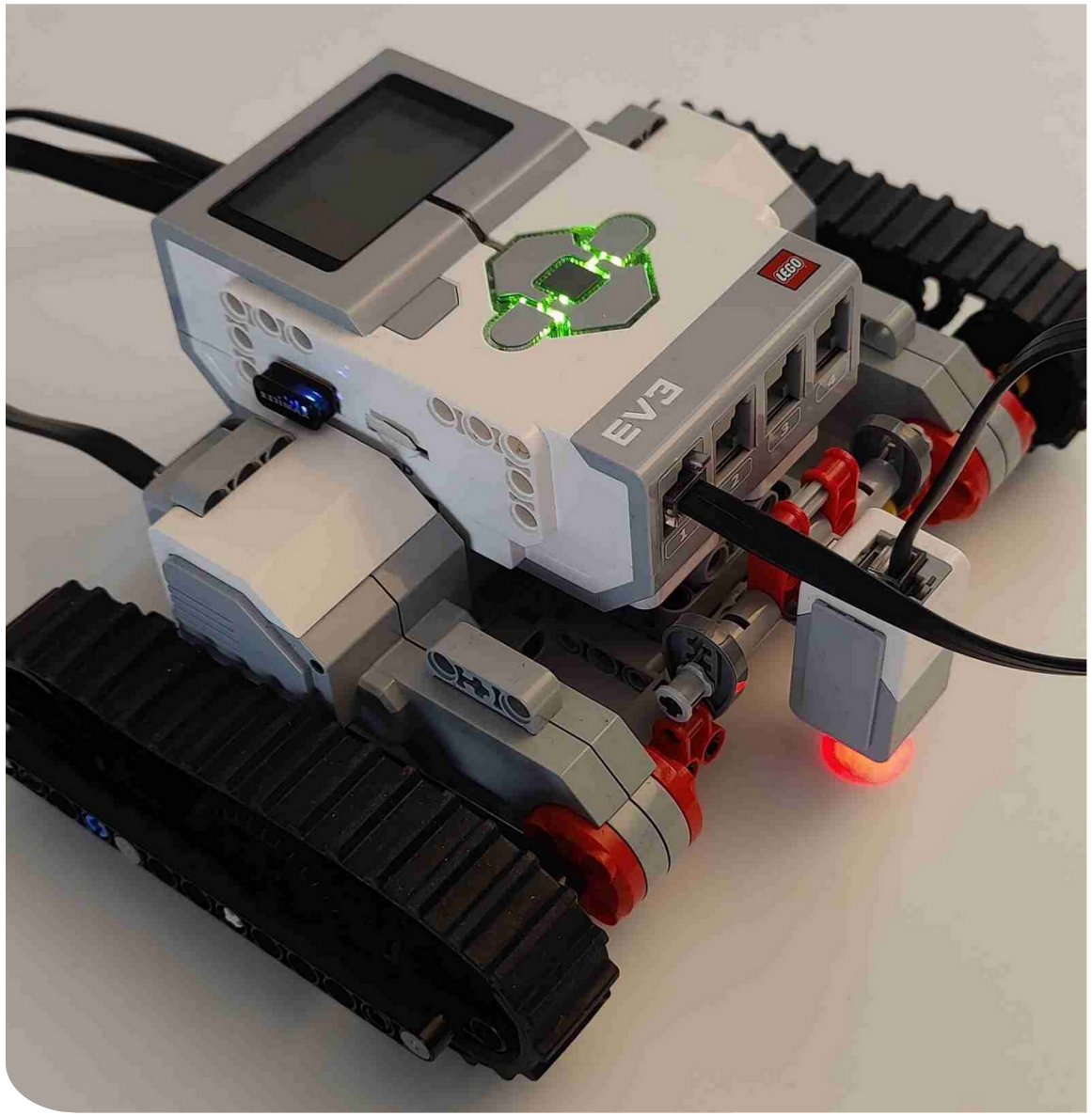
University of Antwerp

EXTENDING THE FTG+PM

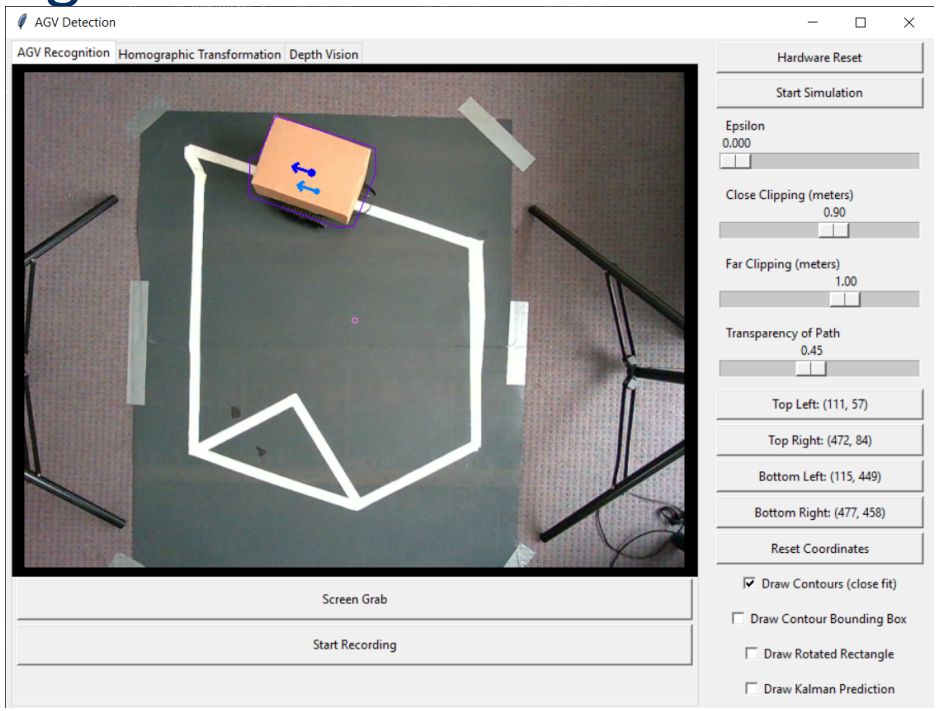
LFR Workflow Modelling

Arkadiusz Ryś, Randy Paredis Model Based Systems Engineering 2022-06-14



Line Following Robot (LFR) Use Case

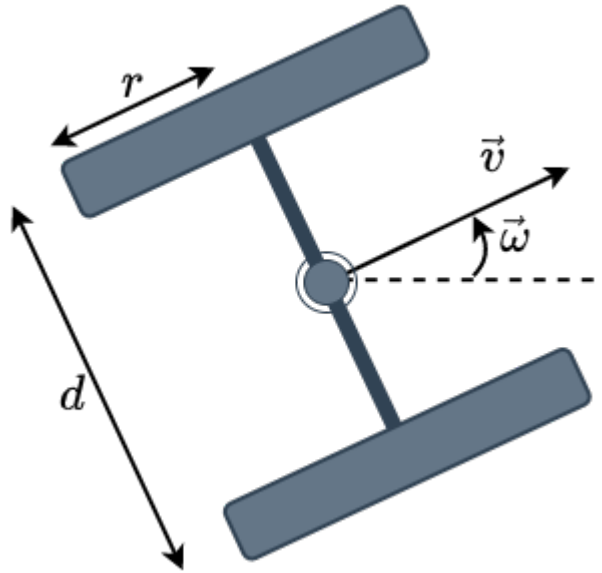
- Follows line on the ground
- Digital Shadow



Kritzinger, W., M. Karner, G. Traar, J. Henjes, and W. Sihn. 2018. "Digital Twin in Manufacturing: A Categorical Literature Review and Classification". IFAC-PapersOnLine vol. 51 (11), pp. 1016-1022.

Line Following Robot (LFR) Use Case

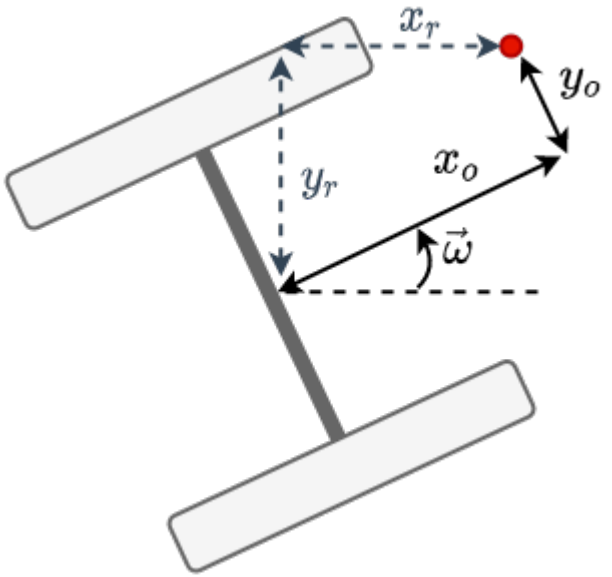
- Wheel radius
- Wheel distance
- Velocity
- Heading



$$\dot{\psi}_L = \frac{1}{r}\left(\dot{v} - \frac{\dot{\omega}\cdot d}{2}\right) \qquad \dot{\psi}_R = \frac{1}{r}\left(\dot{v} + \frac{\dot{\omega}\cdot d}{2}\right)$$

Line Following Robot (LFR) Use Case - Offset

- Wheel radius
- Wheel distance
- Velocity
- Heading
- X-axis offset
- Y-axis offset

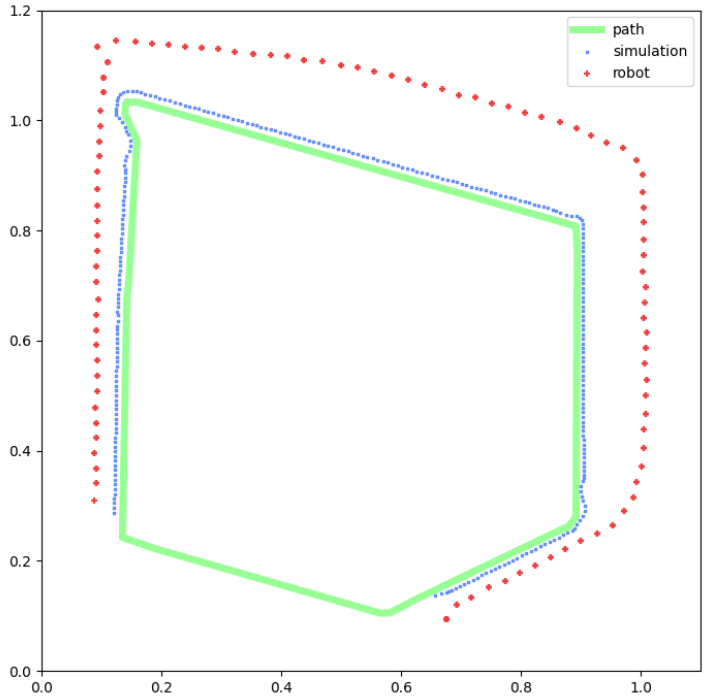


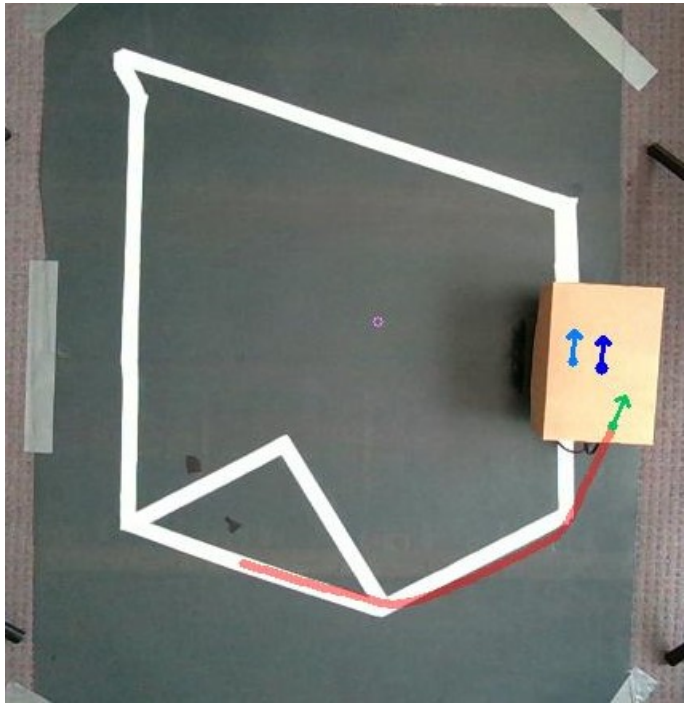
$$\dot{\psi}_L = \frac{1}{r}\left(\dot{v} - \frac{\dot{\omega}\cdot d}{2}\right) \qquad \dot{\psi}_R = \frac{1}{r}\left(\dot{v} + \frac{\dot{\omega}\cdot d}{2}\right)$$

Design Iterations

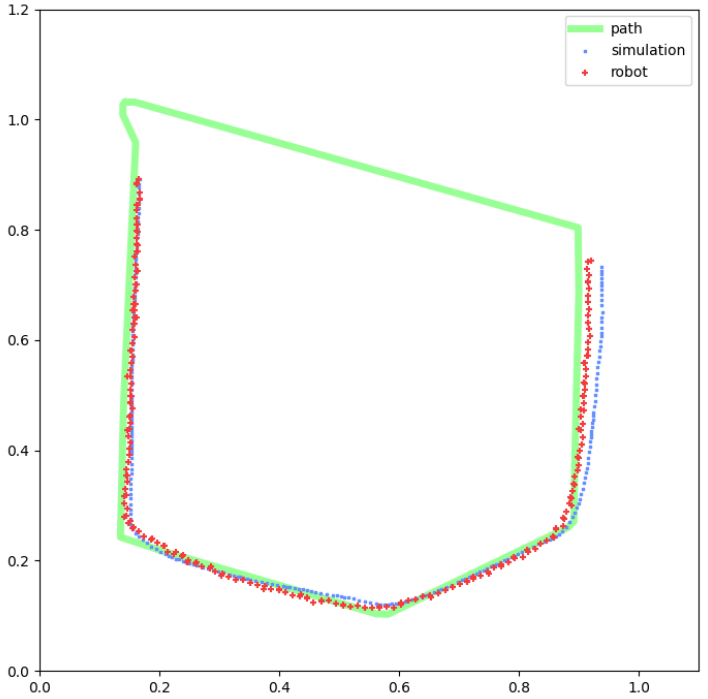
Models of different complexity describing the same system

Initial Version A





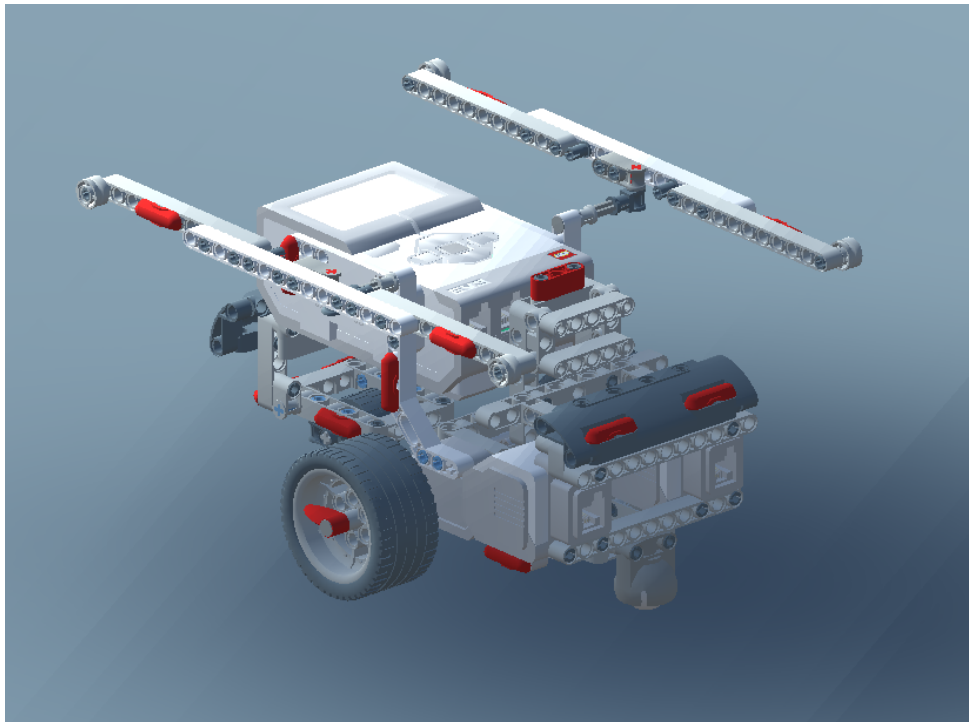
Optimized Version B



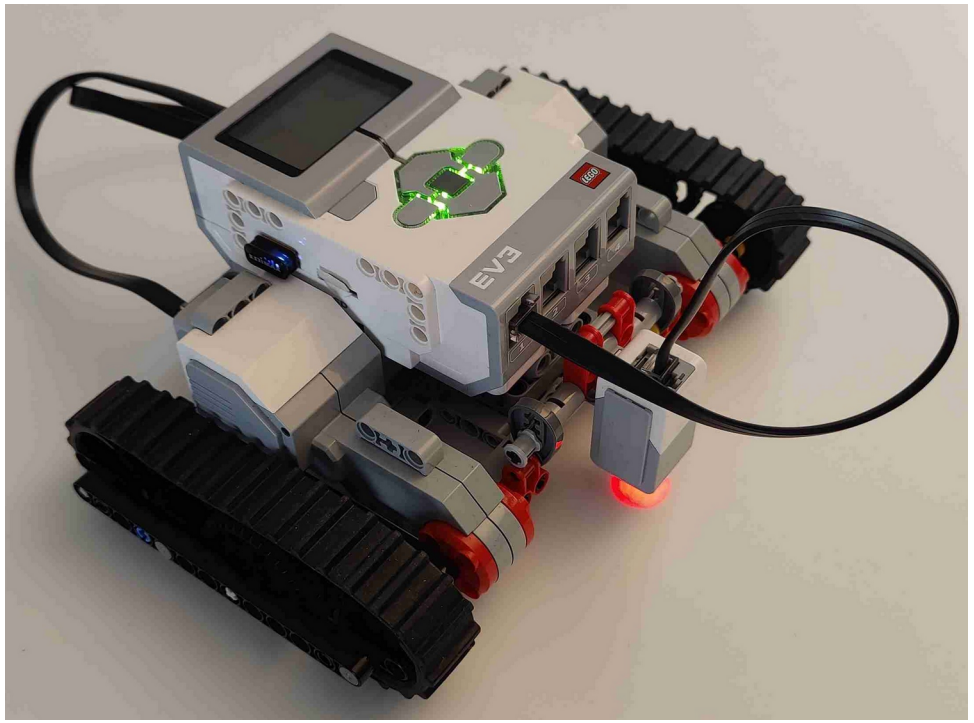
Design Iterations

Models of different complexity describing the same system

Initial Version A



Optimized Version B



Line Following Robot (LFR) Use Case - Query

- **Wheel radius**
- **Wheel distance**
- **Velocity**
- **Heading**
- **X-axis offset**
- **Y-axis offset**

```
SELECT * FROM ARTIFACTS AS art WHERE
art.metamodel CONFORMS TO trace:"heading"
```

	A	B	C	D
1	time	x	y	heading
596	118.8	0.215843	-0.29999	0.677788
597	119	0.216126	-0.29976	1.302247
598	119.2	0.216222	-0.29941	1.599066
599	119.4	0.216212	-0.29904	1.46084
600	119.6	0.216252	-0.29868	1.124072
601	119.8	0.216409	-0.29836	0.877111
602	120	0.216641	-0.29808	0.865045
603	120.2	0.216877	-0.2978	1.027622
604	120.4	0.217065	-0.29749	1.198563
605	120.6	0.217197	-0.29715	1.255207
606	120.8	0.21731	-0.2968	1.190118
607	121	0.217445	-0.29647	1.084936
608	121.2	0.217614	-0.29615	1.025846
609	121.4	0.217803	-0.29583	1.041682
610	121.6	0.217986	-0.29552	1.099589
611	121.8	0.218151	-0.2952	1.146234
612	122	0.218301	-0.29487	1.151624
613	122.2	0.218449	-0.29453	1.123763
614	122.4	0.218606	-0.29421	1.092062
615	122.6	0.218773	-0.29388	1.080216
616	122.8	0.218944	-0.29356	1.090973

Context is important

while managing data/information/knowledge

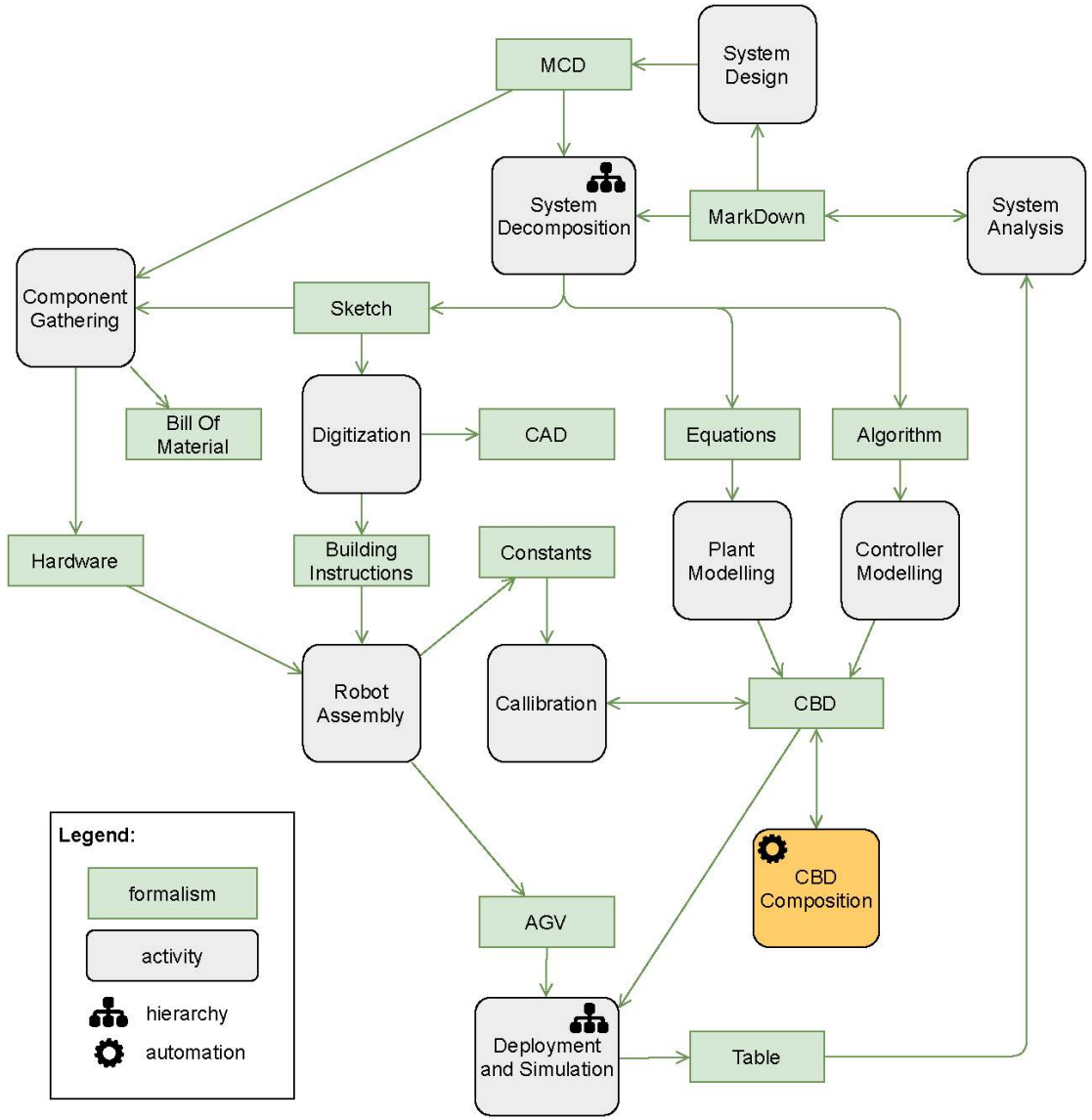
- **Types**
- **Relationships**
- **Properties**
- **Workflows**

Formalism Transformation Graph (FTG)

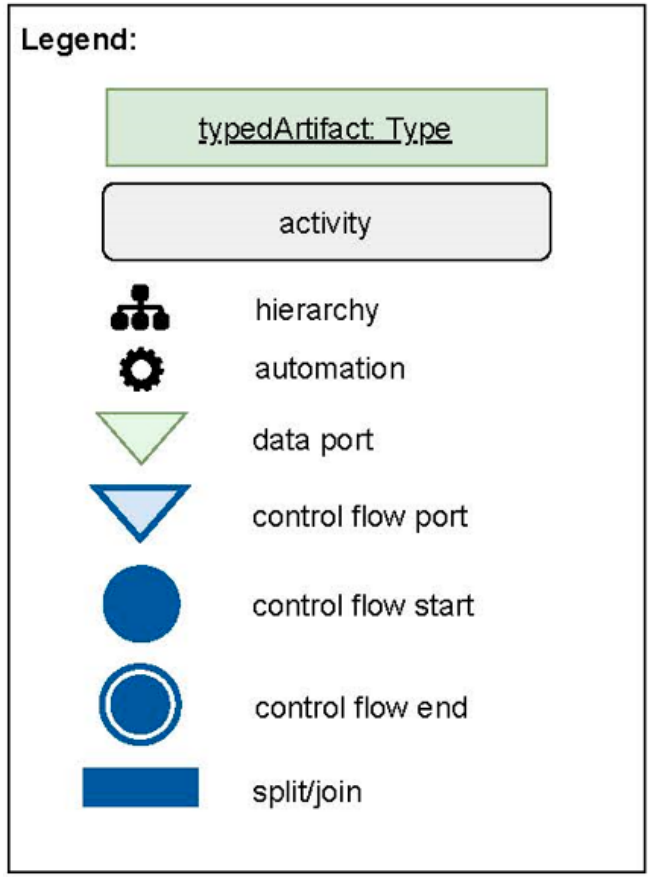
Process Model (PM)

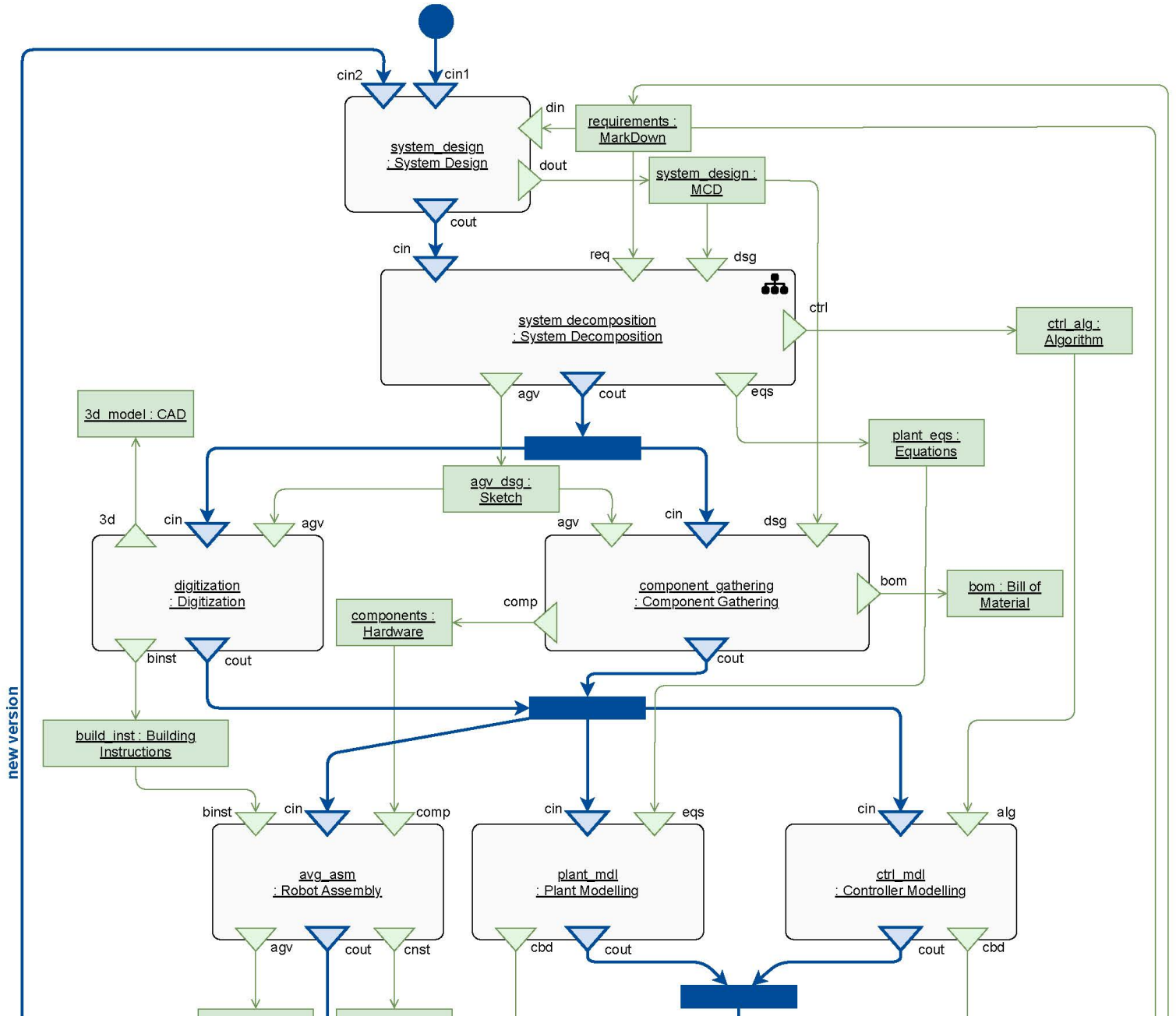
Process Trace (PT)

Formalism Transformation Graph

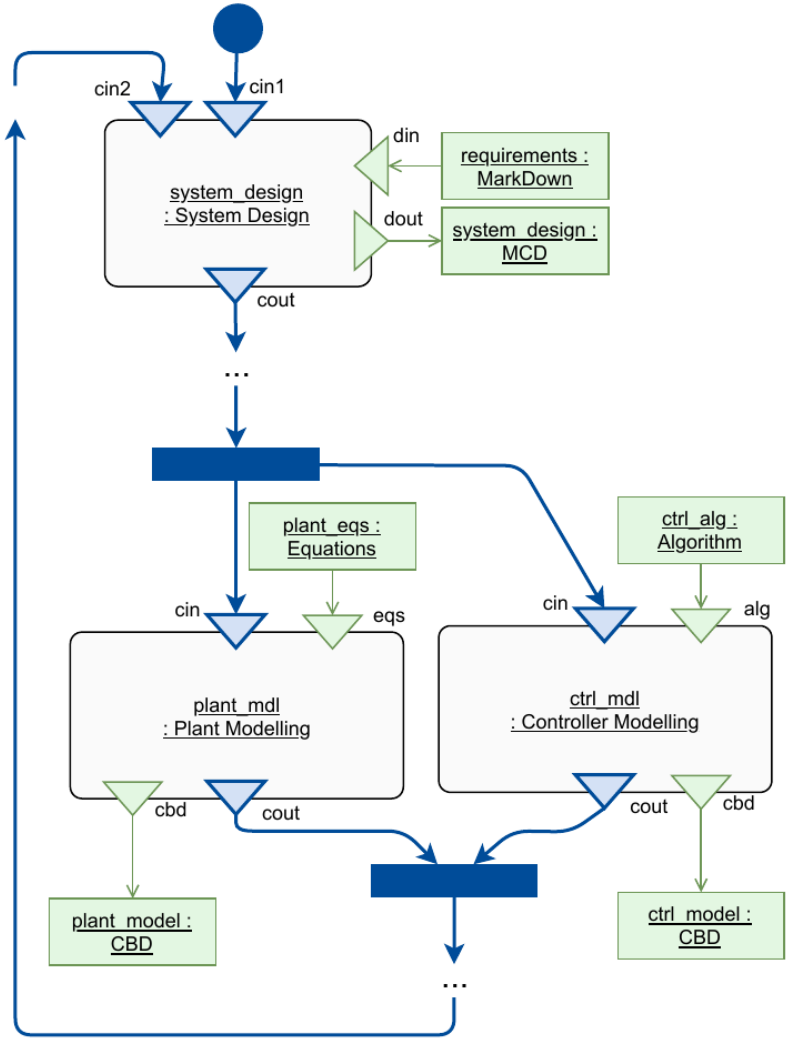


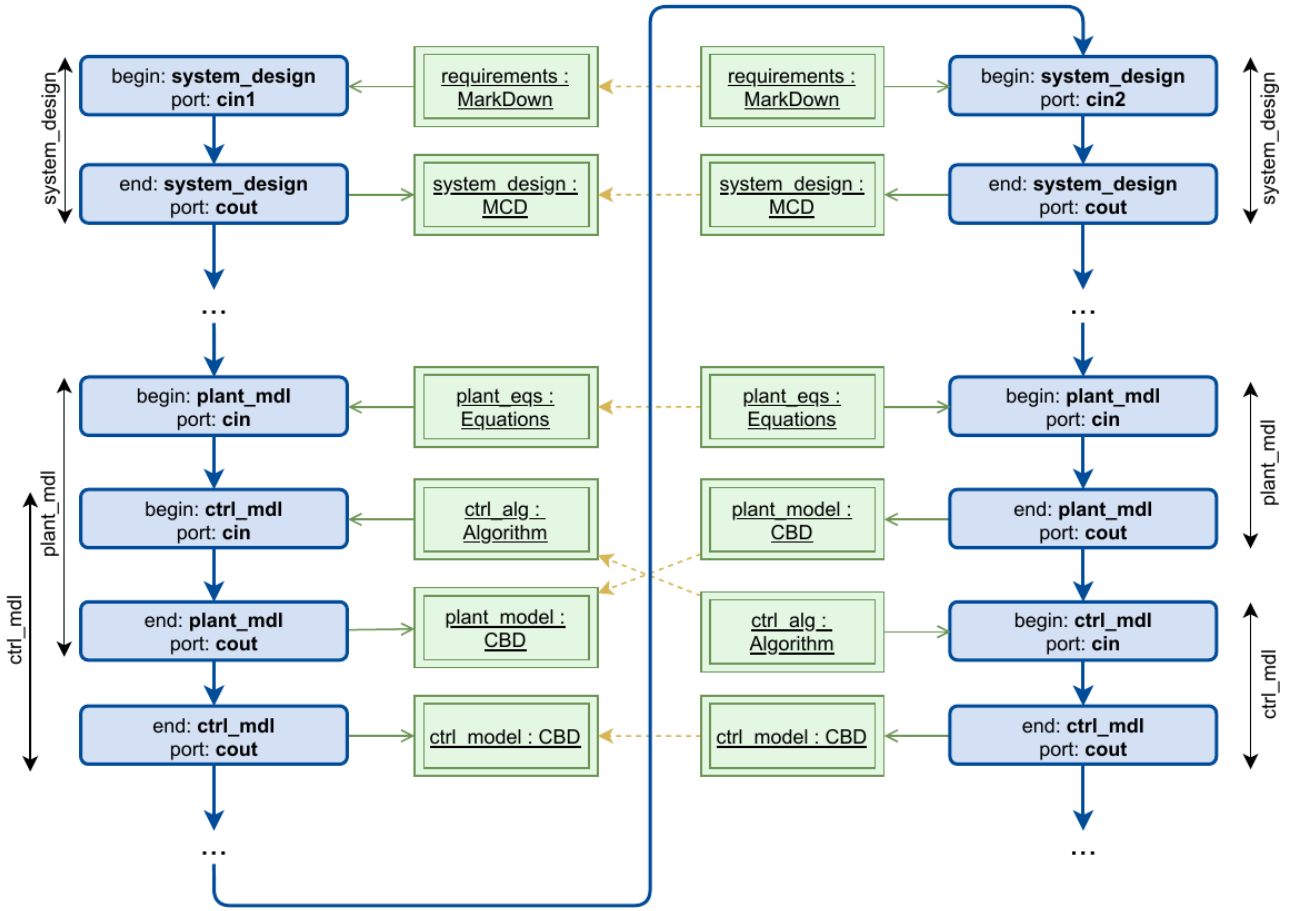
Process Model



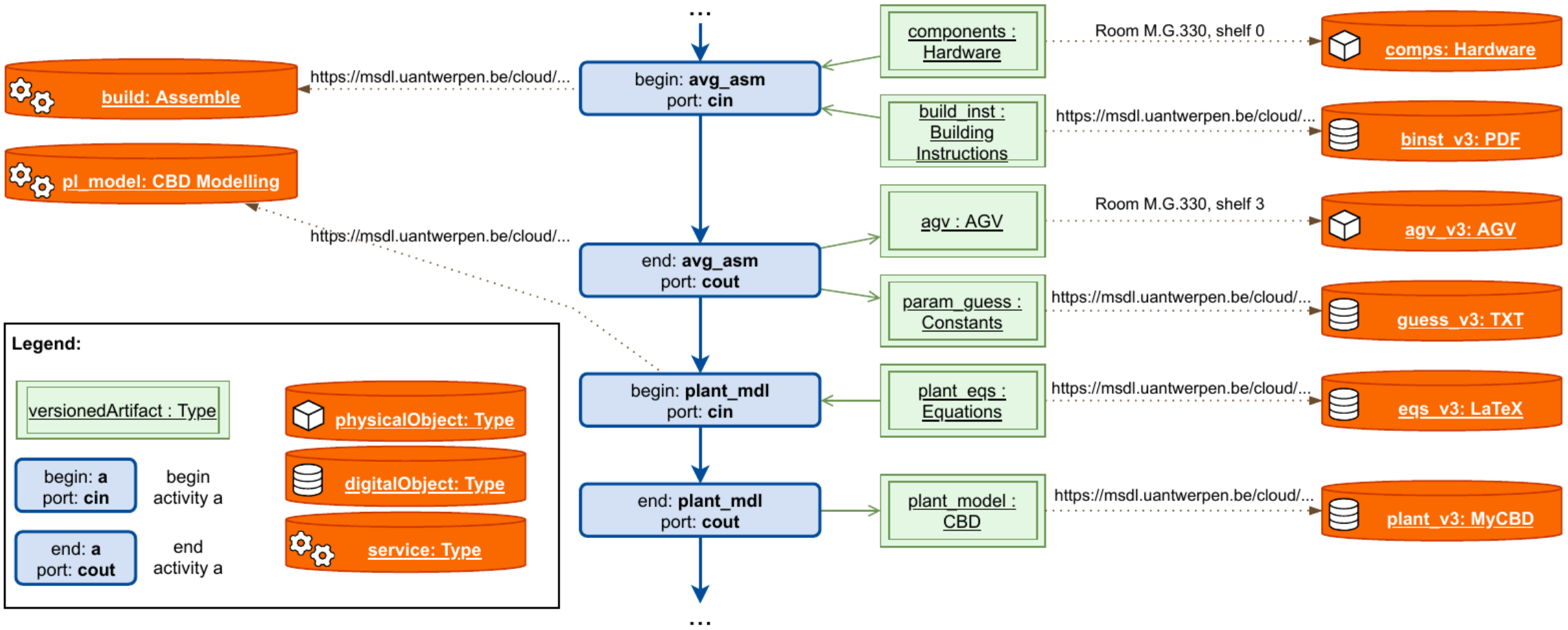


Process Trace





Adapters (Storage, Services, Real-World Artifacts)



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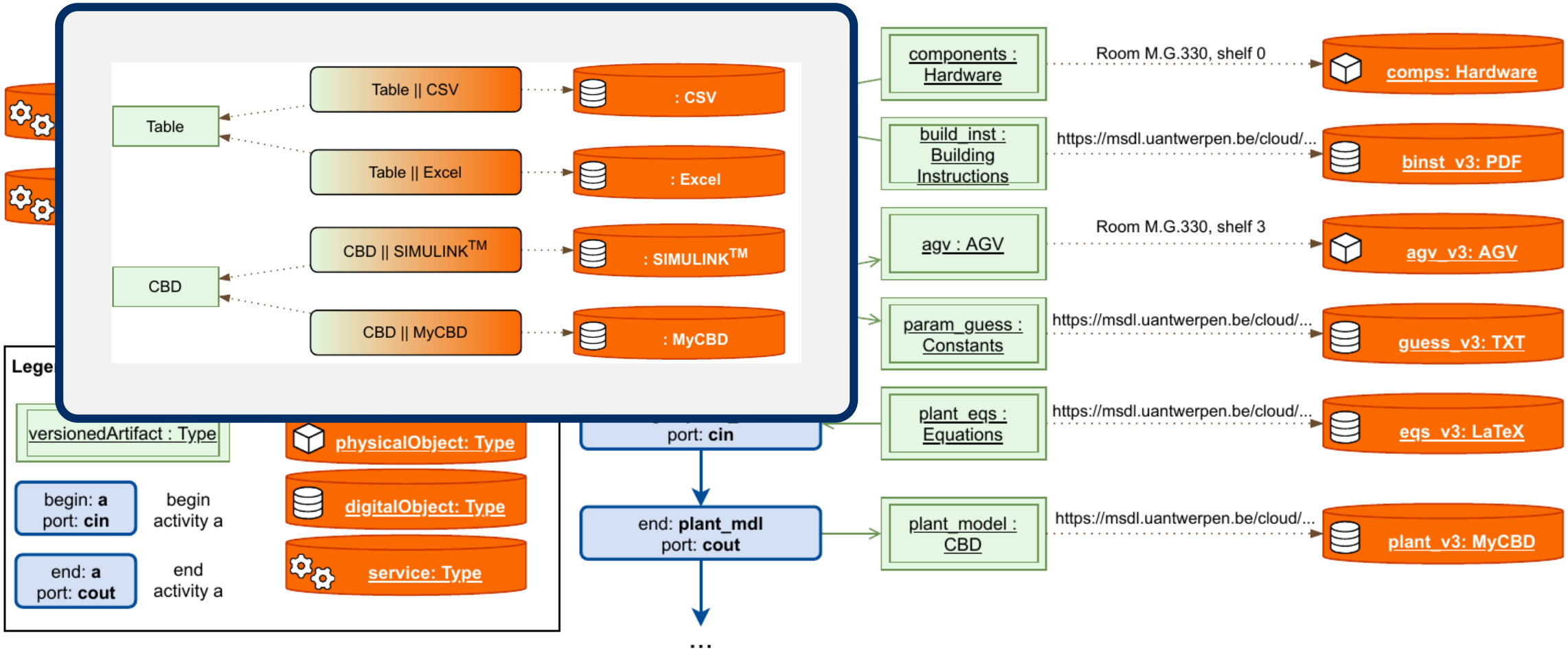


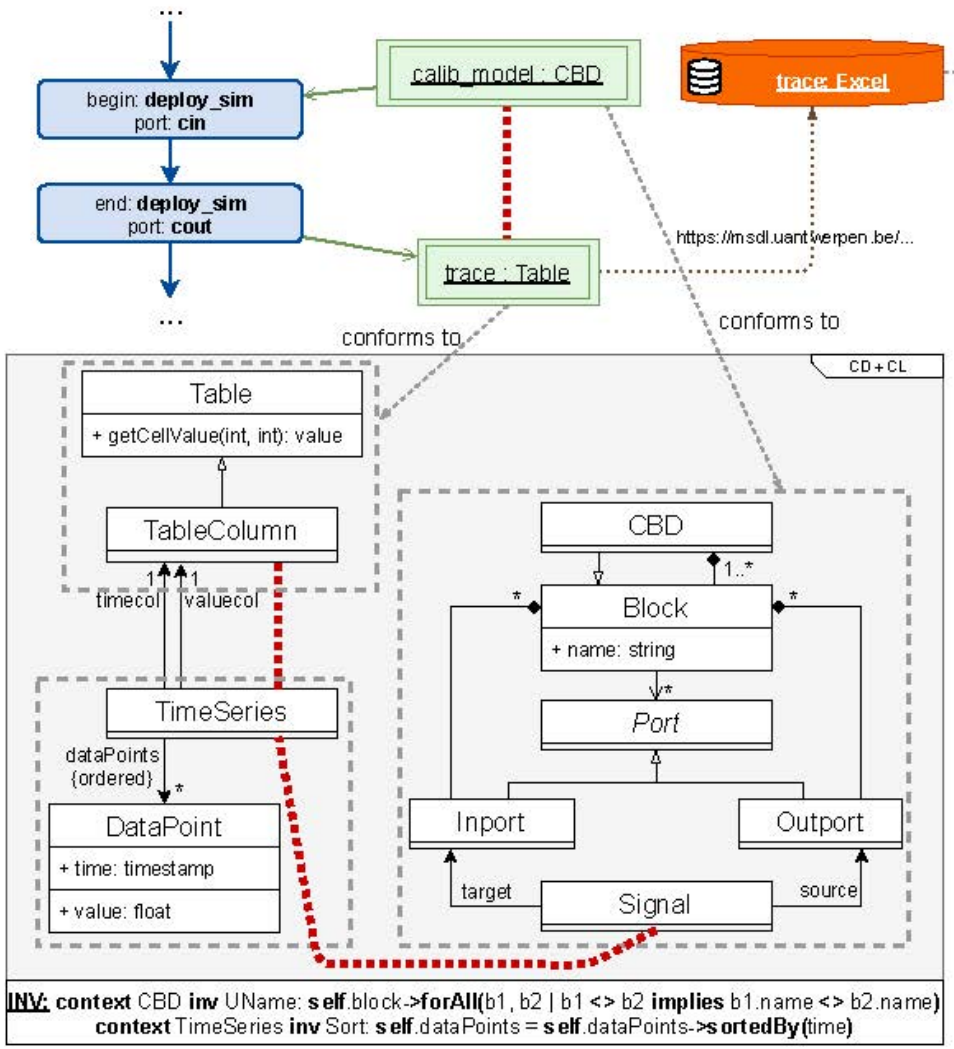
Types of traceability

- Traceability linking experiment and system
- Traceability across artifact versions
- Traceability based on properties of interest
- Traceability between artifacts on different levels of detail
- Fine-grained traceability between artifact elements
- Traceability between instances and types

We make use of the recorded process traces to answer queries

Fine-grained traceability between artifact elements

SELECT * FROM ARTIFACTS **AS** art **WHERE** art.metamodel **CONFORMS TO** trace:"heading"



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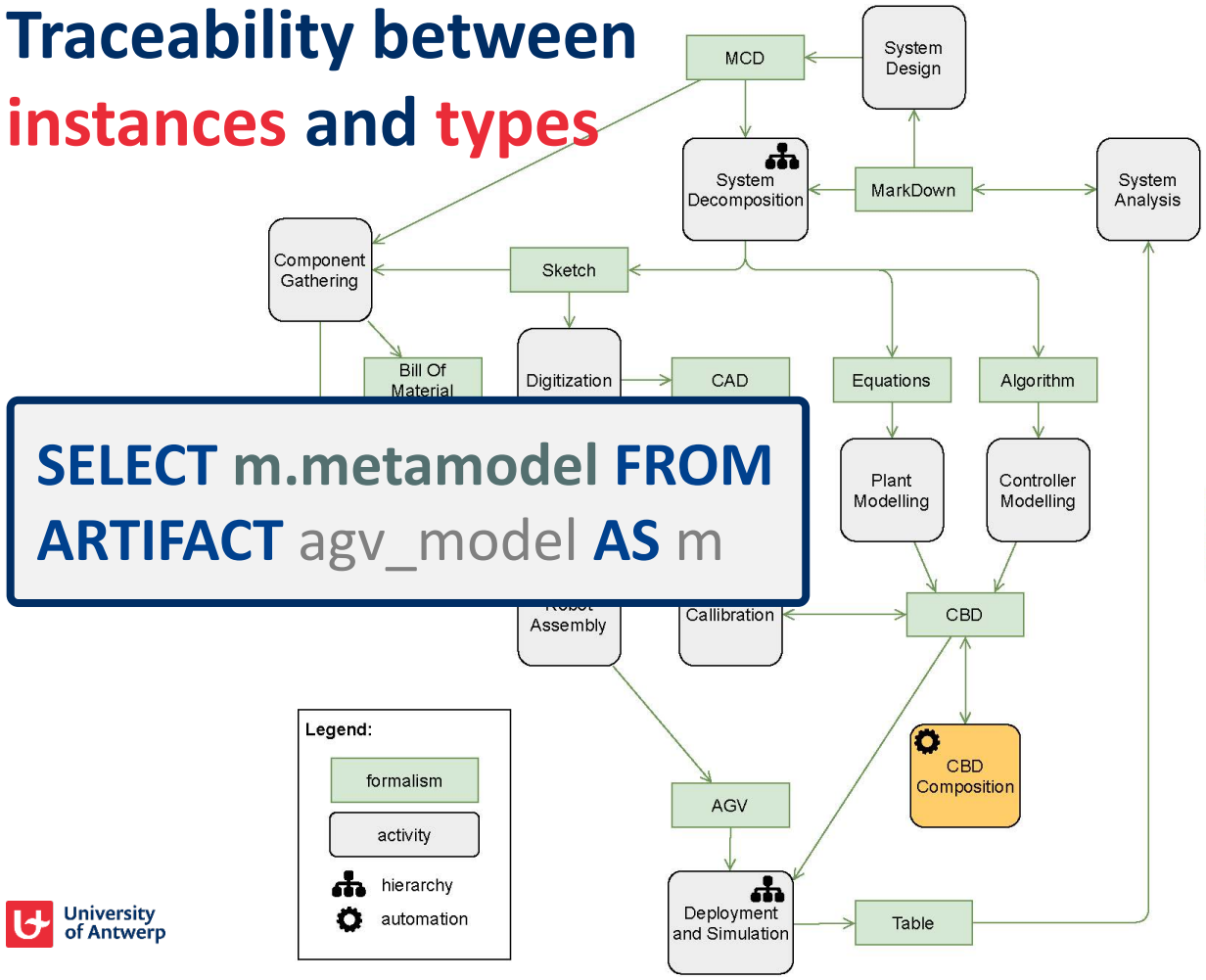
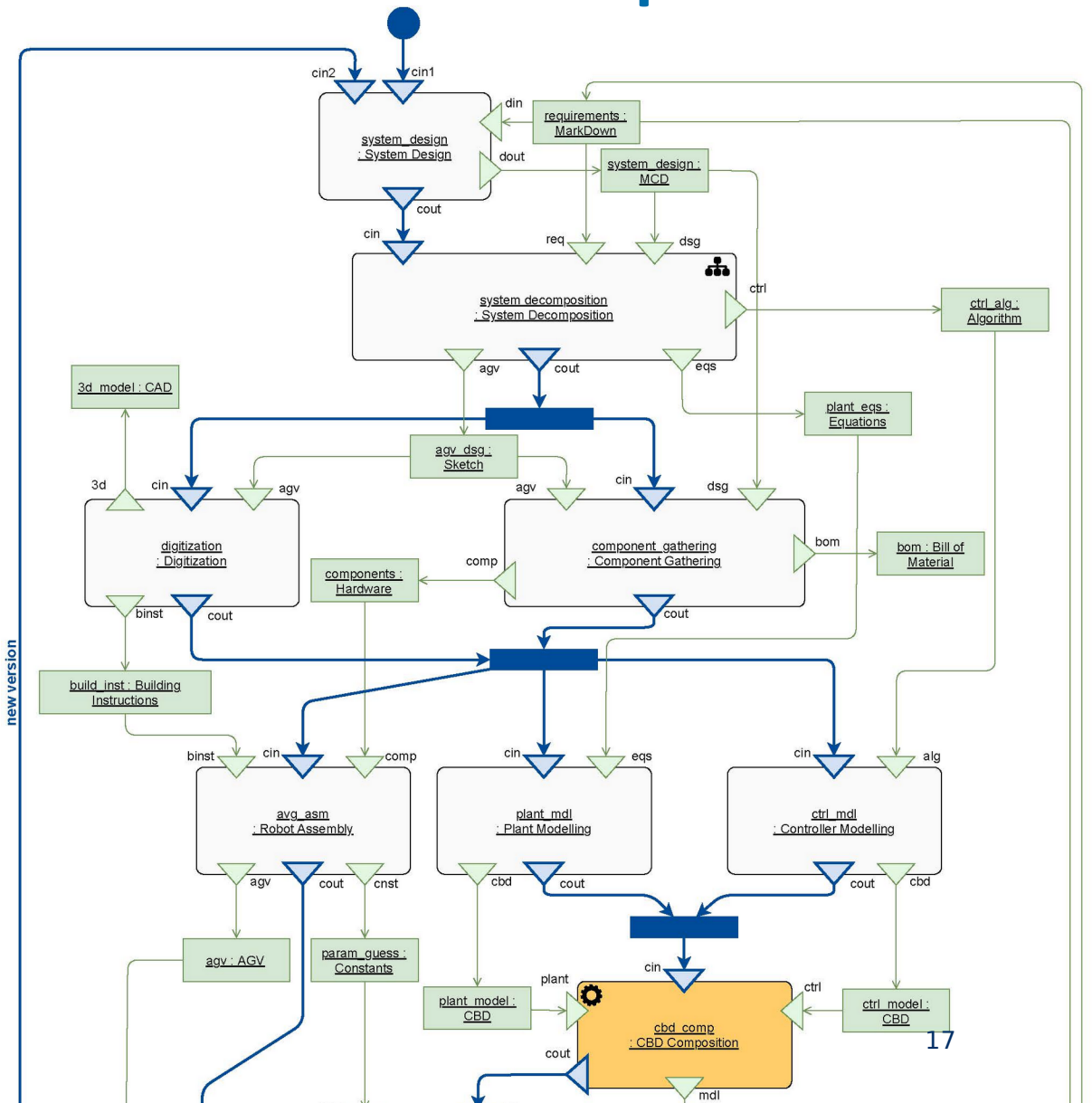
Traceability between instances and types



SELECT m.metamodel **FROM ARTIFACT** agv_model **AS** m



Benefits

- Efficient data retrieval
- Easy to understand modelling environment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