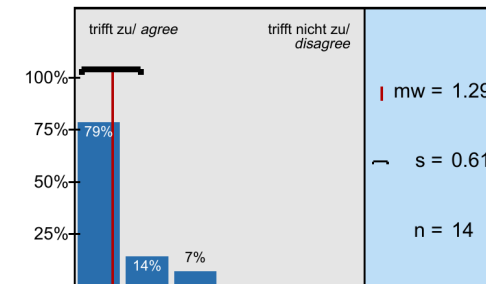
Die / der Lehrende kann auch schwierige Sachverhalte gut erklären.



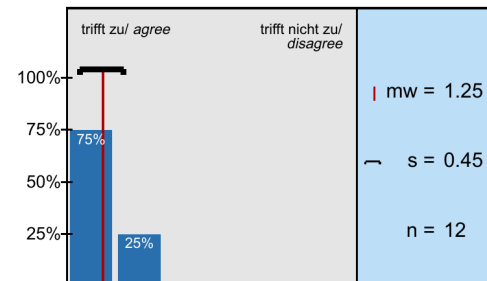
Ich werde zum Mitdenken motiviert.
I am encouraged to think for myself.



Ich kann die in dieser Lehrveranstaltung behandelten Inhalte und Methoden beschreiben und erläutern.



Die Lehrveranstaltung gibt einen guten Überblick über das Themengebiet.



Course Evaluation Results

Feedback

5. Kommentare / Comments

5.1) Was hat Ihnen an der Lehrveranstaltung besonders gut gefallen ? (Nur innerhalb der Berandung schreiben!)
Which elements of the course did you like in particular? (Please do not write outside the borders.)

- The lecture content is actually quite interesting and the organisation of homeworks allows for a lot of freedom and self-organisation.
- everything

5.2) Was hat Ihnen an der Lehrveranstaltung nicht gefallen ? (Nur innerhalb der Berandung schreiben!)
Which parts of the course did you not like? (Please do not write outside the borders.)

- I pretty much didn't have any dislike about the course but just one.
Submission of assignments can be made in moodle. Or make the submission folder accessible without removing them so that we can be sure of our submissions
- Most homeworks are completely unrelated to the course. This course is mainly an economics class with computer science aspects while most homeworks are just coding excercises, which is not taught in the course.
- none

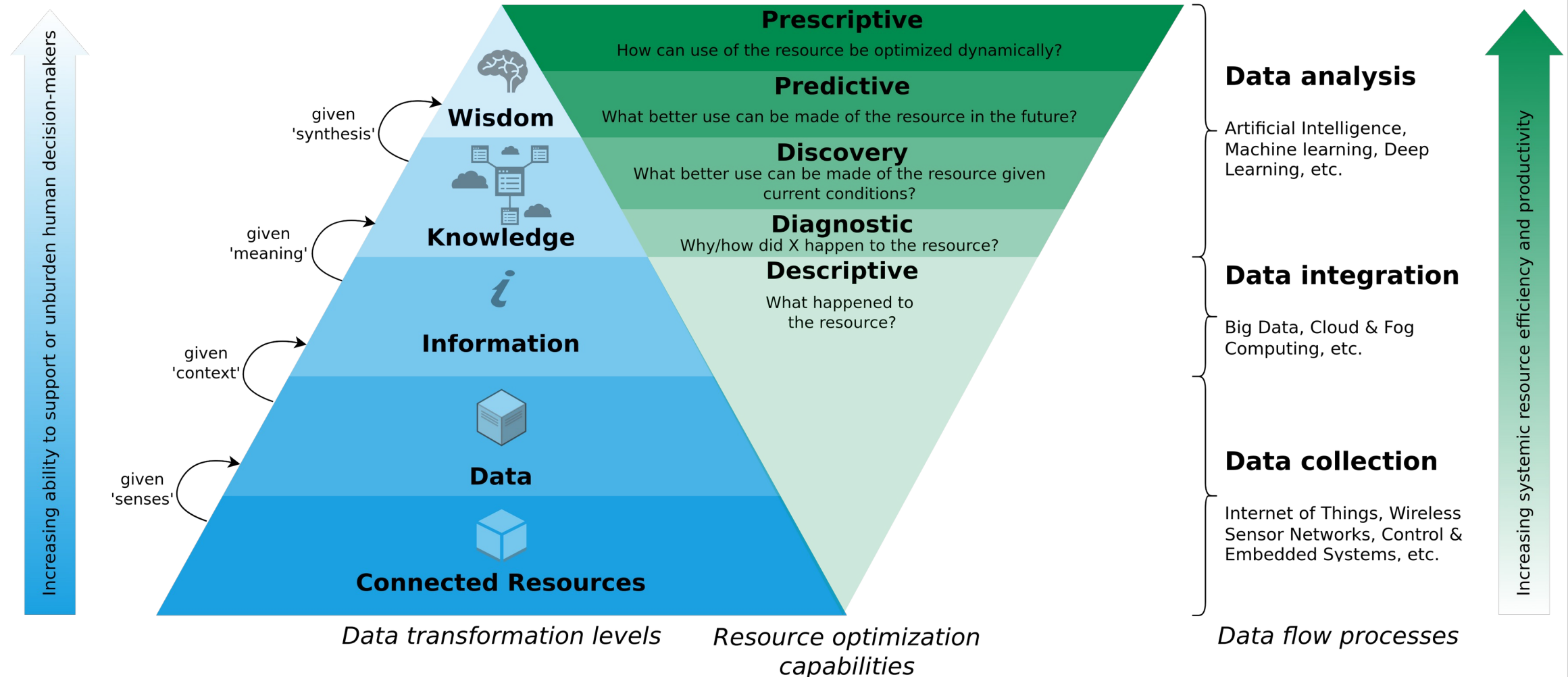
5.3) Welche Verbesserungsvorschläge haben Sie ? (Nur innerhalb der Berandung schreiben!)
What suggestions for improvement do you have? (Please do not write outside the borders.)

- A good homework should allow students to recap the important lecture contents and be the best possible preperation for an exam.
A summary about the course contents in the details section on studIP would be helpful to allow students to get an overview of the course beforehand.
- Assignments Folders can be improved to be made little easier for us to make changes etc.. and don't remove the folder files for our reference.
- none



BACK TO THE LECTURE

A Data-Driven Smart Circular Economy Framework



The Nature of Technology

- In the past many new technologies have emerged and disrupted existing economical models.
- B. Arthur stipulates that an *economy is an expression of its technologies*
 - Thus, it can be argued that the current unsatisfying state of the Circular Economy reflects a lack of sufficiently developed technologies that express themselves within the CE.
 - Or, more precisely – difficulties of the stakeholders in combining the technologies that are required to enable the CE.

Performance Economy to Sharing Economy

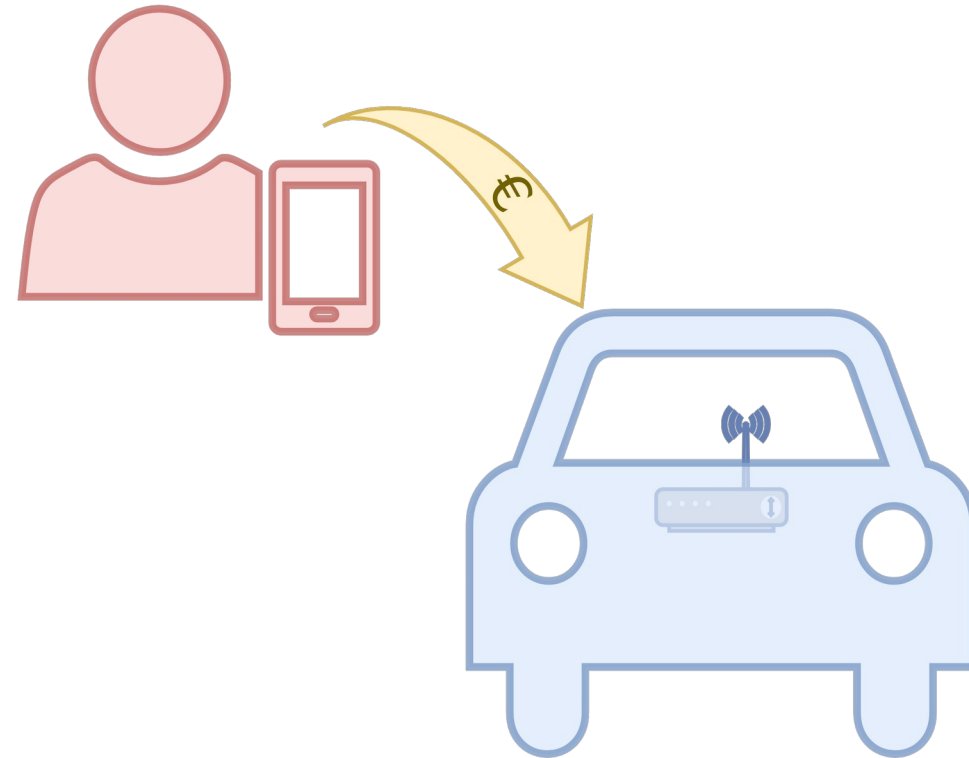




INTRODUCTION

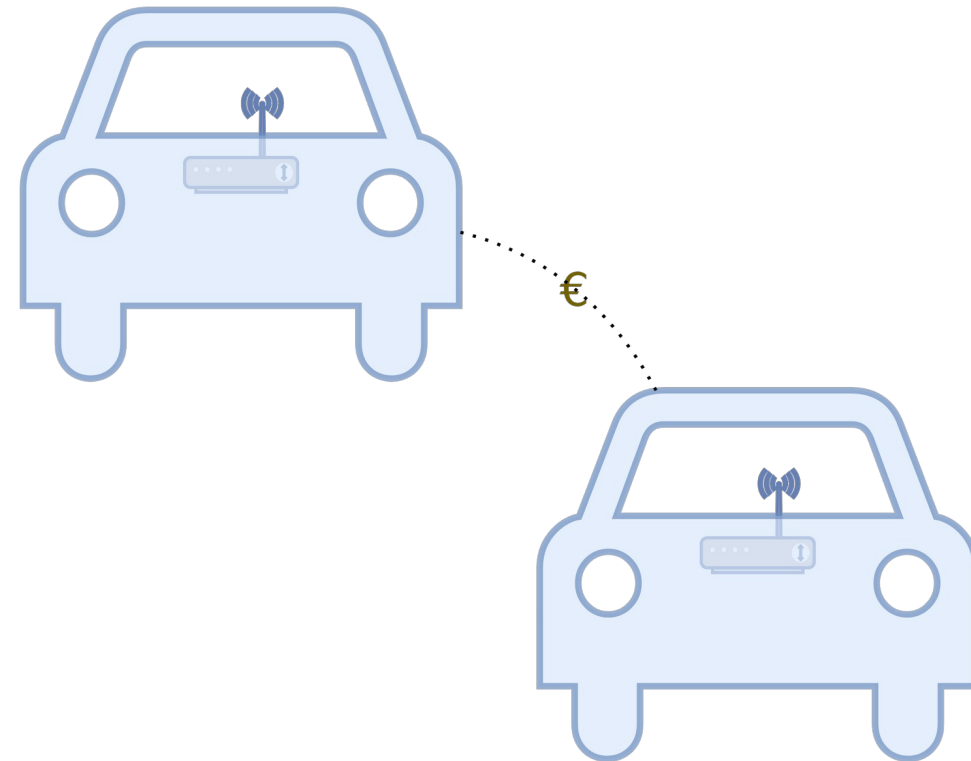
Machine-to-Human (M2H)

- Machine-to-Human (M2H)
- For example → Transportation-as-a-Service



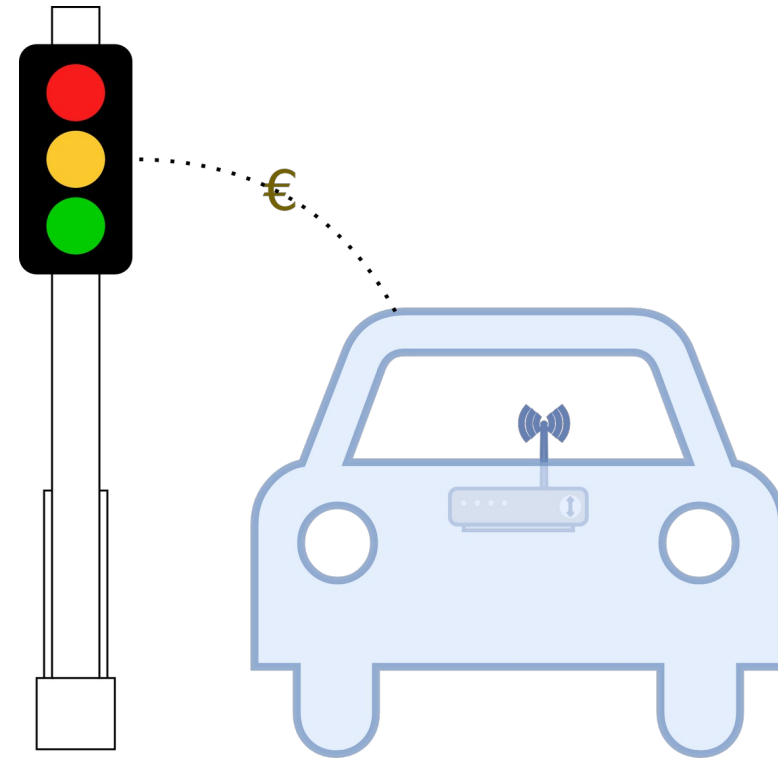
Machine-to-Machine (M2M)

- Machine-to-Machine (M2M)
- For example → Road space negotiations

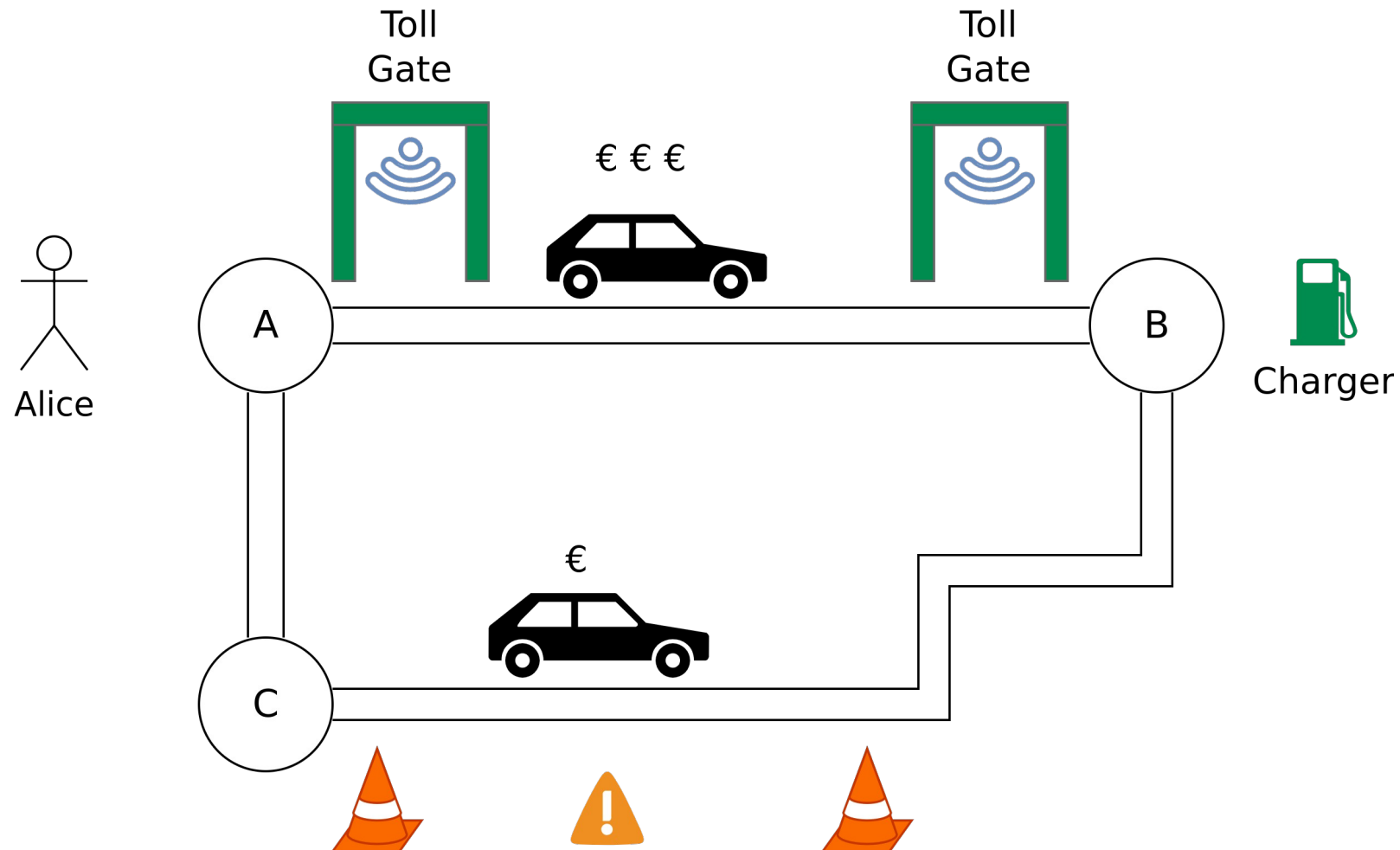


Machine-to-Infrastructure (M2I)

- Machine-to-Infrastructure (M2I)
- For example → Smart parking, electric vehicle charging or traffic information



Running Case



MOBI Grand Challenge 2019 - Chorus Mobility

[Transforming Urban Mobility](#)

[MOBI Grand Challenge Submission Video](#)



THE M2X ECONOMY

M2X Economy

Machine-to-Human (M2H)
+
Machine-to-Machine (M2M)
+
Machine-to-Infrastructure (M2I)
=
Machine-to-Everything (M2X)

M2X Economy

Machine-to-Human (M2H)
+
Machine-to-Machine (M2M)
+
Machine-to-Infrastructure (M2I)
=
Machine-to-Everything (M2X)

M2X Economy → Is the result of business interactions, transactions and collaborations among entities of the M2X ecosystem.

M2X Economy - Definition

“The M2X Economy is the result of interactions, transactions, collaborations and business enactments among humans, autonomous and cooperative smart devices, software agents, and physical systems.

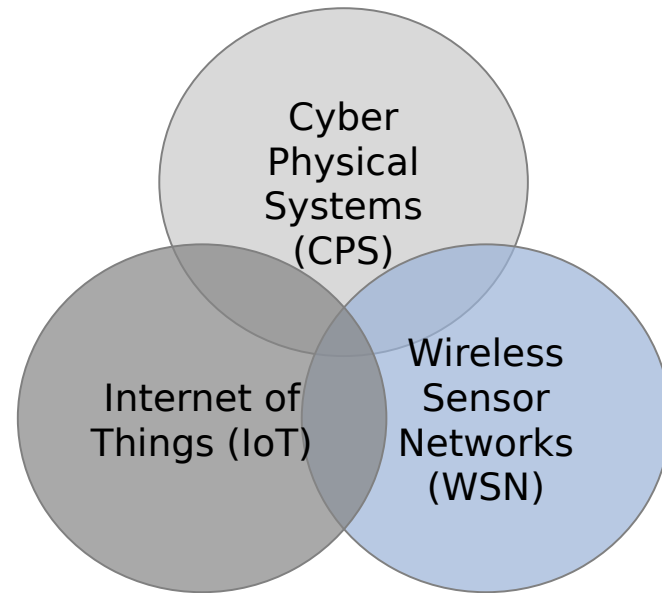
The corresponding ecosystem is formed by automated, globally-available, heterogeneous socio-technical e-governance systems with loosely coupled, P2P-resembling network structures and is characterized by its dynamic, continuously changing, interoperable, open and distributed nature. Thereby, the M2X Economy employs concepts such as cyber-physical systems, the Internet of Things, and wireless sensor networks.”

M2X Economy - Definition

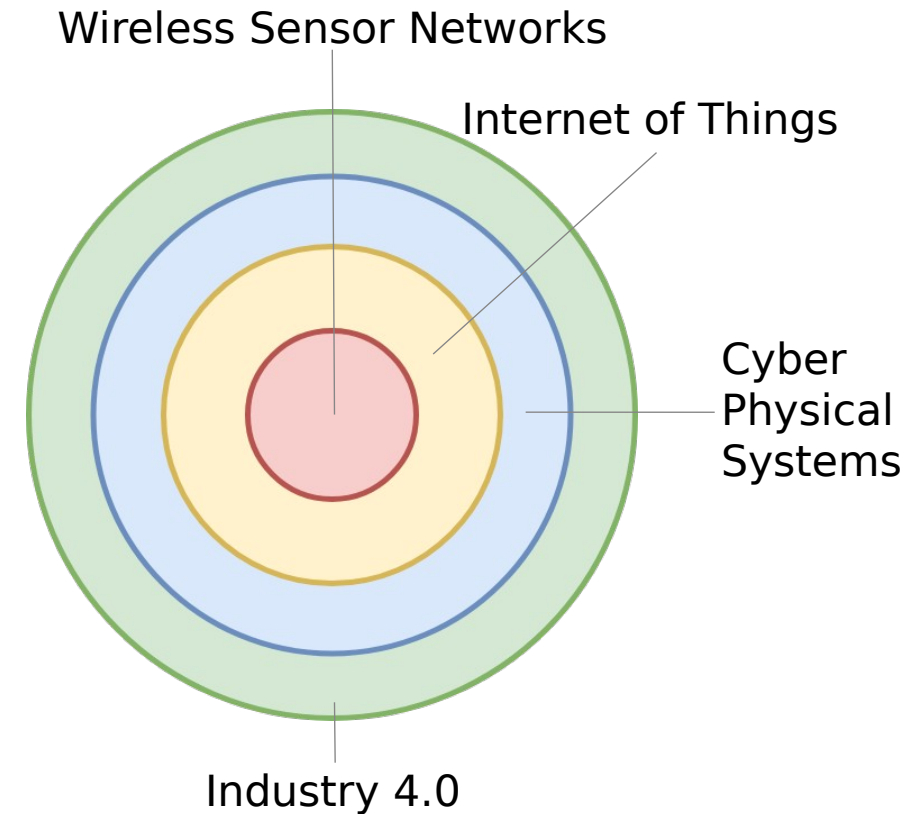
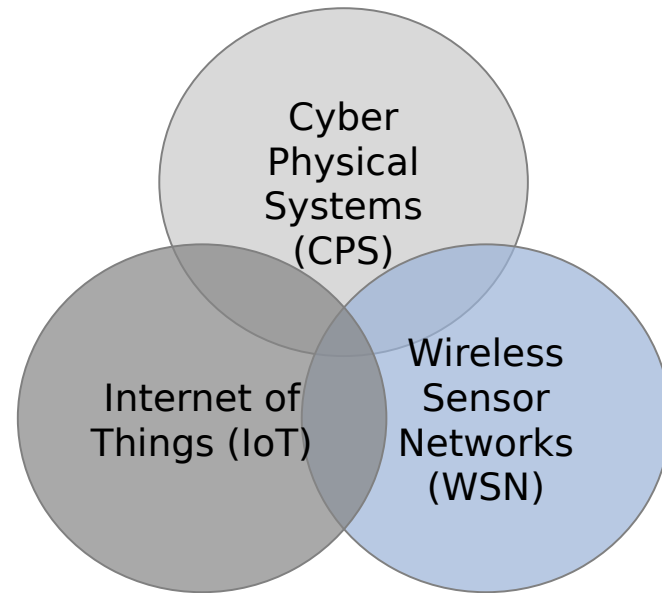
*“The M2X Economy is the result of **interactions, transactions, collaborations and business enactments** among humans, autonomous and cooperative smart devices, software agents, and physical systems.”*

*The corresponding ecosystem is formed by automated, **globally-available, heterogeneous socio-technical e-governance systems** with loosely coupled, P2P-resembling network structures and is characterized by its dynamic, continuously changing, **interoperable, open and distributed** nature. Thereby, the M2X Economy employs concepts such as cyber-physical systems, the Internet of Things, and wireless sensor networks.”*

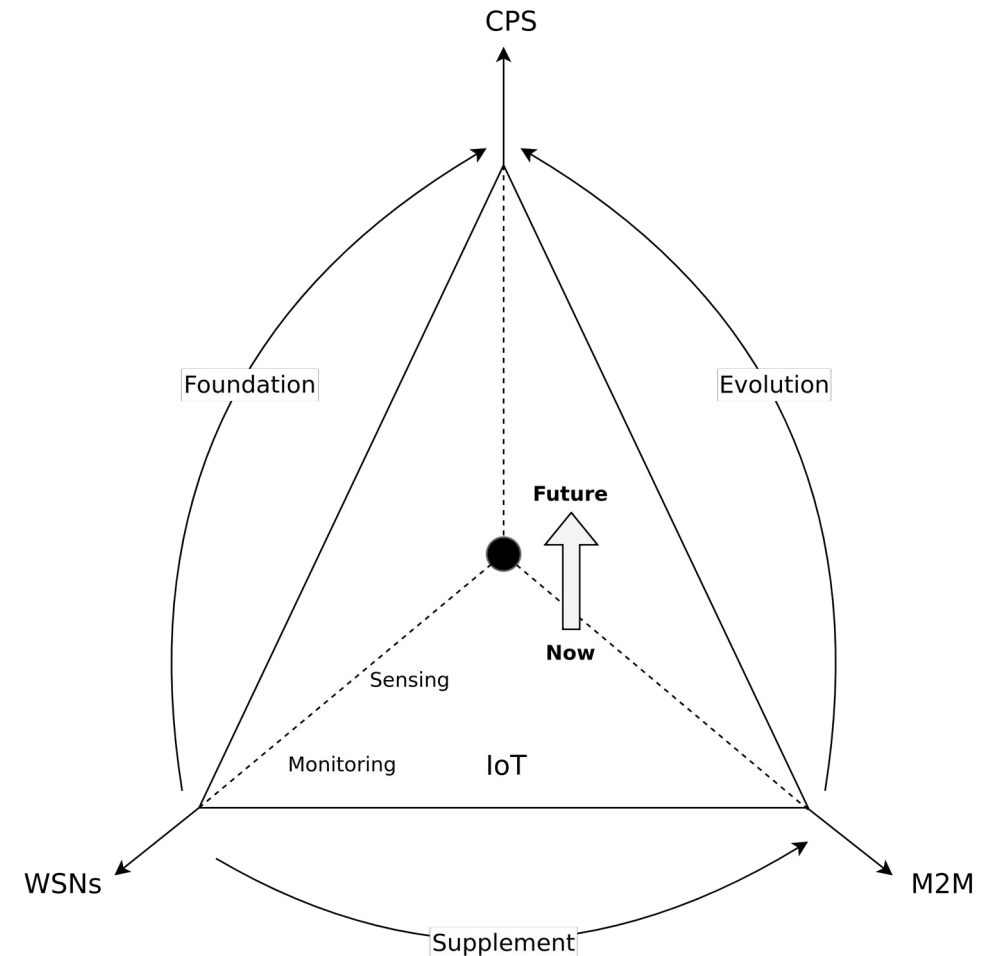
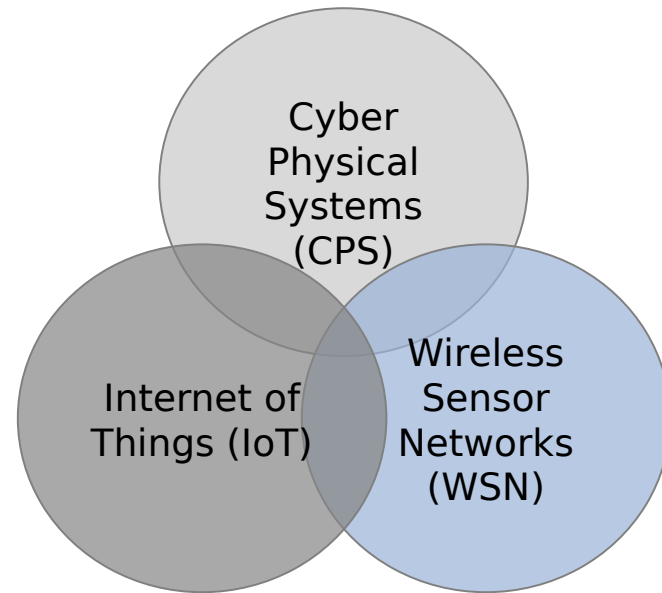
State of the Art - IoT, CPS, WSN, etc.



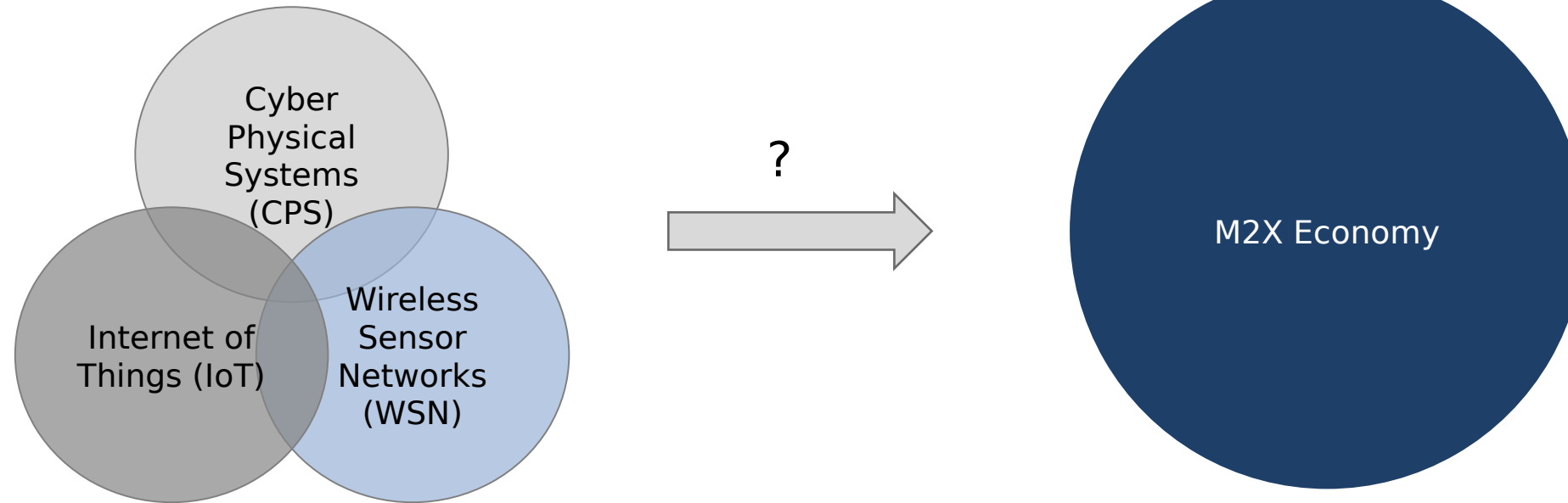
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State of the Art - IoT, CPS, WSN, etc.



What is missing?



What is missing?

The M2X Economy

—

Concepts for Business Interactions, Transactions and Collaborations Among Autonomous Smart Devices

Dissertation

for the award of the degree

“Doctor rerum naturalium” (Dr.rer.nat.)

of the Georg-August-Universität Göttingen

within the Doctoral program Ph.D. Programme in Computer Science (PCS)

of the Georg-August University School of Science (GAUSS)

Submitted by

Benjamin Leiding

from Rostock (place of birth)

Göttingen 2019



THE M2X ECONOMY – BUILDING BLOCKS

Everything is a Contract

- TaaS, road space negotiations, smart parking, electric vehicle charging, toll gate payments, etc.
 - Roughly the same process

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 - Why would we want to do that?

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- Abstraction towards a general lifecycle for value exchange, collaborations, and business enactments of the M2X Economy

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 - Why would we want to do that?
- Abstraction towards a general lifecycle for value exchange, collaborations, and business enactments of the M2X Economy
 - We stipulate that all M2X-related interactions, transactions, collaborations, and further enactments can be governed and represented using a blockchain-based smart contract.

Contracts

- Traditional understanding of a contract:
 - Written or spoken agreement enforceable by law
 - Parties involved voluntarily engage to establish a consensus

Contracts

- Traditional understanding of a contract:
 - Written or spoken agreement enforceable by law
 - Parties involved voluntarily engage to establish a consensus

- In most business cases, contracts:
 - are documents
 - identify the contracting parties uniquely
 - describe service that is offered for some form of compensation
 - list a set of additional clauses such as service-delivery dates, penalties, etc.

Contracts

- But traditional contracts:
 - are often underspecified → does not work for machines
 - do not provide sufficient details about the actual transaction process
 - friction between the contracting parties, e.g., one party assumes a specific product certificate before delivering a partial compensation and the other party assumes the opposite

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 - friction between the contracting parties, e.g., one party assumes a specific product certificate before delivering a partial compensation and the other party assumes the opposite
- Deadlocks lead to costly conflict resolutions, or even a collapse of the entire contract transaction.
- Enforcement of traditional contracts proves to be either too complicated, time consuming, or impossible, certainly in international circumstances.



Electronic Contracts

So what is the solution?

Electronic Contracts

So what is the solution?

■ Electronic smart contracts

- Enable and govern business transactions using a computerized transaction protocol such as a blockchain
- Smart contracts are computer programs for the consistent execution by a network of mutually distrusting nodes where no arbitration of a trusted authority exists
- Readable/processable by machines and humans alike

→ Fact tracking, non-repudiation, auditability, and tamper-resistant storage of information in a distributed multi-stakeholder setting, e.g., the M2X Economy.

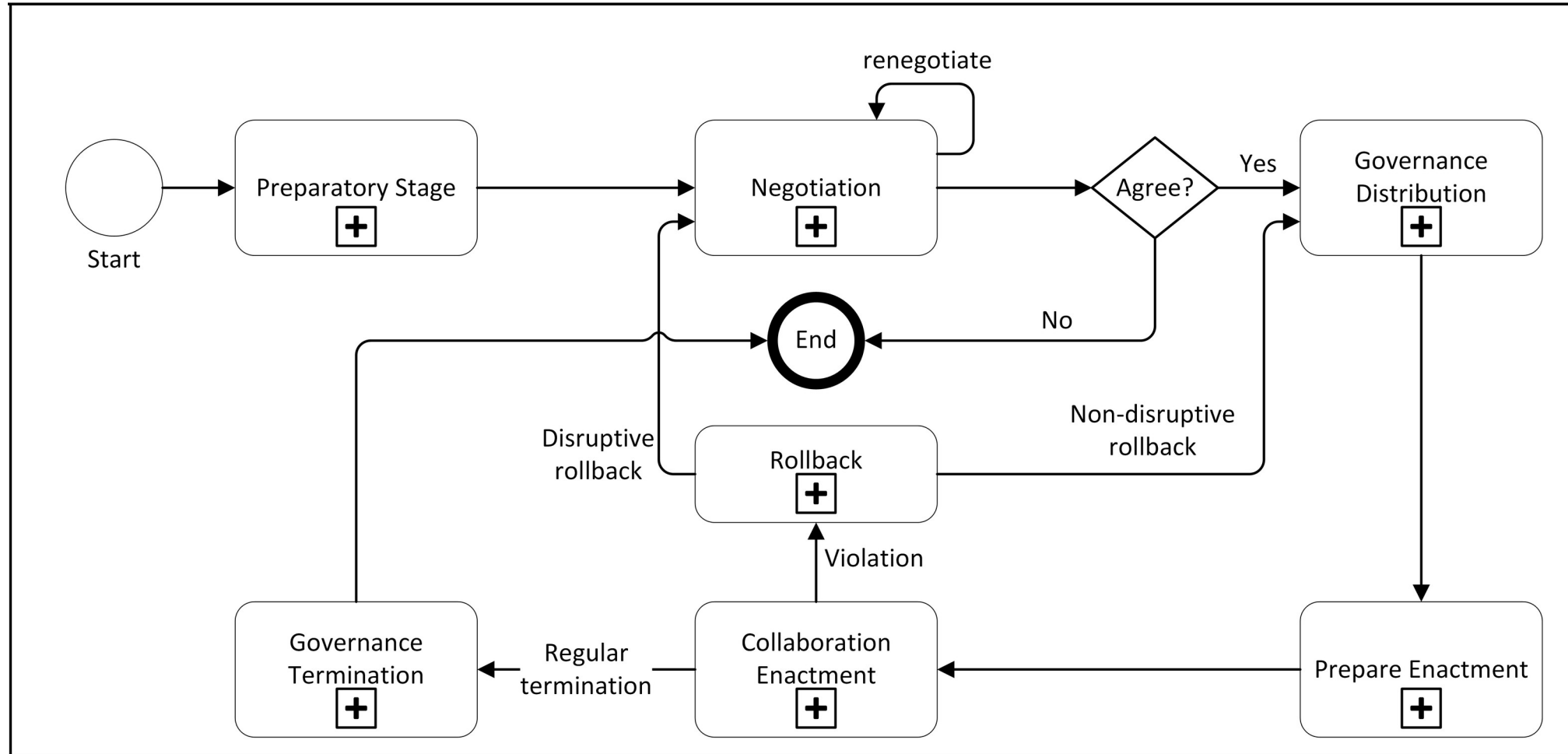
Blockchain Technology

- Append-only data structure secured by interconnected hashes
- Distributed and decentralized data storage with a global consensus mechanism
 - Neutral territory between stakeholders
 - Immutability
 - Non-repudiation and auditability

Blockchain Technology

- Append-only data structure secured by interconnected hashes
- Distributed and decentralized data storage with a global consensus mechanism
 - Neutral territory between stakeholders
 - Immutability
 - Non-repudiation and auditability
- Enables Smart Contracts:
 - On-chain programs → State changes stored on-chain
 - Autonomous, deterministic and auditable execution of programs

Digital Contract Lifecycle



Based on: Leiding (2020) – The M2X Economy – Concepts for Business Interactions, Transactions and Collaborations Among Autonomous Smart Devices

Norta (2016) – Designing a Smart-Contract Application Layer for Transacting Decentralized Autonomous Organizations

Norta (2015) – Creation of Smart-Contracting Collaborations for Decentralized Autonomous Organizations

Norta (2015) – Establishing Distributed Governance Infrastructures for Enacting Cross-Organization Collaborations

Norta et al. (2015) – Conflict-Resolution Lifecycles for Governed Decentralized Autonomous Organization Collaboration

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Lifecycle - Preparatory Stage

- Select contract based on pre-configured templates provided by a corresponding business hub, e.g., blockchain
- Collect entity-related information:
 - Identifiers
 - Wallet addresses
 - Location
 - Jurisdiction
- Specify contract conditions:
 - Departure location
 - Final destination
 - Vehicle size
 - Departure/arrival time

Lifecycle - Negotiation

- Negotiate an agreement among the involved stakeholders
- Essentially:

Needs of the client (get from A to B) vs. needs of the service provider (compensation for service)

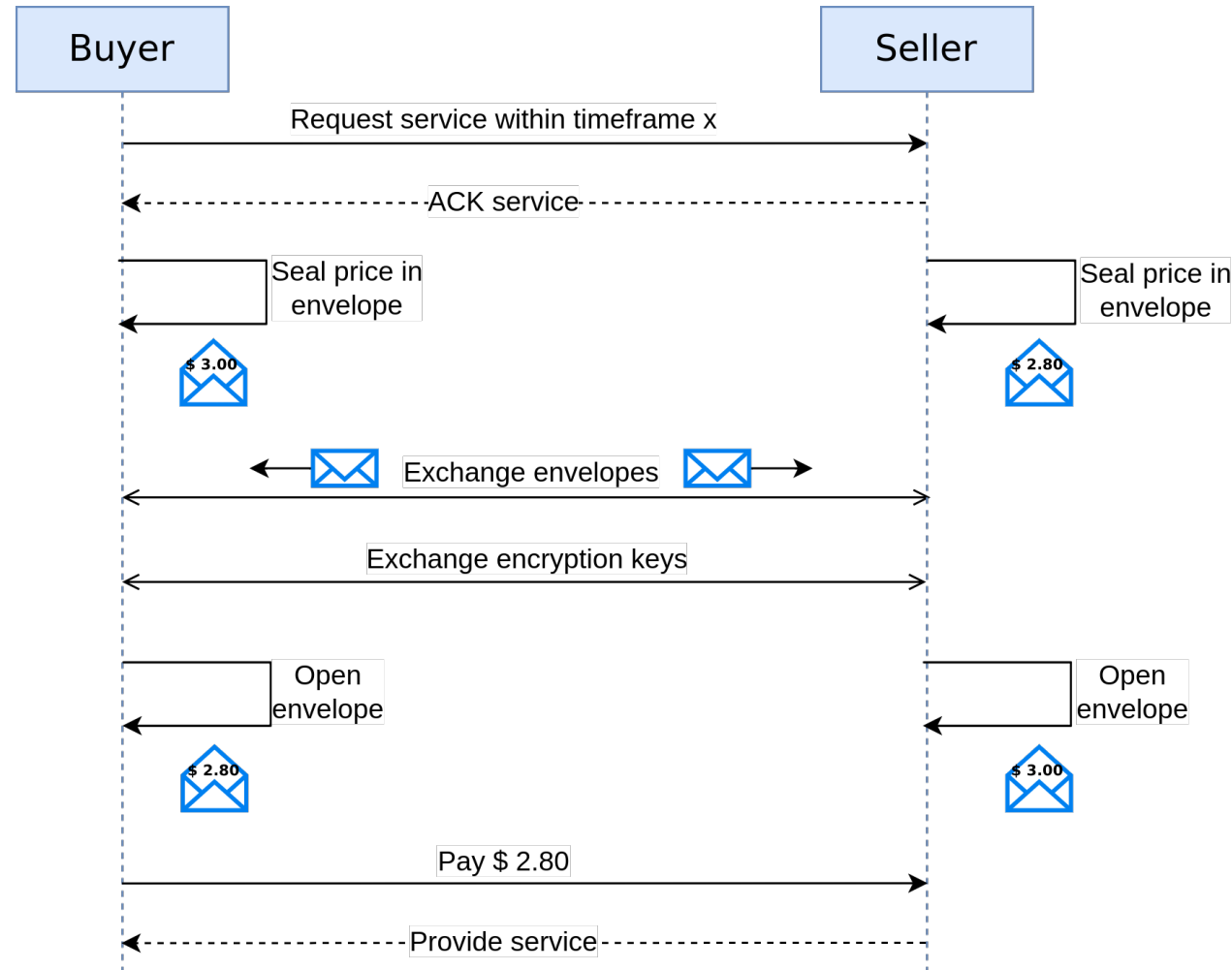
Lifecycle - Negotiation

- Negotiate an agreement among the involved stakeholders
- Essentially:

Needs of the client (get from A to B) vs. needs of the service provider (compensation for service)

- In case the entities agree on the negotiated conditions → All involved parties sign the contract and express their approval
- In case no agreement is reached → Trigger contract rollback

Auctions and Negotiations - 1-to-1



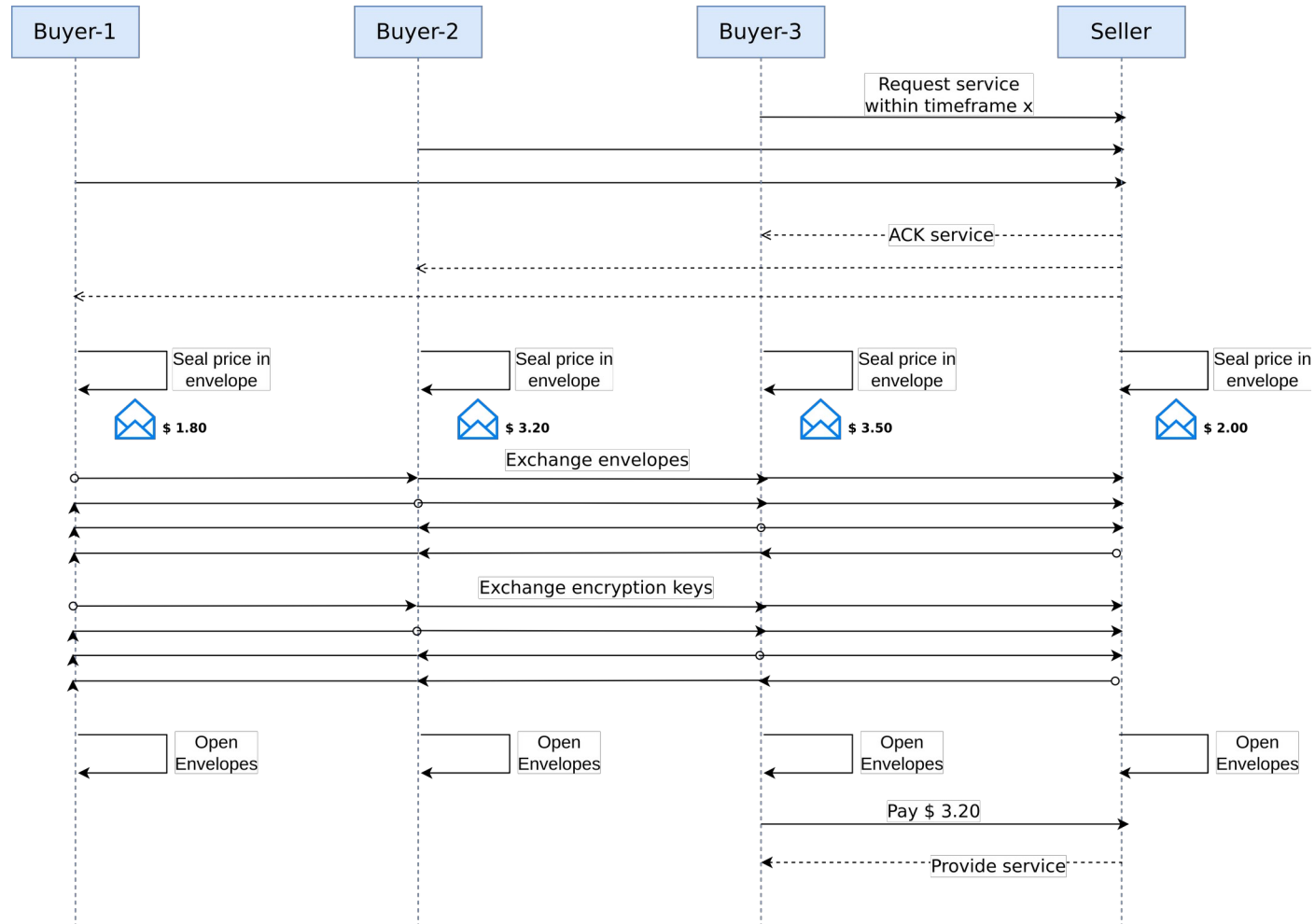
Leiding (2020) – The M2X Economy – Concepts for Business Interactions, Transactions and Collaborations Among Autonomous Smart Devices

Leiding and Vorobev (2018) – Enabling the V2X Economy Revolution Using a Blockchain-based Value Transaction Layer for Vehicular Ad-hoc Networks

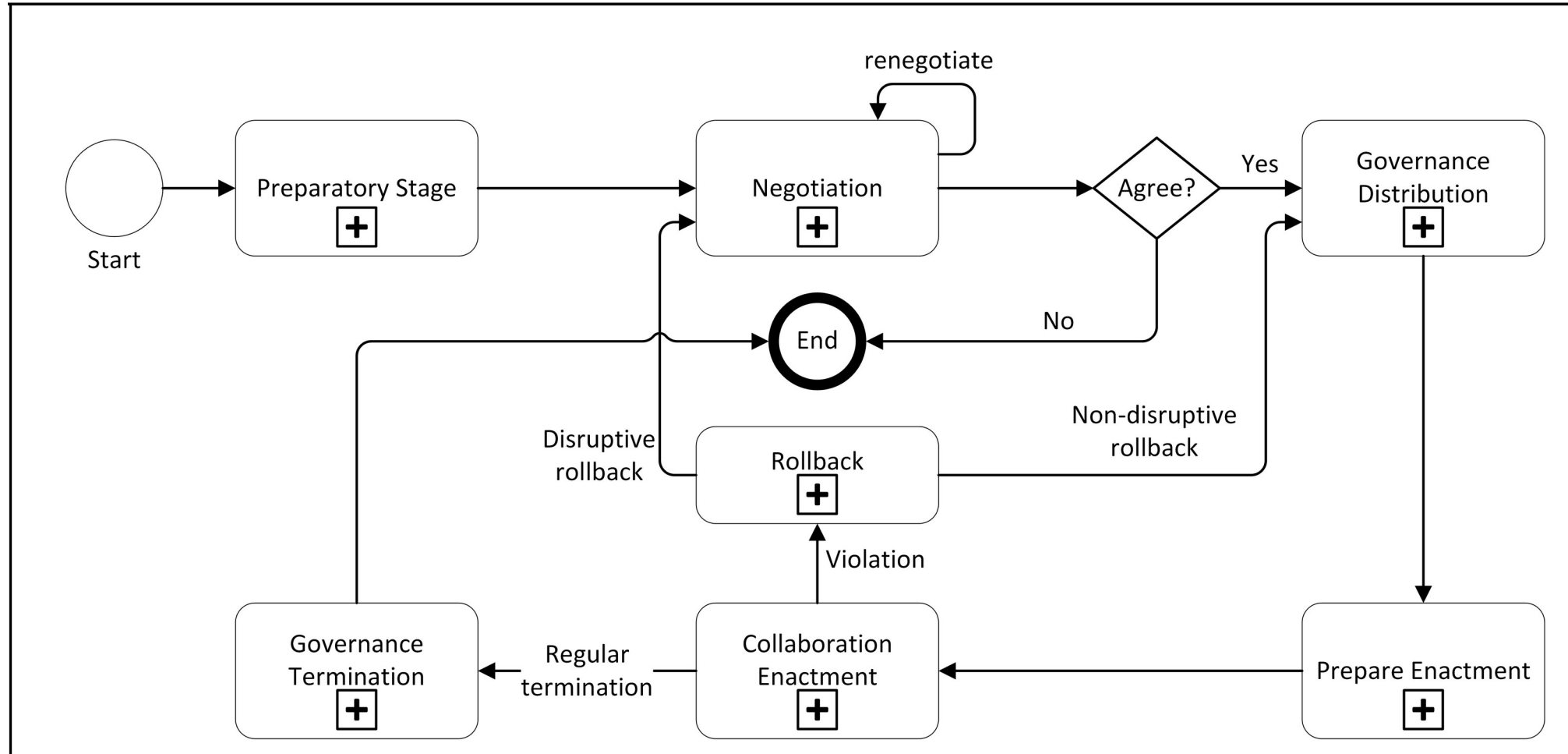
Leiding and Vorobev (2019) – Enabling the Vehicle Economy Using a Blockchain-Based Value Transaction Layer Protocol for Vehicular Ad-Hoc Networks - Whitepaper

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Auctions and Negotiations - 1-to-Many



Digital Contract Lifecycle



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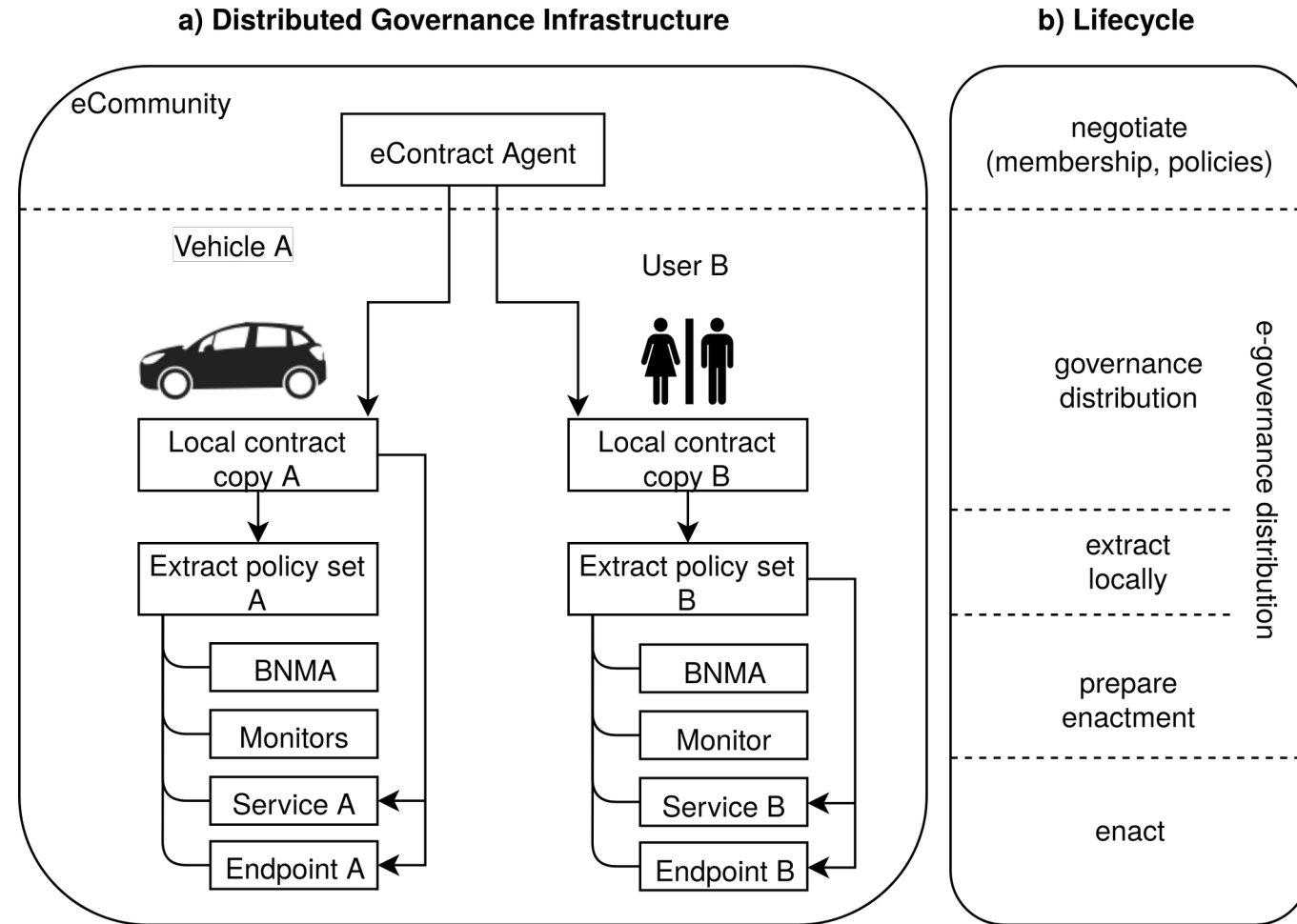
Lifecycle - Governance Distribution

- A smart contract between the involved parties is established and serves as a DGI (distributed governance infrastructure)-coordinating agent
- Each participating entity receives a local contract copy containing the rights and obligations of each party
 - e.g., transporting the user to the correct location
- Obligations are observed by monitoring services or monitors, e.g., IoT-sensors

Lifecycle -Prepare Enactment

- Prepare and provide concrete required process endpoints, e.g., for payment processing
- Creation of communication endpoints so that the services of the partners are able to communicate with each other
- Liveness check of connected services

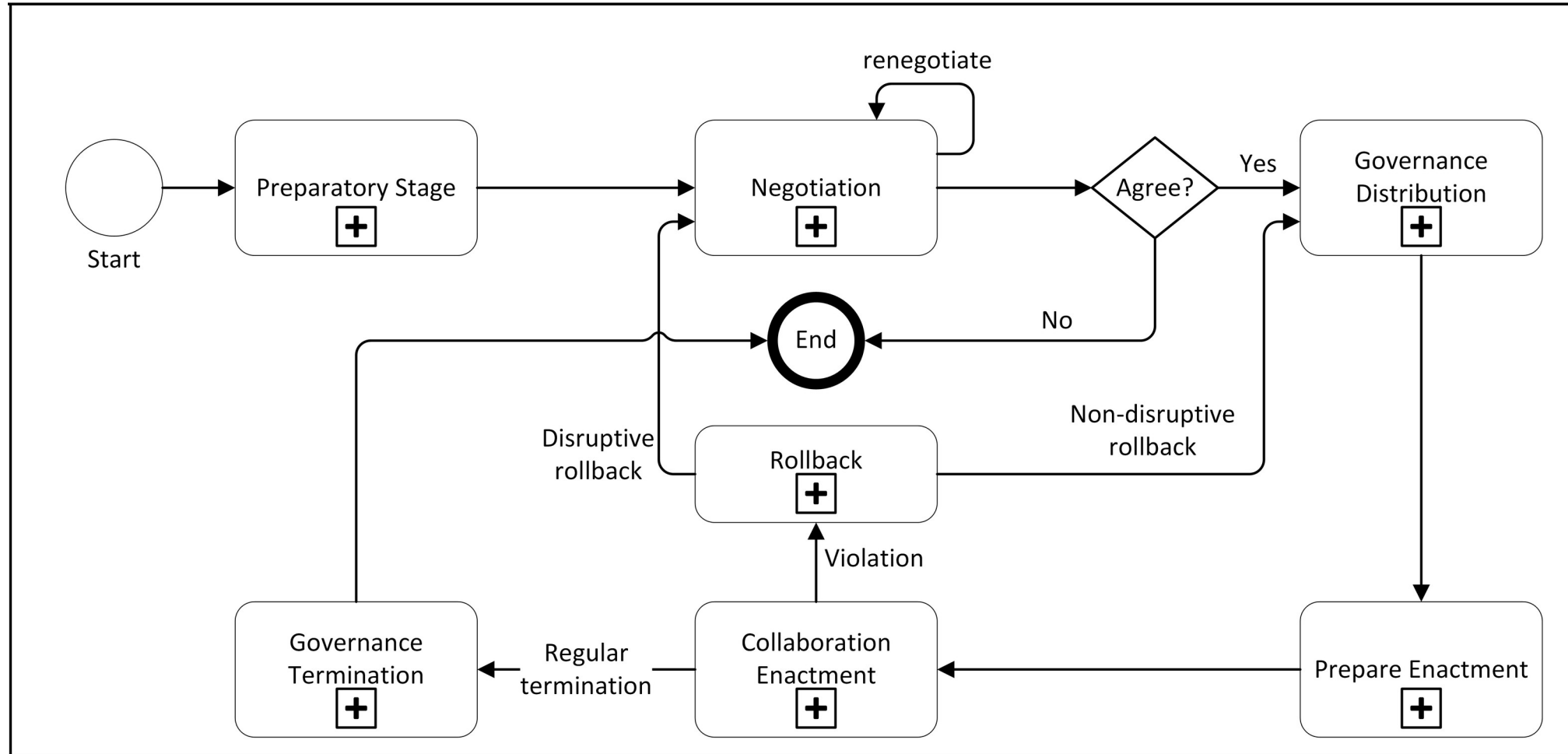
Governance



Lifecycle - Enactment

- Pick up the user and transport the user to the final destination
- Monitor contract obligations and check for violations

Digital Contract Lifecycle



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Lifecycle - Conflict Resolution and Rollback

What if something goes wrong?
(failing to transport the user to the agreed-upon destination)

Lifecycle - Conflict Resolution and Rollback

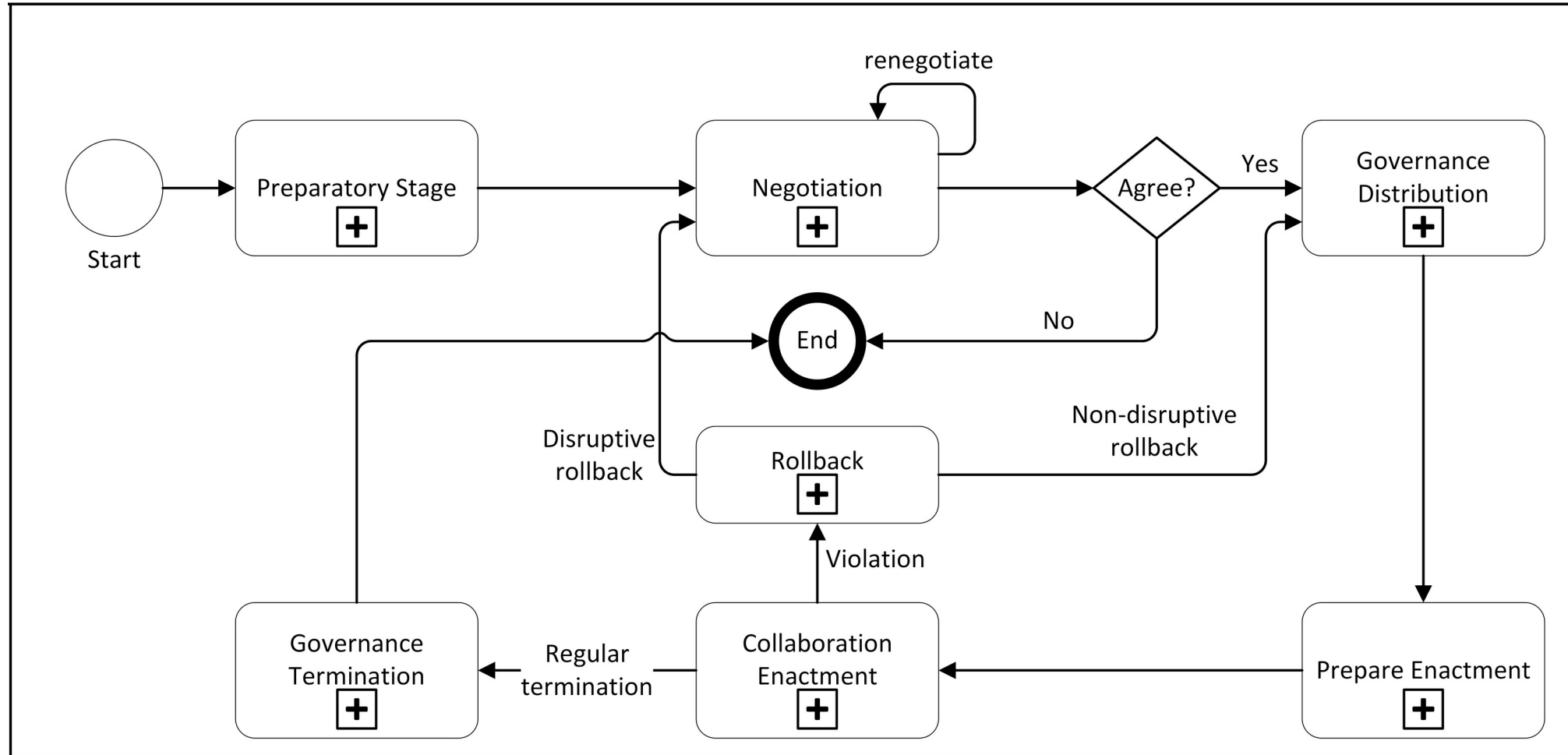
What if something goes wrong?
(failing to transport the user to the agreed-upon destination)

- Two options:
 - Immediate rollback
 - Mediation process that is supervised by a conflict resolution escrow service
- Can be calming or disruptive

Lifecycle - Governance Termination

- Contract terminates, or expires either after the user arrives at the final destination, or when the contract is prematurely terminated
- Dismantle DGI and everything that was setup before the enactment

Digital Contract Lifecycle



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M2X Modalities



M2X Modalities

- Environment integrity

M2X Modalities

- Environment integrity
- Accountability and logging

M2X Modalities

- Environment integrity
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- Privacy

M2X Modalities

- Environment integrity
- Accountability and logging
- Privacy
- Trust

M2X Modalities

- Environment integrity
- Accountability and logging
- Privacy
- Trust
- Market behavior



WHY BLOCKCHAIN TECHNOLOGY?

Why Blockchain Technology?

- Smart contracts
 - Enable and govern business transactions/interactions and collaborations
 - No need for arbitration via a trusted authority
 - Readable/processable by machines and humans alike
 - Fact tracking, non-repudiation, auditability, and tamper-resistant storage of information in a distributed multi-stakeholder setting

Why Blockchain Technology?

- Smart contracts
 - Enable and govern business transactions/interactions and collaborations
 - No need for arbitration via a trusted authority
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 - Fact tracking, non-repudiation, auditability, and tamper-resistant storage of information in a distributed multi-stakeholder setting
- Automation and economy of scale via computerized transaction protocol

Why Blockchain Technology?

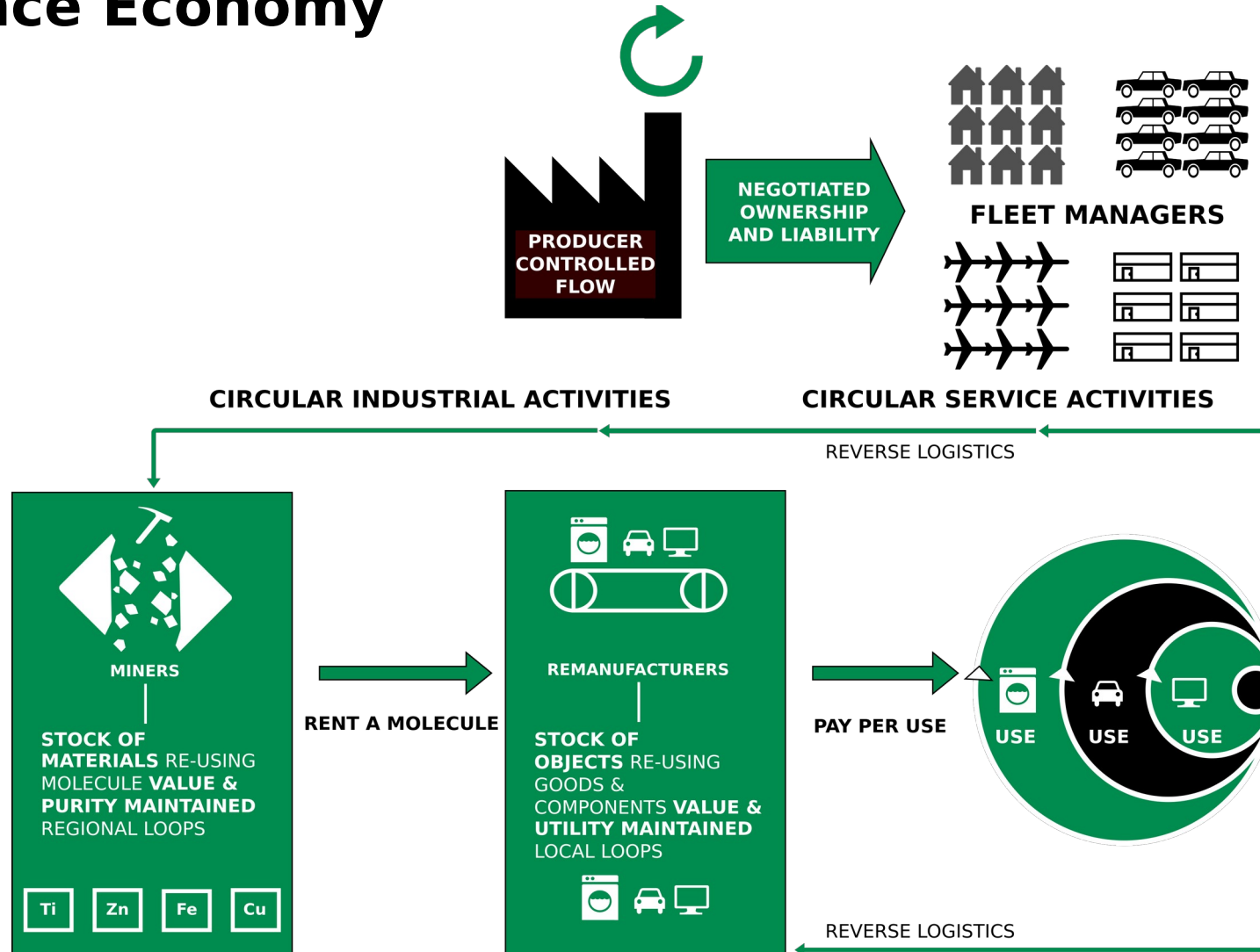
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 - No need for arbitration via a trusted authority
 - Readable/processable by machines and humans alike
 - Fact tracking, non-repudiation, auditability, and tamper-resistant storage of information in a distributed multi-stakeholder setting
- Automation and economy of scale via computerized transaction protocol
- Decentralized, distributed, open and interoperable ecosystem without lock-in effects instead of silo-like oligopoly structures

M2X ECONOMY → CIRCULAR ECONOMY (2.0)

The Nature of Technology

- In the past many new technologies have emerged and disrupted existing economical models.
- B. Arthur stipulates that an *economy is an expression of its technologies*
 - Thus, it can be argued that the current unsatisfying state of the Circular Economy reflects a lack of sufficiently developed technologies that express themselves within the CE.
 - Or, more precisely – difficulties of the stakeholders in combining the technologies that are required to enable the CE.

Performance Economy





WHAT'S NEXT?

What's next?

- Circular Economy ✓

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- Circular Economy ✓
- IoT ✓

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- Circular Economy ✓
- IoT ✓
- Vision of M2X as a potential enabler for the PE/CE2.0 ✓

What's next?

- Circular Economy ✓
- IoT ✓
- Vision of M2X as a potential enabler for the PE/CE2.0 ✓

Missing building block → Blockchain Technology

Questions?

Further Resources

- B. Leiding, P. Sharma, A. Norta, “The Machine-to-Everything (M2X) Economy: Business Enactments, Collaborations, and e-Governance”, Future Internet 13.12 (2021): 319.
- B. Leiding, “The M2X Economy – Concepts for Business Interactions, Transactions and Collaborations Among Autonomous Smart Devices”, PhD Thesis, University of Göttingen, Göttingen, Germany, 2020.
– [Link](#).