DTInsight: A Tool for Explicit, Interactive, and Continuous Digital Twin Reporting

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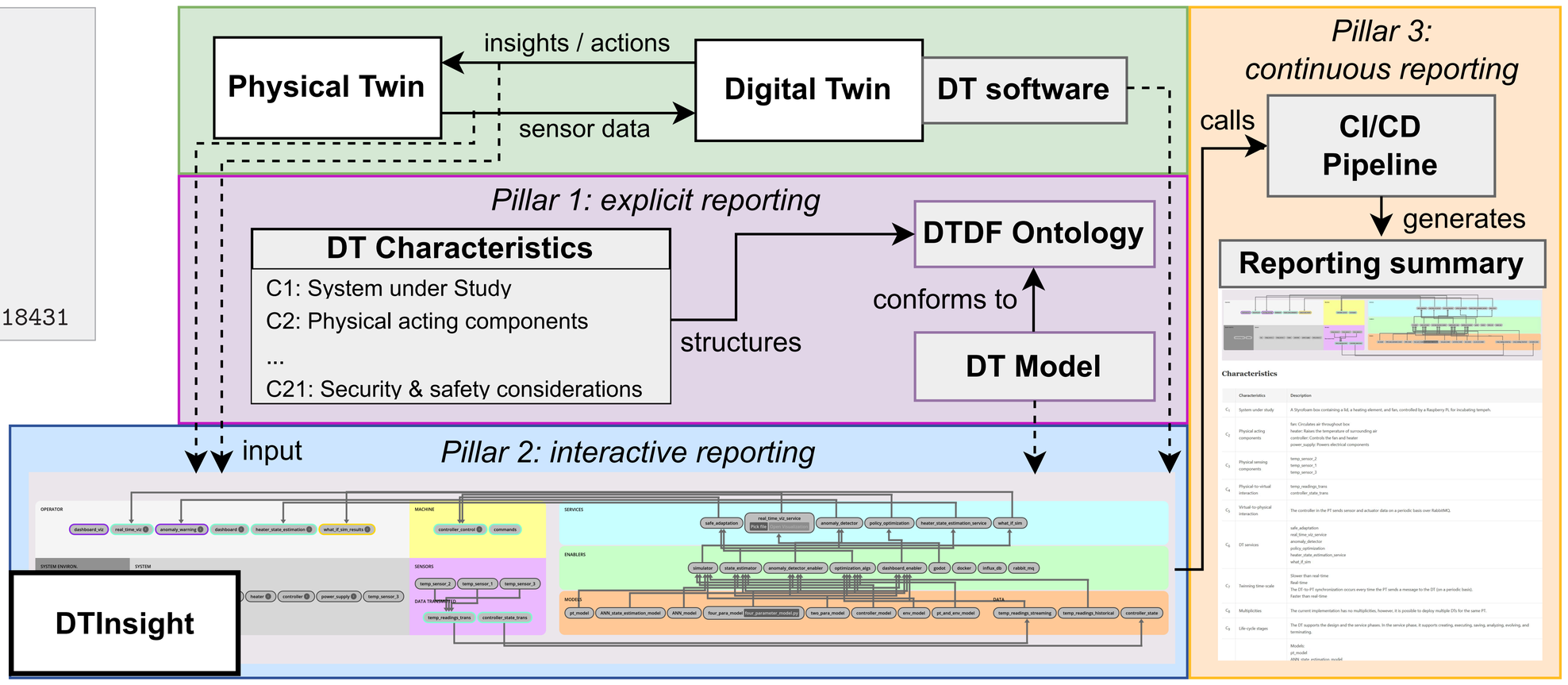


Abstract

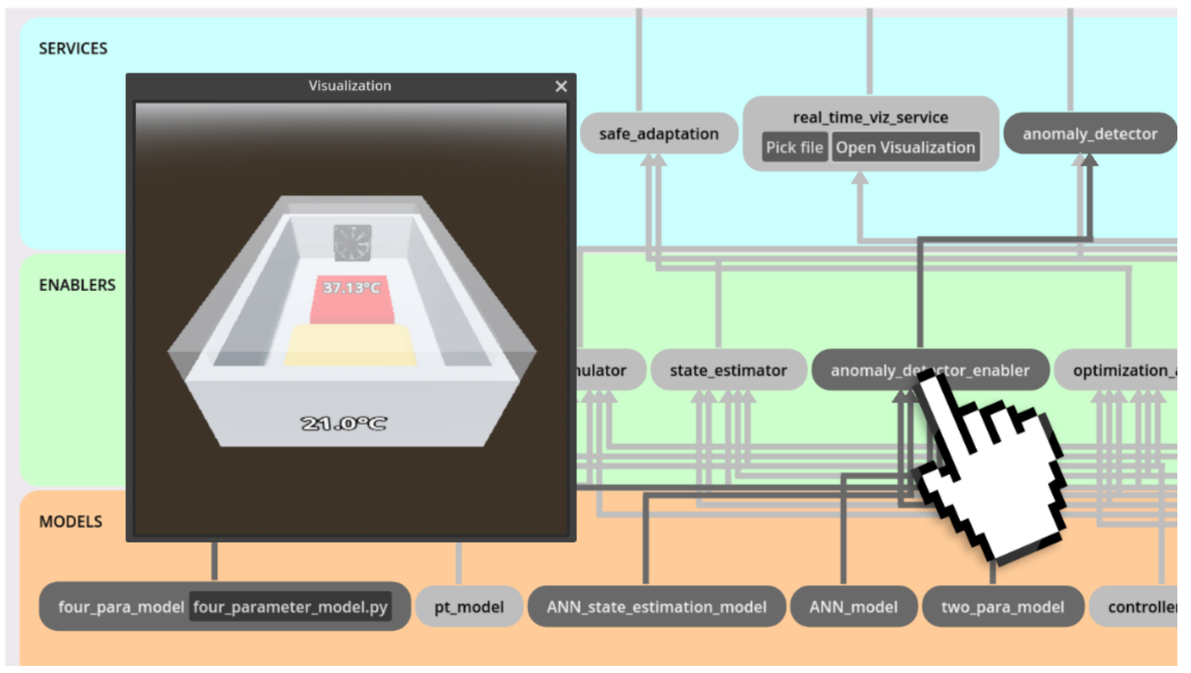
- Problem: DTs evolve over time and stakeholders need tools to **understand current characteristics and architecture at any point**
- We present **DTInsight:** a systematic, automated tool for **DT reporting**
- Three main features:
  - **(1) Explicit** DT characteristic summaries captured in ontological models
  - **(2) Interactive** DT conceptual architecture visualization
  - **(3) Continuous** integration into a live reporting page (via CI/CD)
- Given a DT model aligned with our **DT Description Framework (DTDF)**, DTInsight enables **up-to-date, detailed, and accessible reports**

(1) Explicit Reporting

```
// SERVICE EXAMPLE (C6)
instance what_if_sim : DTDFVocab:Service [
DTDFVocab:provides what_if_sim_results
DTDFVocab:atStage baseDesc:operation ]

// ENABLER EXAMPLE (C11)
instance simulator : DTDFVocab:Enabler [
DTDFVocab:enables what_if_sim ]

// MODEL EXAMPLE (C10)
instance controller_model : DTDFVocab:Model [
DTDFVocab:inputTo simulator, state_estimator,
    optimization_algs ]

// DESCRIBED CHARACTERISTIC EXAMPLE (C20)
instance standardization : DTDFVocab:Standardization [
base:desc "Communication is carried out using AMQP
    standard via RabbitMQ. Behavioral models have been
    produced following the FMI standard version 2." ]
```

- **Prior work:**
  - Showed DT reporting lacks key details, limiting research and practice
  - Developed a 21-characteristic framework (DTDF) for complete and systematic DT reporting [2]
- **Explicit reporting contribution:**
  - DTDF formalized in Ontology Modeling Language (OML), defining:
    - An *OML vocabulary* of DTDF concepts
    - An *OML description* instantiating those concepts
  - Facilitating the creation of formal, machine-readable DT representations
  - Enabling querying via SPARQL, powered by Apache Jena Fuseki
  - Compatible with openCAESAR Rosetta editor [3]

(2) Interactive Reporting



- *DT constellation:* Interactive DT conceptual architecture visualization to **report both structure and behavior**
- Generated from an ontology using Godot game engine
- Three main capabilities:
  1. Hover to explore data flows between components
  2. View DT component scripts
  3. Visualize real-time sensor data (graphs or 3D)

(3) Continuous Reporting

- Designed for both DT experts and non-technical stakeholders needing **continuous updates on DT development**
- CI/CD pipeline (GitHub Actions) **auto-generates a live report page** with a summary table and interactive DT constellation
- Example report available at https://oakeslabmtl.github.io/DTDF/

Conclusion & Future work

- DTInsight improves stakeholder communication by making DT reporting:
  - **Explicit**: via ontology-based modeling
  - **Interactive**: through structural + behavioral architecture visualization
  - **Continuous**: with automated reporting page generation
- Provides a domain-specific DT view with 21-characteristic framework [2]
- Code available at https://github.com/oakeslabmtl/DTInsight
- **Future work:**
  - Automate ontology modeling using LLMs
  - Drag-and-drop DT construction using DTInsight
  - Reveal further DT behaviour and deepen observability

[1] Fiter *et al.* (2025) DTInsight: A Tool for Explicit, Interactive, and Continuous Digital Twin Reporting. Proceedings of EDTconf.

[2] Gil *et al.* (2024). Toward a systematic reporting framework for digital twins: a cooperative robotics case study. Simulation, 101(3), 313-339.

[3] Elaasar *et al.* (2023). openCAESAR: Balancing agility and rigor in model-based systems engineering. In MODELS-C (pp. 221-230). IEEE.