



Business Informatics Group

# Demand-driven, and Architecturally Coordinated, Development of Digital Twins

Henderik A. Proper

TU Wien, Vienna, Austria

**MIDas4CS**

4th Workshop on the Modelling and Implementation of  
Digital Twins for Complex Systems





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LUXEMBOURG  
INSTITUTE OF SCIENCE  
AND TECHNOLOGY



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# Towards Demand-driven, and Architecturally Coordinated, Development of Digital Twins

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# MIDas4CS

4th Workshop on the Modelling and Implementation of  
**Digital Twins** for Complex Systems

# Digital Twins

Lots of “bling bling”



# Digital Twins

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Lots of “*bling bling*” and then there are “LLMs”  
as the *blingiest bling* of all



# Digital Twins

Lots of “bling bling” and then there are “LLMs”  
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# Digital Twins



Lots of “*bling bling*” and then there are “LLMs” as the *blingiest bling* of all

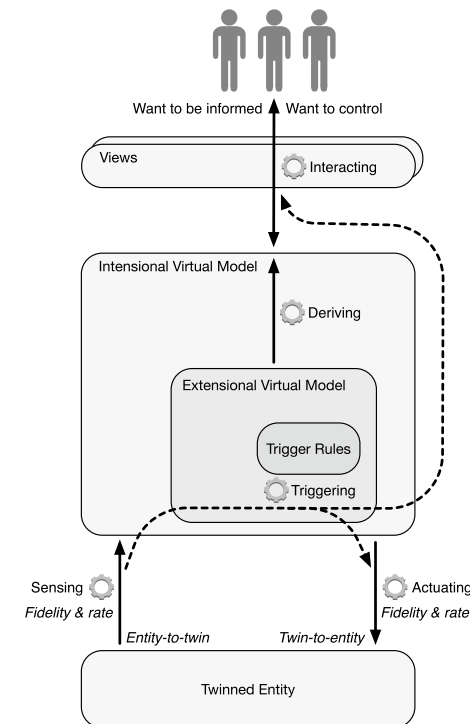
So ...

- *What does it cost? (CapEx + OpEx)*
- *What does it bring?*

*Integration and synergy with the “rest” of the enterprise 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.

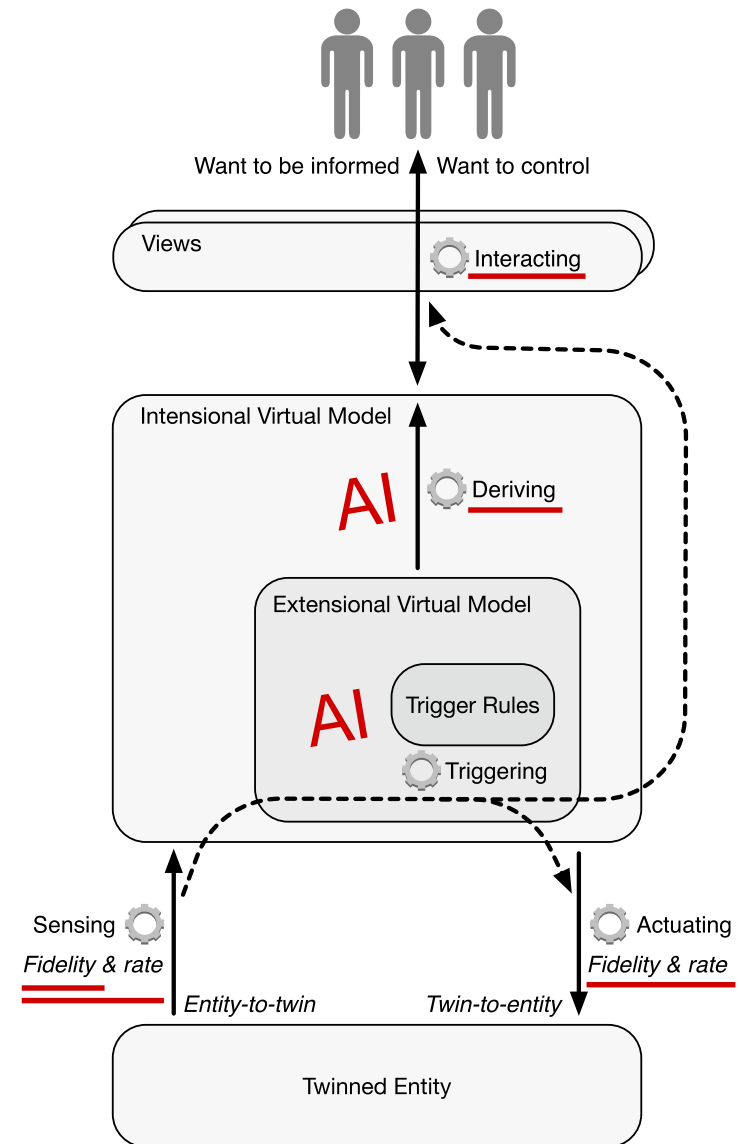
# Digital Twin functionalities

Digital Model

Digital Shadow

Digital Twin

Digital Bling 😊



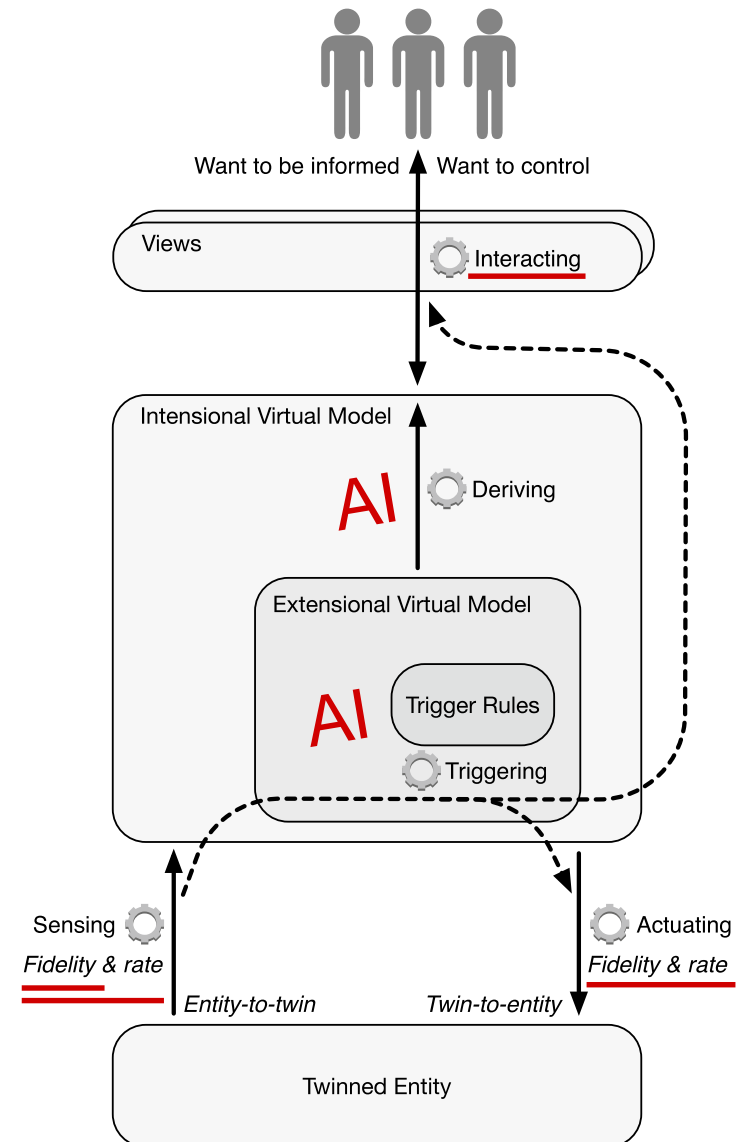
# Digital Twin functionalities

Digital Model

Digital Shadow

Digital Twin

Digital Decision Workbench

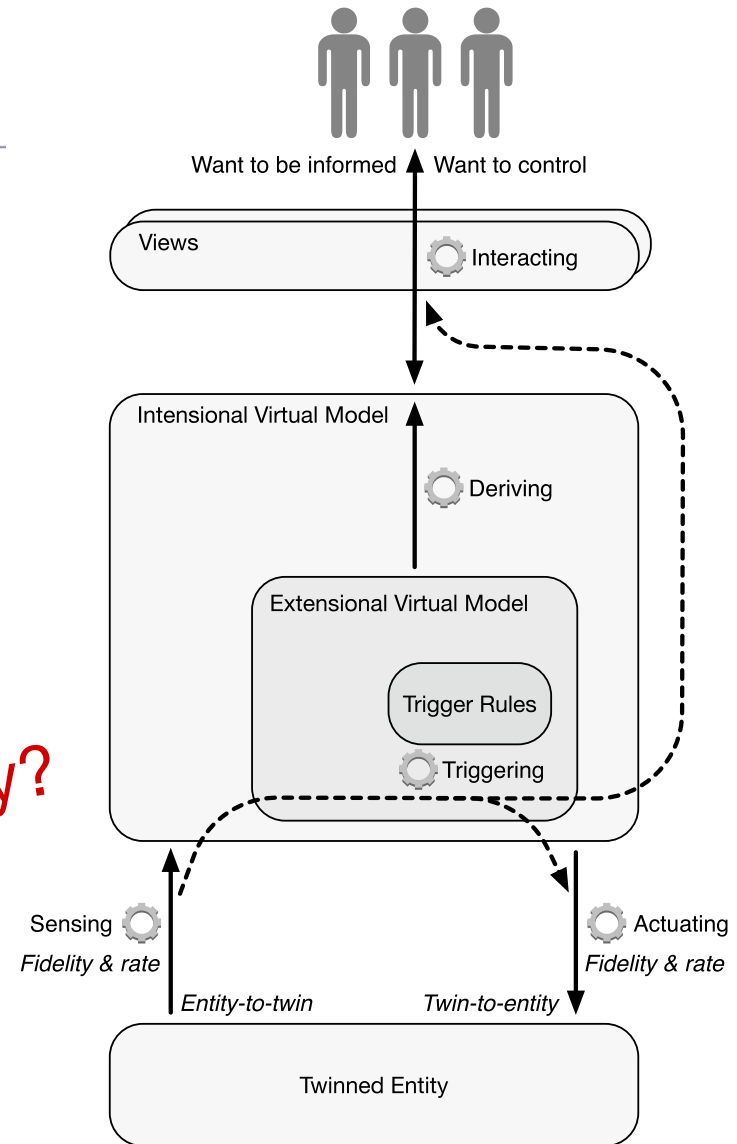


# Generalised questions

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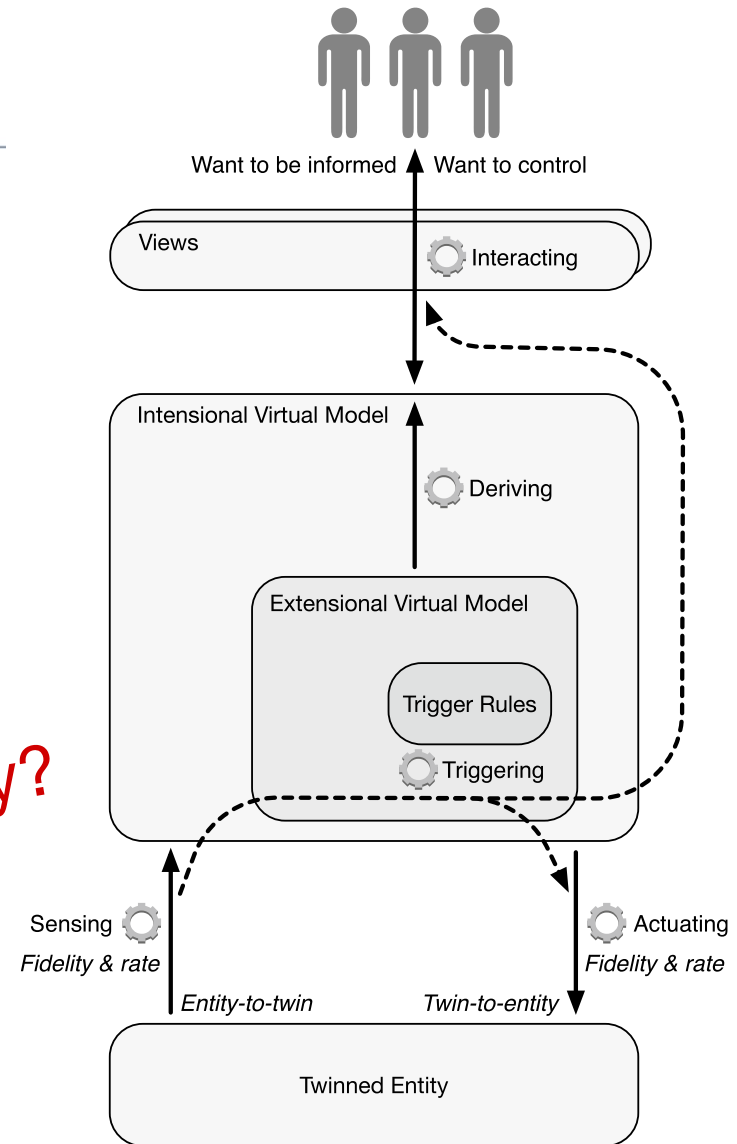
Costs, benefits, integration & synergy?  
Enterprise architecture?



# Generalised questions

Digital Twin | virtual model  
DDW | fidelity & rate

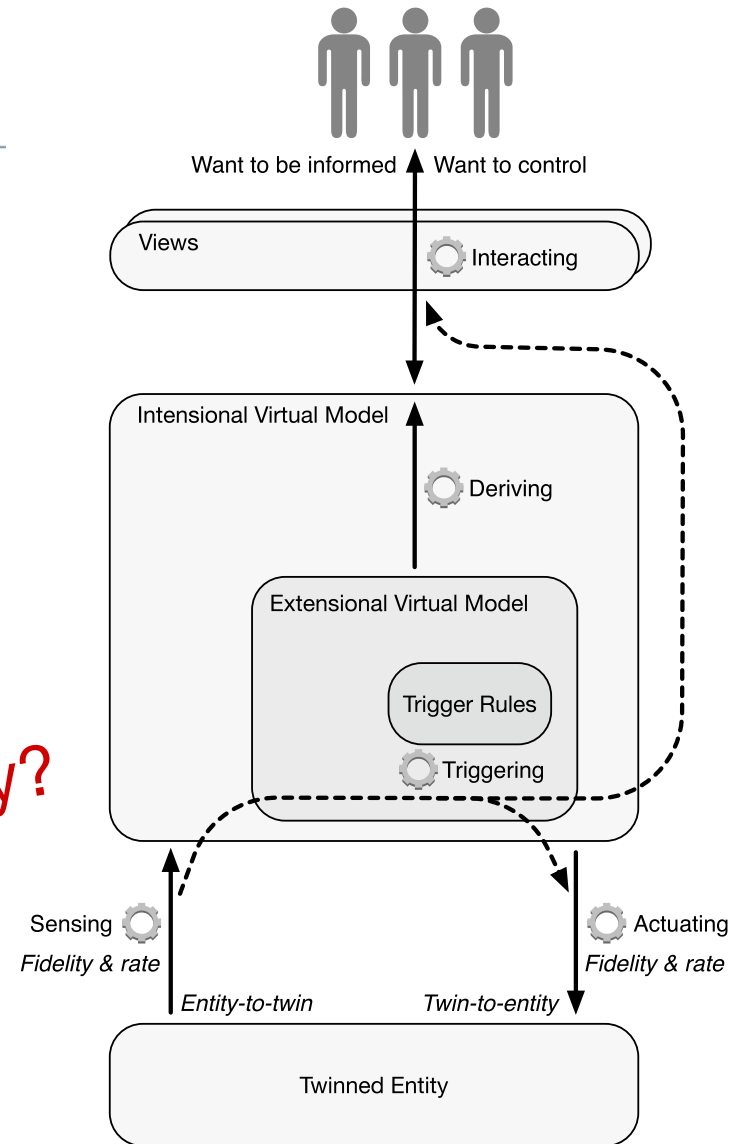
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# Generalised questions

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# Generalised questions

Digital Twin  
DDW

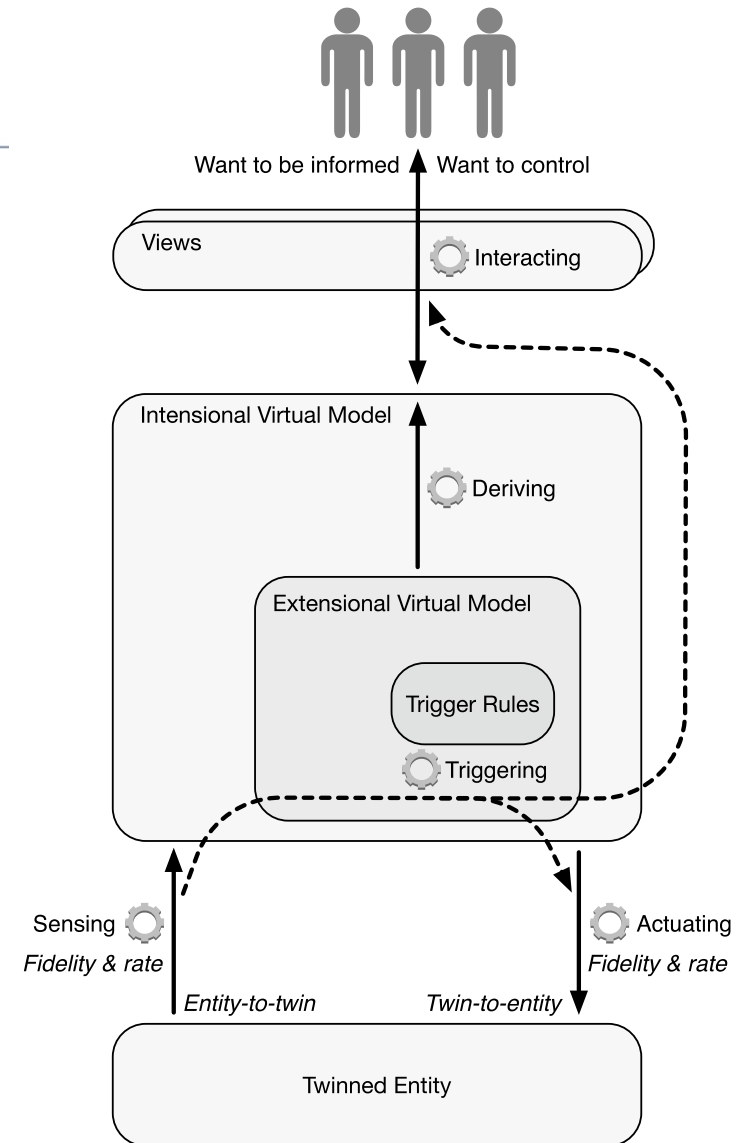
model  
fidelity & rate

(MD)DSS

IS in general

RoME ViA RiME

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

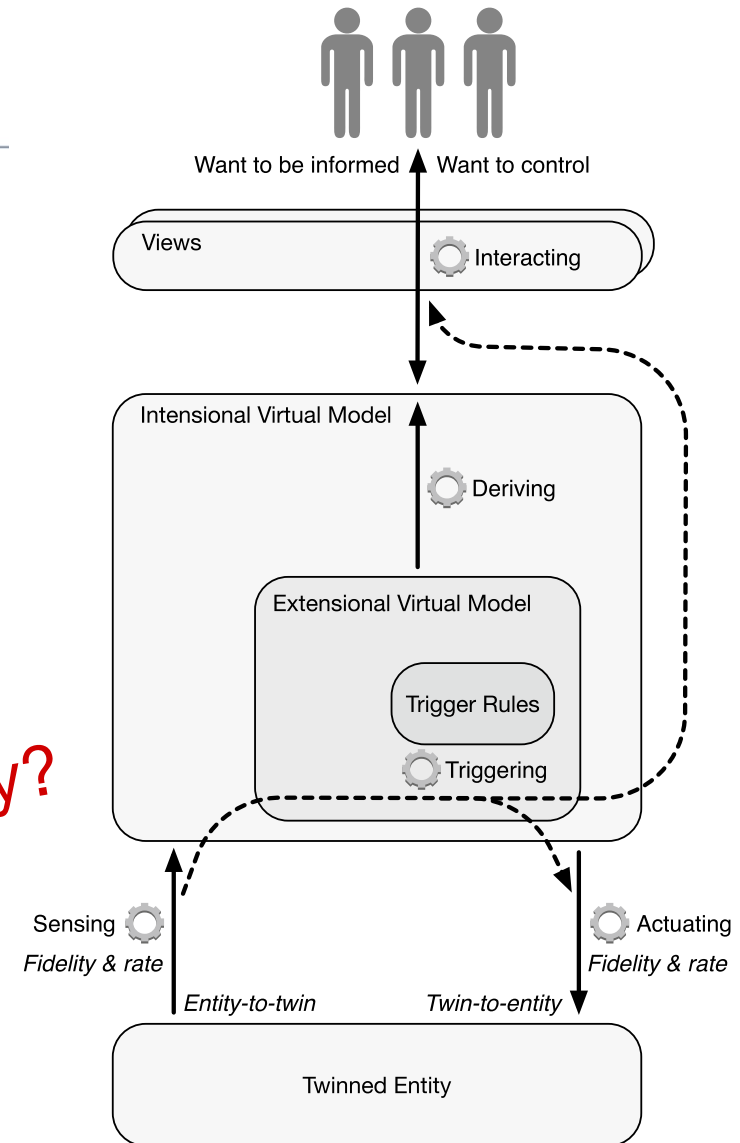
Digital Twin  
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IS in general

Costs, benefits, integration & synergy?  
Enterprise architecture!



## Remaining agenda

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Planning challenges for Digital Twins

Understanding the benefits of Digital Twins

Architectural Coordination of Digital Twin development

## Remaining agenda

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▶ Planning challenges for Digital Twins

Understanding the benefits of Digital Twins

Architectural Coordination of Digital Twin development

# Some planning challenges for Digital Twins

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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, LNBI, pp. 281–297. Springer, Berlin, Germany, 2026.

Marianne Schnellmann, and Henderik A. Proper. "From Gut Feeling to Data-Driven Decisions: Exploring Digital Twin supported Decision-Making for Real Estate Management". To be presented, tomorrow, at CAiSE 2026.

# Some planning challenges for Digital Twins

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Ad-hoc & isolated development

Lack of user awareness & engagement

Fragmented & complex data ecosystems

Potential for synergies in the IT landscape

Data collection and integration

*Costs, benefits, integration & synergy?  
Needs architectural coordination ...*



## Remaining agenda

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Planning challenges for Digital Twins

- ▶ Understanding the benefits of Digital Twins

Architectural Coordination of Digital Twin development

## **Added value of DT-based decision support**

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A Digital Twin in the role of a Digital Decision Workbench

Decision-making: taking, executing, monitoring, evaluating

Added value of more/better data to support decision-making?

Added value of actuating changes back to the twinned entity?

Added value of advanced interaction to enable users to be better informed by the available data?

# Added value of DT-based decision support

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## Exploring:

- Marianne Schnellmann, and Henderik A. Proper. "From Gut Feeling to Data-Driven Decisions: Exploring Digital Twin supported Decision-Making for Real Estate Management". To be presented, tomorrow, at CAiSE 2026.
- Callista Raschauer, Marianne Schnellmann, and Henderik A. Proper. "Digital Twins for Building Renovation – What is the Added Value?". In: Research Challenges in Information Science, pp. 596–611. Springer, 2026.
- and more to come, including RoME work

# Added value of DT-based decision support

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## 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 are decisions made across these steps?
- Potential/Proven added value of DT?
- Uses cases of DT based DS?

## Building renovation, with sustainability as driver

Callista Raschauer, Marianne Schnellmann, and Henderik A. Proper. "Digital Twins for Building Renovation – What is the Added Value?". In: Research Challenges in Information Science, pp. 596–611. Springer, 2026.

## Reported (mostly claimed) added value for DT

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Direct added value, such as:

- Reduced energy consumption
- Lower maintenance costs

Indirect value streams, such as:

- Preventive maintenance
- Pro-active performance optimisation

Callista Raschauer, Marianne Schnellmann, and Henderik A. Proper. "Digital Twins for Building Renovation – What is the Added Value?". In: Research Challenges in Information Science, pp. 596–611. Springer, 2026.

## Q&Q-ing the added value

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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

Callista Raschauer, Marianne Schnellmann, and Henderik A. Proper. "Digital Twins for Building Renovation – What is the Added Value?". In: Research Challenges in Information Science, pp. 596–611. Springer, 2026.

## Q&Q-ing the 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?*

## Remaining agenda

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Planning challenges for Digital Twins

Understanding the benefits of Digital Twins

▶ Architectural Coordination of Digital Twin development

# Architectural coordination

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Enterprise transformation (intra & inter)

Involves many change initiatives cutting across the “business-to-IT stack”

Ideally in line with the overall business strategy ...

How to coordinate these initiatives?

How to ensure their alignment?

How to govern the portfolio of change initiatives?

How to engage the relevant stakeholders?

## Some planning challenges for Digital Twins

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Ad-hoc & isolated development

Lack of user awareness & engagement

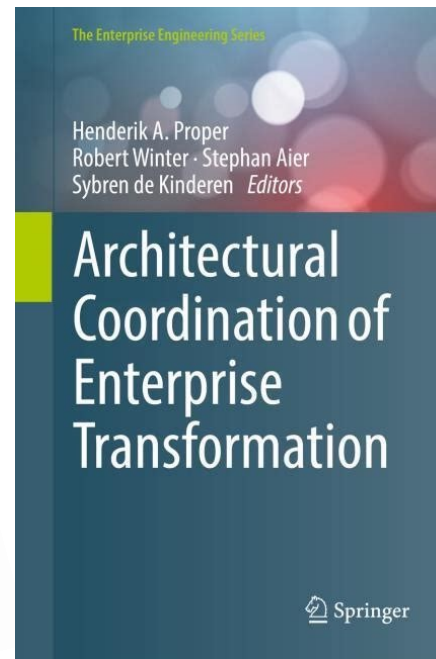
Fragmented & complex data ecosystems

Potential for synergies in the IT landscape

Data collection and integration

# Architectural coordination

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# Architectural coordination; Typical artefacts used

(ArchiMate) models

Views, views, views, ...

Architecture principles

Business cases

(Needs-driven) roadmaps



# Architectural coordination; Digital Twin development

What is the context of the decision-making?

What is the decision-making process?

Expected/achieved added value of the DT (DDW)

Integration and synergy

Functionalities, fidelity, rates



# Architectural coordination; Digital Twin development

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What is the context of the decision-making?

Motivation extension

What is the decision-making process?

Business layer

Expected/achieved added value of the DT (DDW)

Add: Cost / benefits extension

Integration and synergy

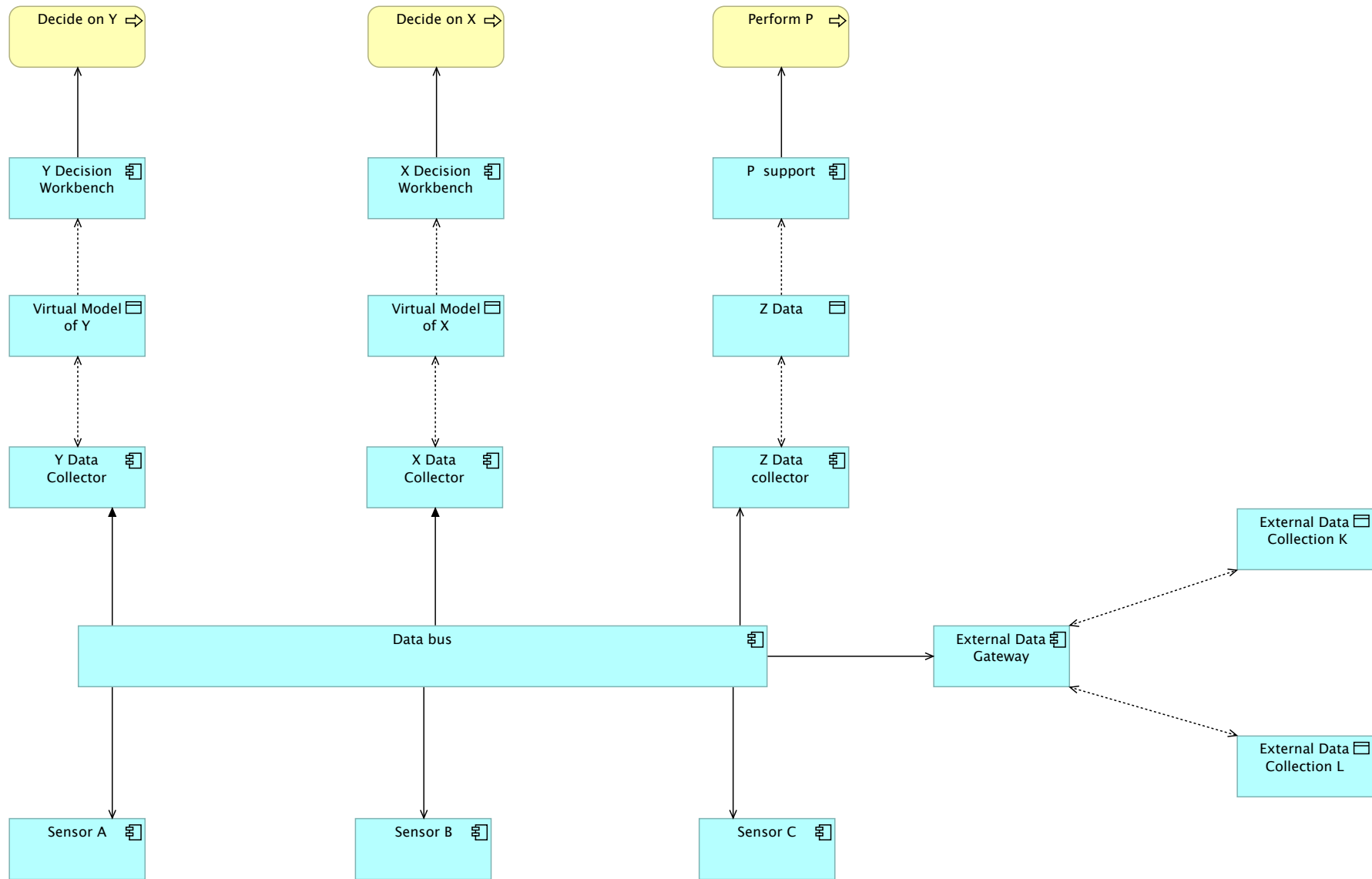
Application & technology layer

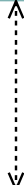
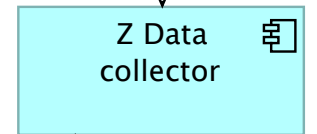
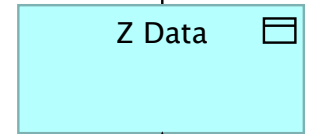
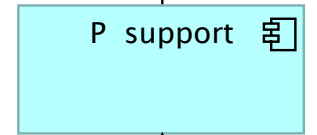
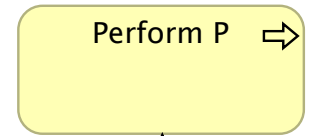
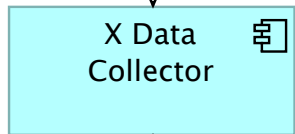
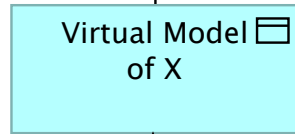
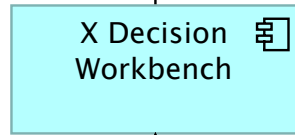
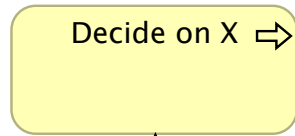
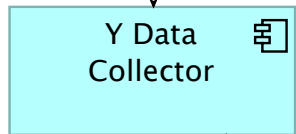
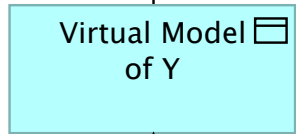
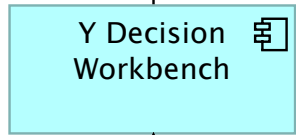
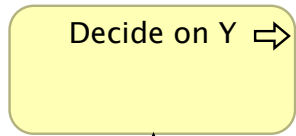
Functionalities, fidelity, rates

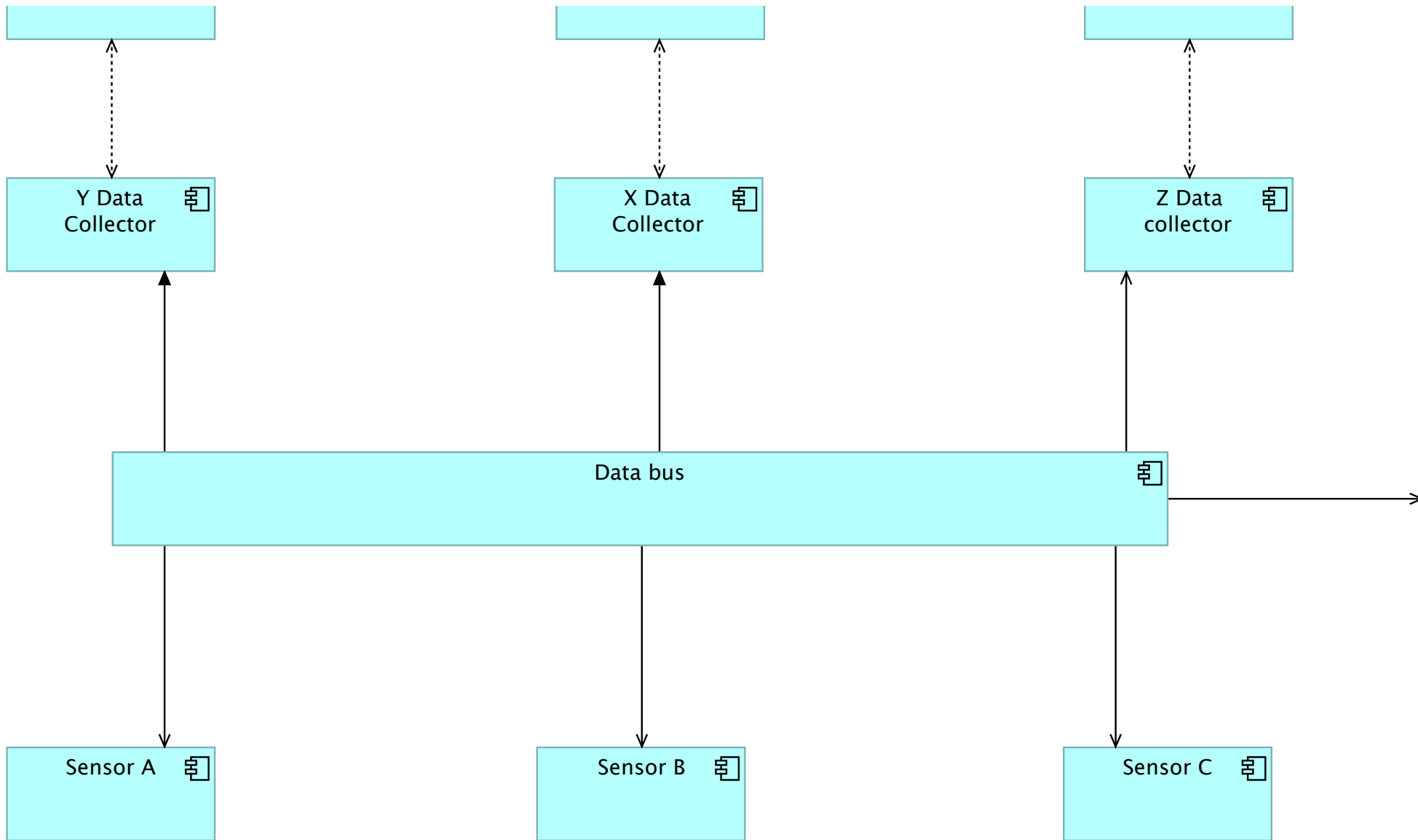
Add: Cost / benefits extension

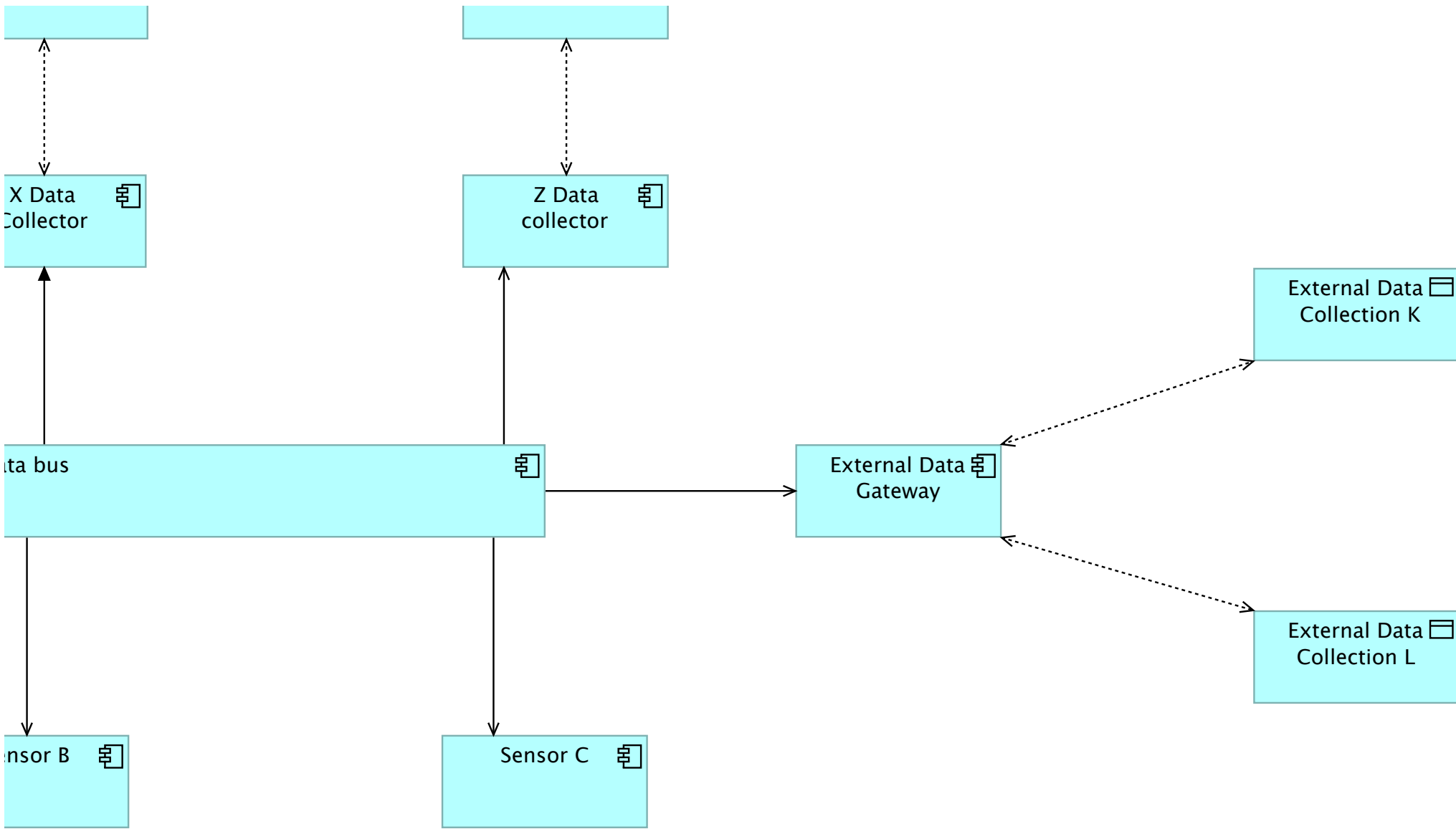
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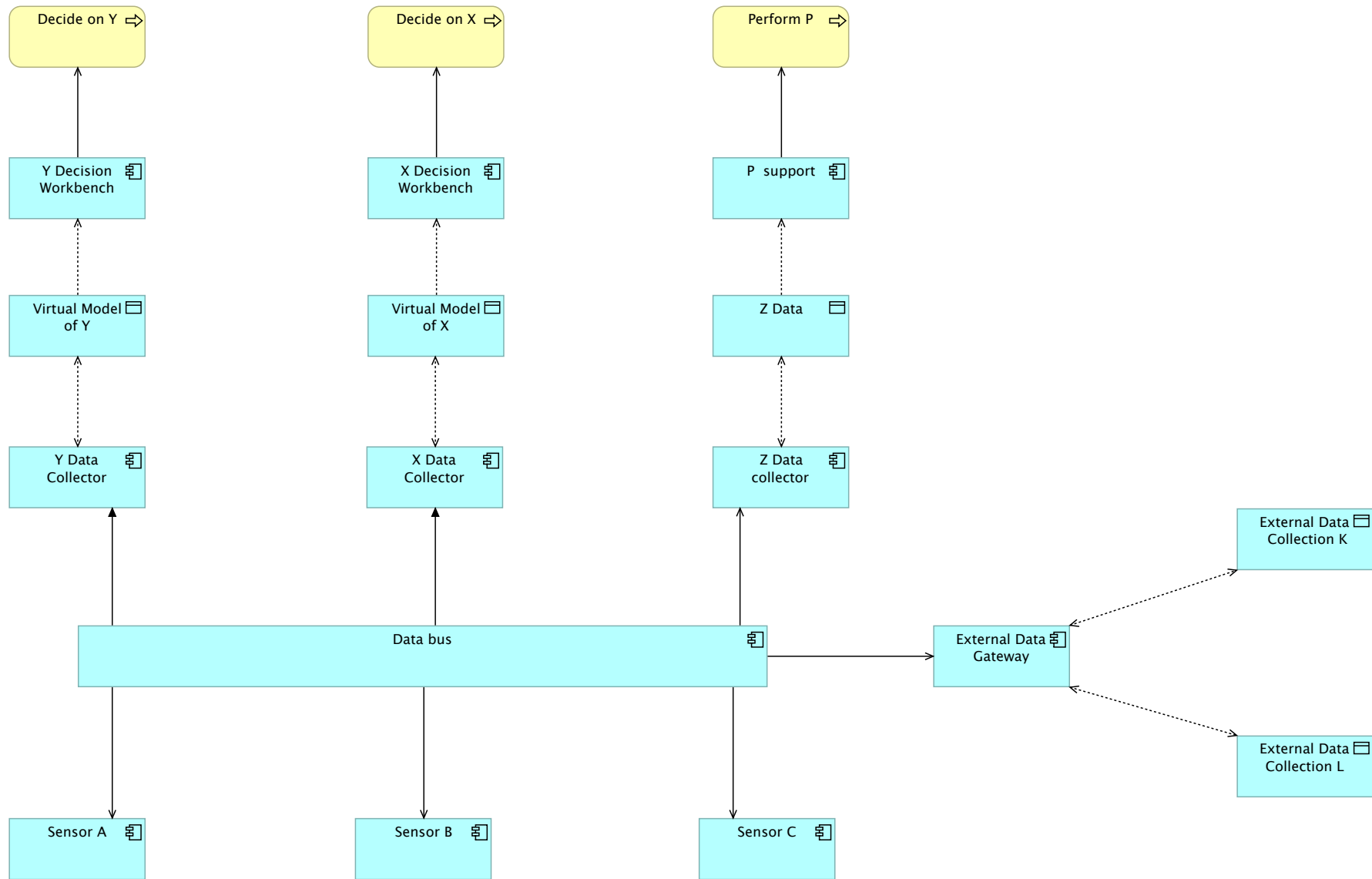


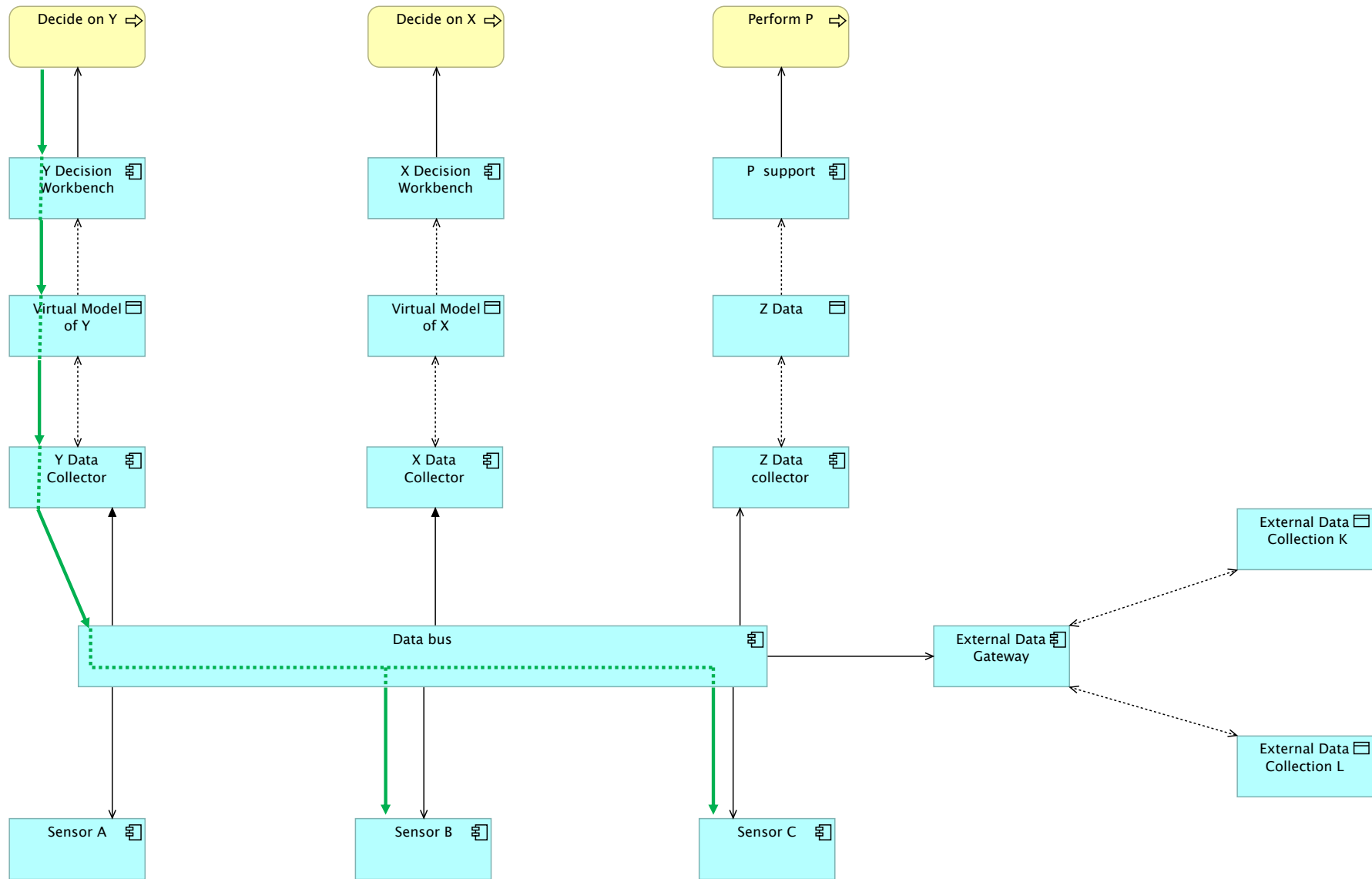


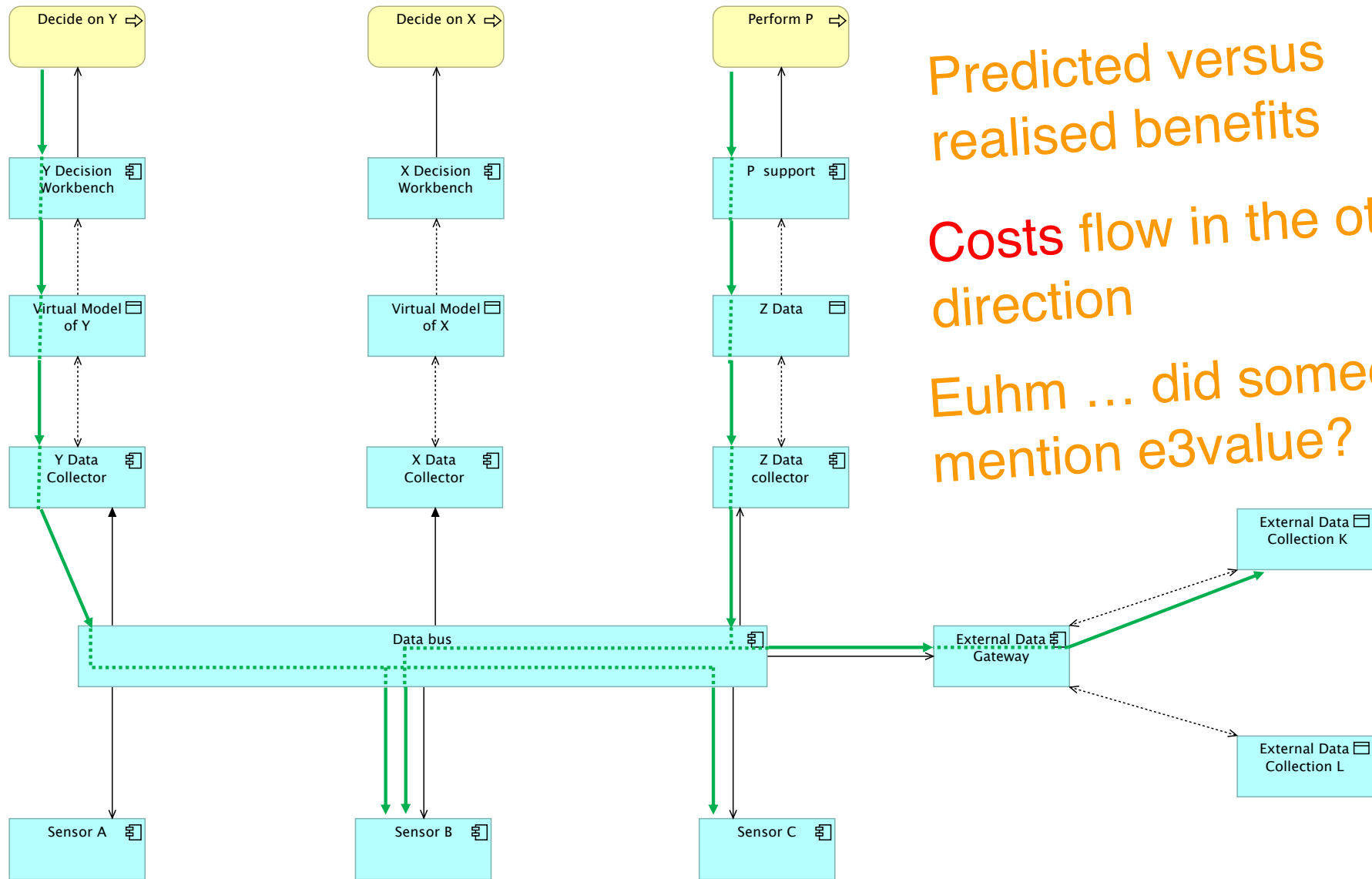












Predicted versus realised benefits

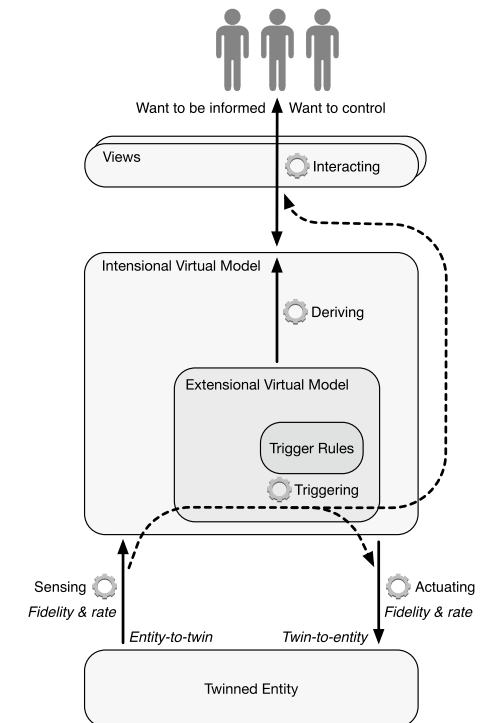
Costs flow in the other direction

Euhm ... did someone mention e3value?

# Digital Twin functionalities; Revisited

Treat the functionalities as components in the architecture, with qualities in line with the need for decision-making support

As a corollary to this ... why not grow/reduce the coverage and depth of DT related functionality based on actual needs and realised benefits?



## Key topics

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Need for a demand-driven perspective on DT development

A functionalities oriented perspective on Digital Twins

Planning challenges for Digital Twins

Understanding the benefits of Digital Twins (as DDW)

Architectural Coordination for DT development

*Need to architectural coordination?*

*Business case for digital twins?*

## **Discussion ...**

*The information-economy of decision making?*

*Cost/benefit propagation in EA models?*