Linked Product Data: Describing Multi-Functional Parametric Building Products using Semantic Web Technologies

PhD Defence, Anna Wagner M.Sc.

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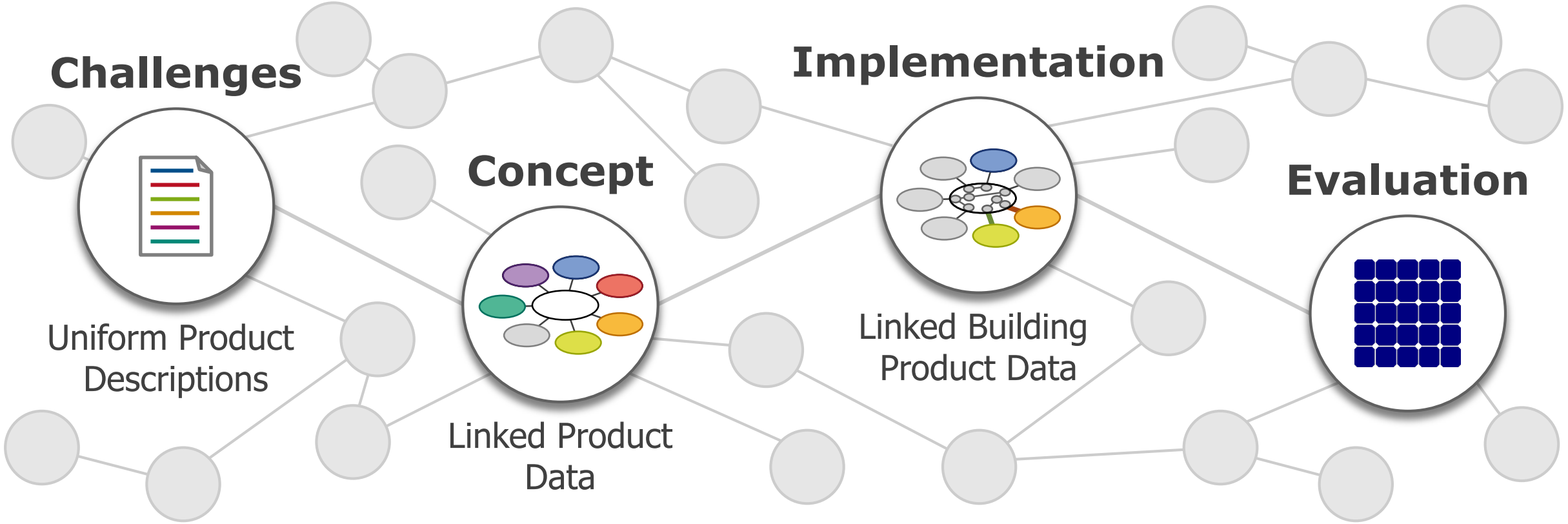
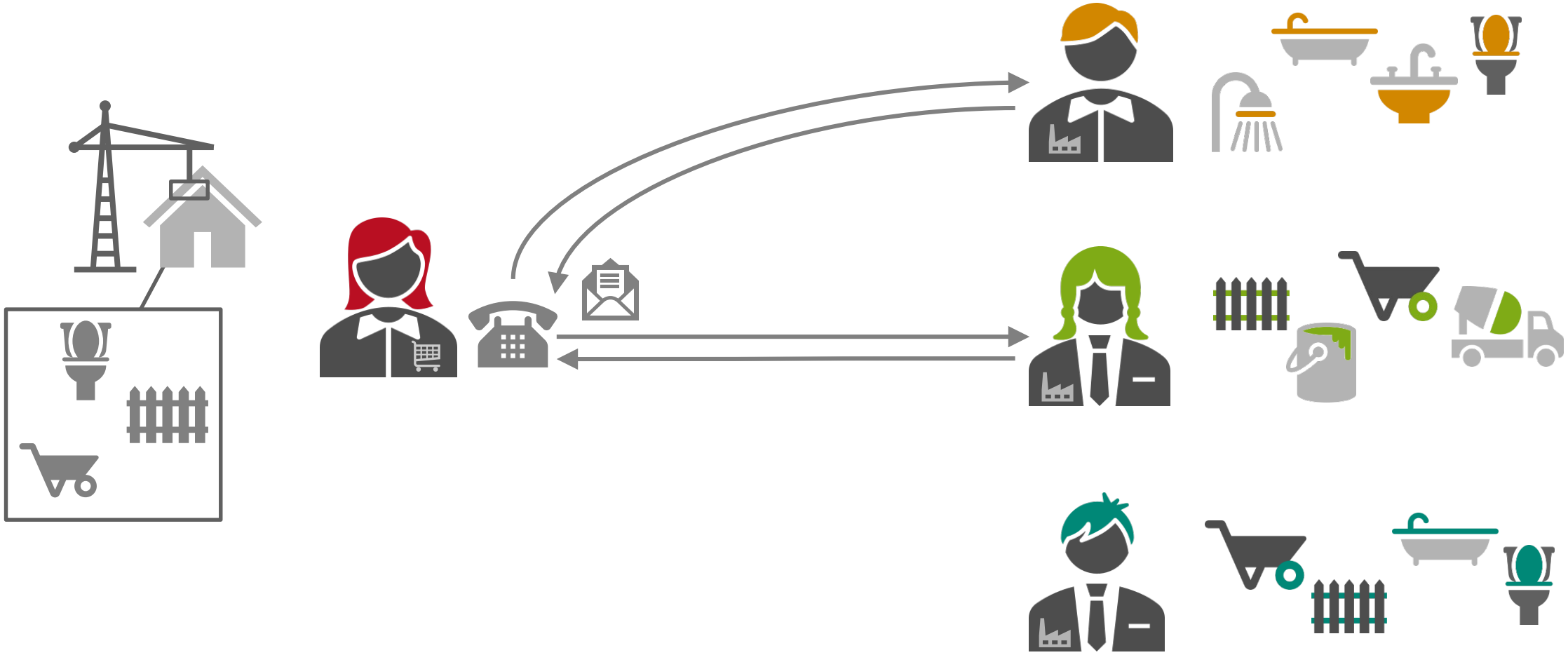


Uniform Product Descriptions
Motivation



Uniform Product Descriptions
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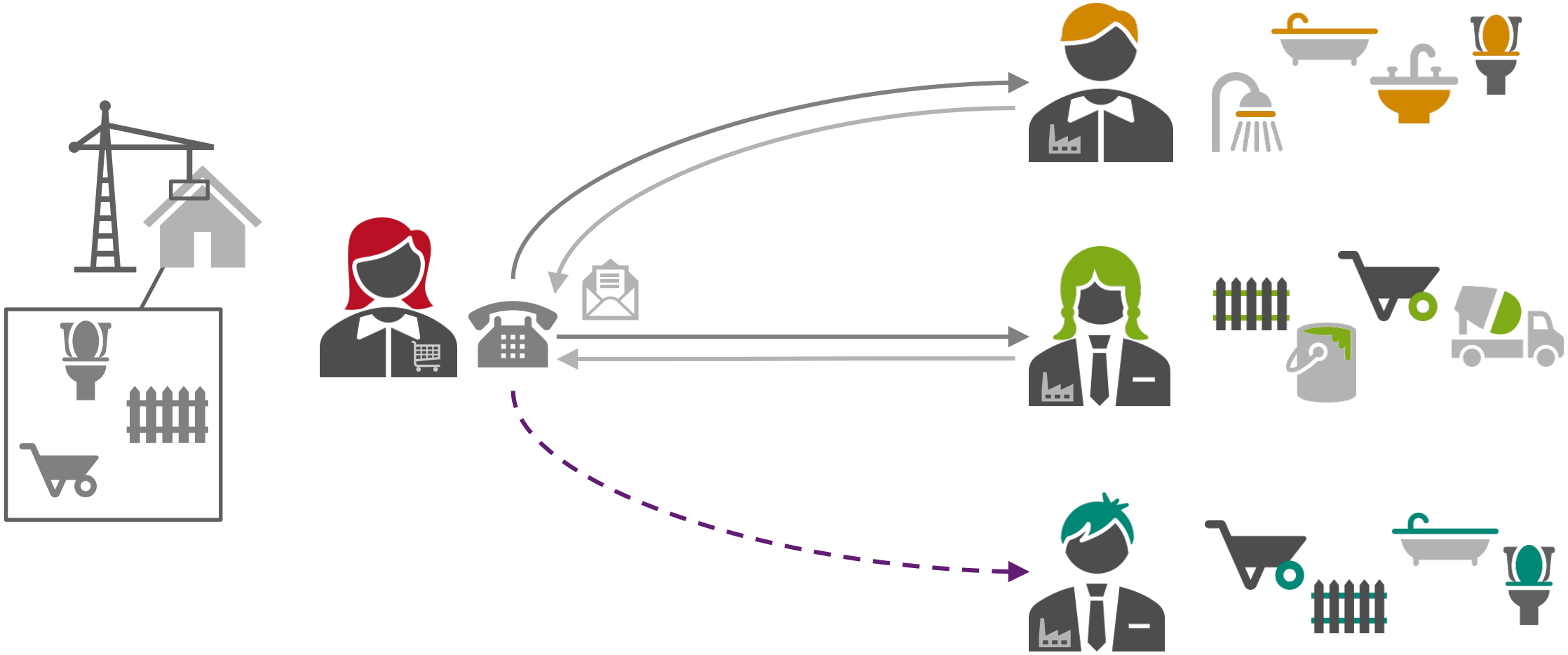

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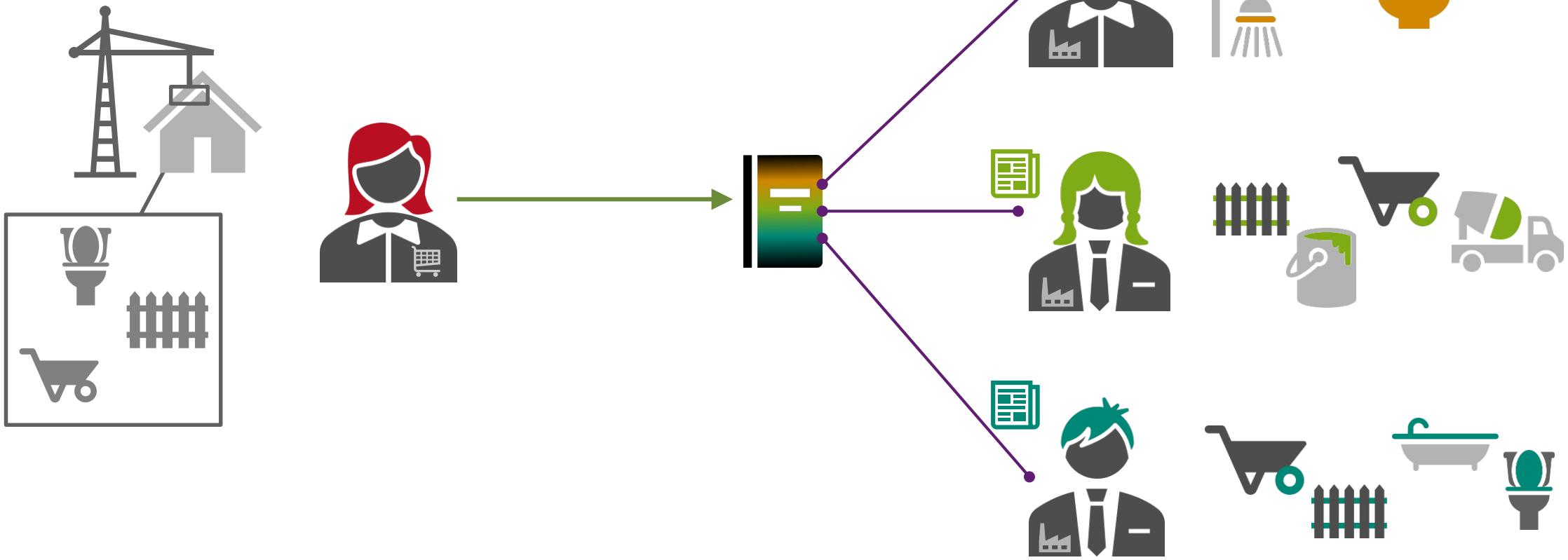

Uniform Product Descriptions
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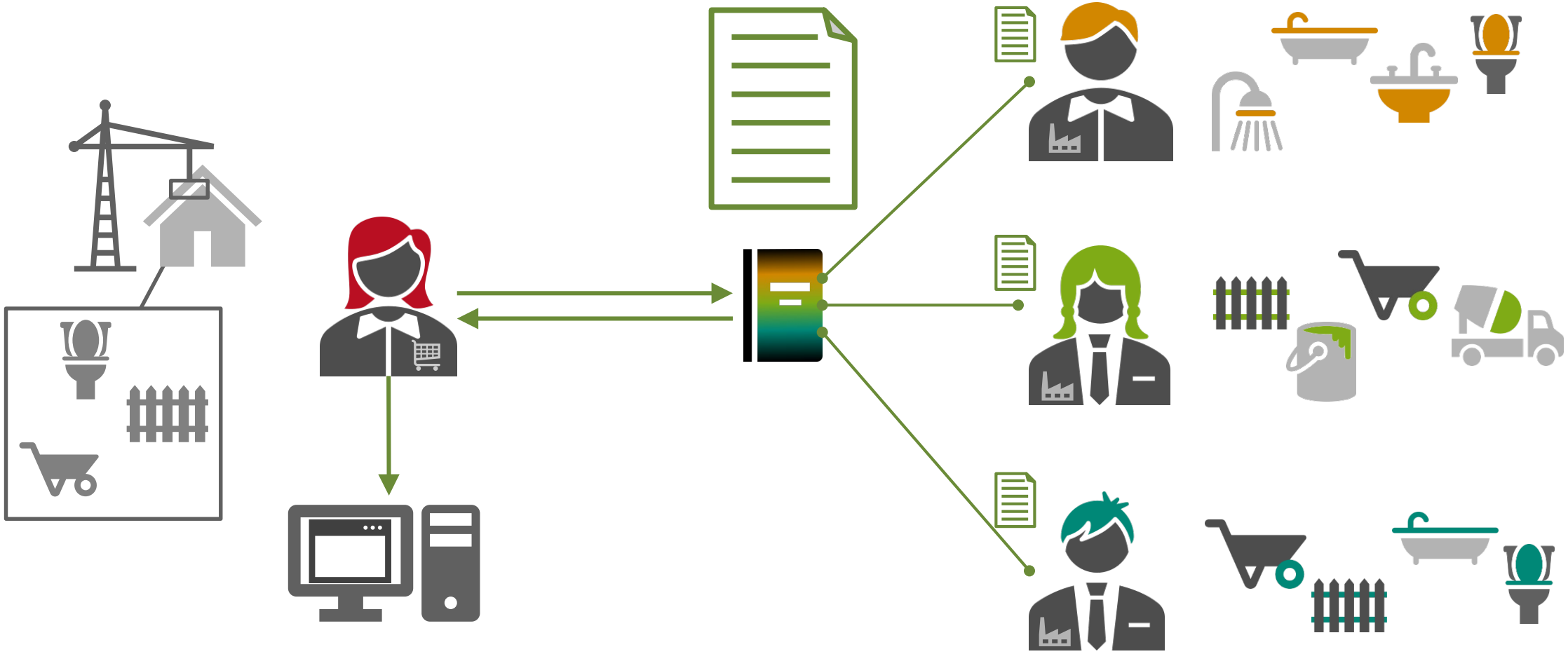

Uniform Product Descriptions
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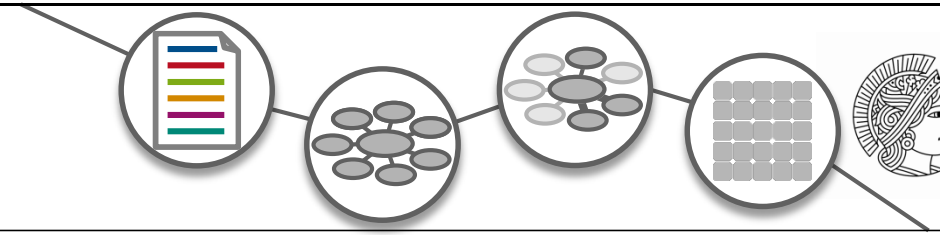

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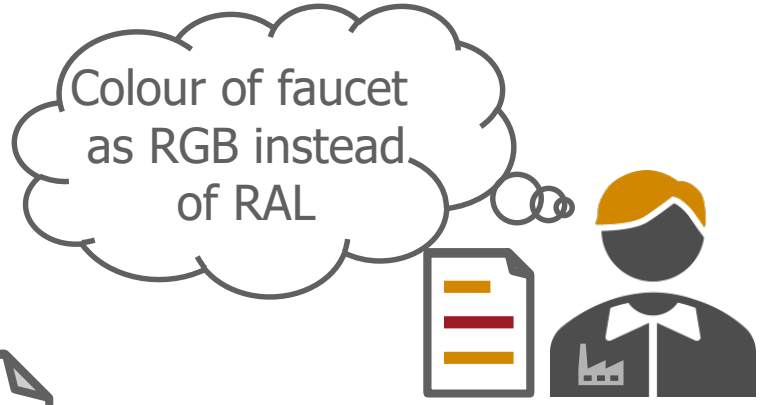
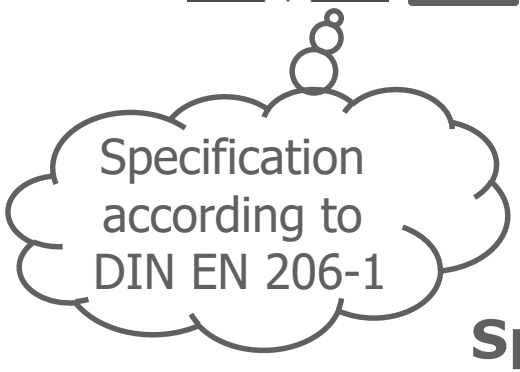


Different Datatype

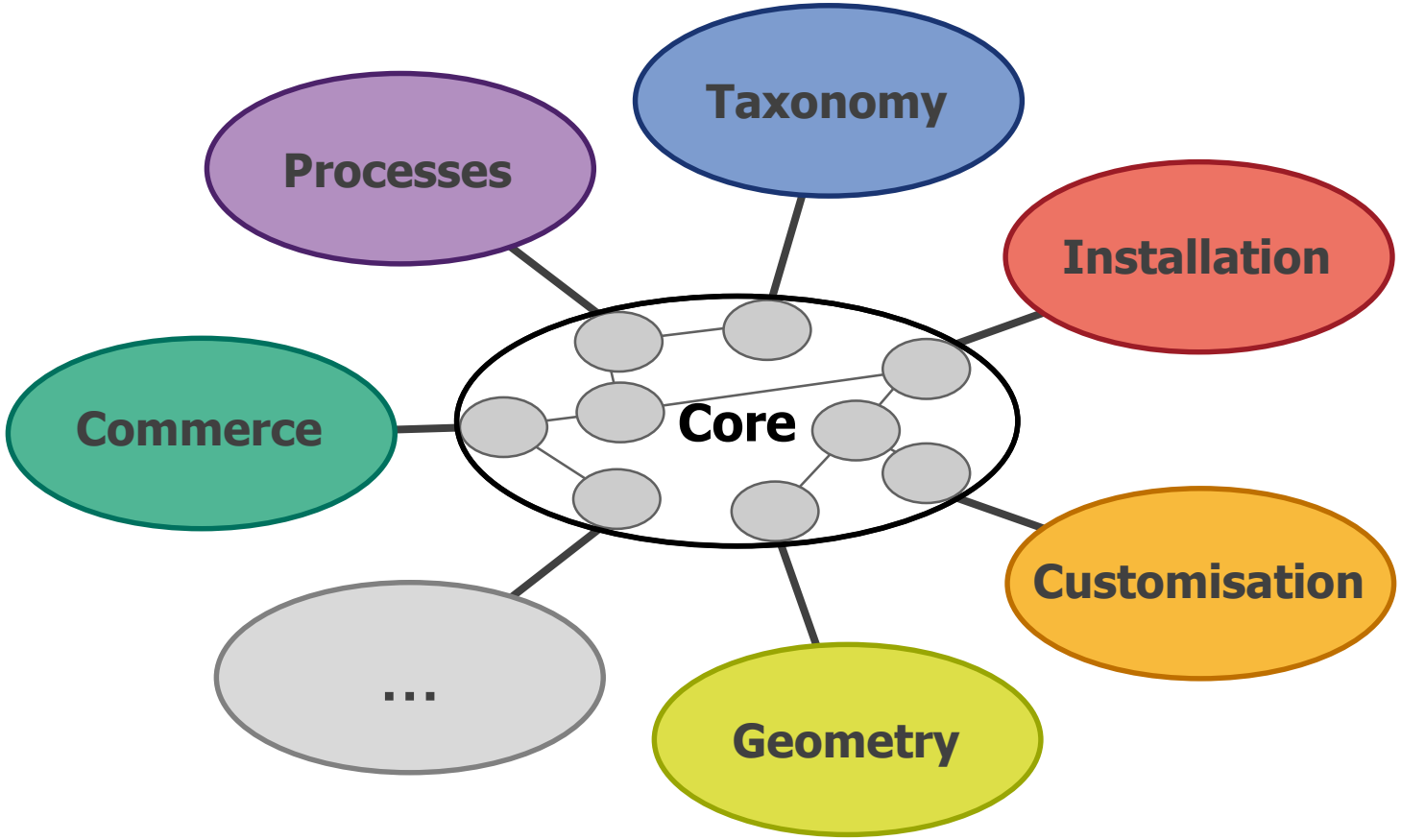


Further Specification

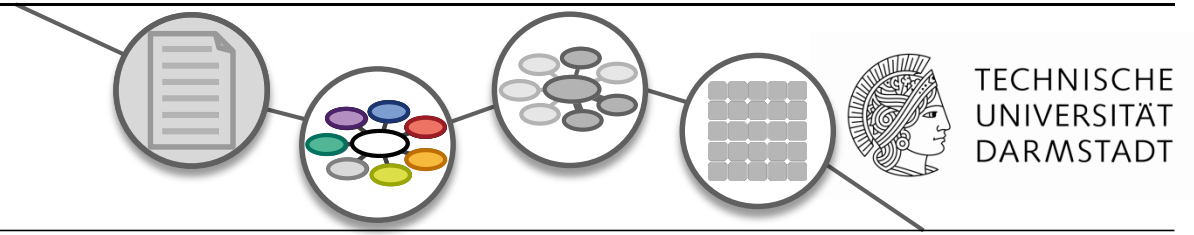
Novel Types or Properties

Linked Product Data
Concept

- Modular
- Extensible
- Flexible
- Queryable
- Machine-readable
- Multi-lingual

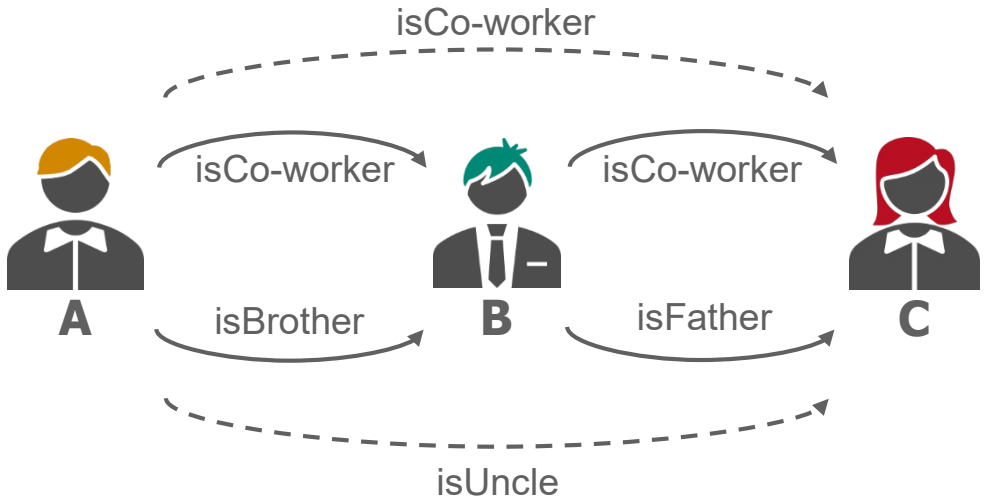


The Semantic Web
Basics



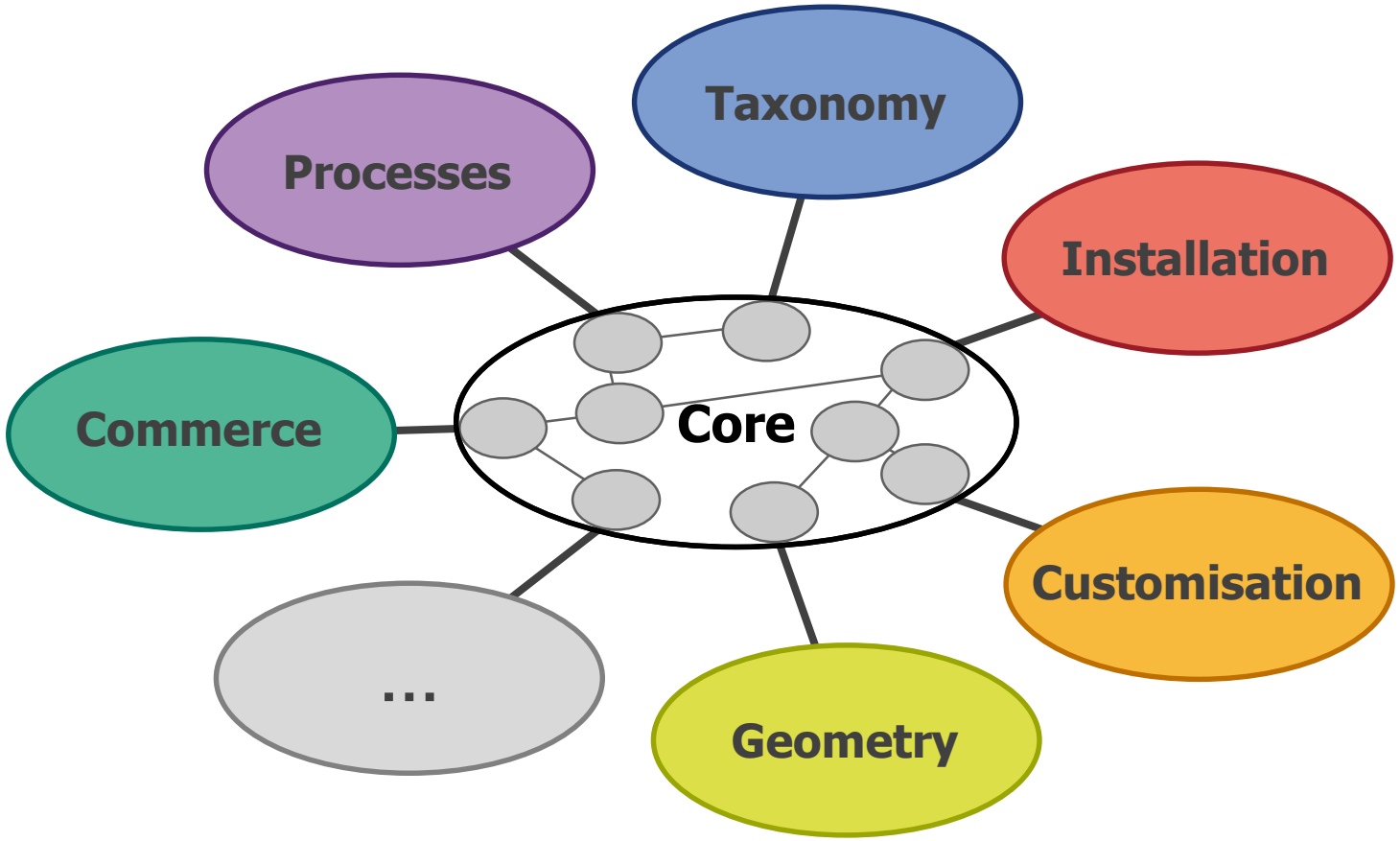
- Graph-based data structure

- Identification via URIs, e.g. URLs
- Schema can be extended by logical axioms
  - Transitivity
  - Property Chains
- Machine-**understandable**

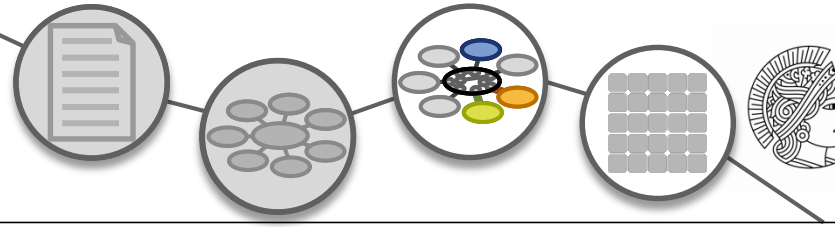


Linked Product Data
Concept

- **Modular**
- **Extensible**
- **Flexible**
- **Queryable**
- **Machine-readable**
- **Multi-lingual**



Linked Building Product Data
Implementation



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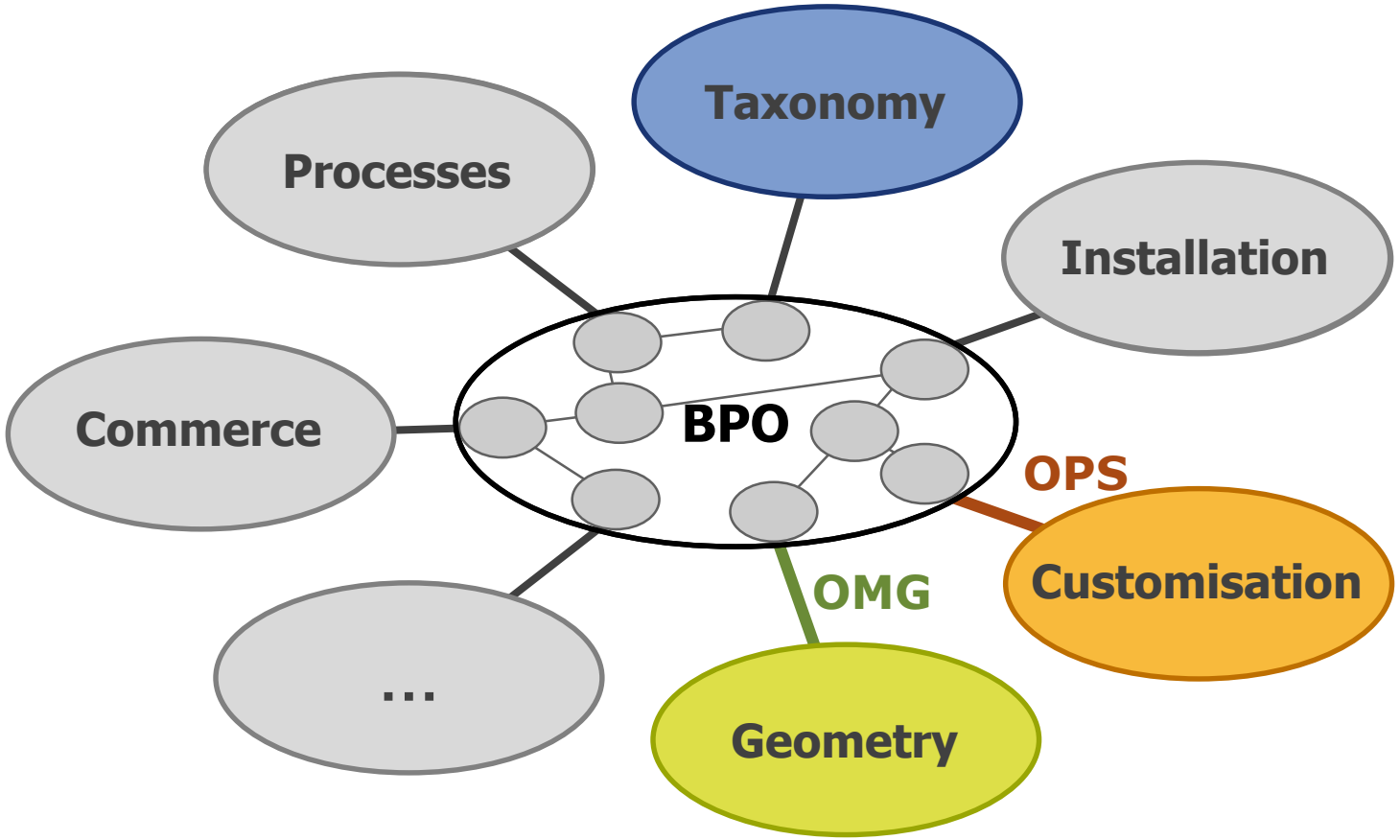


buildingSMART Data Dictionary (bSDD)

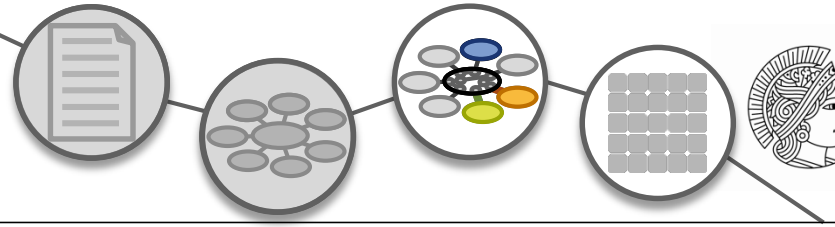
Building Product Ontology (BPO)

Ontology for Managing Geometry (OMG)

Ontology for Parametric Systems (OPS)

Geometry Ontologies | MathML

Building Product Ontology Overview



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Ontology Profile

BPO: Building Product Ontology

Scope:

Product Composition, Attributes

Perspective:

Generic

Size:

Small

Logic:

Transitivity, Property Chains

Related to:

Alignment Schema.org

Alignment SEAS

Compositional structure:

- Geometry
- Subparts
- Interconnections

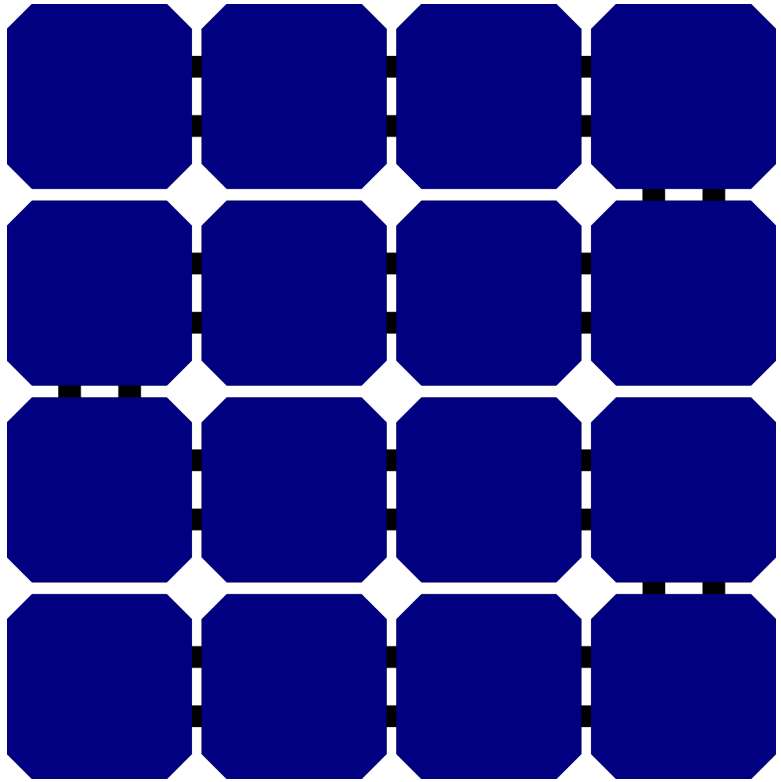
Attributes:

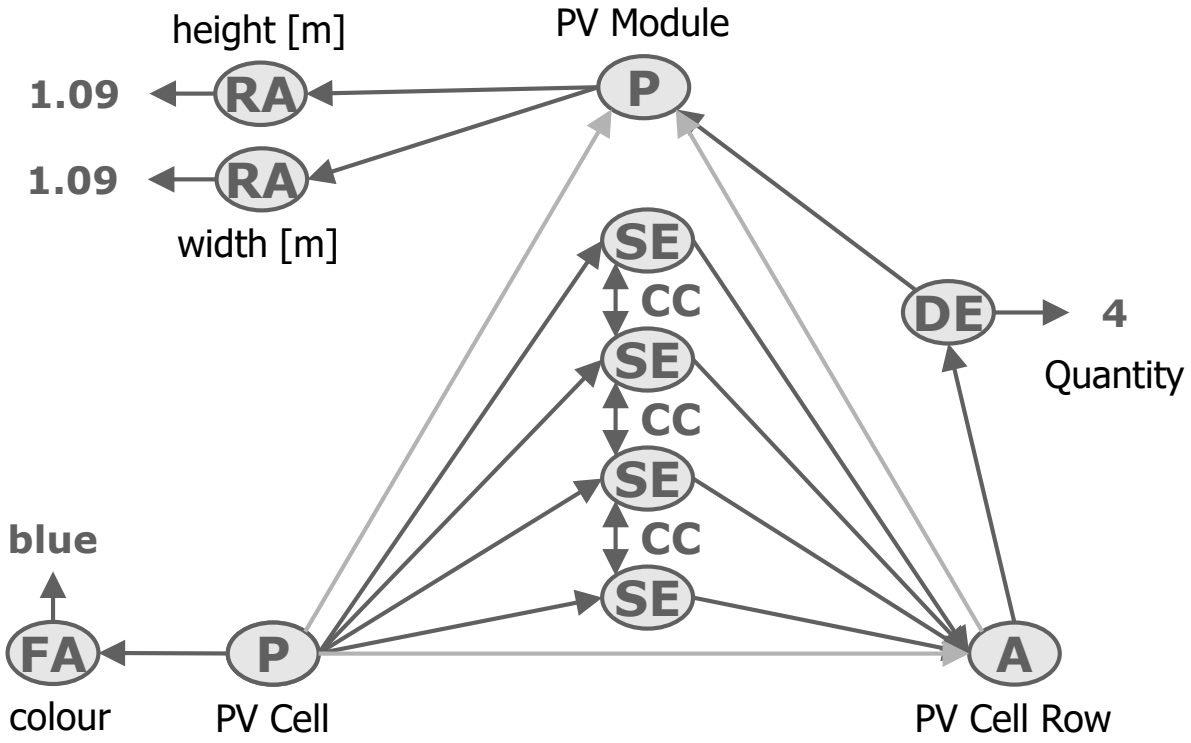
- Non-geometric information

<u>Little domain knowledge in BPO</u>

Domain taxonomy required!

Building Product Ontology
Concepts

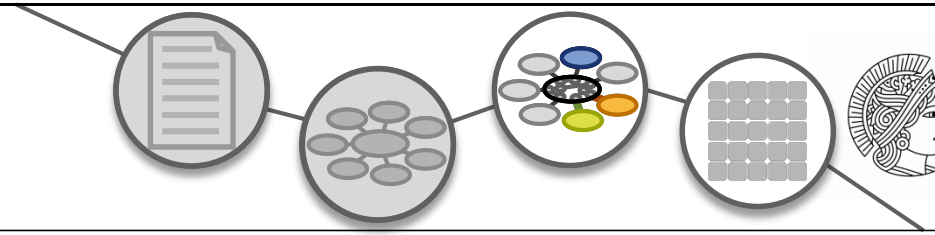




E: Element
A: Assembly
P: Product
SE: Singular Entity

DE: Dynamic Entity
CC: Component Connection
FA: Fixed Attribute
RA: Ranged Attribute

Ontology for Managing Geometry Overview



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Ontology Profile

OMG: Ontology for Managing Geometry

Scope:

Connecting / Relating Geometry Descriptions

Perspective:

Generic

Size:

Small

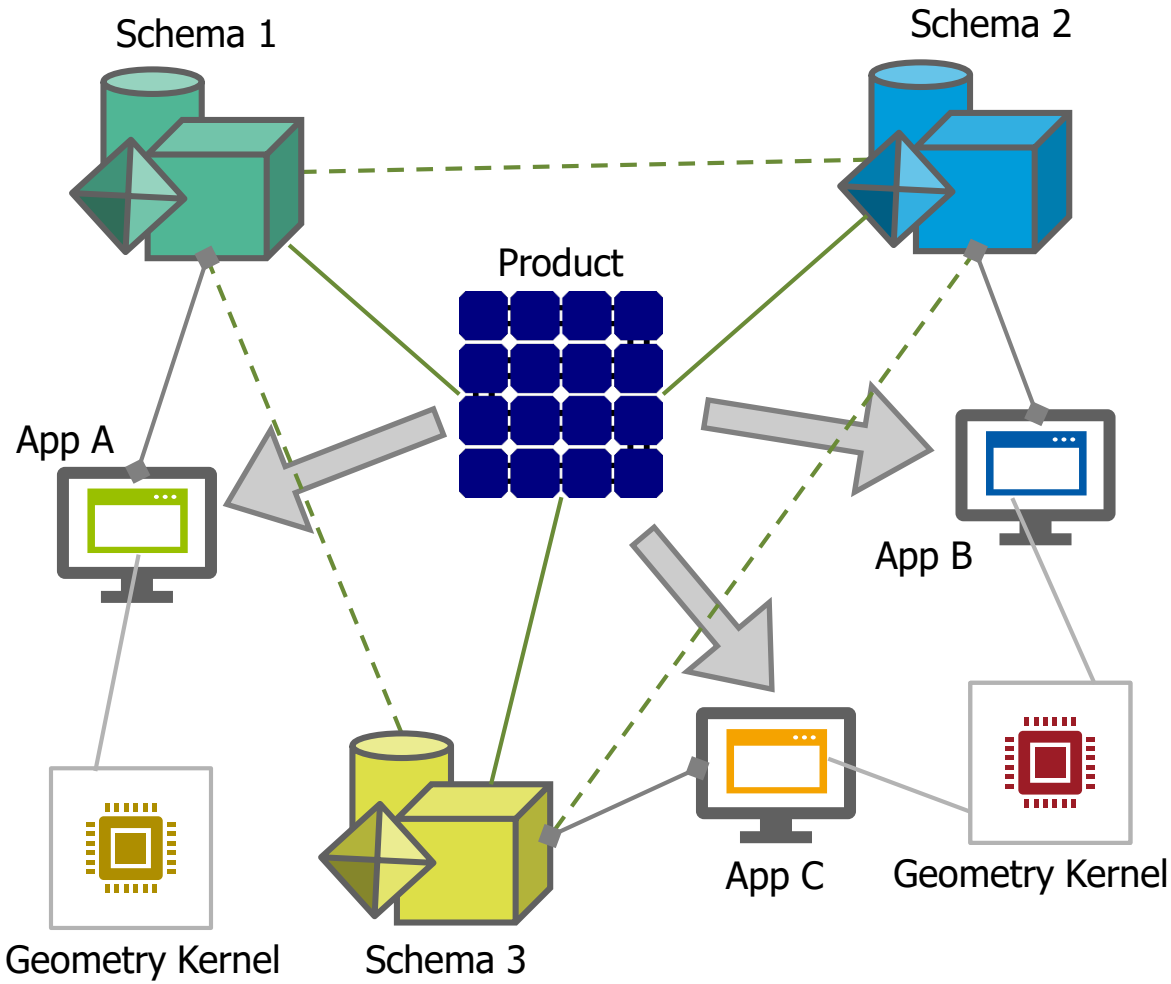
Logic:

Property Chains

Related to:

Alignment SEAS

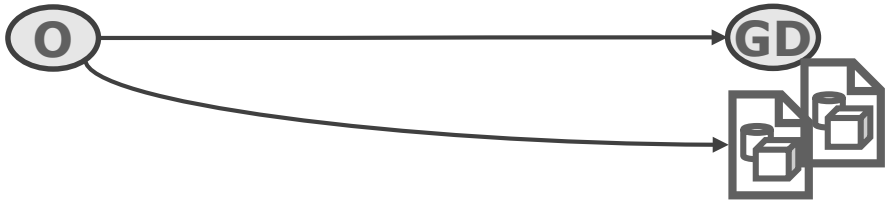
Inspired OPM



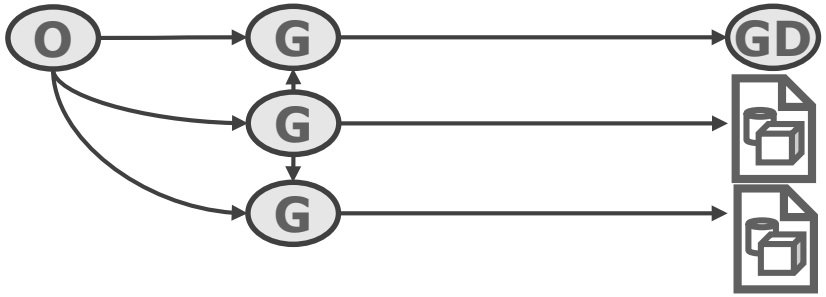
Ontology for Managing Geometry
Modelling Levels

Implemented in three levels to optimise complexity for individual use cases

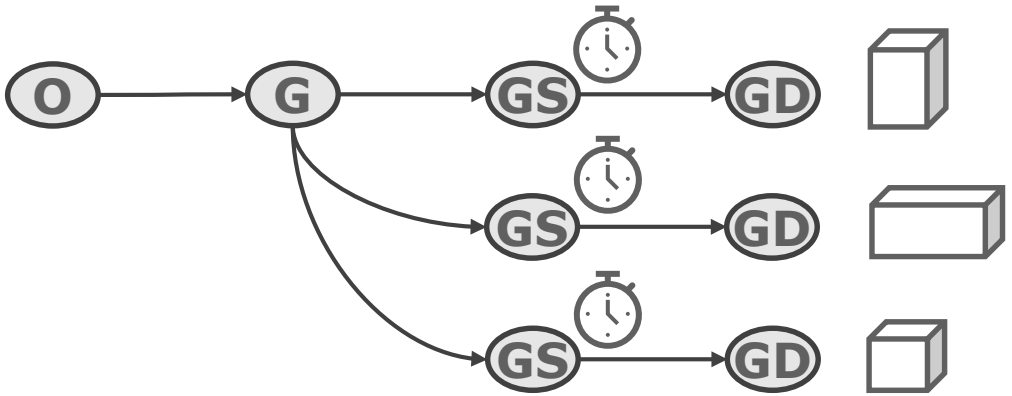
Level 1: Direct connection



Level 2: Objectified connection

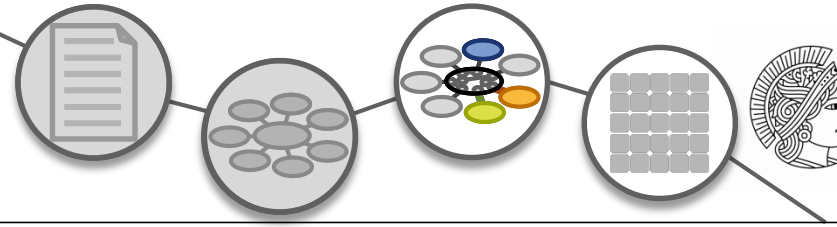


Level 3: Twice objectified connection



O: Object
GD: Geometry Description
G: Geometry Node
GS: Geometry State

Ontology for Parametric Systems Overview



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Ontology Profile

OPS: Ontology for Parametric Systems

Scope:

Defining Parametric Systems and Variables

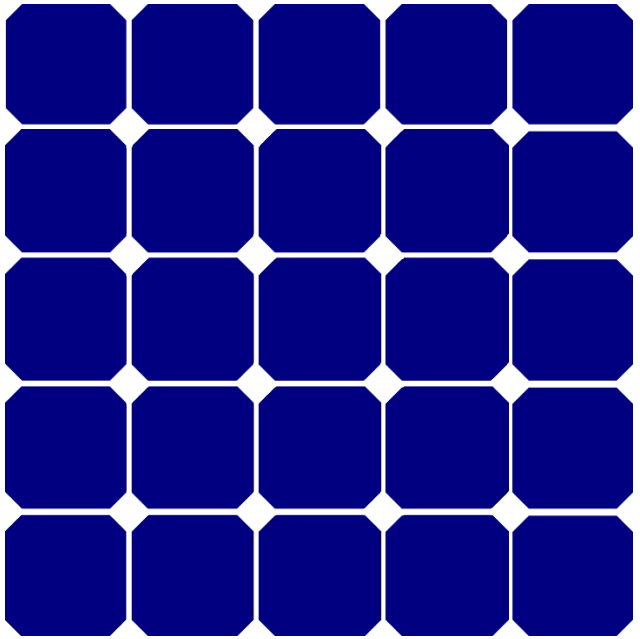
Connecting Constraints

Perspective:

Generic

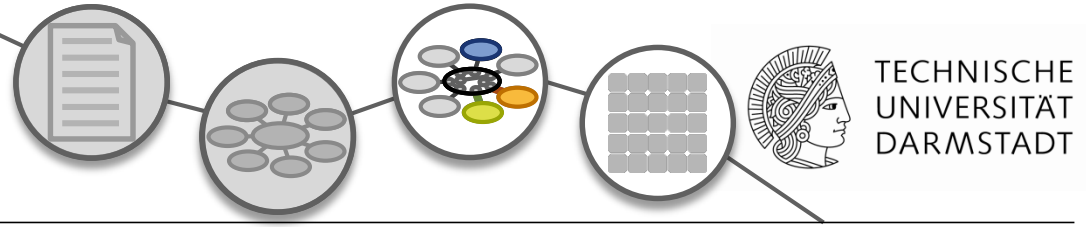
Size:

Small



- Automatic placement of additional PV cells
- Recalculation of the module's efficiency
- Quality-check of results

Ontology for Parametric Systems
Concepts



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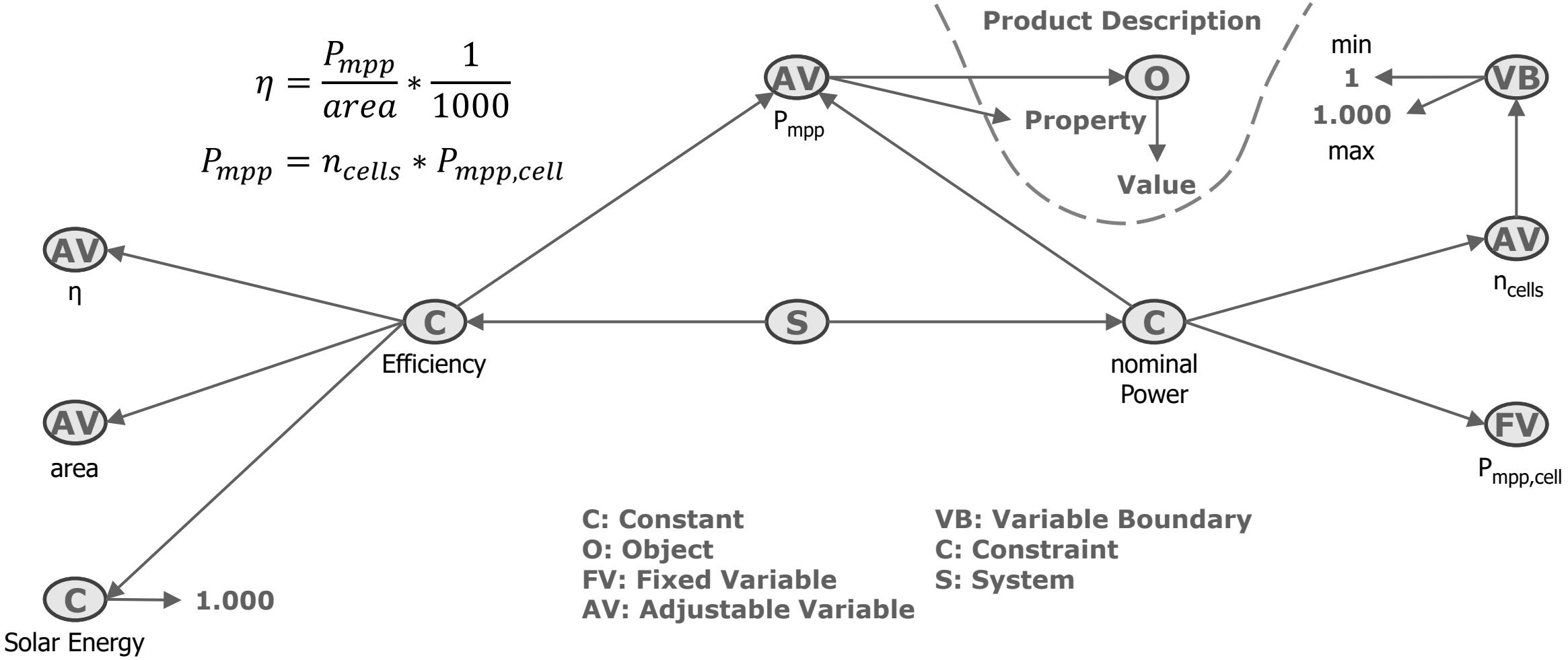
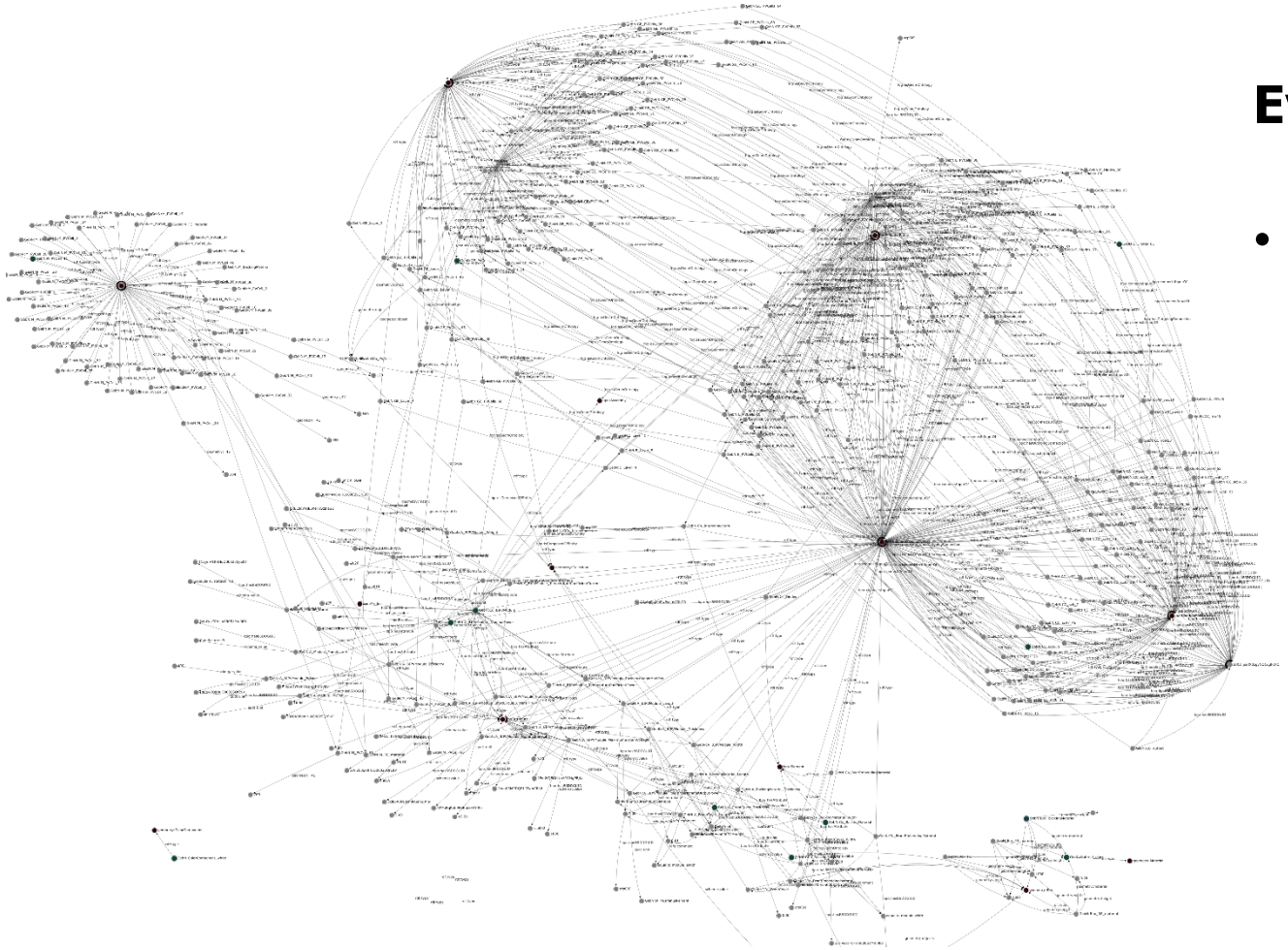
$$\eta = \frac{P_{mpp}}{area} * \frac{1}{1000}$$

$$P_{mpp} = n_{cells} * P_{mpp,cell}$$



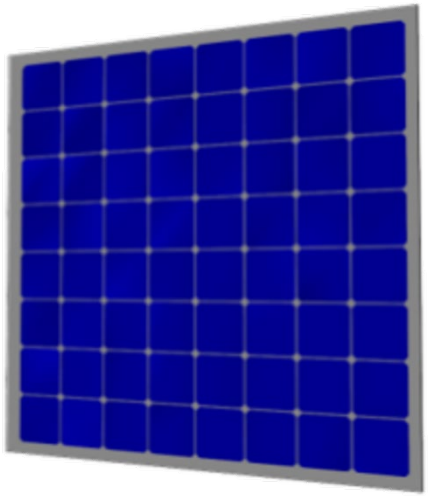
Evaluation
Example Implementations

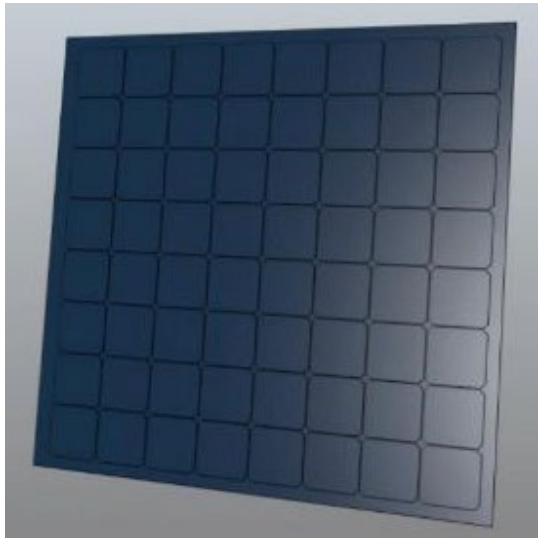


Evaluated criteria:

- Extensive product descriptions

Evaluation
Example Implementations

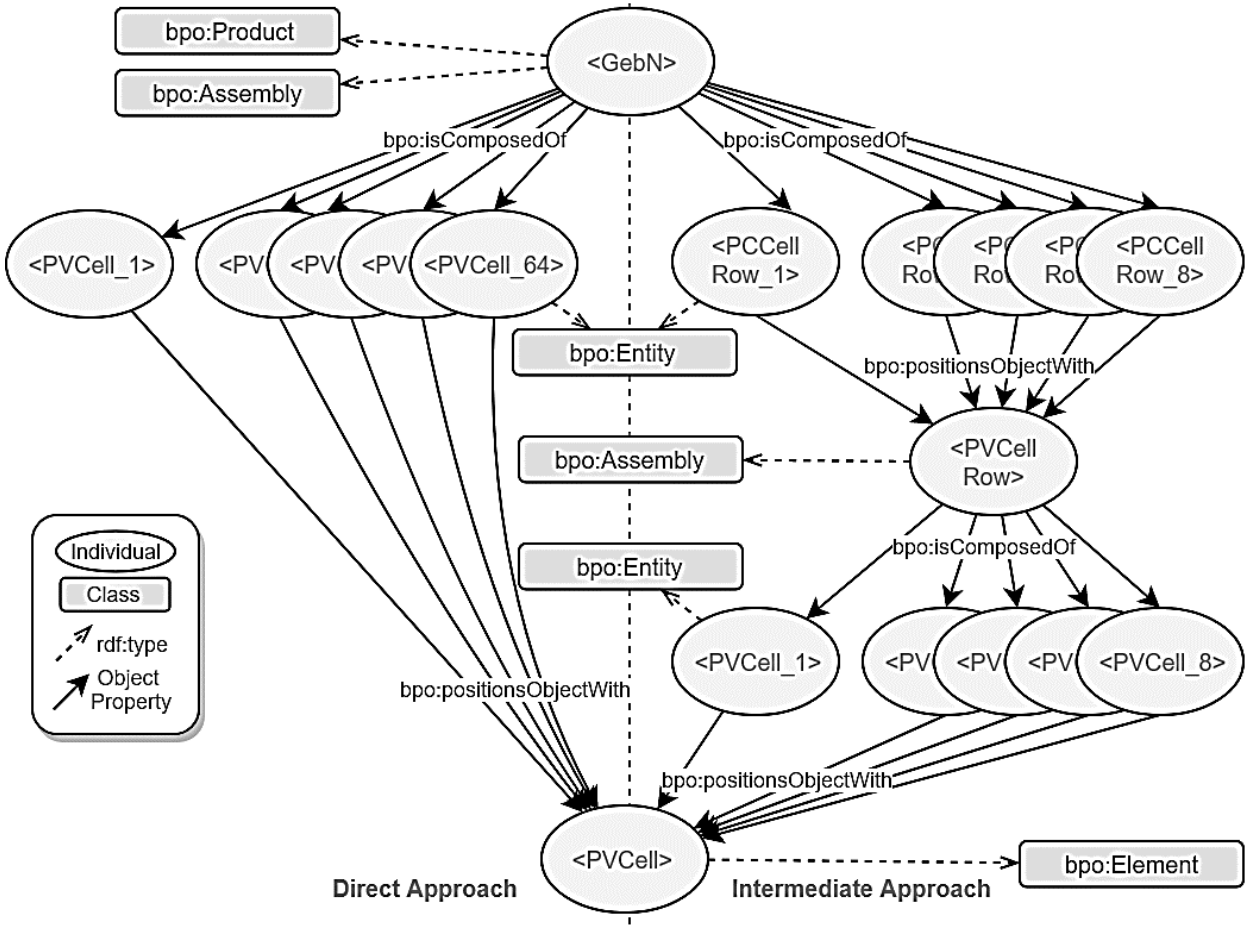




Evaluated criteria:

- Extensive product descriptions
- Modularity

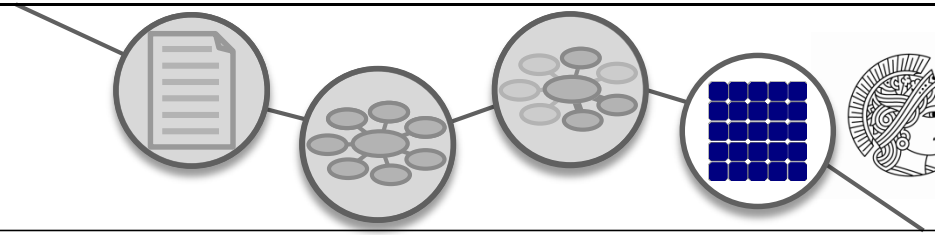
Evaluation
Example Implementations



Evaluated criteria:

- Extensive product descriptions
- Modularity
- Freedom of modelling

Evaluation
Example Implementations



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$$integer N_x = \frac{x_{module} - (2 * gap_{module}) + spacing_{cell}}{x_{cell} + spacing_{cell}}$$

$$integer N_y = \frac{y_{module} - (2 * gap_{module}) + spacing_{cell}}{y_{cell} + spacing_{cell}}$$

$$N_{cells} = N_x * N_y$$

$$(spacing_{cell} - spacing_{cell,min} + 2 * (gap_{module} - gap_{module,min}) < x_{cell}$$

$$(spacing_{cell} - spacing_{cell,min} + 2 * (gap_{module} - gap_{module,min}) < y_{cell}$$

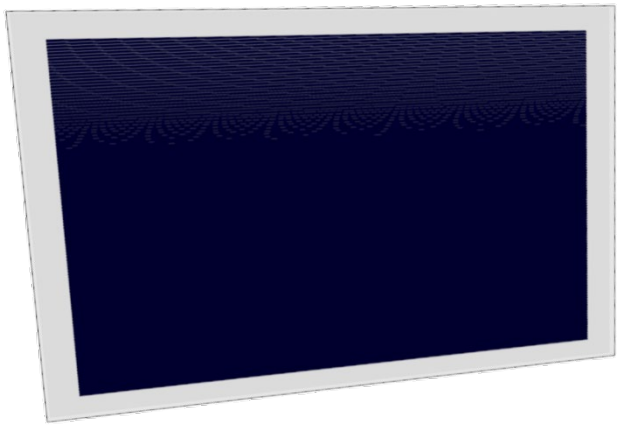
$$P_{mpp} = N_{cells} * P_{mpp,eff,cell}$$

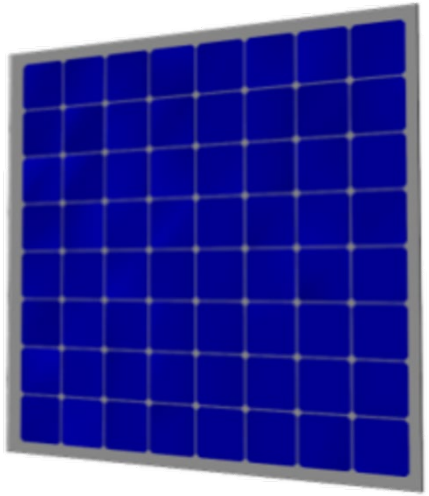
$$\eta = \frac{P_{mpp}}{x_{module} * y_{module}} * \frac{1}{1000}$$

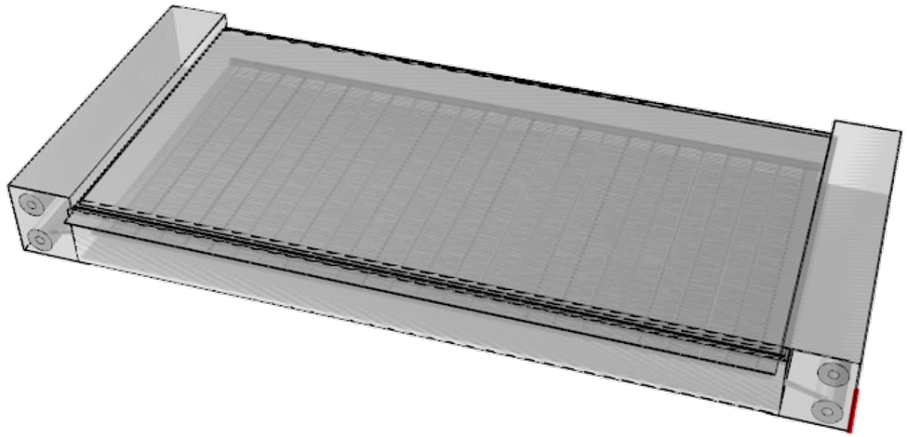
Evaluated criteria:

- Extensive product descriptions
- Modularity
- Freedom of modelling
- Parametric product descriptions

Evaluation
Example Implementations





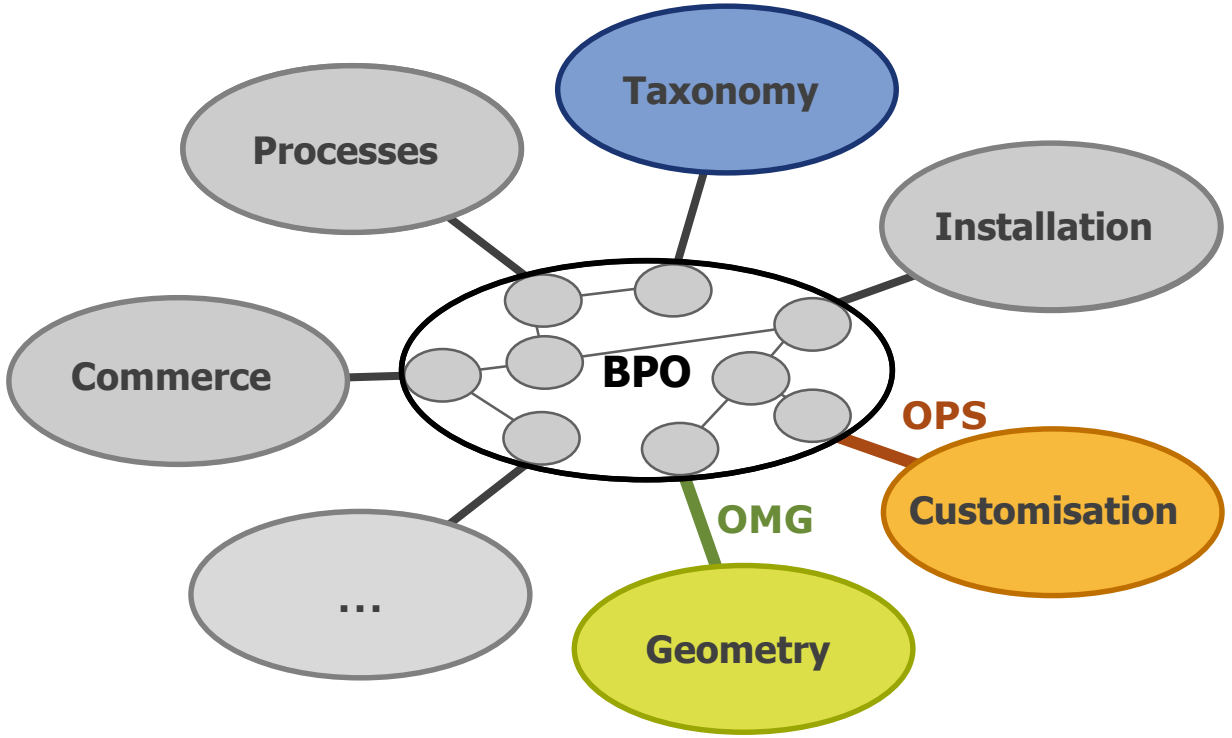


Evaluated criteria:

- Extensive product descriptions
- Modularity
- Freedom of modelling
- Parametric product descriptions
- Uniform querying and reasoning

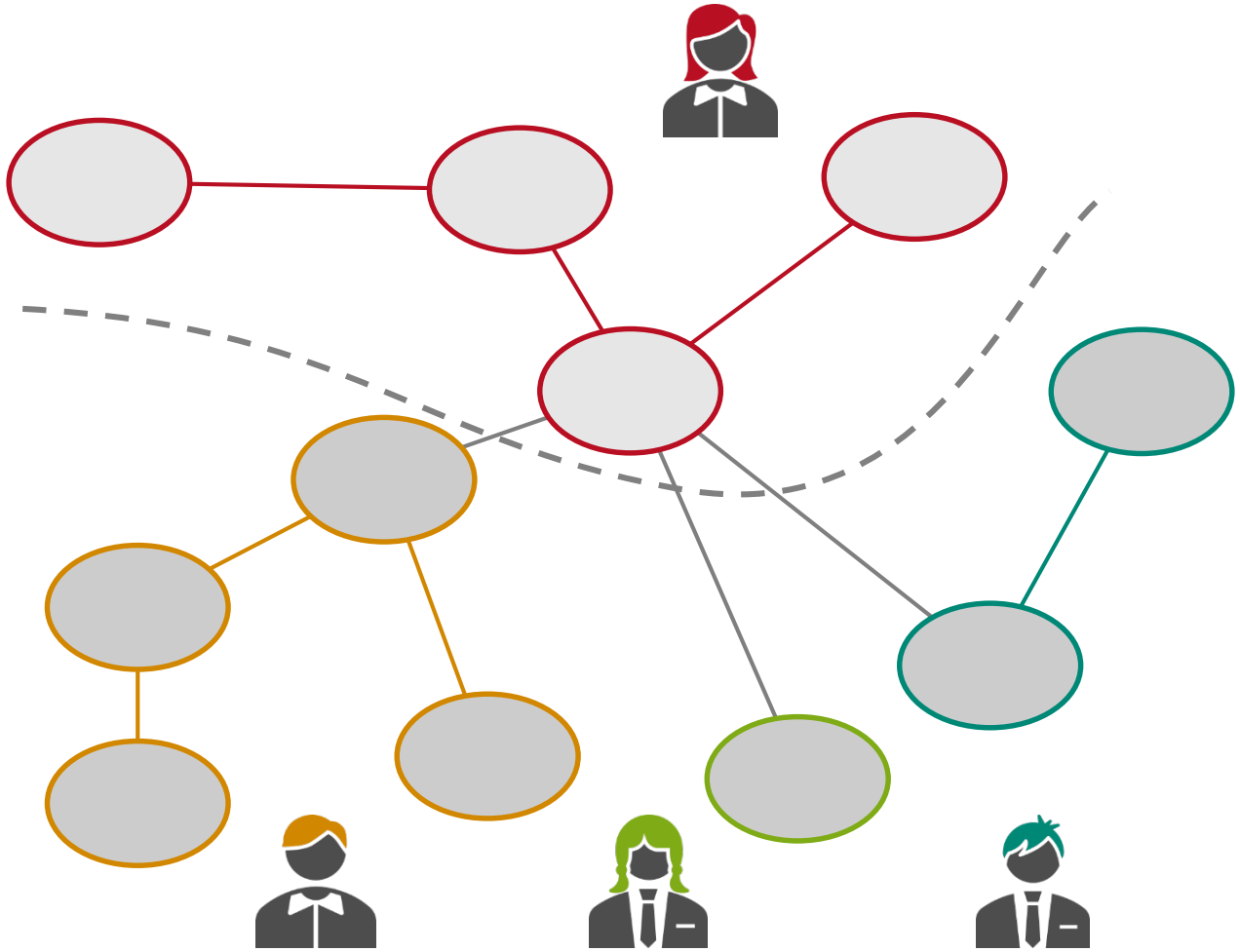
Conclusion

- ✓ All evaluated criteria could be met
  - Flexible and modular product description



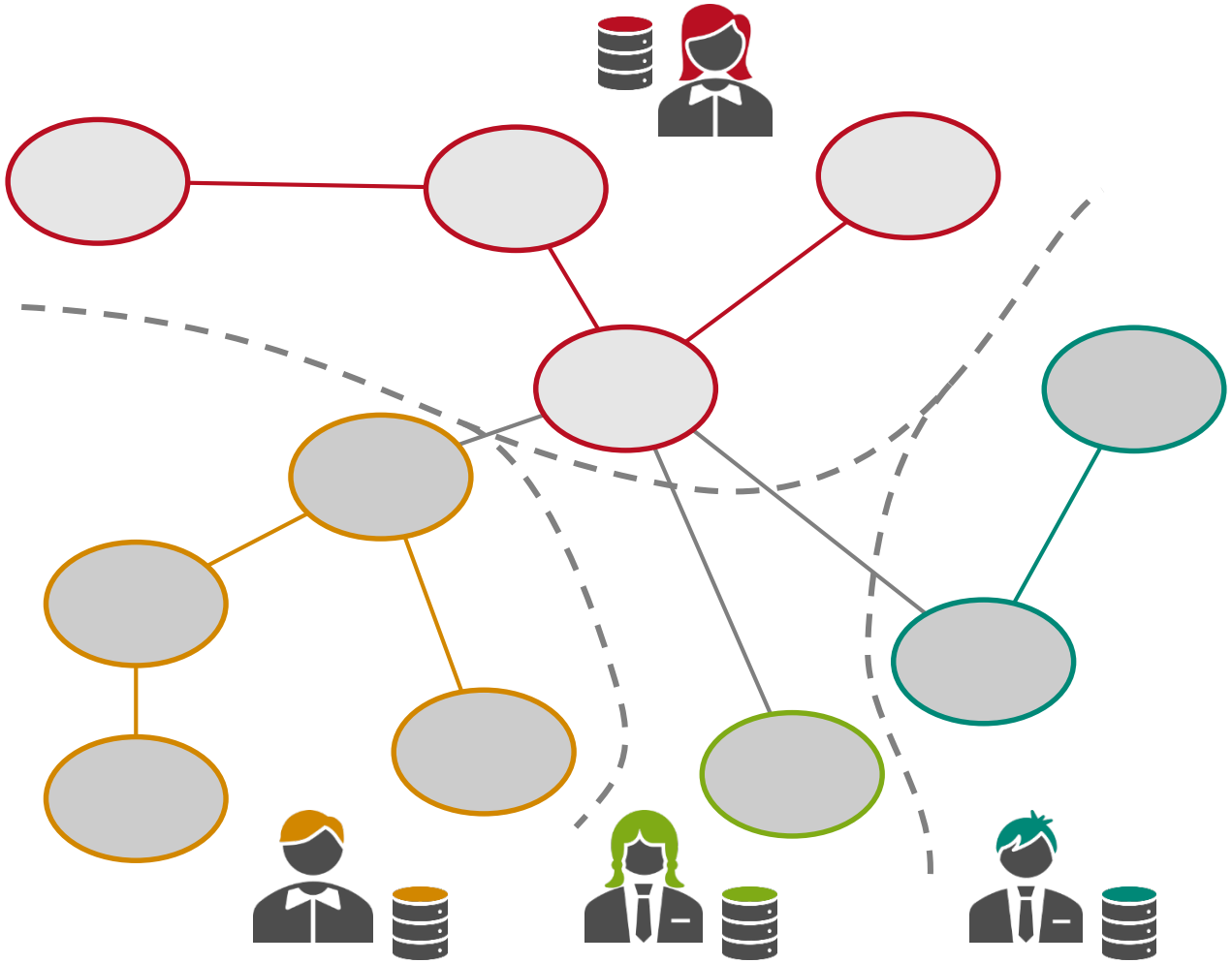
Conclusion

- ✓ All evaluated criteria could be met
  - Flexible and modular product description
- ✓ Straight-forward integration of product data into Linked Building Data



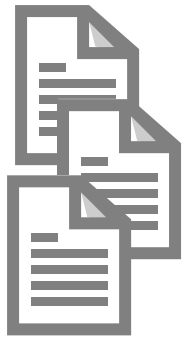
Conclusion

- ✓ All evaluated criteria could be met
  - Flexible and modular product description
- ✓ Straight-forward integration of product data into Linked Building Data
- ✓ Application of Linked Data facilitates distributed data storage systems



Conclusion

- ✓ All evaluated criteria could be met
  - Flexible and modular product description
- ✓ Straight-forward integration of product data into Linked Building Data
- ✓ Application of Linked Data facilitates distributed data storage systems
- ✓ Dissemination of introduced ontologies in corresponding working groups



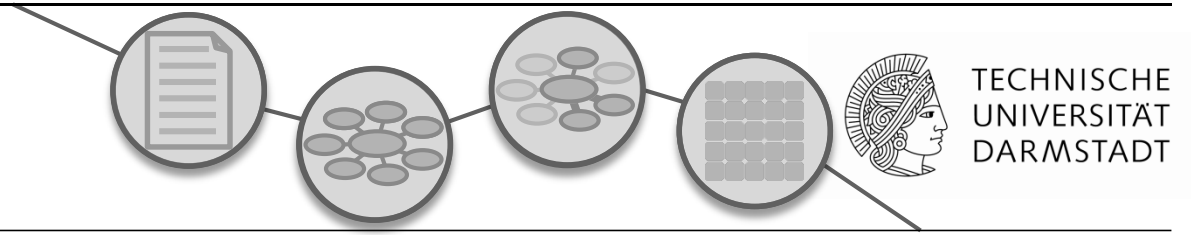
publications at international conferences and workshops

publications in international journals (incl. co-authorships)

World Wide Web Consortium (W3C): Linked Building Data Community Group

Linked Building Data Community (outside of W3C)

Conclusion



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  - Flexible and modular product description
- ✓ Straight-forward integration of product data into Linked Building Data
- ✓ Application of Linked Data facilitates distributed data storage systems
- ✓ Dissemination of introduced ontologies in corresponding working groups

- ϟ Full extent of benefits only show with broad applications
  - Wide acceptance requires development of processing tools
- ϟ Currently missing Linked Data taxonomy for AEC
- ϟ Lacking Alignment of OMG and OPS

SCOPE

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THANK YOU FOR YOUR ATTENTION!

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