# Adaptive learning-based time series prediction framework for building energy management

Daniel Schachinger, Jürgen Pannosch, Wolfgang Kastner

Automation Systems Group
TU Wien, Vienna, Austria
https://www.auto.tuwien.ac.at

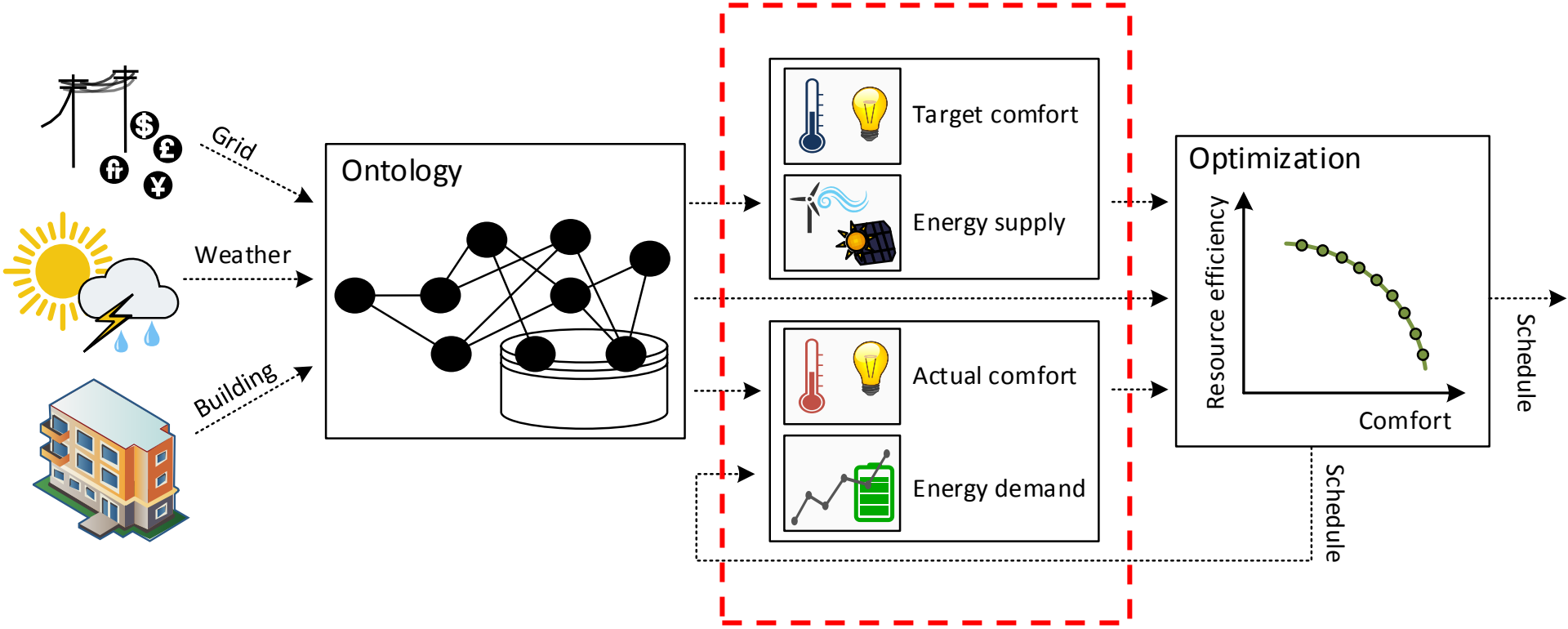
# Contents

# Motivation

- Importance of building energy management
- Knowledge about (building) process behavior
  - Precondition for optimization
  - Expensive engineering approach
  - Inherent in monitoring data

→ **Ontology-based prediction framework**

# Framework design



# Model identification

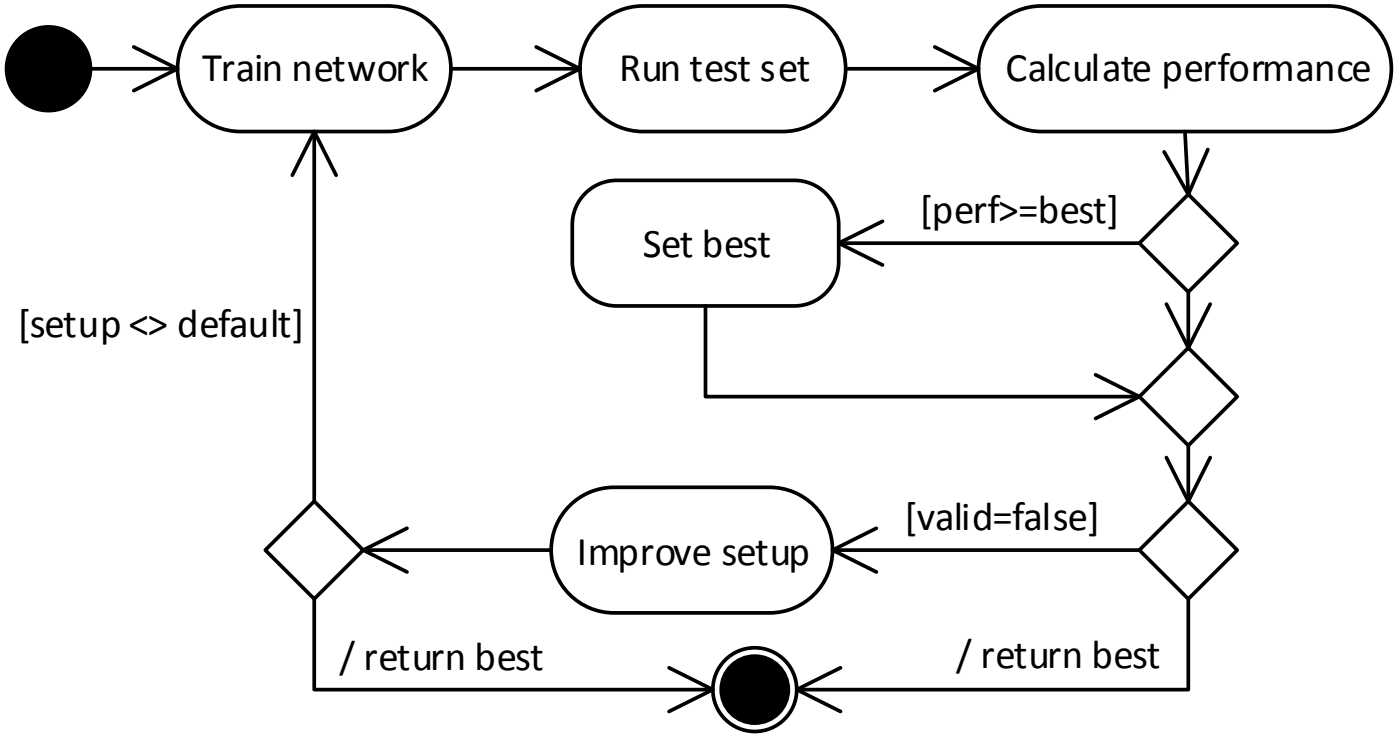
- Ontology as basis
- Interpret context information
- Find services for
  - Energy production
  - Comfort targets
  - Energy consumption
  - Comfort influences

# Model identification

```
SELECT DISTINCT ?data ?zone ?type ?parent
WHERE
{
  ?data rdf:type sc:DataService.
  ?data s
  ?data s
  ?contro
  ?data s
  ?contro
  ?paramD
  ?paramC
  ?type r
}
```

| Data | Zone | Type | Parent |
|---|---|---|---|
| indoor_temp | office_3 | TemperatureParameter | outdoor_temperature |
| | | | outdoor_radiation |
| indoor_hum | office_2 | HumidityParameter | outdoor_temperature |
| | | | indoor_temperature |
| … | … | … | … |

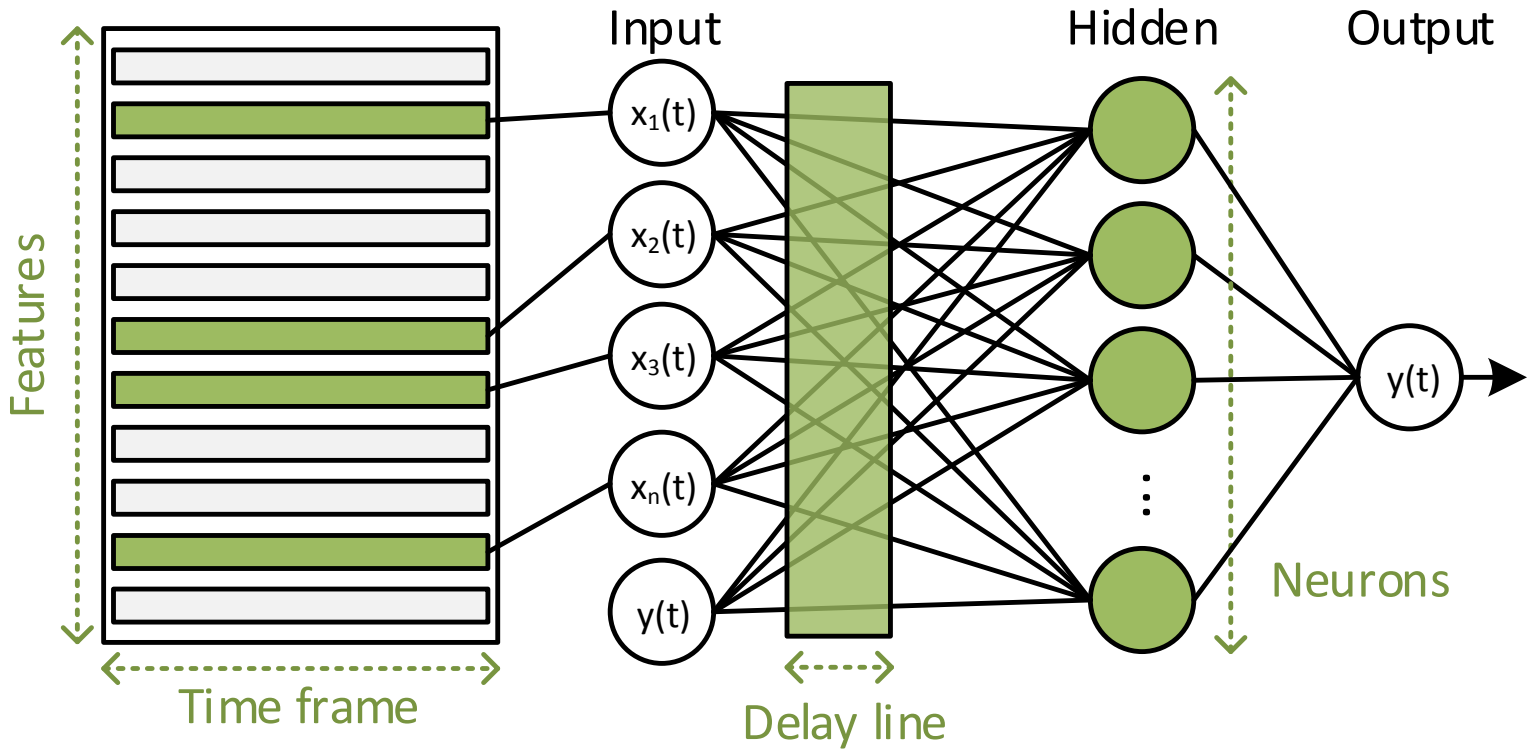
# Network design scheme



# Performance calculation

- Comparison to thresholds
- Indication of retraining or modification
- Utilization of monitoring data
- Measures based on forecast error
- Calculation of weighted, relative deviation from threshold
- Ranking of forecast models

# Improvement heuristic



# Improvement heuristic

- Ordering of variables
  1. Feature set
  2. Length of time frame
  3. Hidden neurons
  4. Delay line
- Not all permutations tested
- Termination after *n* unsuccessful steps

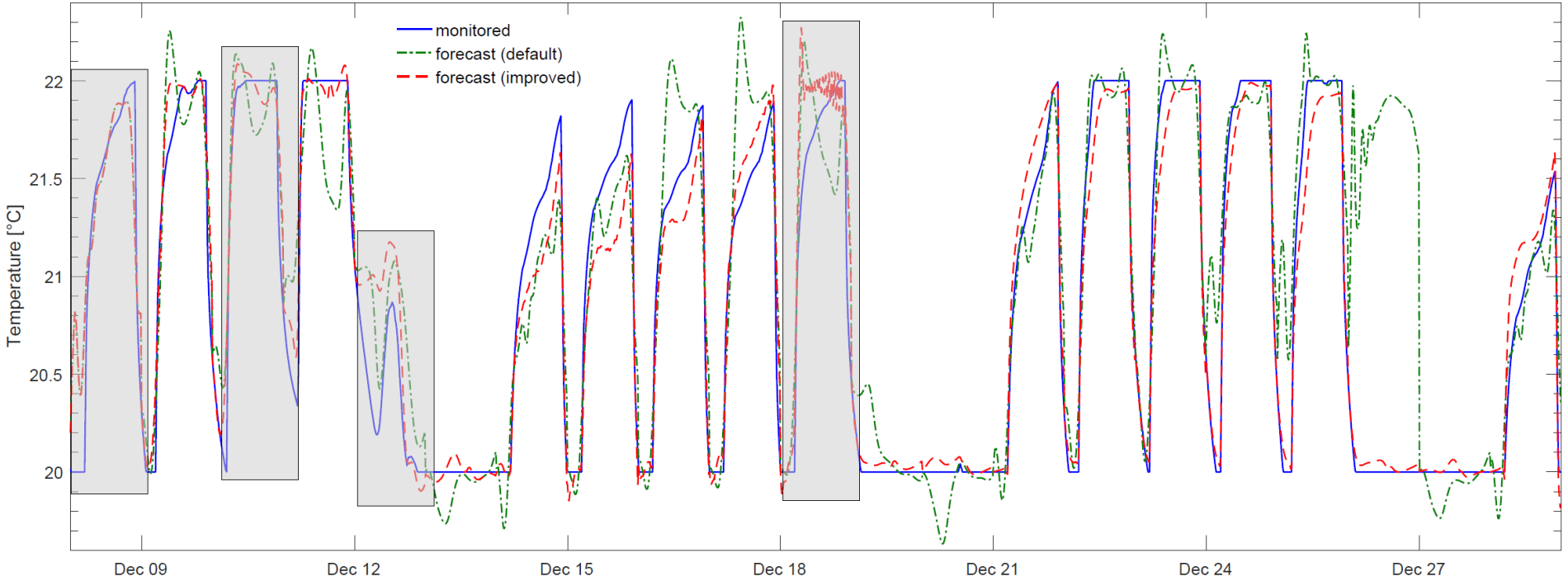
# Online assessment

- Integration into optimization workflow
- Triggered by monitoring data
- Continuous evaluation
- Optional reconfiguration
- Mobile training principle

# Evaluation

- Simulation framework: EnergyPlus
- Building: office building
- Size: 3 floor with 5 zones
- Location: Vienna, Austria
- Systems:
  - PV production
  - Controllable HVAC system

# Evaluation


monitored
forecast (default)
forecast (improved)
Temperature [°C]
22
21.5
21
20.5
20
Dec 09
Dec 12
Dec 15
Dec 18
Dec 21
Dec 24
Dec 27

# Evaluation

- Importance of training set
- Careful selection of thresholds and weights
- Gradual adjustment of thresholds
- Performance trends instead of ex post assessment
- Filters for smoothing
- Suitable alternative to expert modeling
- Transparent and automatic integration

# Conclusion

- **Data-driven modeling of building processes**
  - Comfort and energy-related time series
  - Automation model creation
  - Continuous evaluation and improvement
- **Future work**
  - Trend approximation
  - Heuristic for default configuration
  - Automatic threshold determination

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**Thank you!**

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