PLM'24 Doctoral Workshop

The use of Digital Twins to bolster the resilience of an IoT System of Systems Infrastructure

Laboratoire
Décision et Information
Pour les Systèmes de Production

Laboratoire
Poly-Industries 4.0

Meriem SMATI

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Université Jean Monnet Saint-Étienne
Université de Lyon

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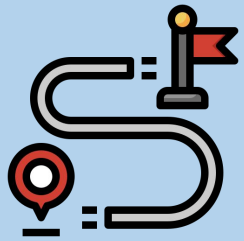
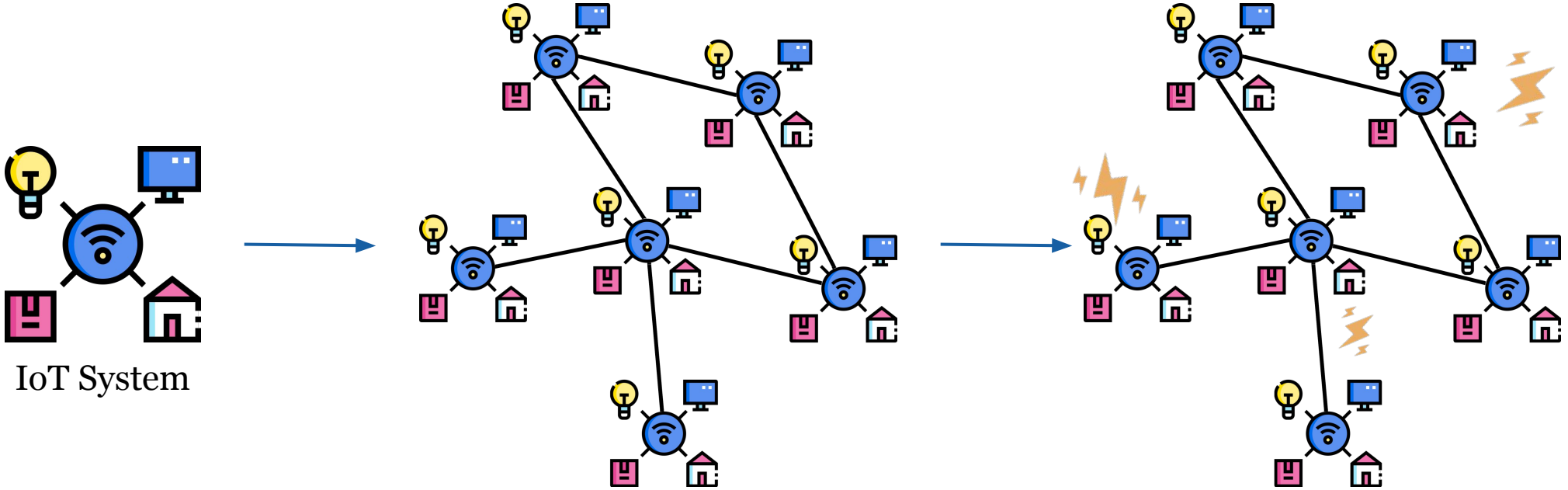
Presentation Outline

Introduction



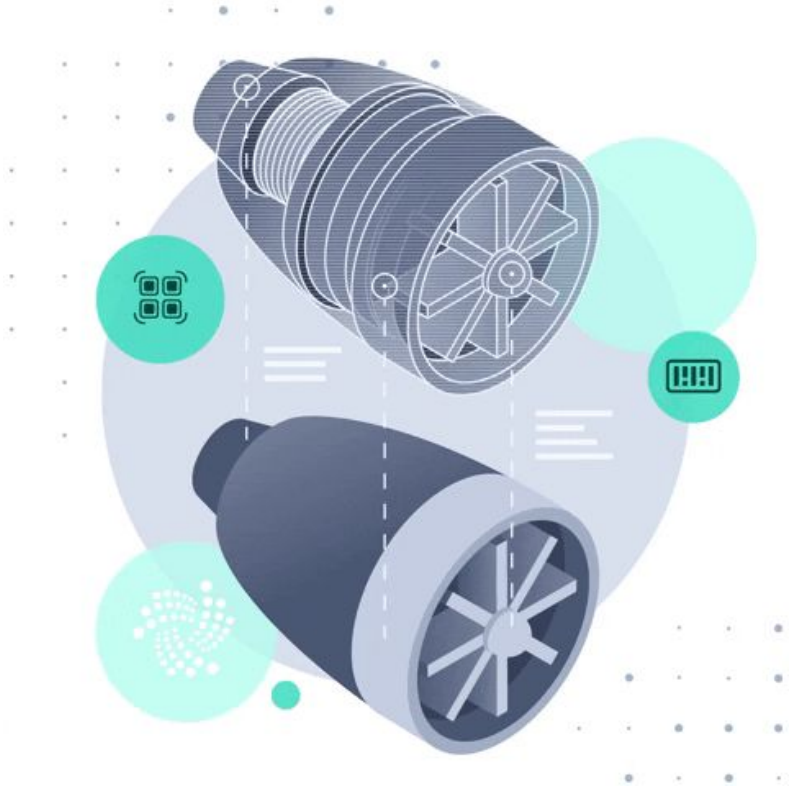
1. Introduction

1.1. Problematic



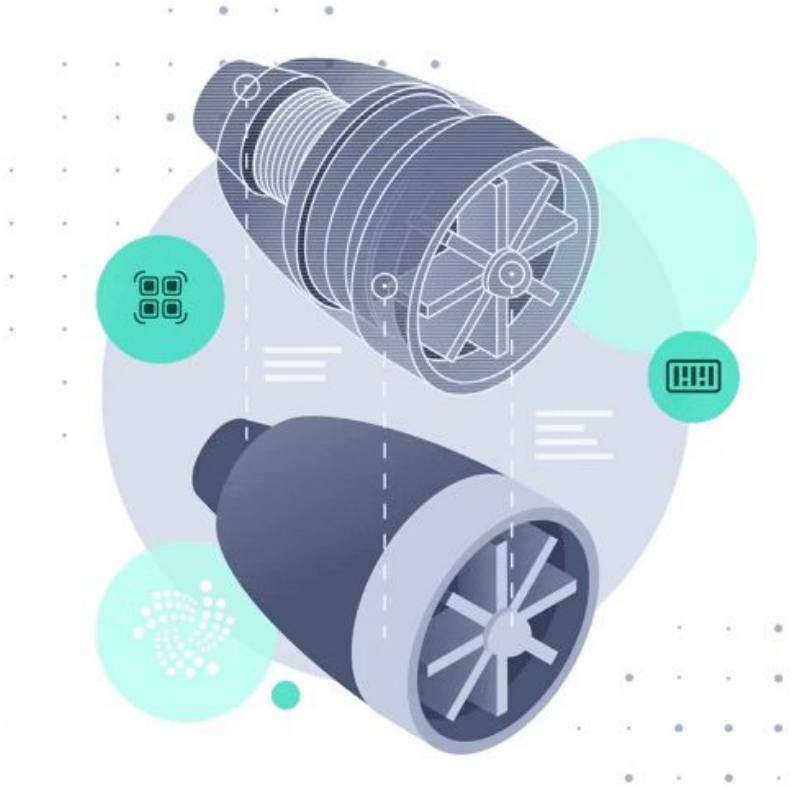
Where is the problem, what should be done and how to make the system resilient?

One technology being considered for addressing these issues is **Digital Twinning**



- Scenario Simulation & Real-time feedback to not affect the PT.
- Process optimization by using predictive maintenance.
- Help with decision-making.

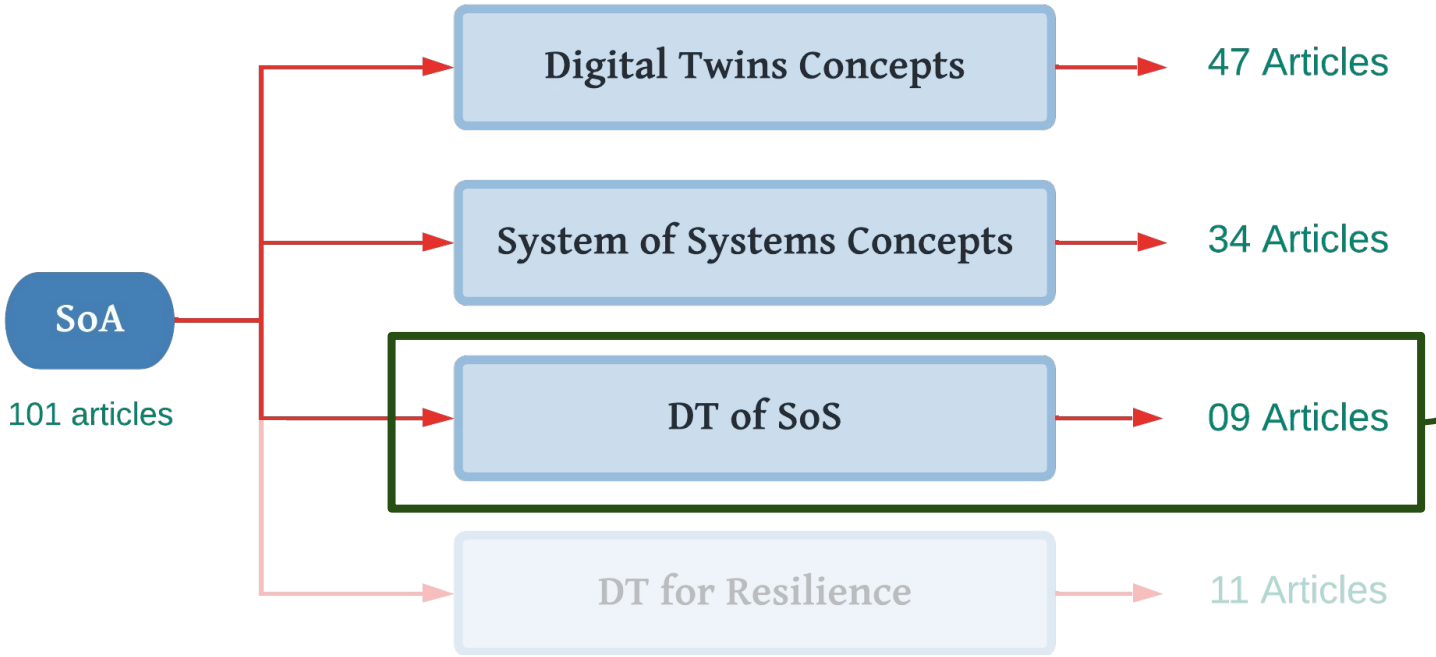
One technology being considered for addressing these issues is **Digital Twinning**



- How can we efficiently integrate multiple Systems DTs to compose a comprehensive SoS?
- What are the specific challenges associated with modeling and simulating the integrations of constituent systems with along with their DTs within an SoS?
- What architecture could ensure consistency and synchronization between individual DTs and the overarching SoS?

State of the Art

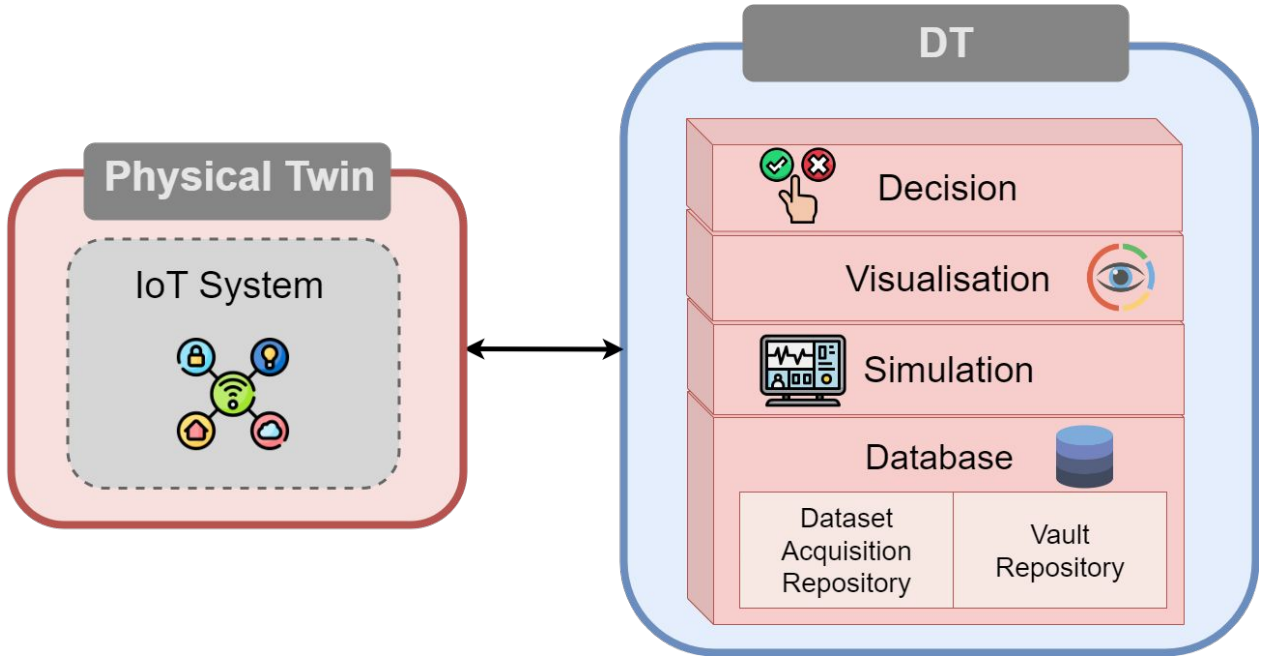
2. State of the Art



Only 9 articles were found on the subject and only theoretical contributions without validation

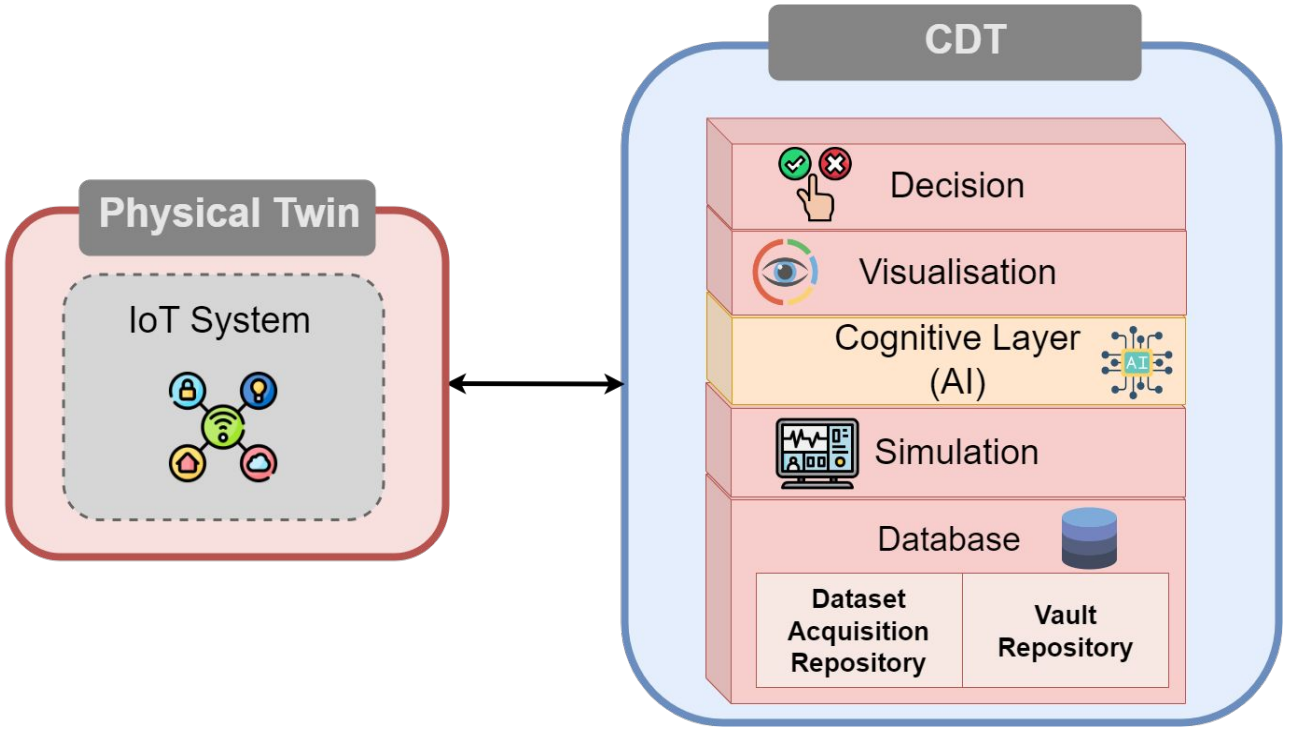
Digital Twins

The Digital Twin is a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level [1][2].

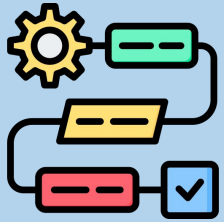


Cognitive Digital Twins

Cognitive Digital Twins are digital twins that possess cognitive capabilities, allowing them to perceive, learn, reason, and solve problems autonomously.

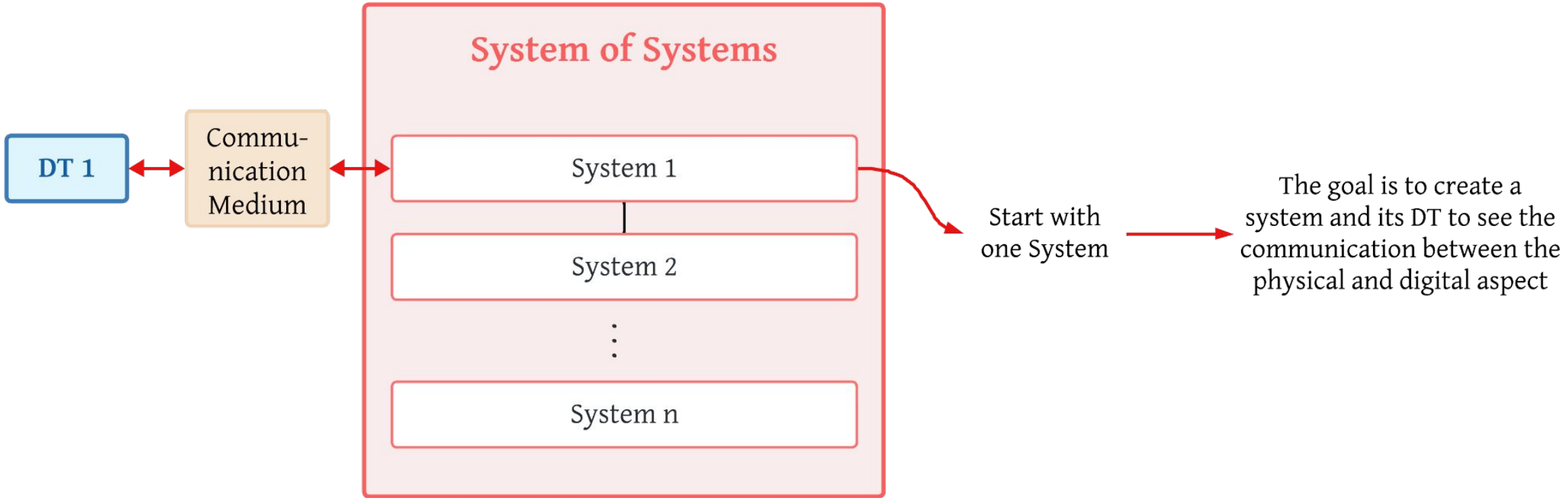


Methodology



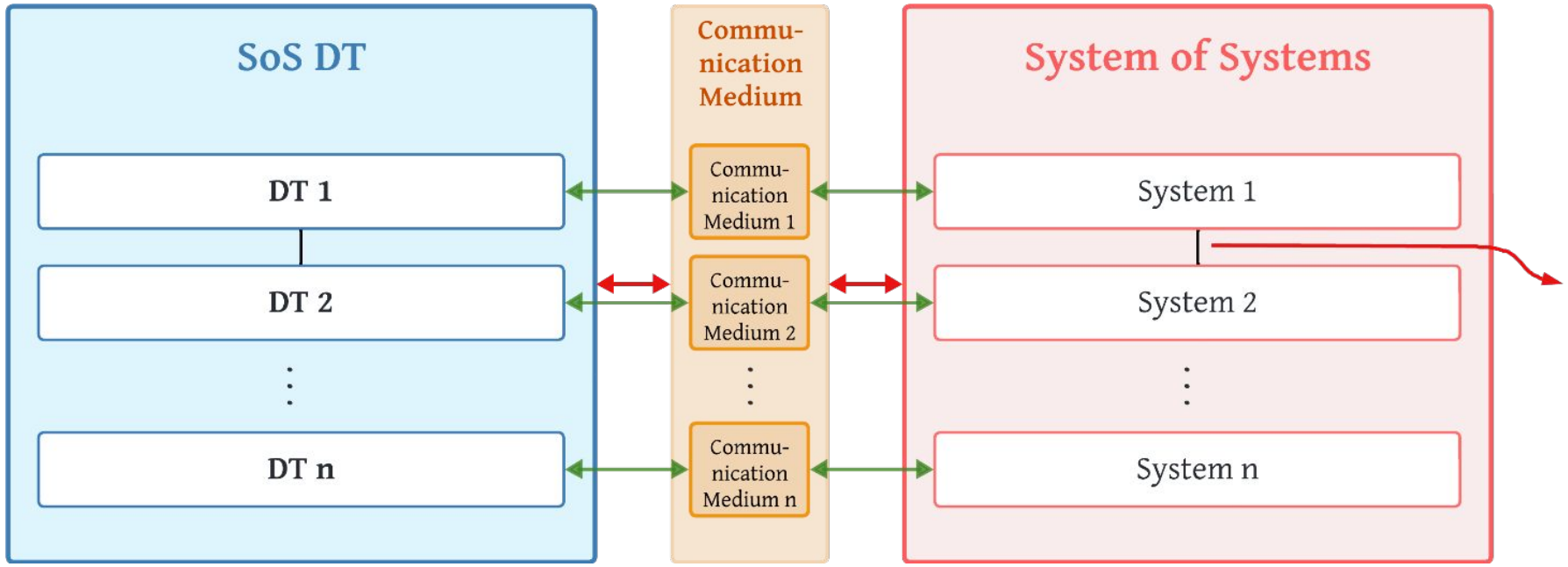
3. Methodology

1. Focus on particularly one system and its DT



3. Methodology

2. Focus on the communication between Systems and DTs



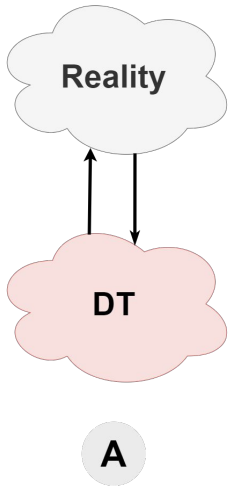
- Depending on the communication between the two systems ? How to model a uni & bidirectional communication ?
- If a system has a DT, how the Digital communication and Physical one is seperated ?
- If a constituent system is integrated later on, how to add a DT in real-time → Scalable and extandable architecture ?

Propositions & Contribution

4. Propositions & Ongoing Work

4.1. Creation of a System and its DT

4.1.1 Creation of a CSDT Layers

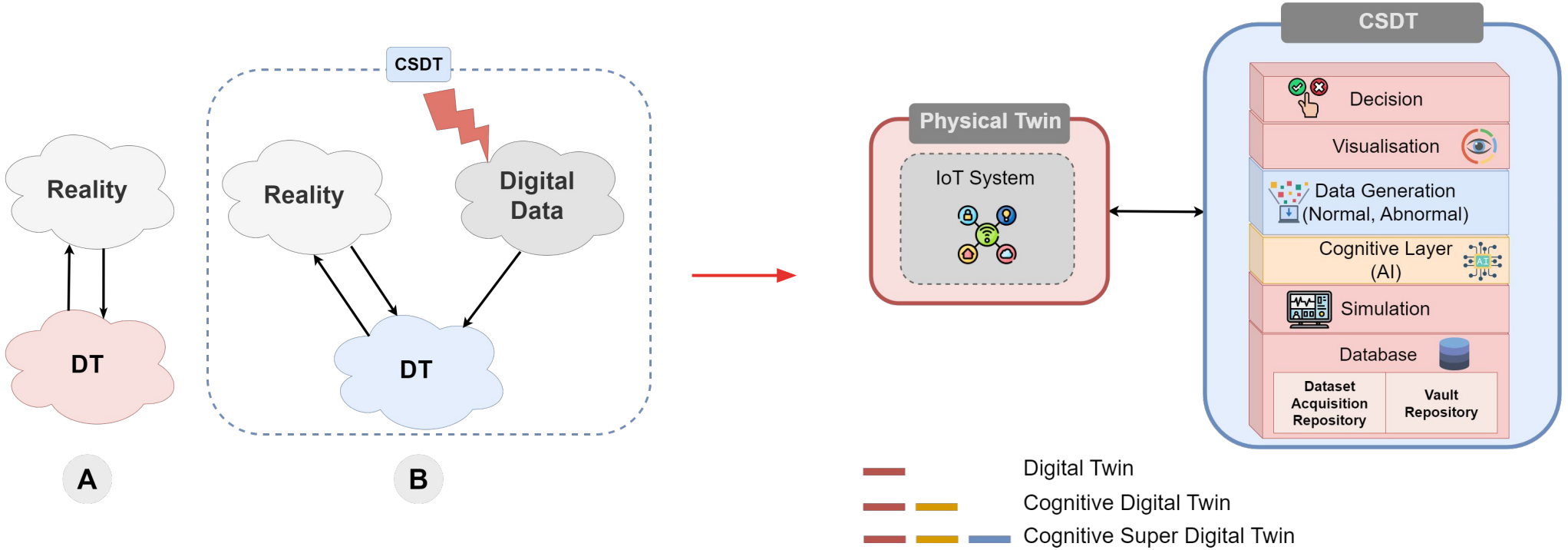


→ Not enough data from the real word

4. Propositions & Ongoing Work

4.1. Creation of a System and its DT

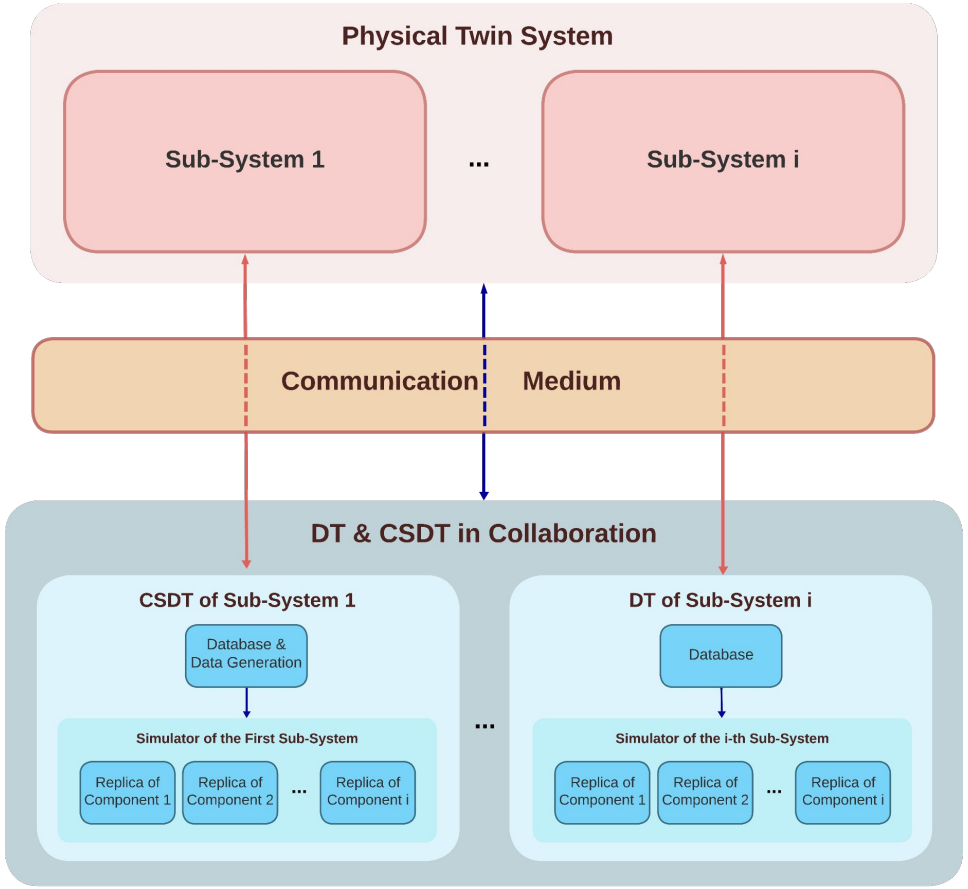
4.1.1 Creation of a CSDT Layers



4. Propositions & Ongoing Work

4.1. Creation of a System and its DT

4.1.2 Generic Architecture



4. Propositions & Ongoing Work

4.1. Creation of a System and its DT

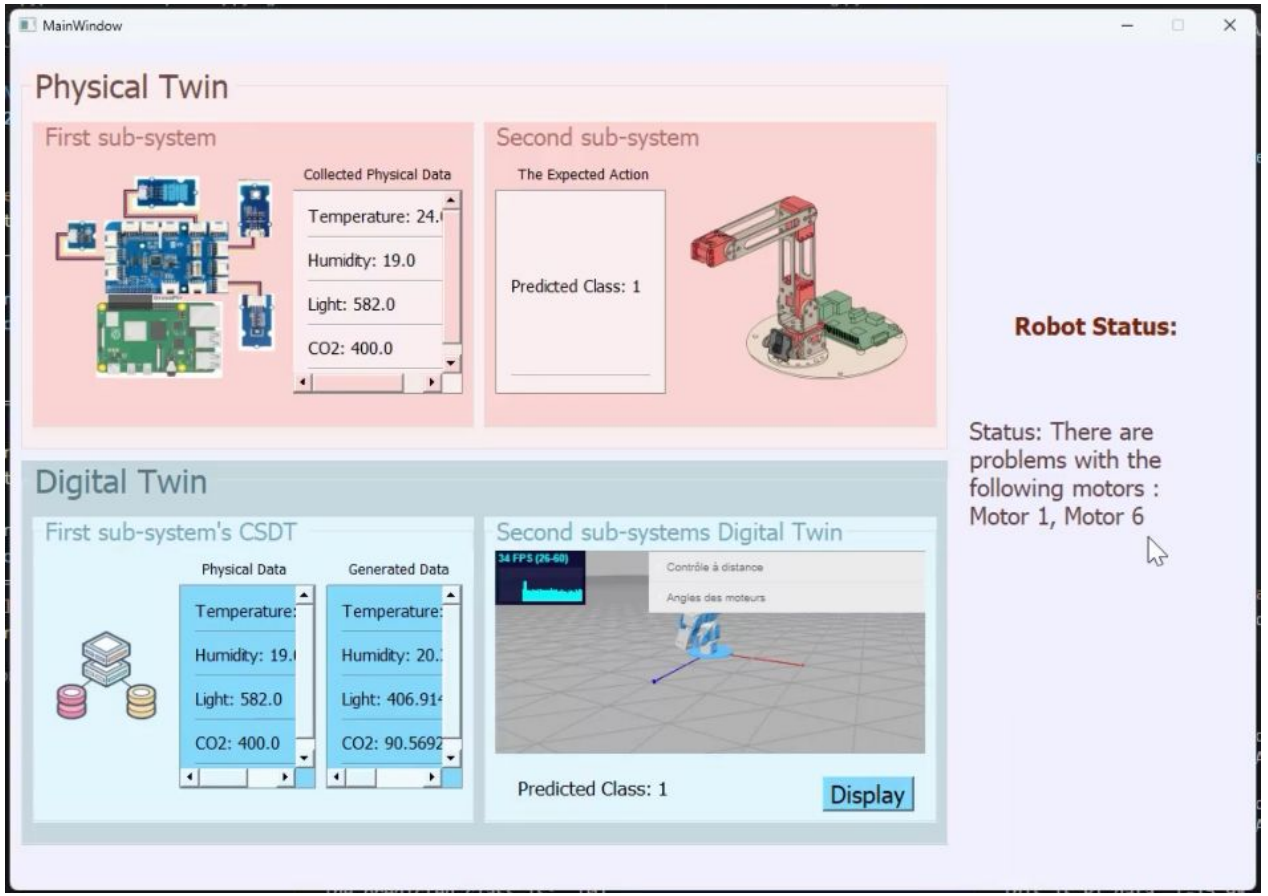
4.1.3 Generic Architecture Applied on a use case

- **Use case:** Occupancy detection
- Two subsystems →  First system collects data
  Second system receives data and moves accordingly
- Find appropriate Machine Learning/Deep Learning models for prediction

4. Propositions & Ongoing Work

4.1. Creation of a System and its DT

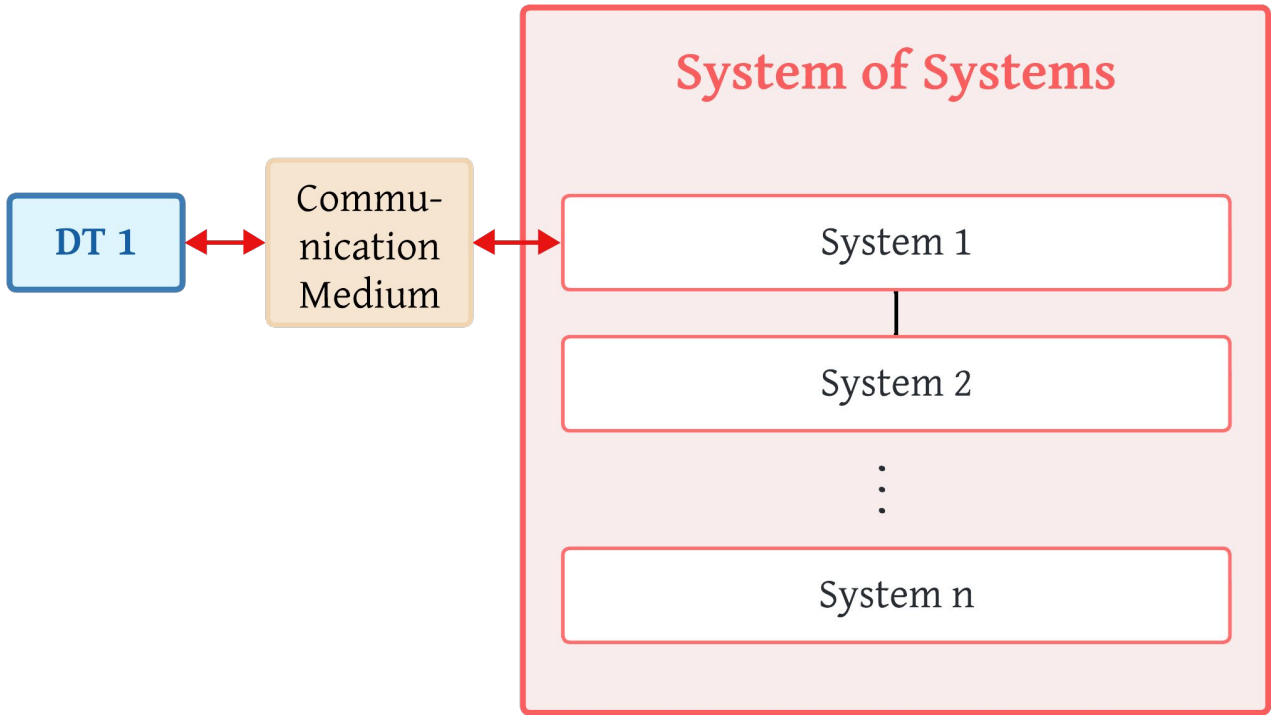
4.1.3 Generic Architecture Applied on a use case



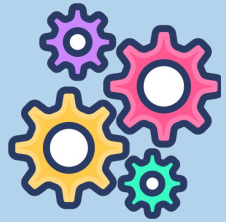
4. Propositions & Ongoing Work

4.1. Creation of a System and its DT

4.1.4 Recap

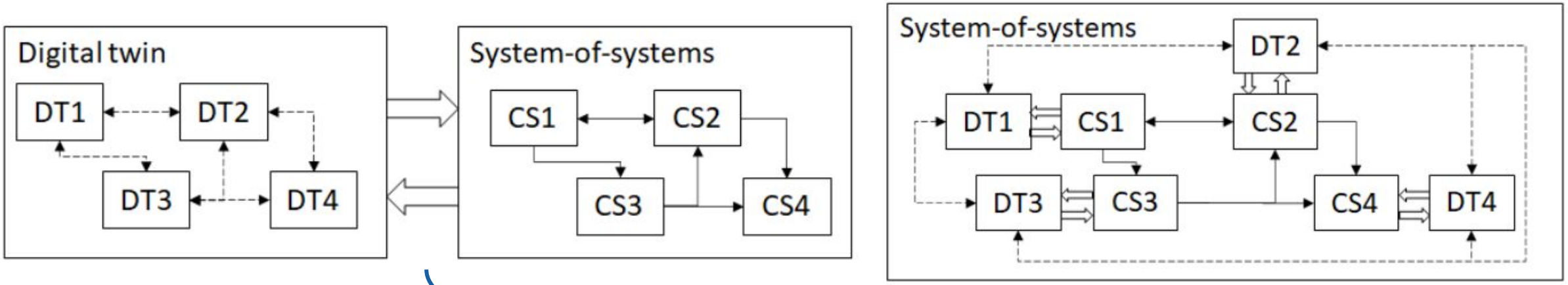


Ongoing Work



4. Propositions & Ongoing Work

4.2. Ongoing Work

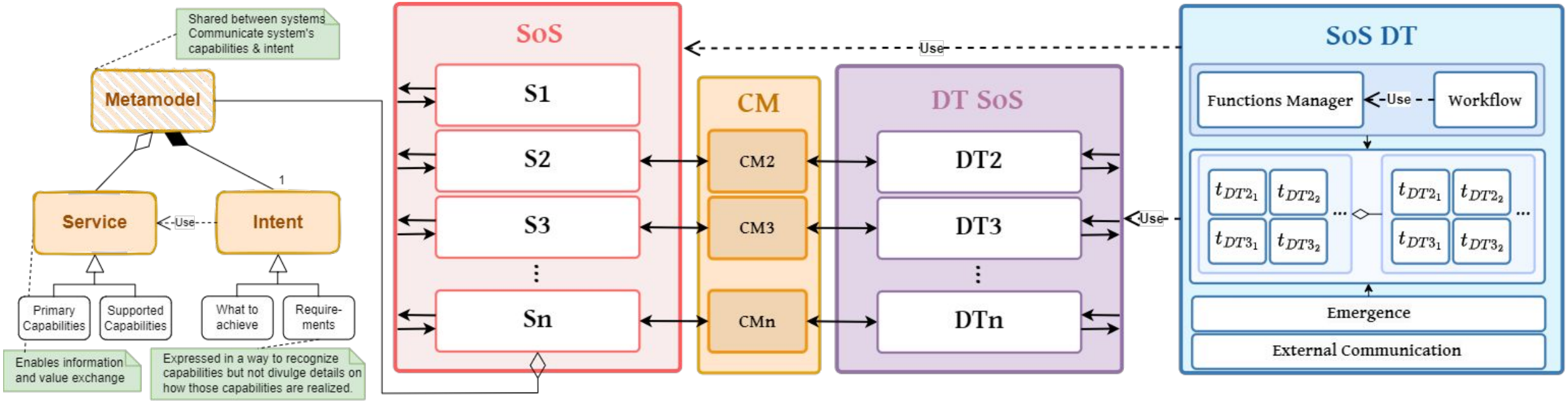


Figures from [5]

Compromise

4. Propositions & Ongoing Work

4.2. Ongoing Work



5. Future Endeavors

- Finish the architecture of SoS DT
- Explore the possibility of creating a metamodel / generic architecture of SoS-DT
- Examination of additional case studies
- Creating a Resilient DT

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7. References

[1] Grieves, M. (2014). Digital twin: manufacturing excellence through virtual factory replication. White paper, 1(2014), 1-7.
[2] Grieves, Michael & Vickers, John. (2017). Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems. 10.1007/978-3-319-38756-7_4.
[3] Mark W. Maier, 1998. "Architecting principles for systems-of-systems," Systems Engineering, John Wiley & Sons, vol. 1(4), pages 267-284.
[4] Grinsztajn, L., Oyallon, E., & Varoquaux, G. (2022). Why do tree-based models still outperform deep learning on tabular data? arXiv preprint arXiv:2207.08815.
[5] Olsson, Thomas & Axelsson, Jakob. (2023). Systems-of-Systems and Digital Twins: A Survey and Analysis of the Current Knowledge. 1-6. 10.1109/SoSE59841.2023.10178527.