Exploring Twinning Variability

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AnSyMo / MSDL

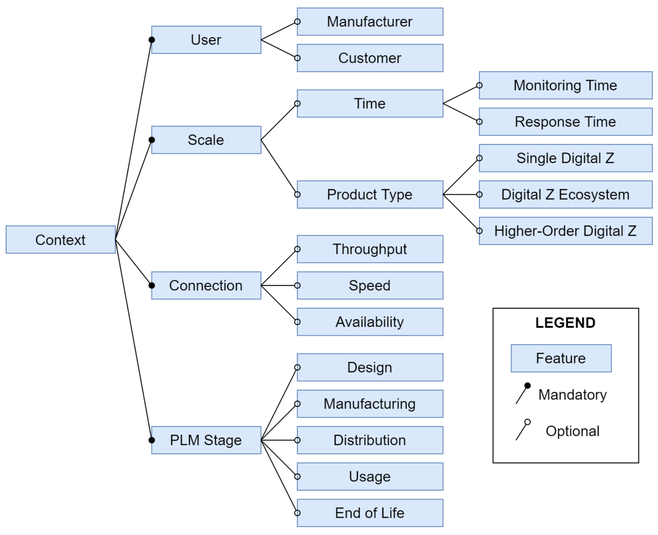
Digitized Products enabling end-to-end design-operation

Goal

(Digital) Twins are heavily influenced by the plethora of choices to be made by system engineers. This work shows how to make these decisions explicit and possibly automated.

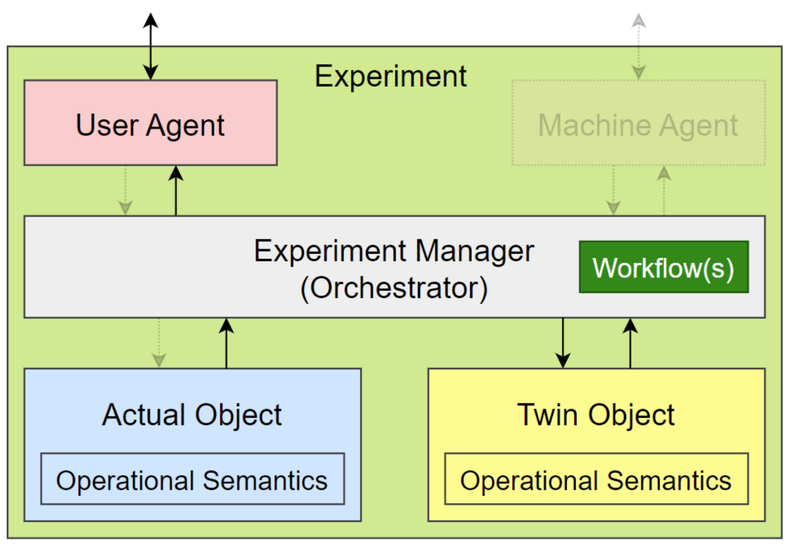
Motivation

- We identify three phases in which choices are made:
  - The ***Problem Phase***: focuses on the exact problem description. This highlights the *goals* w.r.t. *Properties of Interest (PoIs)* for which a Twin is to be constructed.

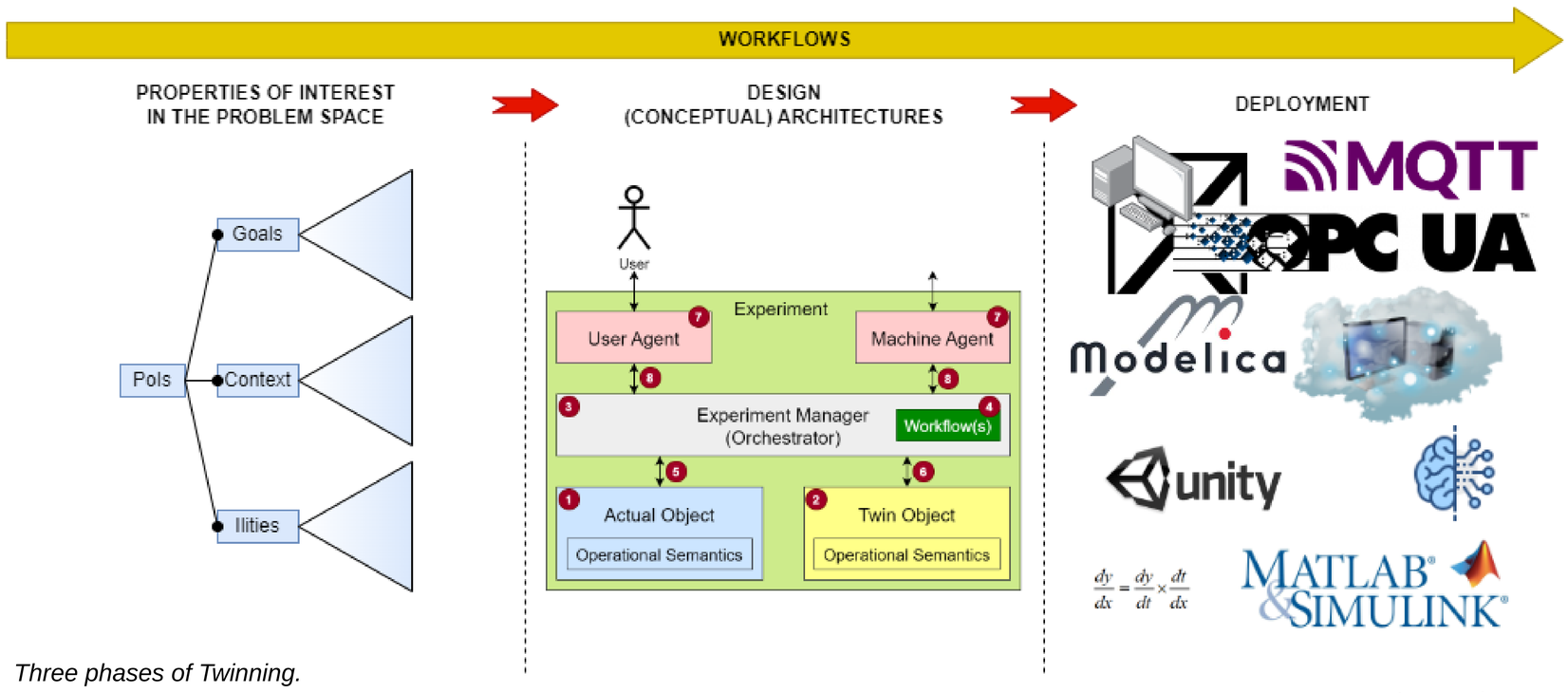


Goals Feature Tree.

  - The ***Architecture Phase***: focuses on the selection of a conceptual architecture.
  - The ***Deployment Phase***: focuses on *how* the system is realized; which technologies are being used; what protocols must be instantiated…
- The choices made in each of these three phases will have impact on cost.
- Illustration: ship movement in port.
- The "Actual Object" (AO) of the port reflects a view on the real-world system and the "Twin Object" (TO) is a simulation.
- The deviation between AO and TO is used to detect anomalies.



Architecture.



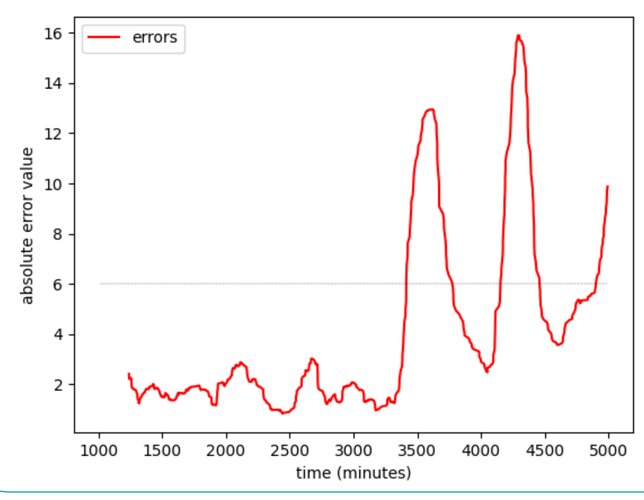
Three phases of Twinning.

Approach

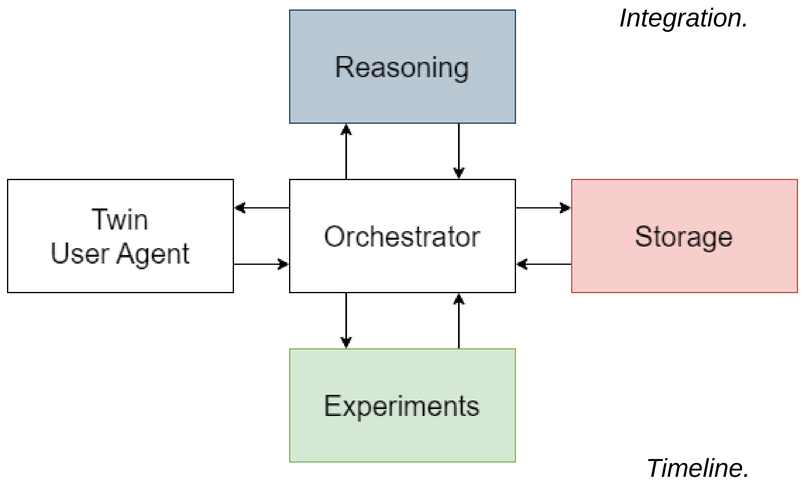
- An extensive literature study resulted in a Feature Tree that structures the goals for which Twins are built.
- Each goal determines the conceptual system architecture, and technologies that may be used in deployment.
- Mathematical models were built to represent the behaviour in the port.
- Multiple twinning architectures may have to be combined due to:
  - Multiple goals/PoIs;
  - Multiple instances vs twin type;
  - Multiple twins, each correspong to a component in a system architecture;
  - Models in Multiple Formalisms used for modelling the same system;
  - Multiple models at different levels of abstraction / detail / fidelity / … for modelling the same system;
  - Multiple copies of the same system (for redundancy);
  - Multiple life-cycle stages.

Results

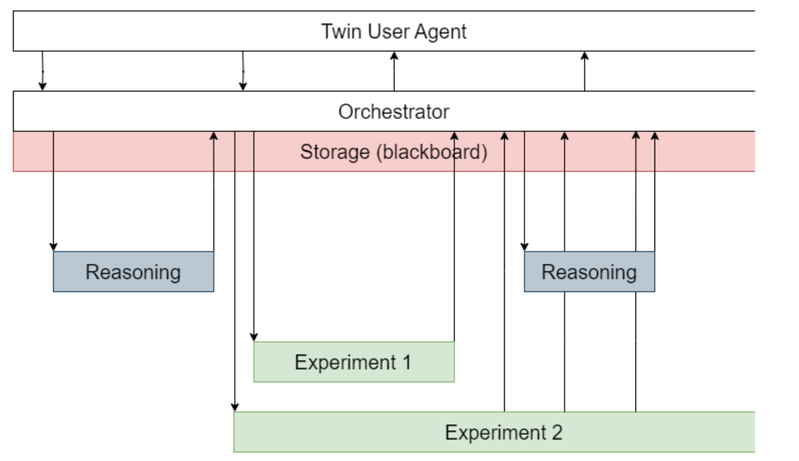
- Example of Anomaly Detection goal, obtained from an experiment in the harbour context.

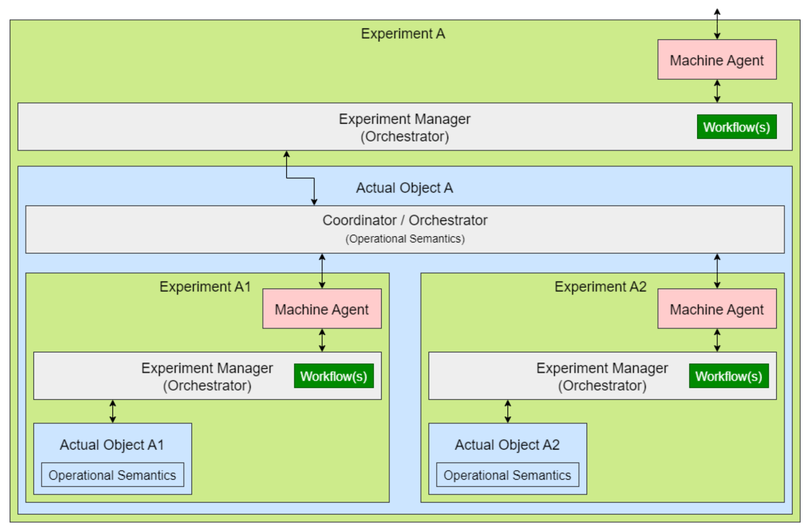


Integration.

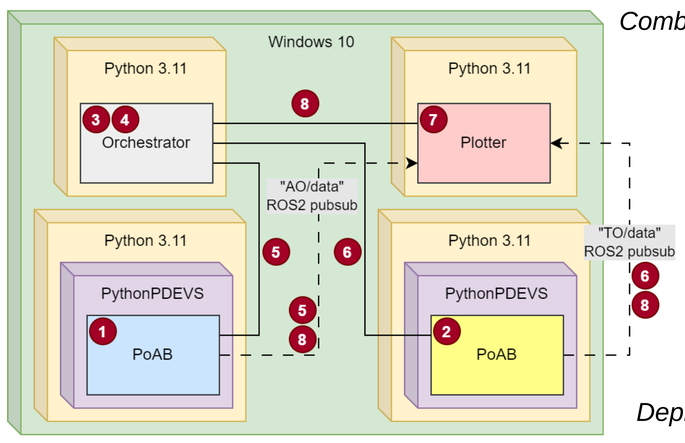


Timeline.





Combinations.



Deployment.

Further reading

Paredis, R., Vangheluwe, H., & Albertins, P. A. R. (2024). *COOCK project Smart Port 2025 D3.1: "To Twin Or Not To Twin"* University of Antwerp. https://doi.org/10.48550/arXiv.2401.12747

Key take-aways

- There is a lot of variability that occurs when creating a Twin.
- We propose a three-phase approach to build twins.

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For Publication