



Ethical Discussion on Blockchain-based Accountability for Secure and Collaborative Digital Twin Environments

A Case Study on Smart City Transportation

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A Brand that Innovates...

Critical Chains Workshop on Blockchain Ethics
17th of December, 2019, University of Reading

- Current Status
- New Concepts, dynamics and use
- Ethical concerns
- Discussion on a smart city case study
- Conclusions and future work

Market and Technology Directions

Digital Twin
Market:
15.66 Billion US\$
→ 2023
(Markets &
Markets)

IoT is booming
(#connected
devices > 75B in
2025)

X4.0 is
becoming
indispensible

e.g. I4.0 market
~\$214B by 2023

Blockchain is
the new big
thing.
Technology
market \$21B
by 2023

Smart city is
now a must!

\$237.6 billion
by 2025

Some top areas

- ❑ Blockchain is **not only cryptocurrency**. It's a new decentralised way of collaborative working.
- ❑ **Blockchain infrastructures are becoming common** in sectors like finance, but also in Health and logistics.
- ❑ Blockchain infrastructures are **still cumbersome** and may not be very effective for fast and responsive systems, like IoT. New approaches like IOTA seek for optimum solutions.
- ❑ **Digital twin** has come to forward especially in **I4.0**. Big companies are planning to provide system infrastructures free but make money from X-as-a-Service business.
- ❑ **Digital twins combine new techniques** of AI, machine learning, prediction algorithms, 3D visualization and interaction, IoT-enabled monitoring, big data analytics.
- ❑ **Security is everywhere**. Not cyber-only but also cyber-physical

Main Innovations

Any 4.0

Cyber-Physical Security

Blockchain

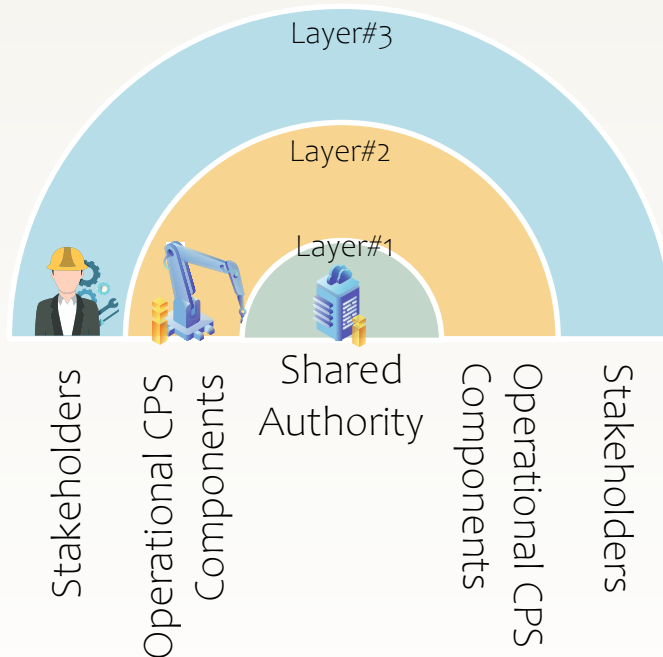
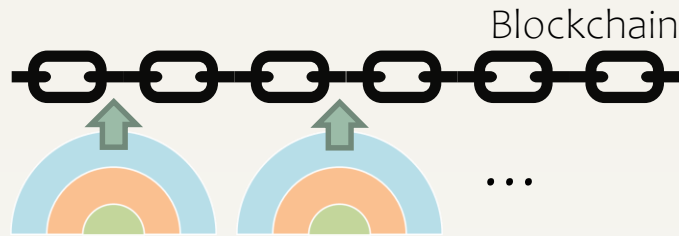
Digital Twin

- ❑ Secure data transmission between the virtual and physical pairs
- ❑ Effective Authentication and authorization
- ❑ Credentials verification of stakeholders
- ❑ Device security and safety against CPS attack

- ❑ Mutual authentication with fine-grained access control,
- ❑ Better verifiability and immutability,
- ❑ Enhanced security, scalability and service availability especially for large-scale distributed manufacturing environments

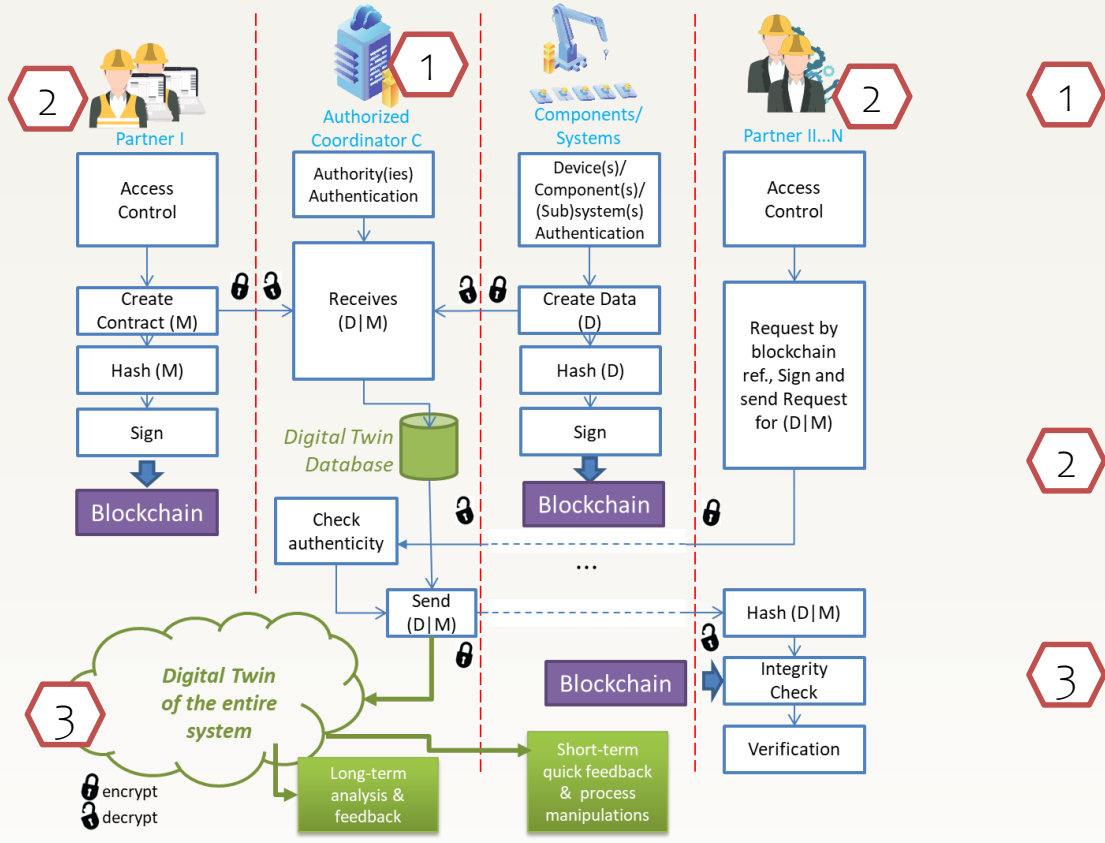
- ❑ X-as-a-Service tools effectively pair physical and virtual systems
- ❑ X-by-design
- ❑ X = AI|Security|Privacy|Accountability

Onion Model



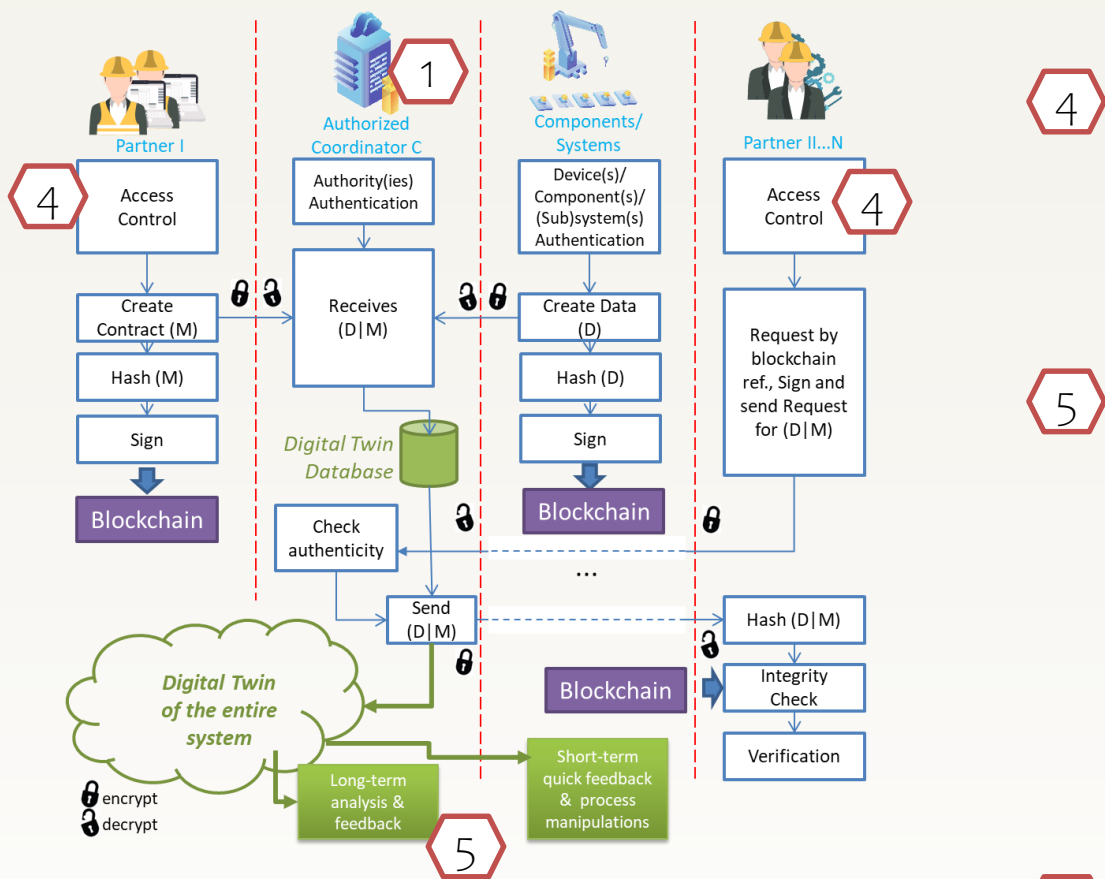
- ❑ Layered model enables **structured collaboration** even in cross-border applications.
- ❑ This is **decentralised** but not fully free of authorisation. There is a **shared authority** in the middle that enables better accountability of processes.
- ❑ This model is not only for **stakeholders** but also **operational cyber-physical components**.
- ❑ All generated, structured and minimised data are **hashed** and stored in **blockchain**.

Ethical Concerns



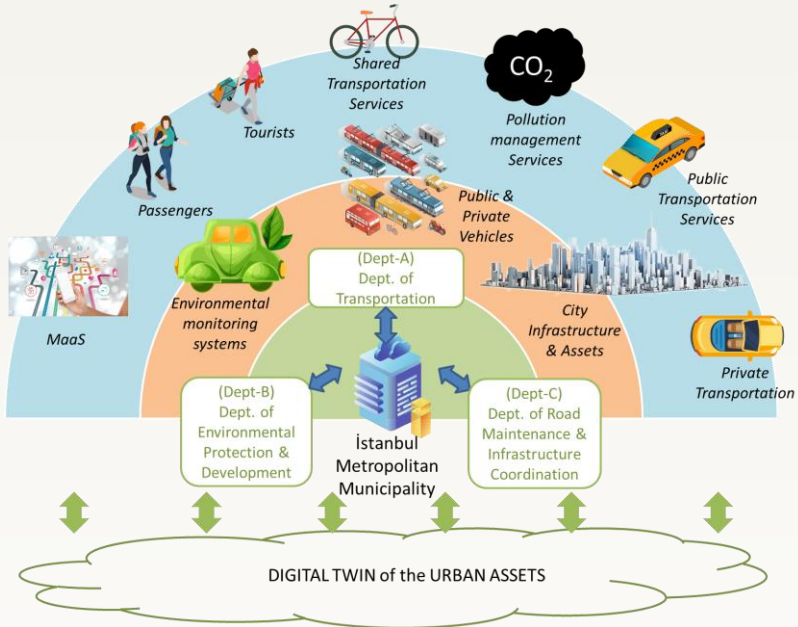
- 1 Decentralisation = leaderless organisations
What happens if something goes wrong? Who will take the responsibility? (better against single point of failure but...)
- 2 If a user exploits the protocol for profit without breaking its rules, isn't it unethical?
- 3 Probing and disclosing security vulnerabilities—can put other people's private data at risk (i.e smart contract)

Ethical Concerns



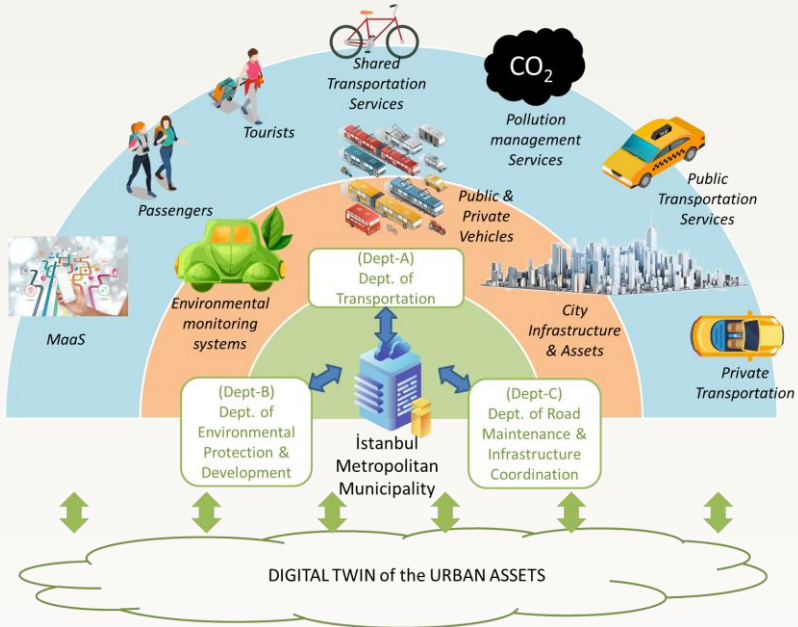
- 4 User authentication data is a private data and should be kept secret. Especially biometric authentication (GDPR sensitive data)
- 5 Short- or long-term digital twin data analysis may present clues about behavior style of usage that can be even biometrically unique; although the personal information is de-linked, anonymised or pseudonymised.
- 6 Accidents or disasters are a part of natural life in Any4.0 environments. What if a malicious user inside hacks the system?

Ethical discussion



- Special Categories of data (GDPR Art.9):
- Movement data may raise ethical concerns.
 - Surveillance systems process biometric data.
 - Environmental monitoring systems may expose personal information about personal life style (i.e. investigation of daily waste/garbage/ time slots of having time at home/bedroom/bathroom,etc.)
 - Payment systems (i.e. Mobility or municipal data) may leak many personal information, likes/dislikes, sexual life, religion, ethnic origin
 - 3D city and building data (city infrastructure) may present personal data about life style (where a person leaves, where her bedroom is)
 - Smart city data about urban assets, like the use of electriccity, energy consumption may expose personal clues.
 - ...

Ethical discussion



Some example privacy leakages:

- **Data concerning health**
 - A person goes to hospital regularly for diabetes or oncological treatment/check-ups.
 - A woman goes to a place very near to a test-tube baby clinic. Does she or her husband have a problem with pregnancy?
- **Religious and philosophical beliefs**
 - A person visits a place 5 times a day, very near the mosque. Is he a muslim?
- **Racial or ethnic origin**
 - A person leaves at a street where minorities stay. Is he an immigrant?
- **Political opinions**
 - A person never goes out after 8 pm. But he has been out in the evenings for more than a week since the outbreak of Yellow Vests protests. Does he support these events?
- **Biometric data**
 - A woman, having extramarital sexual relations with a man, takes a taxi. The mobile payment API applies facial recognition. However, by accident, man's face appears in the background by accident. This photo is somehow infiltrated to public web (by accident or cyber attack).

- ❑ CPS utilized in any Industry 4.0 (namely Any 4.0) and Digital Twin application or smart system can be realized over a decentralized blockchain-enabled architecture.
- ❑ Blockchain can be useful for data integrity and accountability, especially in large-scale multi-stakeholder systems. If there is a strong autonomy or lesser hierarchy, think twice!
- ❑ A layered structure where authorities at the inner layer may provide a shared authorization enabling non-repudiation of faults and defeats in a CPS.
- ❑ Blockchain may secure private transactions. However, recording such big and streaming data in blockchains is still not effective. Storing data in off-chain infrastructures is still open to vulnerabilities and leakages.
- ❑ Ethical issues are still open to discussion. Very strong authentication, secure storage and data transmission are indispensable features of any blockchain infrastructure

The proposed system should be implemented by an agile, fast, energy-efficient and less complex blockchain infrastructure.

IoT-enabled Semantic framework should be developed to cover many «X»s for XaaS and X-by-design dealing with a generic solution for Any4.0 and Digital Twin applications.

Decentralized mechanisms can be encouraged with reward and cryptocurrency-based incentives for wider take-up.

An elastic solution that can be improved by many contributors is needed to tackle specific problems, considering ethical concerns, and diversify the solution stacks.



For more technical information: Kanak, Alper, Niyazi Ugur, and Salih Ergun. "A Visionary Model on Blockchain-based Accountability for Secure and Collaborative Digital Twin Environments." *2019 IEEE International Conference on Systems, Man and Cybernetics (SMC)*. IEEE, 2019.

This presentation has been supported within the European Union Horizon 2020 Programme for research, technological innovation and demonstration under Grant Agreement number SU-DS-05:833326: **Critical-Chains**

Questions/Comments



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