Using UML and OCL Models to realize High-Level Digital Twins

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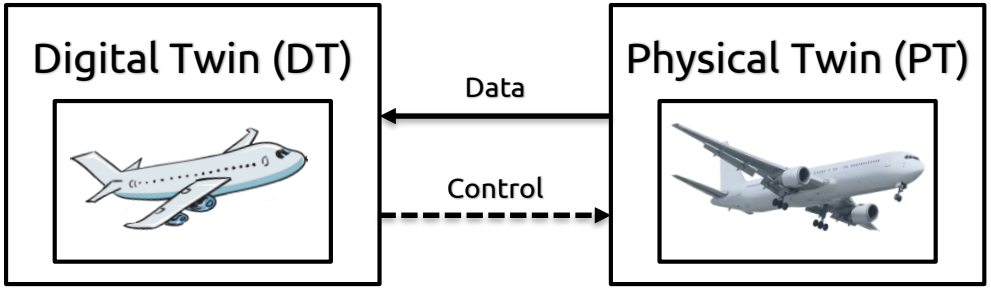
What is a Digital Twin?



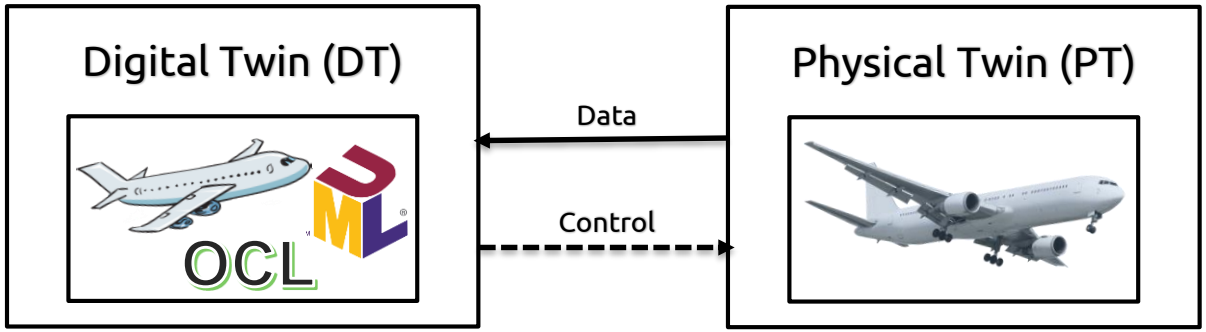
A Digital Twin is a comprehensive digital representation of an actual system, service or product (the Physical Twin), synchronized at a specified frequency and fidelity [1].

[1] Digital Twin Consortium, “Glossary of digital twins,” 2021. [Online]. Available: https://www.digitaltwinconsortium.org/glossary/index.htm

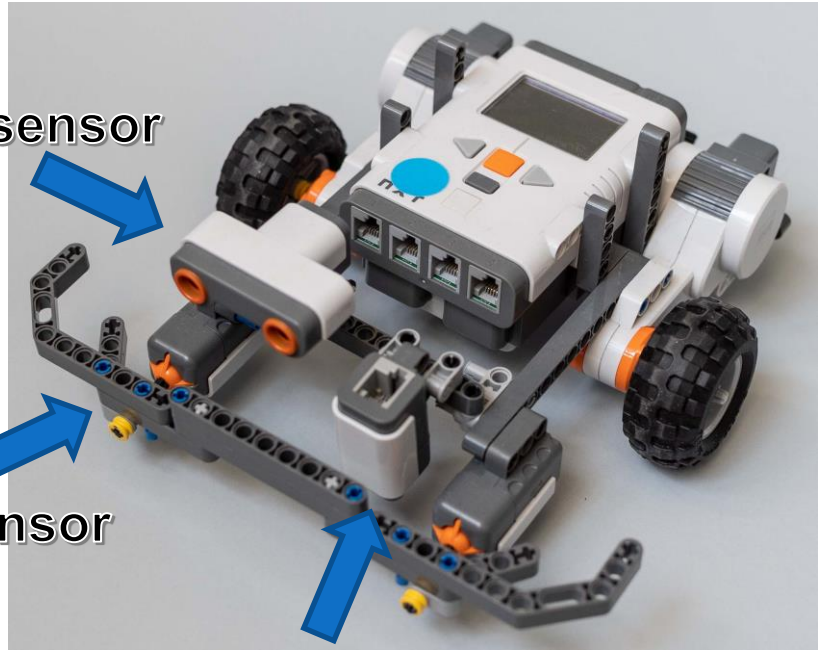
Our approach

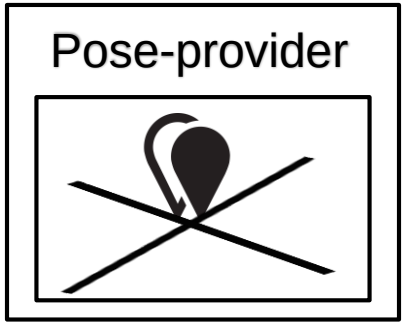
Digital Twins are **pretty complex software** systems since they need to emulate the actual physical system faithfully

Raise the level of abstraction using **software models** during their development

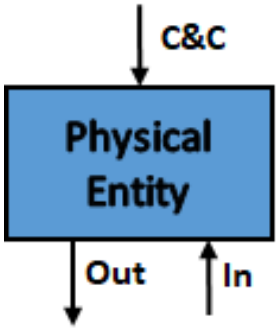


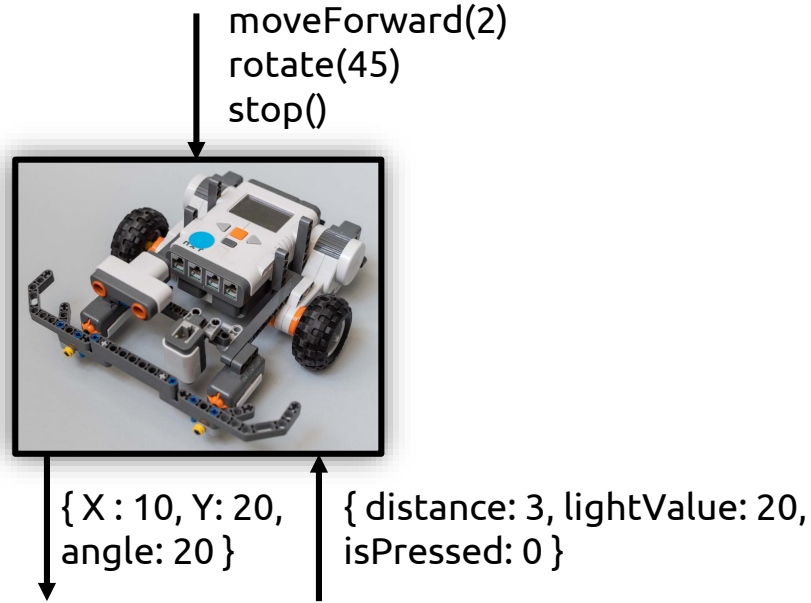
Running example: a Lego Mindstorms Car





A framework for defining and deploying DTs





A framework for defining and deploying DTs

Data Lake

- It connects the PT and DT
- It implements the Blackboard architectural pattern

Drivers

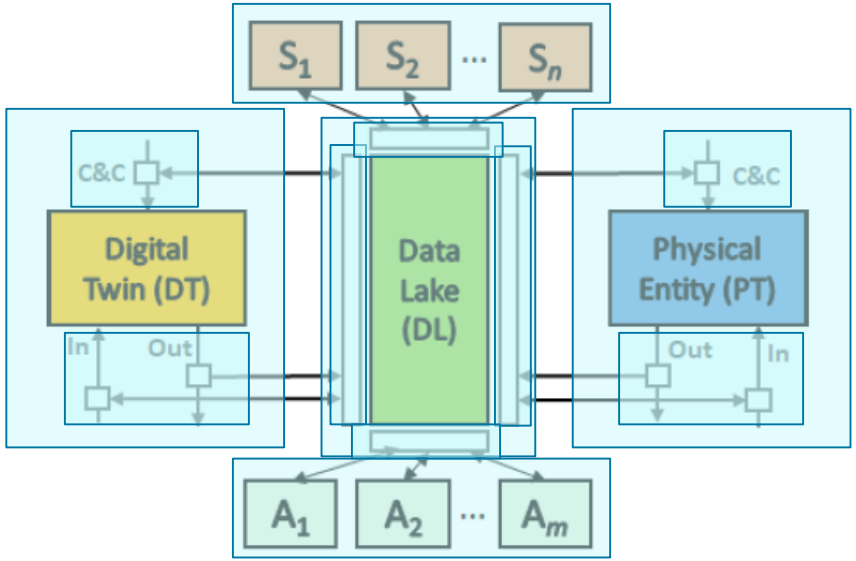
- Transform the data into formats that each component understands

Service components

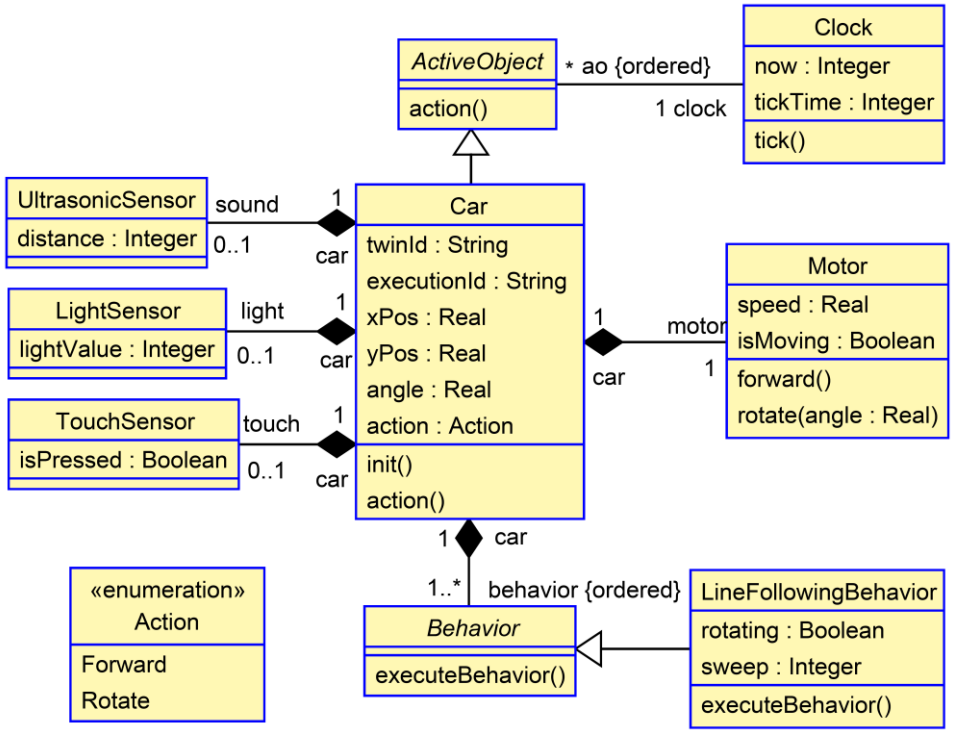
- Implement additional functionality for the system (dashboards, IA algorithms)

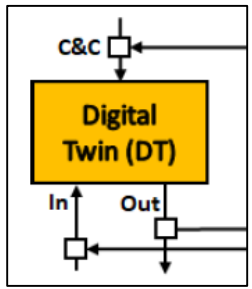
Analysis components

- Implement different type of tests on the physical entity, the twin or even on service components

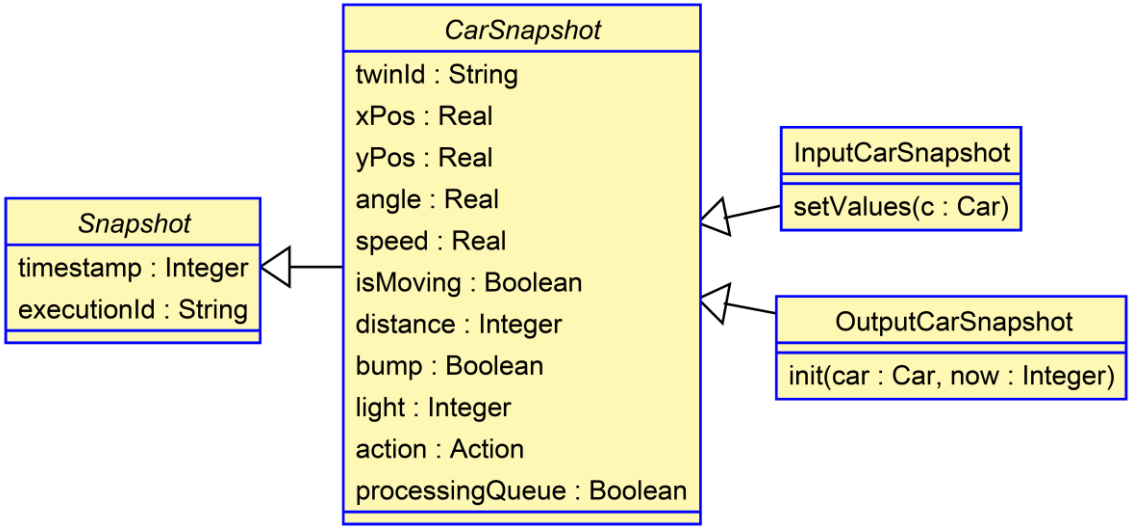


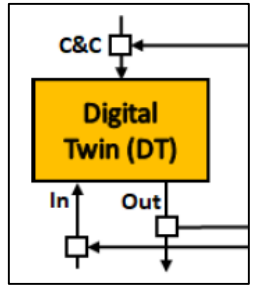
Implementation of the framework: UML Model of the Car



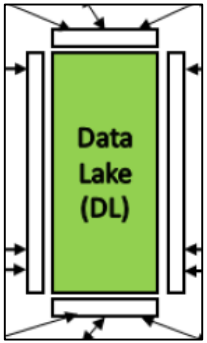


Implementation of the framework: Snapshots





Implementation of the framework: Data Lake

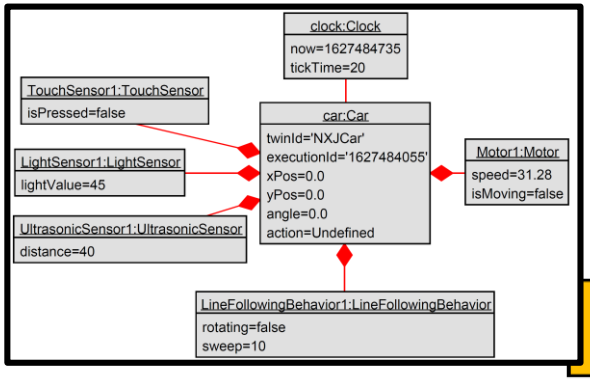


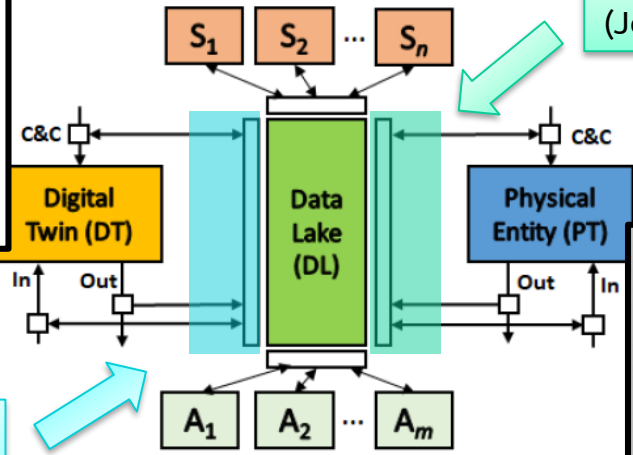
redis

twinId : executionId : timestamp

```
HGETALL NXJCar:1627484055:1627484375
 1) "twinId"              2) "NXJCar"
 3) "bump"                4) "0"
 5) "processingQueue"     6) "0"
 7) "light"               8) "45"
 9) "angle"               10) "-0,52"
11) "executionId"         12) "1627484055"
13) "yPos"                14) "-0"
15) "speedFactor"         16) "31,28"
17) "isMoving"            18) "0"
19) "xPos"                20) "0"
21) "action"              22) "Rotate"
23) "distance"            24) "40"
25) "timestamp"           26) "1627484375"
```

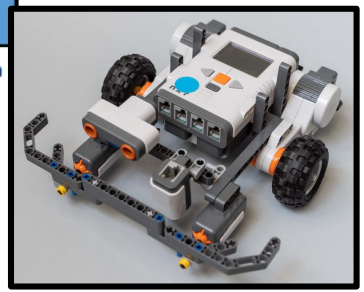
Implementation of the framework: Connections



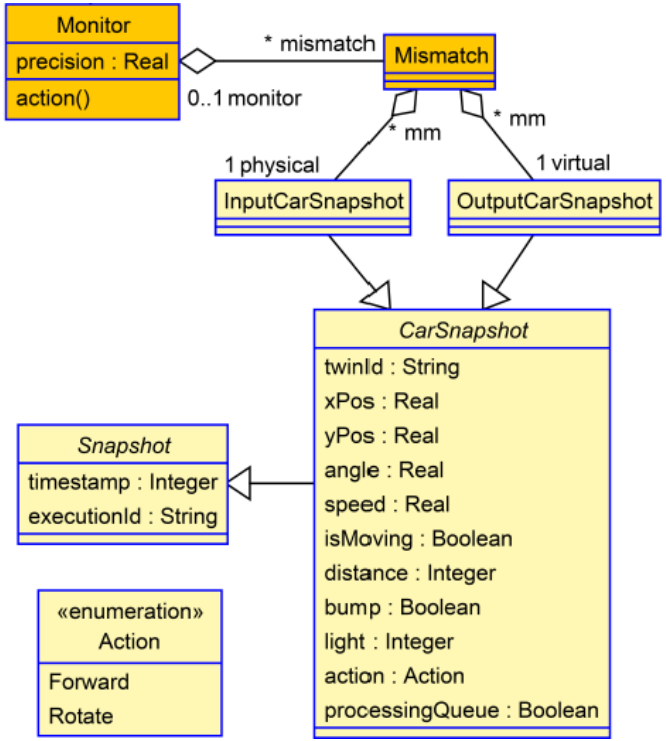


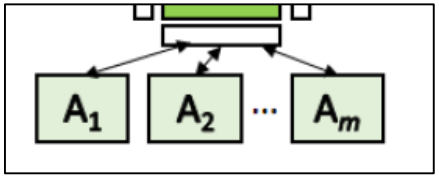
Publish-subscribe service (Jedis) and a **socket**

Publish-subscribe service (Jedis) and a **USE Plugin**



Implementation of the framework: Example of Analysis component





Summary and conclusions

In our contribution, we show how it is possible to use **UML and OCL models** for the specification of DTs to **verify their expected behavior** in the early stages of development.

Advantages

- ❑ The framework allows **replacing the high-level models with lower-level implementations**
- ❑ The DT model can be specified at **the needed fidelity level** depending on the type of analysis that we want to perform.
- ❑ It also allows to **analyze and validate any part of the software** independently

Future work

- ❑ Validate the proposal with **further physical systems**
- ❑ Create more **analysis and services modules**.
- ❑ Evaluate **the framework performance** under stressful conditions to determine its scalability and applicability to larger systems

Thank you for your attention

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