

# Conceptual Models of Digital Twins and Digital Shadows

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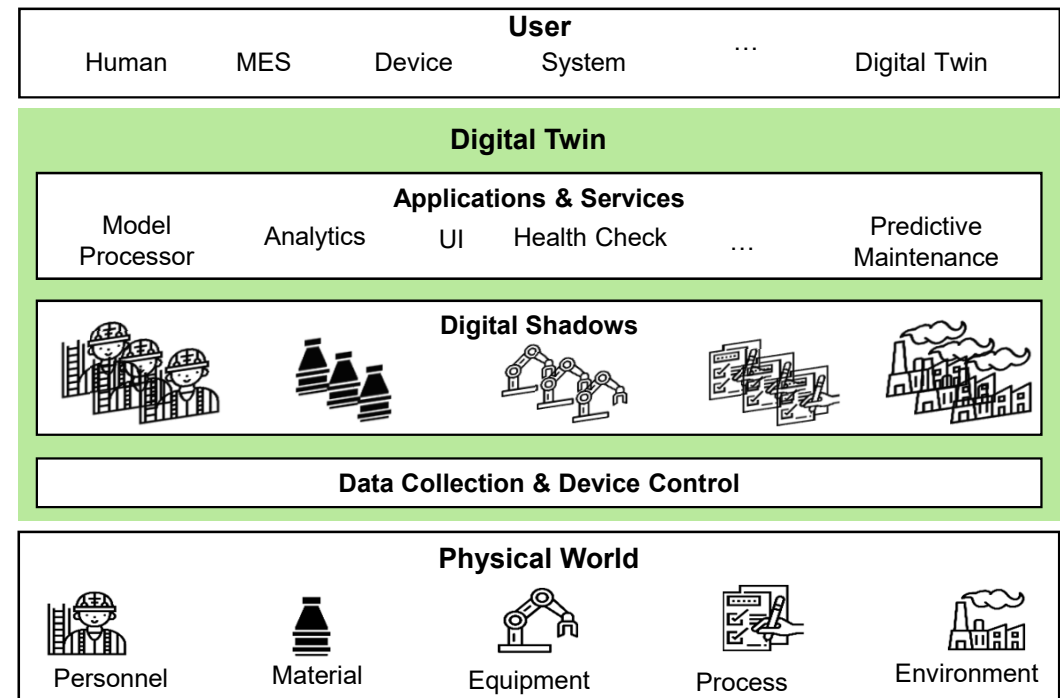
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# Digital Twin of Cyber-Physical Production Systems

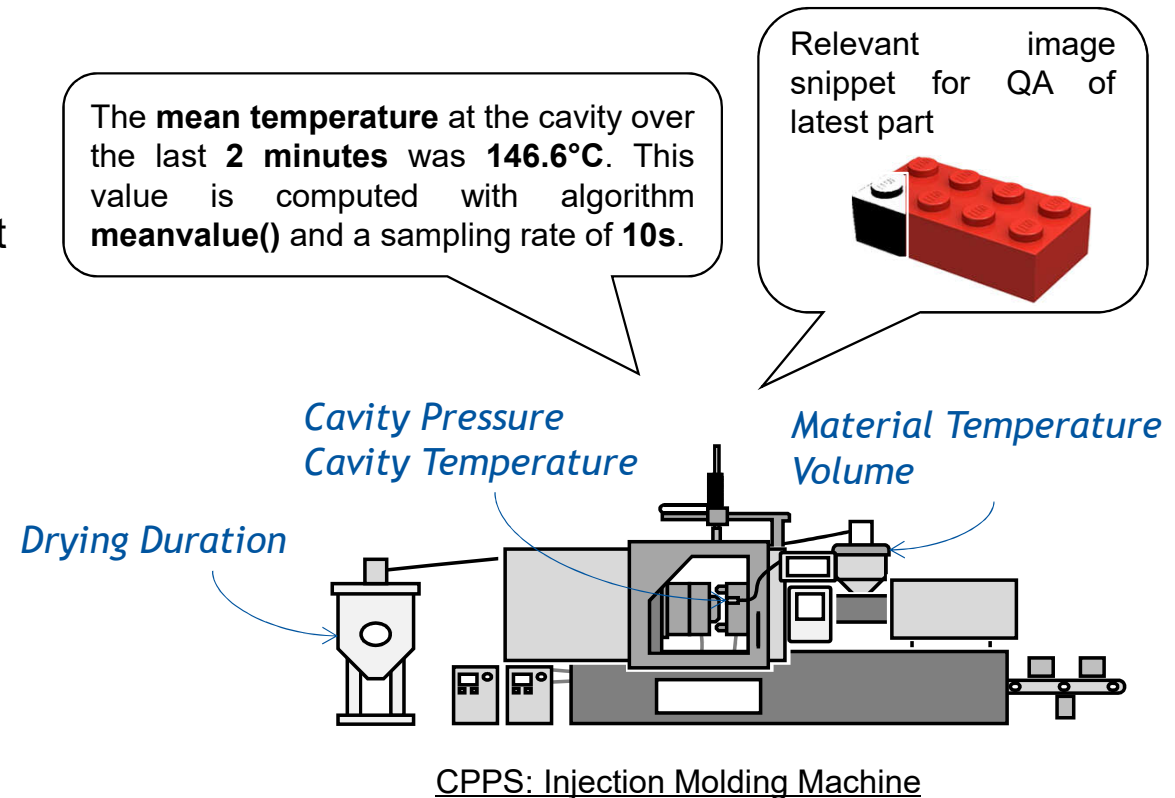
A Digital Twin of a system consists of a **set of models of the system**, a set of **digital shadows**, and provides a **set of services** to use the data and models purposefully with respect to the original system.

- Digital Shadows encapsulate **service-specific data** about the physical system and its context
- The Digital Twin contains a set models, these may be
  - **Engineering models** about the physical system or the Digital Twin
  - **Derived** from engineering models
  - **Abstractions from data traces** collected over time of operation
- **Digital twin contains functionalities for retrieving Digital Shadows** and uses their encapsulated knowledge for its services



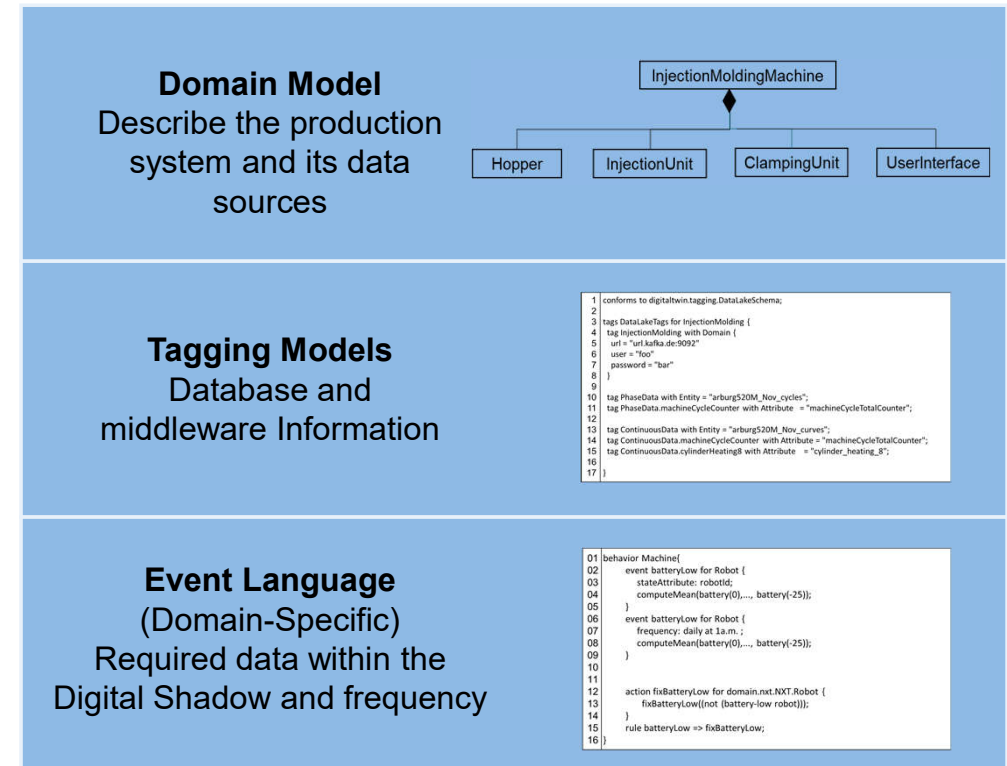
## Digital Shadows Provide Insights in Production Processes

- Sensors provide lots of **raw data**
  - Analyzing in time not possible
  - **Unstructured**
- Reduced data set may be **sufficient** to gain insight about the system's state
- **Data Quality** depends on sensor, sampling rate
- **Metadata** missing (Units, date of measurement)
- Create **Digital Shadows**, that:
  - Time reduced
  - Preprocessed
  - Qualitatively reduced (black and white instead of colored picture)
  - Enriched with **semantic information**



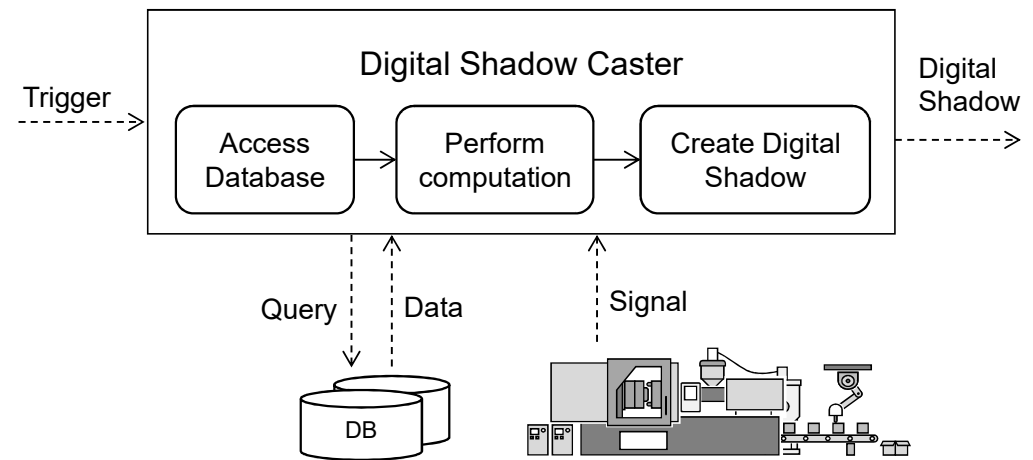
# Specifying Digital Shadow Types

- Each analysis of a Digital Twin service requires specific information
- There exist different Digital Shadow Types that also contain information on how to construct Digital Shadows
- Digital Shadow Types encapsulate
  - Data points: Which data about the system, the process, or its context is required
  - Frequency: How often should Digital Shadows be created
  - Data sources

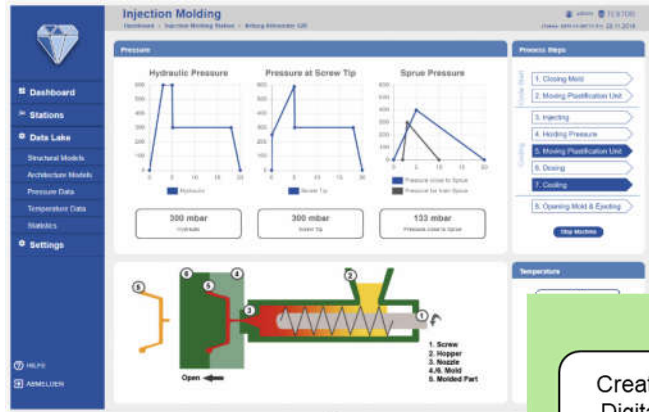


## Digital Shadow Infrastructure

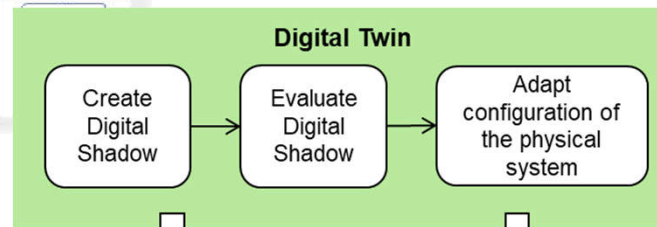
- Digital twin contains a component that creates Digital Shadows
  - **Generated** based on domain models, Tagging Models, Event Language models
- Digital shadow caster:
  - Knows the **Digital Shadow Types**
  - **Creates Digital Shadows** if triggered (by clock event or CPS event)
  - **Knows Infrastructure**, e.g., data bases that store data of the physical system, middleware Information to listen to signals



# Thank You!



*Cockpit visualizing digital shadows and enabling user interaction with the Digital Twin*



*Automating experiments on the machine to identify best configuration via Digital Twin*

- Model-driven development of Digital Twins
- Automating experiments through Digital Twins
- Event language for specifying Digital Twin behavior and digital shadows

- More about our approach on model-driven Digital Twins:

[www.se-rwth.de](http://www.se-rwth.de)

- More about the Internet of Production

[www.iop.rwth-aachen.de](http://www.iop.rwth-aachen.de)