Business Informatics Group

Digital Twins for Building Renovation – *What is the added value?*

Callista Raschauer[1], Marianne Schnellmann[1], and Hende*rik* A. Proper[1]

[1]TU Wien, Vienna, Austria

Business Informatics Group

UNIVERSITY OF APPLIED SCIENCES UTRECHT

Digital Twins for Building Renovation – *What is the added value?*

Callista Raschauer[1], Marianne Schnellmann[1], and Hende*rik* A. Proper[1,2]

[1]TU Wien, Vienna, Austria
[2]HU University of Applied Sciences, Utrecht, The Netherlands

Background to this paper

Digital Twins

- Lots of "*bling bling*"

and then there are "LLMs" as the *blingiest bling* of all

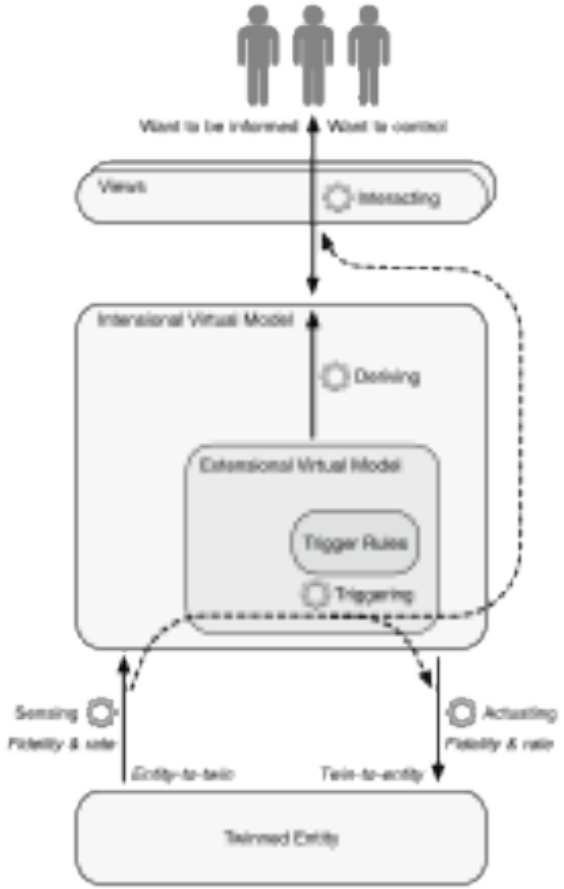
Right …

- *What does it cost?*
- *What does it bring?*

Integration and synergy with the "rest" of the information architecture?

Marianne Schnellmann, Marija Bjeković, Henderik A. Proper, and Jean-Sébastien Sottet. "Towards Architectural Coordination of Digital Twin Development in Urban Planning". In: The Practice of Enterprise Modeling – 18th IFIP Working Conference, PoEM 2025, Geneva, Switzerland, December 3-5, 2025, Proceedings, vol. 570, LNBIP, pp. 281–297. Springer, Berlin, Germany, 2026.

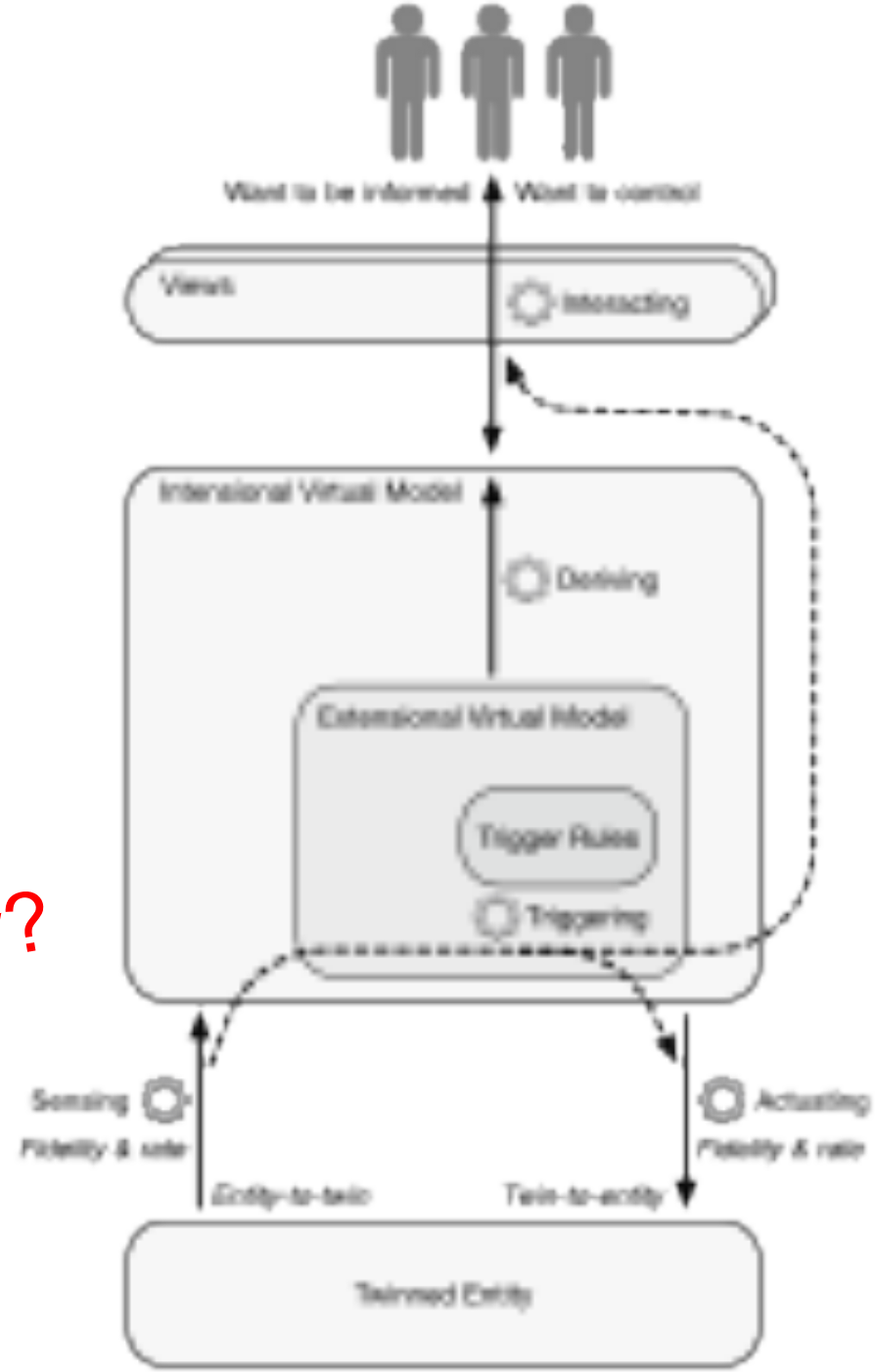
Digital Twin Functionalities



Marianne Schnellmann, Marija Bjeković, Henderik A. Proper, and Jean-Sébastien Sottet. "Towards Architectural Coordination of Digital Twin Development in Urban Planning". In: The Practice of Enterprise Modeling – 18th IFIP Working Conference, PoEM 2025, Geneva, Switzerland, December 3-5, 2025, Proceedings, vol. 570, LNBIP, pp. 281–297. Springer, Berlin, Germany, 2026.

Digital Twin Functionalities

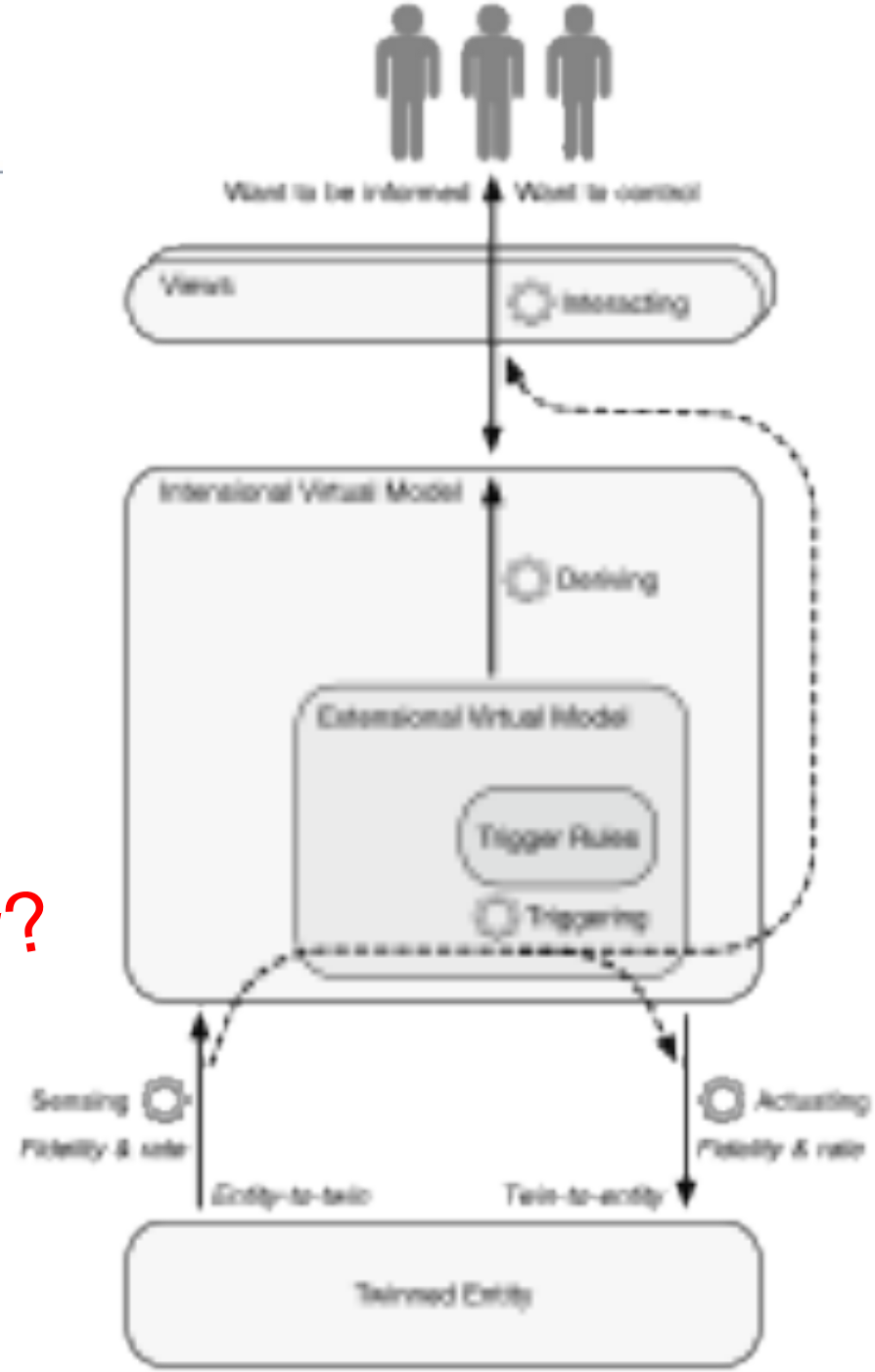
Costs, benefits, integration & synergy?



Generalised questions

Digital Twin | virtual model
fidelity & rate

Costs, benefits, integration & synergy?



Generalised questions

Digital Twin

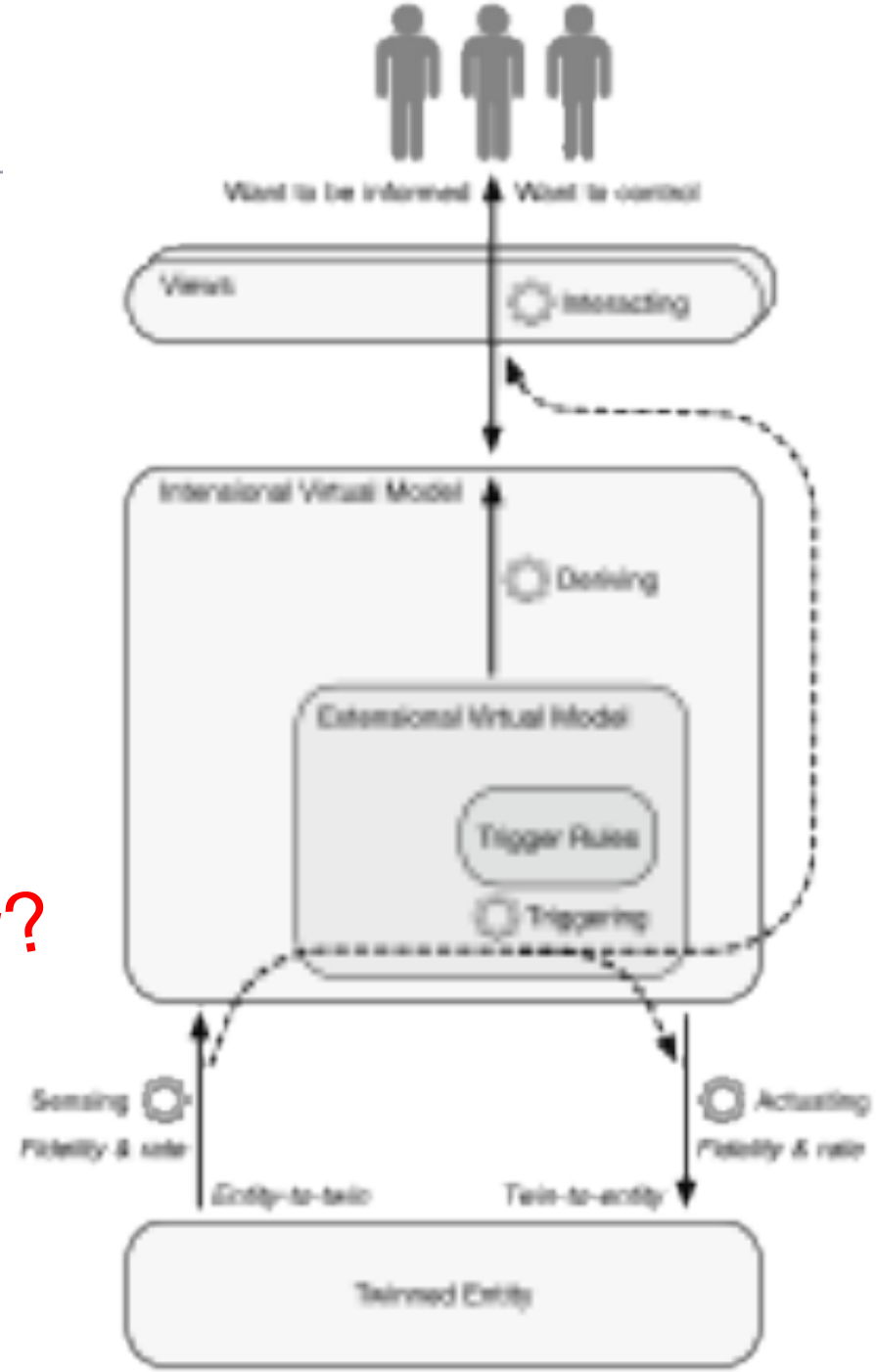
(MD)DSS

IS in general

virtual model fidelity & rate

RoME ViA RiME

Costs, benefits, Integration & synergy?



Henderik A. Proper and Giancarlo Guizzardi, "Modeling for Enterprises; Let's go to RoME-ViA-RiME". In: Proceedings of the Forum at Practice of Enterprise Modeling 2022 (PoEM-Forum 2022) co-located with PoEM 2022, London, UK, November 23-25, 2022, vol. 3327, CEUR Workshop Proceedings, pp. 4–15. CEUR-WS.org, 2023

Generalised questions

Costs, benefits, integration & synergy?

This paper

Two specialisations:

- DT based DS
- Building renovation, with sustainability as driver

This paper

DT based DS

- What is the context of the decision-making?
- What are the steps in building renovation?
- What is the decision-making process? *How*
- How are decisions made across these steps?
- Potential/Proven added value of DSS
- Uses cases of DT based DS?

Building renovation, with sustainability as driver

Building renovation for sustainability

EU's sustainability targets

85% of buildings in the EU were constructed before 2000

75% of these buildings have a poor energy performance

Globally; 90% of today's buildings will still be in use in 2050

Building renovation; Key types of activities

Operations & facility management

Condition assessment monitoring

Transformation planning

Each with its own potential for DT based DS

Research approach

Not intended as a full scale SLR

Focused on a first understanding of why, and how, DTs are used in a renovation context

```
“Digital Twin” AND “building renovation”
“Digital Twin” AND (“renovation” OR “retrofit” OR “refurbishment”)
“Digital Twin” AND (“value quantification” OR “RoI” OR “LCCA”)
```

enhanced with more synonyms
open to different views on what a DT is

Selection criteria

Be situated in the context of building renovation

Have relevance to DT functionality

Application, methodology, or evaluation of DT technology

In- and exclusion criteria

Academic papers as the primary body of literature

Only publications in (an) English

Generally published within the last 10–12 years

Supplemented by selected industry reports from reputable organisations for additional practical insights

Analysis

Iterative development of a framework of (renovation specific) DT functionalities (focus: operations & facility management)

Relevant categories of added value of DT functionality towards the decision-making processes

Attempt to identify ways to qualify, or even quantify, the added value

Framework; Operations & facility management

Four main DT functionalities in use:

1. Real-time monitoring of environmental and system parameters
2. Continuously processing live data streams
3. Performance simulation
4. Statistical and/or ML model based forecasting

Framework; Operations & facility management

Used across five main use cases:

1. Predictive maintenance
2. Real-time monitoring and anomaly detection
3. Energy performance simulation and analysis
4. Occupancy & space-utilisation analytics
5. Safety risk management

Reported (mostly claimed) added value for DT

Direct added value, such as:

- Reduced energy consumption
- Lower maintenance costs

Indirect value streams, such as:

- Preventive maintenance
- Pro-active performance optimisation

Quantifying added value

Requires some kind of "*economic framework*"

Primary candidates for further investigation, in the context of building renovation:

- Life Cycle Cost Analysis (LCCA) evaluates long-term ownership and operational costs
- Return on Investment (RoI) assesses benefits relative to DT costs

Quantifying added value

Requires some kind of "*economic framework*"

Future work; "*The information-economy of decision making*"

- What are the benefits/costs of more/better data
- What are the benefits/costs of more/better ways for humans to "glean" relevant information from the data?

Risk/opportunity driven approach:

- *What goes-wrong/is-missed if … a wrong decision is made?*

Concluding remarks …

ChatGPT: "*Digital Twins can support more informed and sustainable renovation decisions, but their value must be understood beyond technological novelty*"

Main open (generic & specialisation) challenges:

- *How do we rigorously assess the information-economic value of (DT-based, AI-powered, data-driven) decision support?*
- *Architectural coordination of the development of such systems to enable integration and synergy with the other parts of the information architecture*