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# Smart Manufacturing, Continuous Improvement and Adaptation of Predictive Models

Gabriel Kronberger, Florian Bachinger, **Michael Affenzeller**

**International Conference on Industry 4.0 and Smart Manufacturing (ISM 2019)**

# Overview

- Predictive Models in Smart Manufacturing
- Concept Drift: Causes and Effects
- Recommendations for Model Management

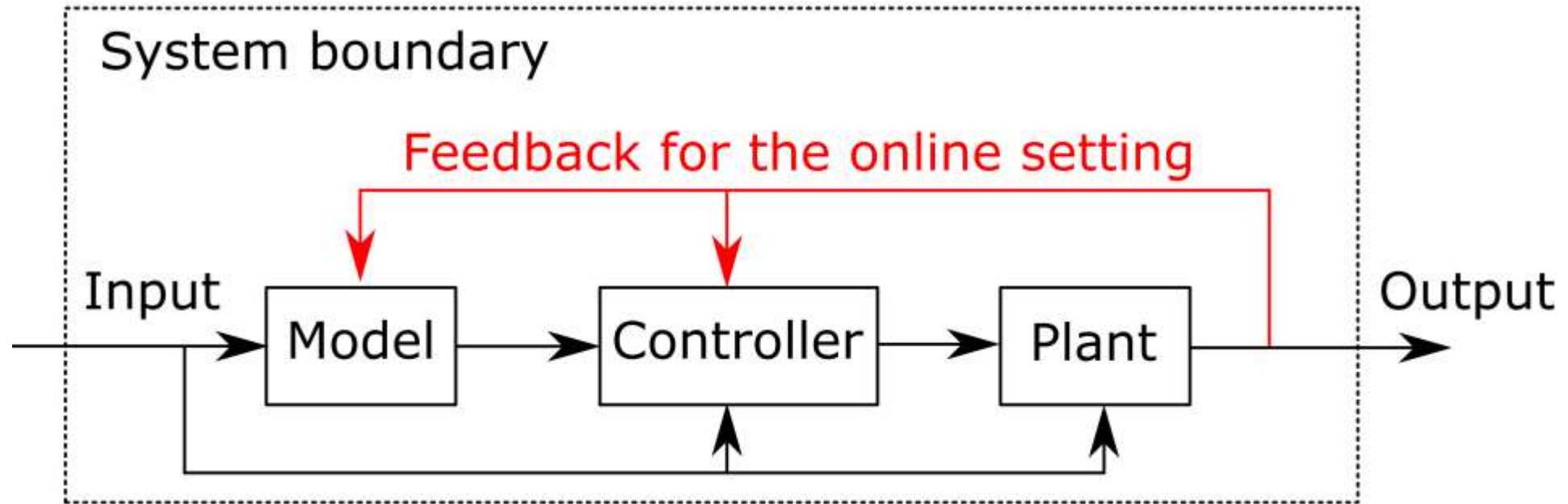
# Predictive Models in Smart Manufacturing

Predictive models are broadly used in smart manufacturing.

- Ressource-efficient processing
- Predictive quality
- Predictive maintenance
- Flexible / self-adaptive scheduling and logistics
- ...

**Focus of this talk:** models for model-driven control of individual plants

# Online vs. offline predictive control

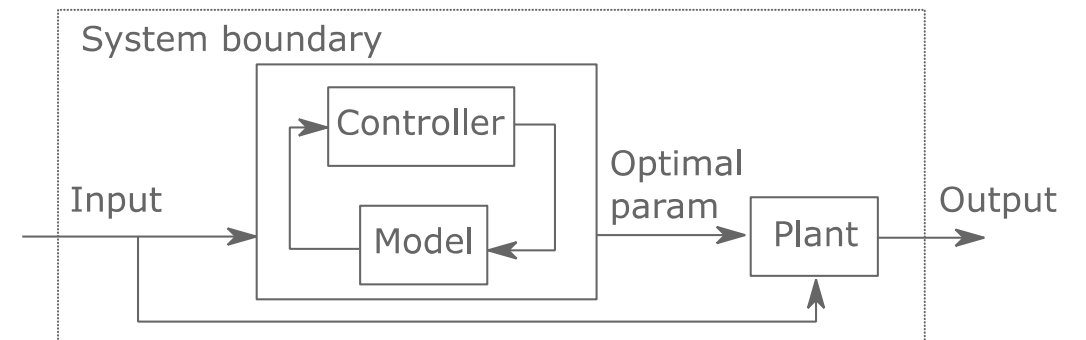


# Example: nitriding (offline)

- Hardening of surfaces of steel products (e.g. tools)
  - Target: product quality
    - surface hardness,
    - compound layer thickness
  - Parameters:
    - Temperature
    - Duration
    - Gas mixture
    - Material
    - ...

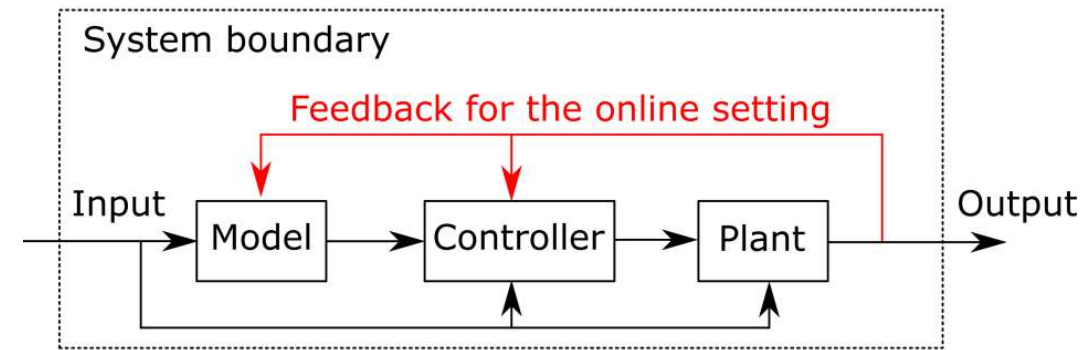
Model output &  
Plant output

Model input &  
Plant input



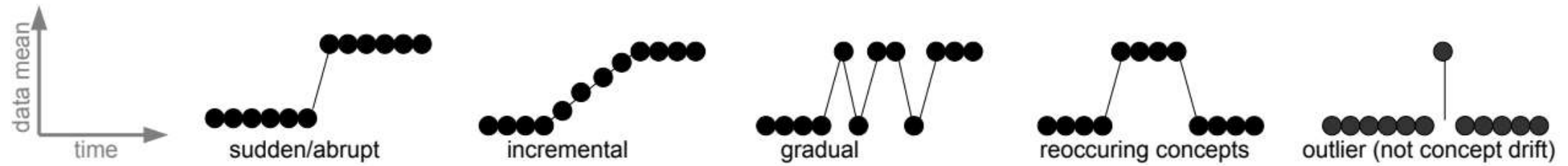
# Example: plastics extrusion (online)

- Targets:
    - throughput,
    - quality
  - Parameters:
    - Temperature
    - Speed (rpm)
    - Material
    - ...
- Model output & Plant output
- Model input & Plant input



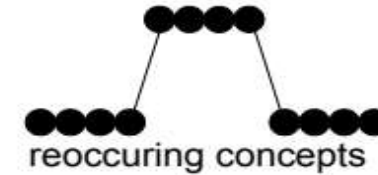
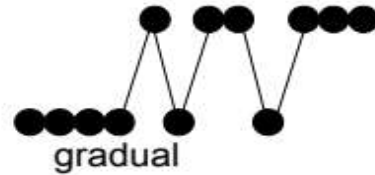
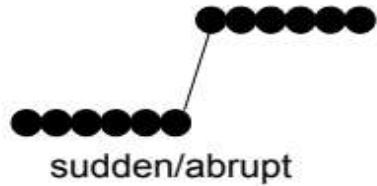
- Predictive model as a **virtual sensor** for product quality

# Concept drift in machine learning



Gama, J., Zliobaite, I., Bifet, A., Pechenizkiy, M., and Bouchachia, A. 2013. *A Survey on Concept Drift Adaptation*. ACM Comput. Surv. 1, 1, Article 1 (January 2013), 35 pages.

# Examples for concept drift in smart manufacturing



- Tool change
- Sensor re-calibration
- Parameter configuration

- Reaction to parameter configuration

- Faulty sensor

- Input material
- Operator

**Short-term**

- Maintenance
- Setup

- Wear
- Deterioration of lubricant
- Input material mix

- Introduction of new product

- Seasonal variation
- Plant-setup for product

**Long-term**

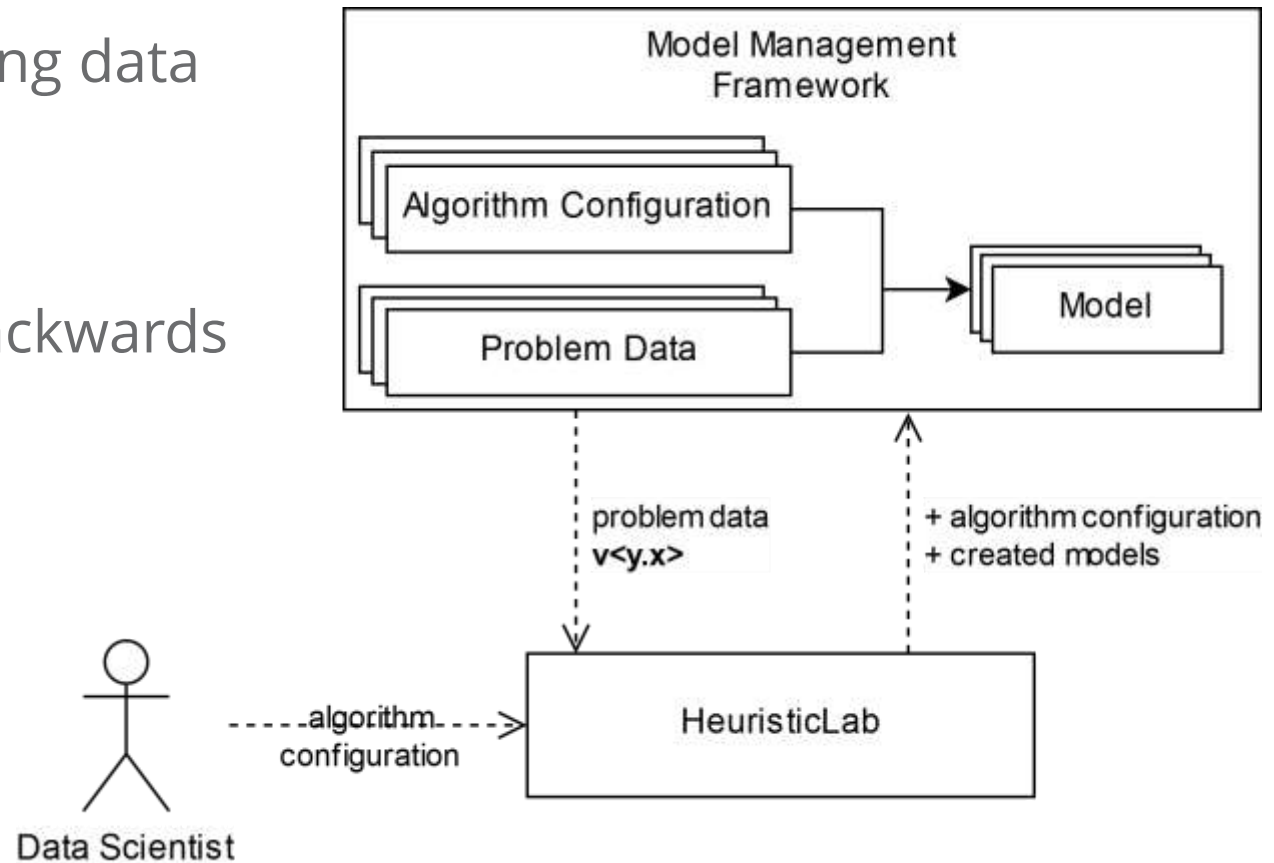


# Model management

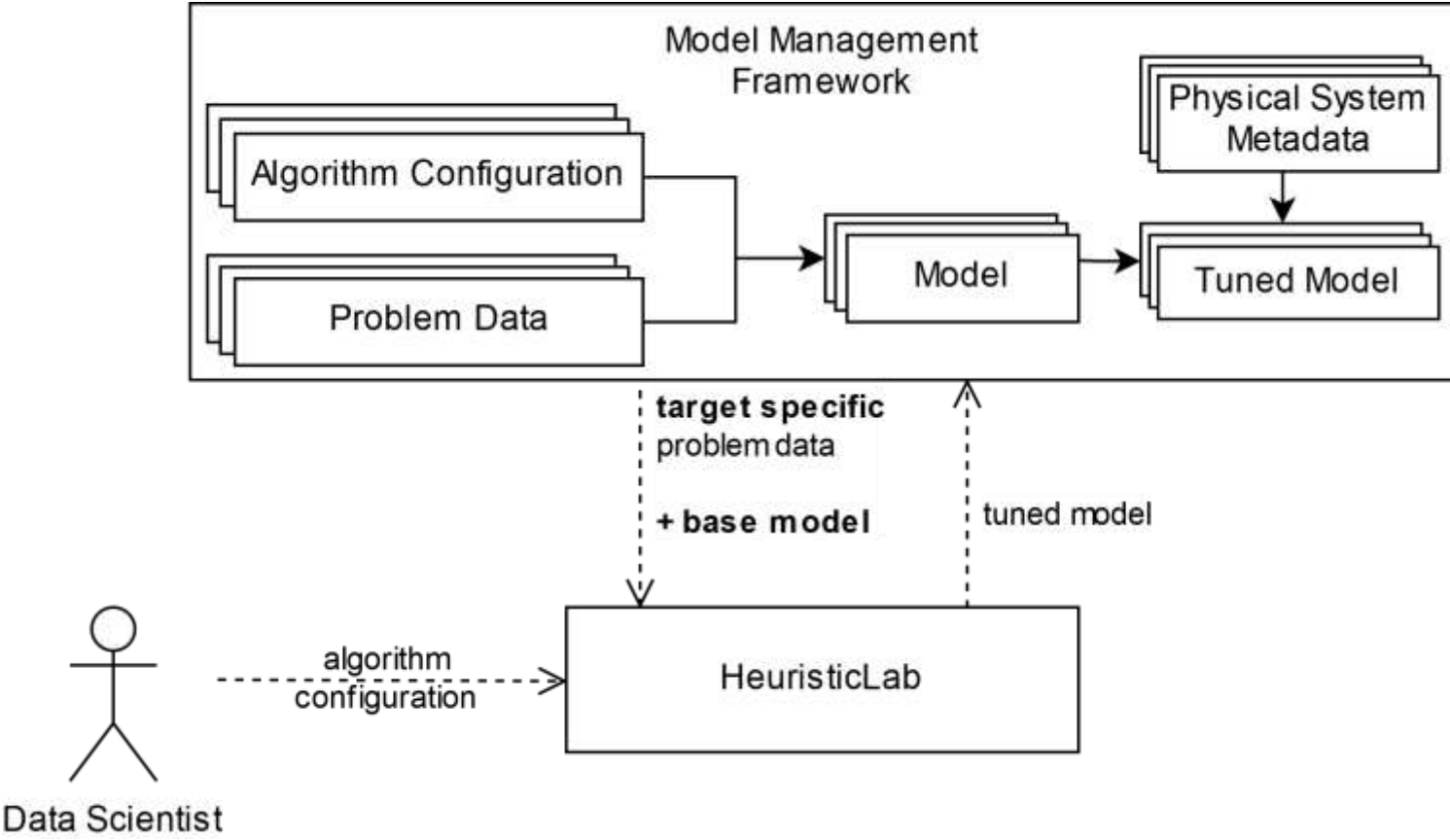
- Versioned storage of models
- Connect models and training data

→ Reproducibility

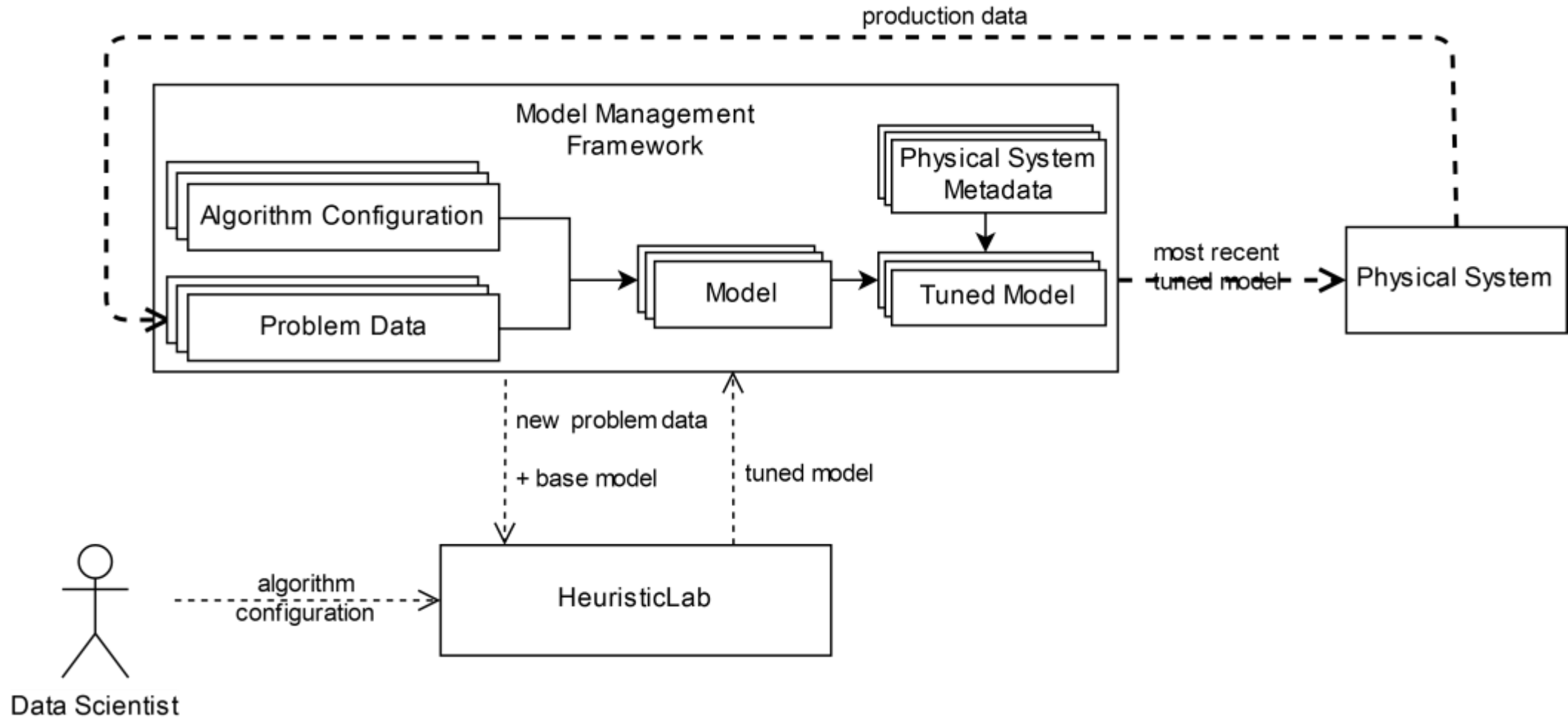
→ Comparison of models backwards and forwards in time



# Adaptation of models



# Deployment





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