Technical University Dresden
Department of Computer Science
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Switching to a holistic perspective on semantic component models in building automation: tapping the full potential of automated design approaches

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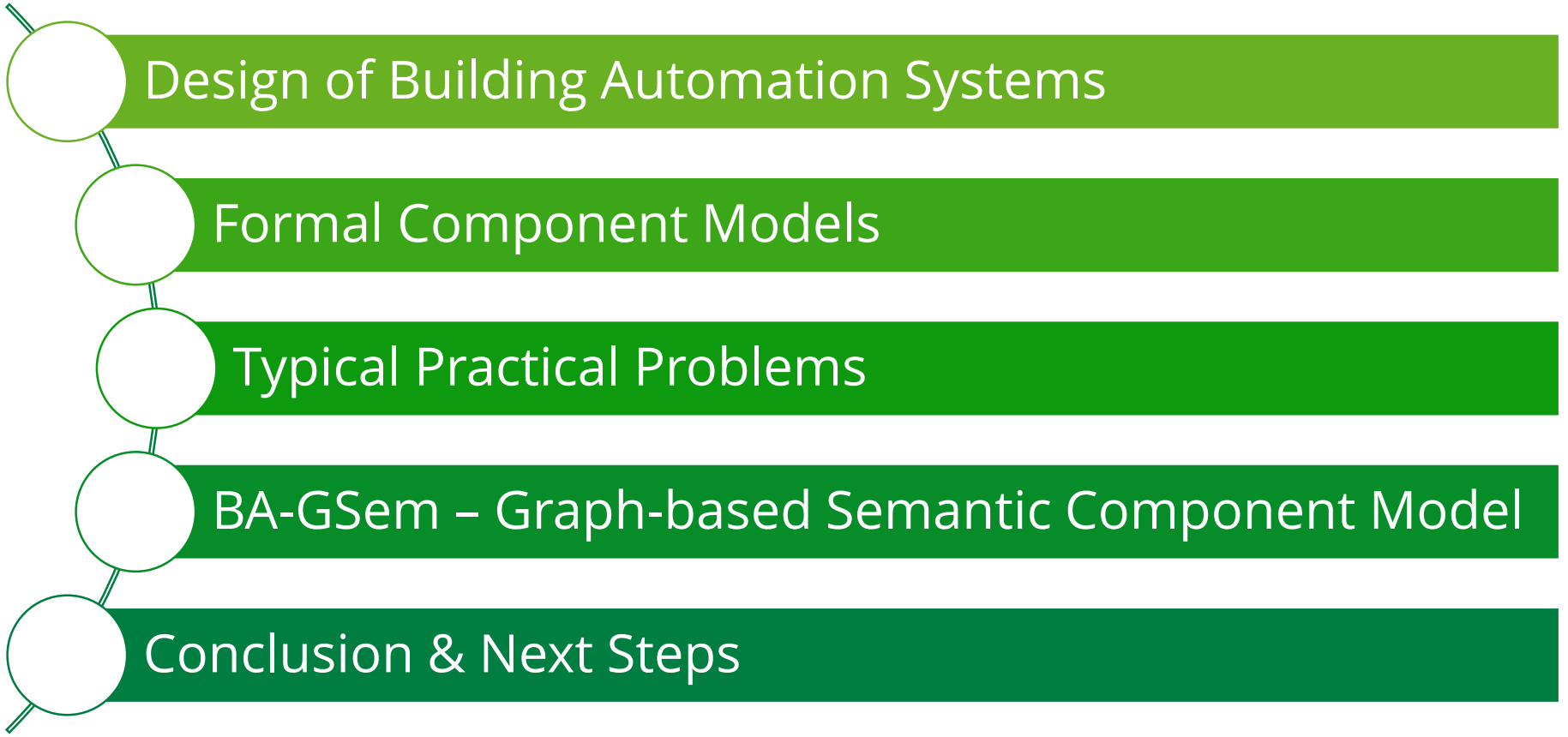
SBE19 Graz

Agenda

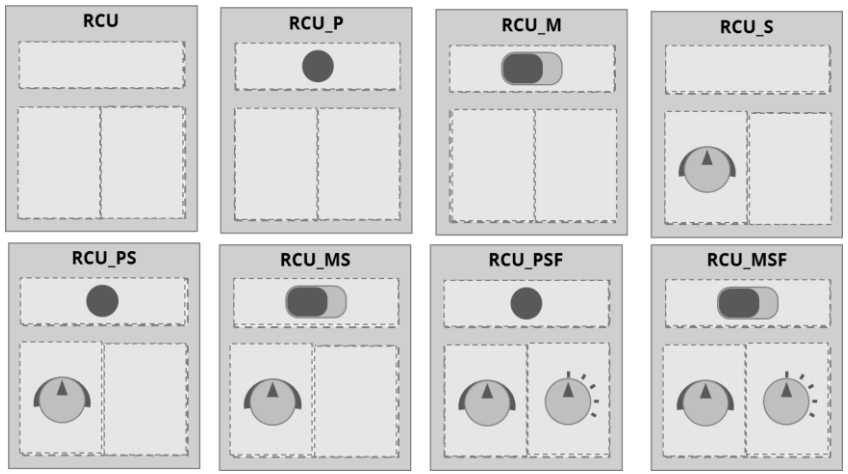

Design of Building Automation Systems
Formal Component Models
Typical Practical Problems
BA-GSem – Graph-based Semantic Component Model
Conclusion & Next Steps

Design of Building Automation Systems
Challenges

Highly complex design process

- Many trades
- Huge number of nodes
- Diversity of technological solutions
  - Many communication technologies
  - Many manufacturers
  - Many devices / device variants available
- Interoperability issues

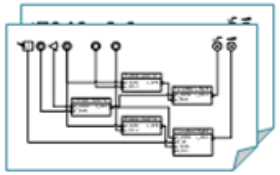
→ Computer-based design tools required for design space exploration



Design of Building Automation Systems
Automated Design Approach

Domain Knowledge
- Based on **VDI 3813** standard
- Domain functionality modeled as function blocks

Algorithms for System-Synthesis
- Exploration of design space
- Multiple Design Candidates determined based on information flows



Domain Knowledge

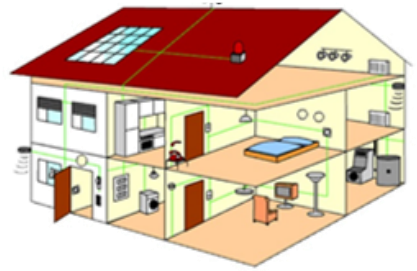
Building Model

User-Requirements

Algorithms for System-Synthesis

Product Repository

Interconnected Automation System



Result:
Multiple Design Candidates

Product Repository
- **Formal models** of **functionality** for automation components

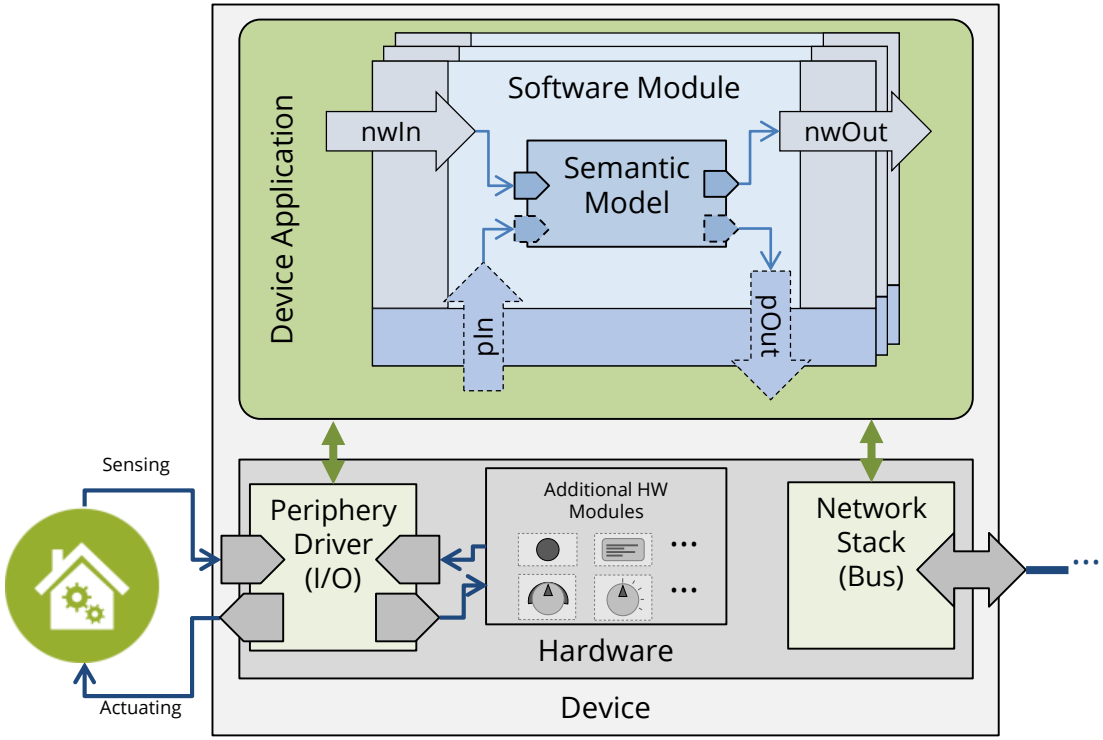
Formal Models of Device Functionality
General Device Model

Building automation system = network of communicating devices

- Functionality
- Information Exchange

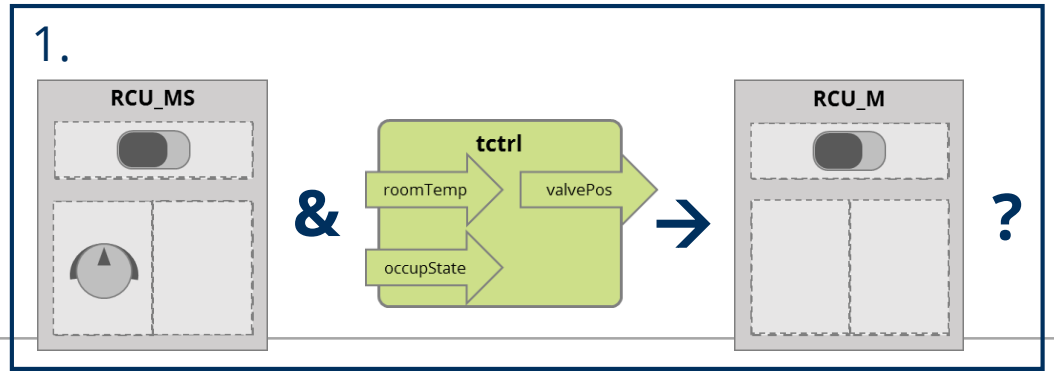
Aspects of Device/Product **& Modeling Aim**:

- Hardware
  → Physical connections
- Device Application / Software Modules
  → Logical connections
- Semantic Model
  → Functionality



Formal Models of Device Functionality
Typical Practical Problems

1. **Consistency** of functionality model
   - “Can a certain functional model be transferred to other device variants?“
   - “Is software ‘TemperatureController‘ usable for a specific device variant?“



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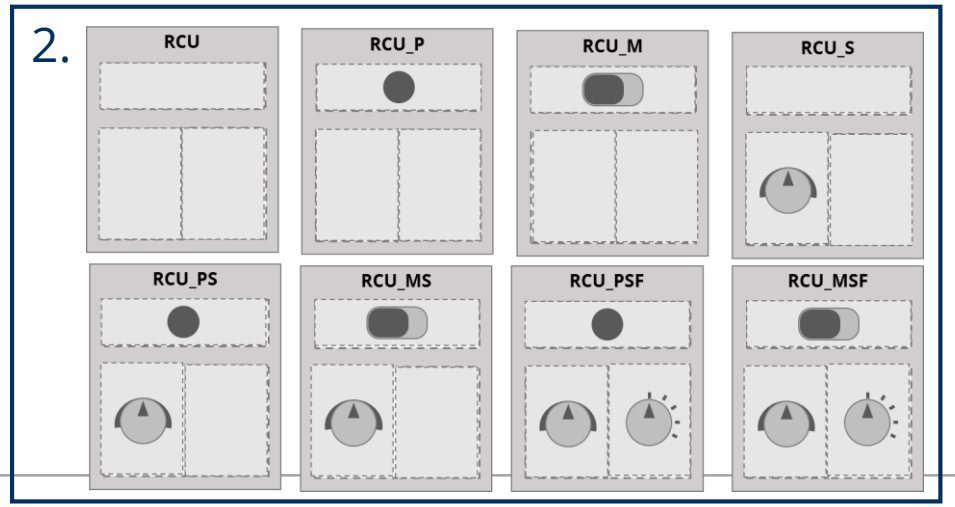
   - “Does each device variant need a whole functional model?“
   - “Are there implicit constraints for functionality assignment of device variants?“



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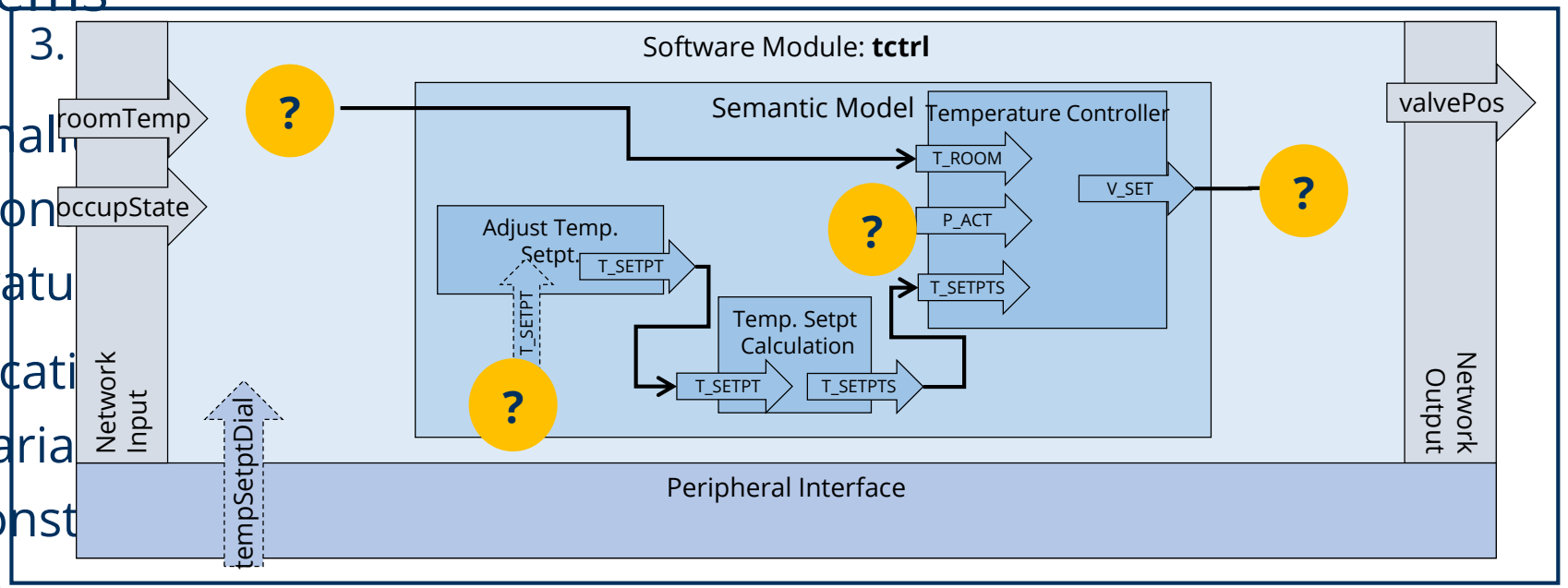

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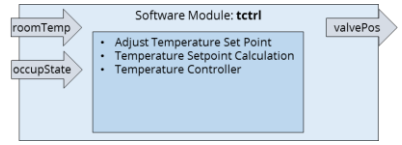
3. Limited model **expressiveness**
   - "What is the information flow and processing in the software?"
4. Heterogeneous model **quality**
   - "Can the models be used for the engineering task?"

4.



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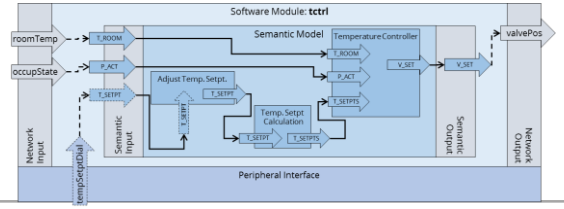


Formal Models of Device Functionality
State of the Art

Classification approaches (eCl@ss, ETIM, profiCl@ss)

- Distinguishes device classes
- Focus on isolated aspects (procurement), coarse functionality

Electronic self-description (LON-XIF, KNXPROD)

- Software interface modeled in formal manner
- Technology-specific models, lack detailed semantic information

Preliminary semantic component model [Dibowski2011]

- Technology-neutral semantic component model
- Interface modeled coaresly (software / semantic), no links between aspects
- Monolithic component models

Formal Models of Device Functionality
Requirements

1. **Precise Modeling**
   - Offer structures with high level of detail

2. **Ease of Specification and Use**
   - Effort for creation in acceptable magnitude
   - Effort for usage in acceptable magnitude

3. **Robustness of Use**
   - Cope with heterogeneous levels of detail

Formal Models of Device Functionality
Contributions

1. **Precise Modeling**
   - Offer structures with high level of detail

   → Graph-based semantic model BA-GSem
2. **Ease of Specification and Use**
   - Effort for creation in acceptable magnitude
   - Effort for usage in acceptable magnitude

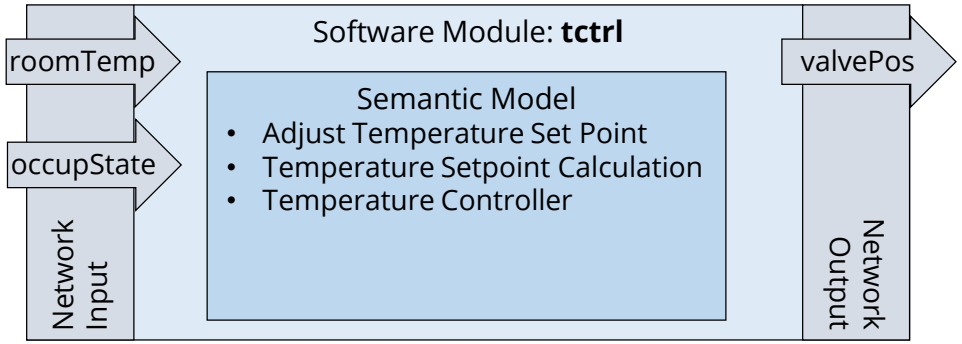
   → Identification of important component aspects for modularization
3. **Robustness of Use**
   - Cope with heterogeneous levels of detail

   → Discussion of impact on system design tasks

BA-GSem
Existing Component Models

Level of Detail: Sem1

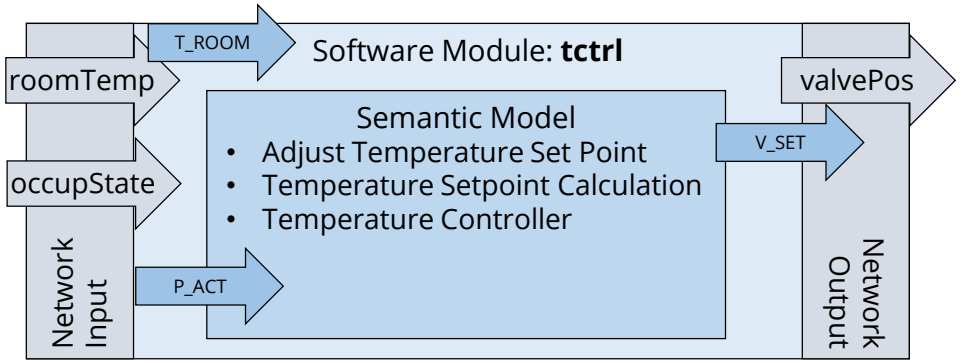
— Set of Semantic Functions



Level of Detail: Sem2

— Set of Semantic Functions

— Semantic Type Annotation for Datapoints

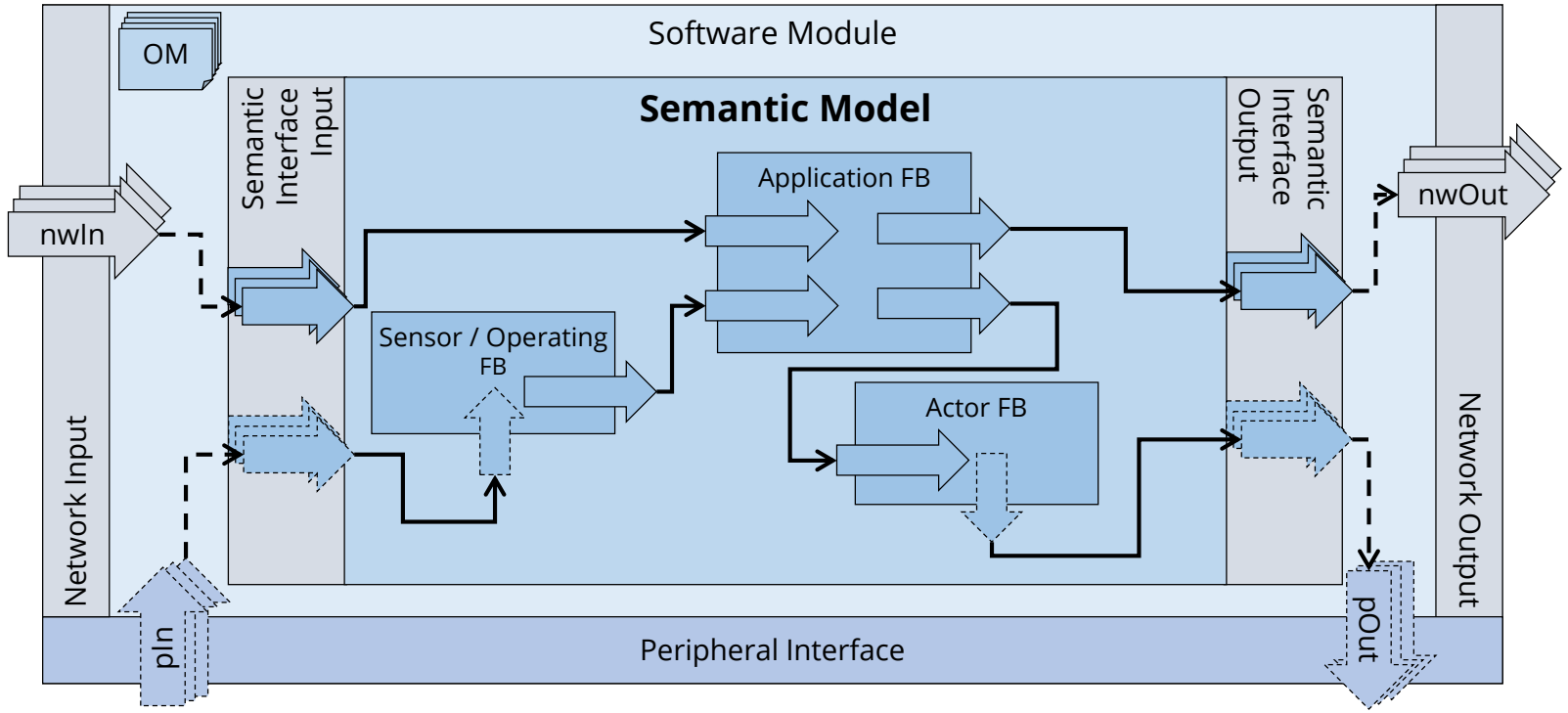


BA-GSem
Graph-based Semantic Component Model

Level of Detail: Sem3 (BA-GSem)

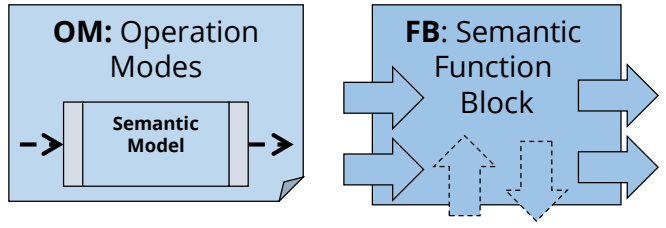
— Functional Component Model of a Software Module

— … in context of an operation mode (= parameterization)



Legend:

- Semantic Information Flow
- Software & Semantic Mapping
- Semantic Data Point (Network)
- Semantic Data Point (Periphery)
- Software Data Point (Network)
- Software Data Point (Periphery)



Conclusion & Future Work

Recap

— Automated design approaches require functional component models

— Drawbacks of existing component models

– Isolated aspects

– High effort

– Low Expressiveness

Proposal of BA-GSem

— High-expressive graph-based semantic model for BA components

— Contains different aspects & relationships → enables modularization

Next steps

— Further reduction of specification effort → Tooling support for model specification

— Integration with product information modeling tools

Thank you for your attention!