TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Bauingenieurwesen Institut für Bauinformatik

Formal Description of a Generic Multi-Model

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Overview

1. Construction Information Processes
2. Objective: Provide explicit and reusable Multi-Model Information
3. Approach: The Generic Multi-Model
4. Application and Adoption Examples
5. Conclusion: Summary and Outlook

Construction Information Processes

Specific Characteristics of Construction Projects

- Uniqueness of Product (Building), Construction Site + Environment, Stakeholders (e.g. Planning Team, Construction Companies, Building Authorities)
- Usually no Prototypes possible
- No Optimization like in Mass Production
- Wide and different Building Regulations

Product Data Technology in the Construction Industry

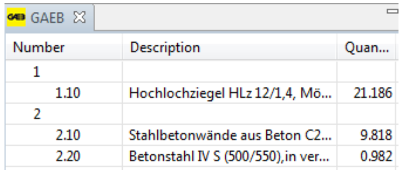
- Research Activities started in the mid. 1980s
- Product Data Model = Building Information Model (BIM)
- One important BIM Standard: Industry Foundation Classes (IFC)

Industry Foundation Classes (IFC)

- ISO-16739, defined by buildingSMART International
- Based on STEP (Standard for the exchange of product model data)
- Defined in EXPRESS
- Hierarchical Layer Architecture, extensible
- Currently serves 9 Domains (Architecture, Construction Management, Facility Management, …)

Construction Information Processes

Basic Actors and Model-Domains of Construction Information Processes



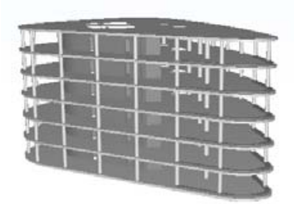
Number	Description	Quan...
1		
1.10	Hochlochziegel HLz 12/1,4, Mö...	21.186
2		
2.10	Stahlbetonwände aus Beton C2...	9.818
2.20	Betonstahl IV S (500/550),in ver...	0.982

Specifications Model

Specification Expert ← produces

Planner

Architect → produces



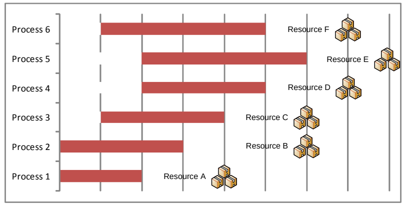
BIM (Architecture Model)

± Costs
± Dates
± Quality

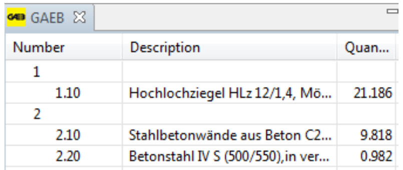
Controller ← calculates

Owner

Project Manager → produces



Schedule Model



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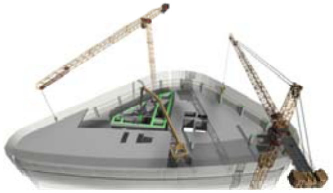
Quantities Model (incl. Prices)

Bid Expert ← produces

Contractor

Site Planner → produces

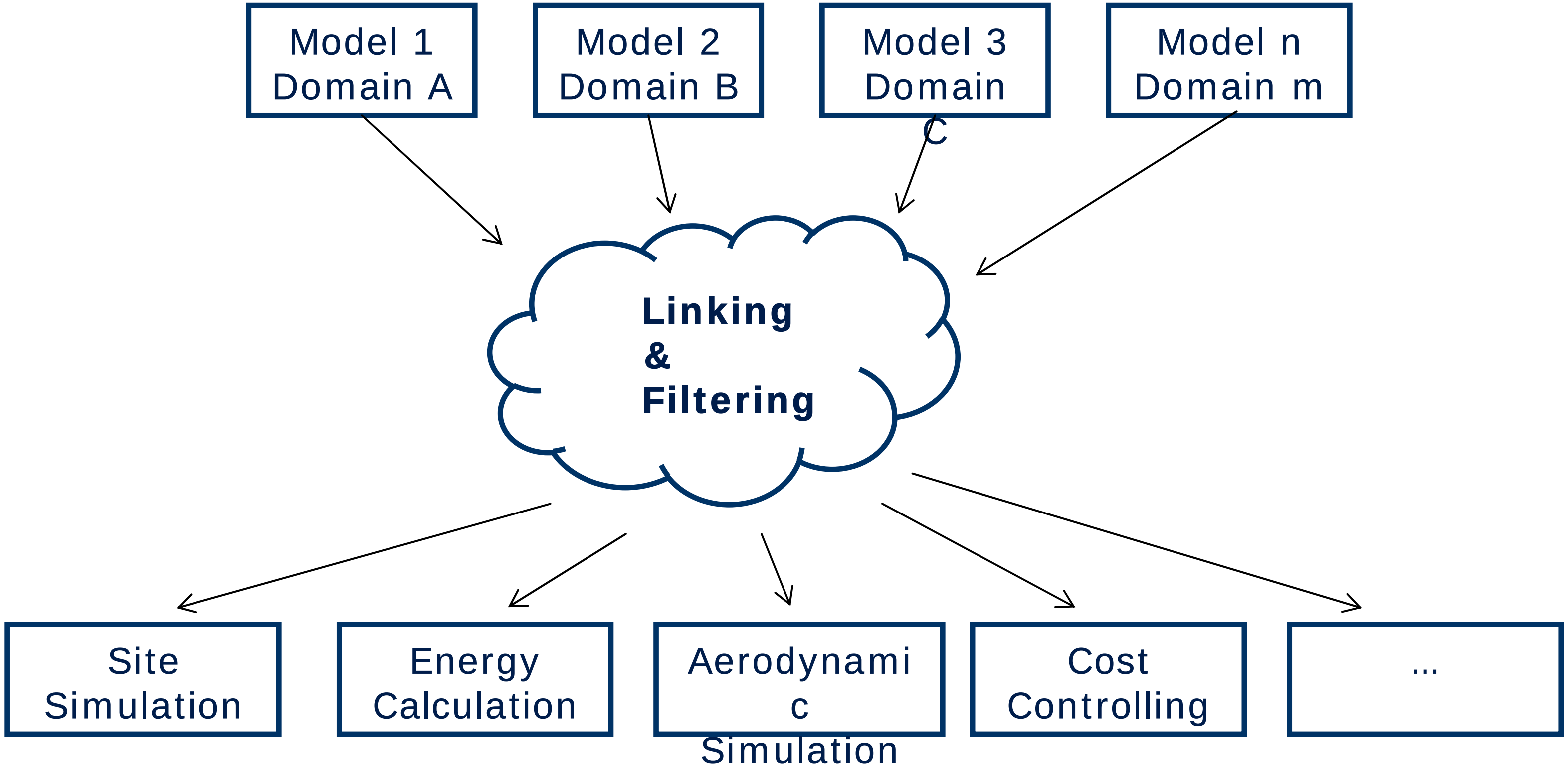


Construction Site Model

Construction Information Processes

nD Modeling Problem:

- Many Orthogonal Domains
- Concurrent and overlapping Model-Schemas per Domain
- **Use of combined Model Information for non intended scenarios** **(Disjunctive Data, Task specific Linking)**



Model 1 Domain A

Model 2 Domain B

Model 3 Domain C

Model n Domain m

Linking & Filtering

Site Simulation

Energy Calculation

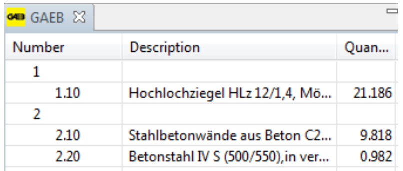
Aerodynamic Simulation

Cost Controlling

...

Construction Information Processes

Multi-Model Example: Calculate Bidding Price



GAEB

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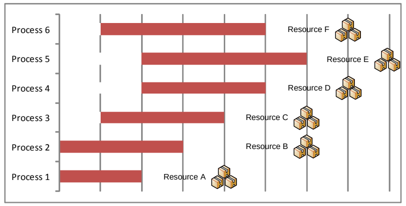
Specifications Model

BIM (Architecture Model)



Schedule Model

Linking
Quality - Wall - Task

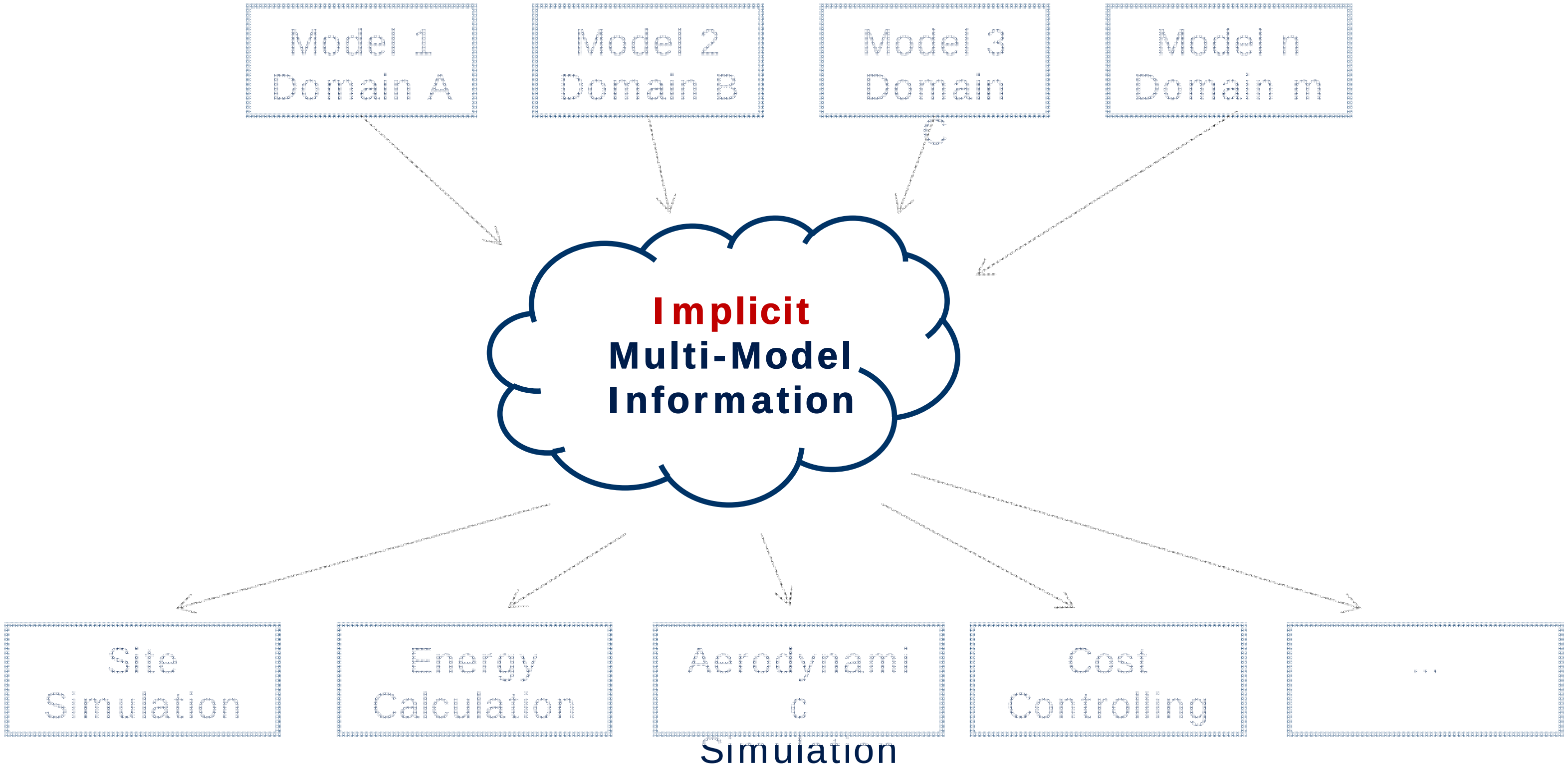
Actual Data Source

Query
ALL walls (quality = “HLZ 36,5“ AND heigth > 4.00 m AND build.end < 28.06.2011)

Objective: Explicit & Reusable MM-Information

Problem: Current Multi-Model Information is

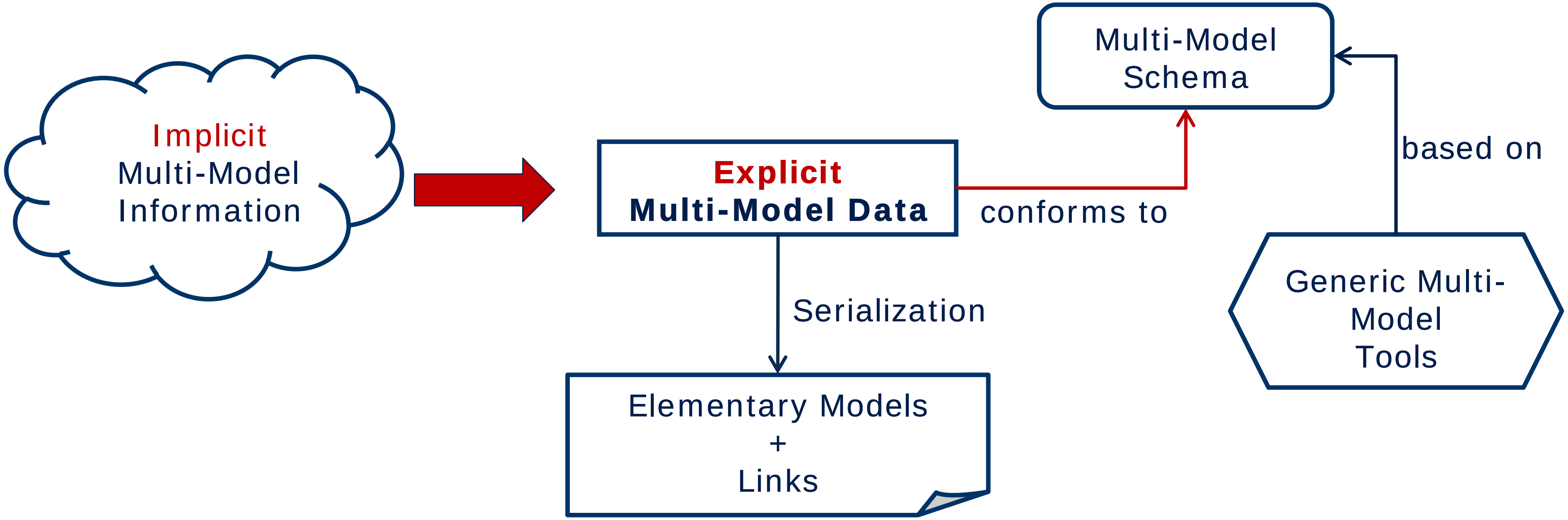
- Implicit - and therefore poorly reusable
- Private - not intended to be interoperable
- Expensive – created manually, by self-written software or expensive expert software (e.g. RIB iTWO, Autodesk Navisworks, Synchro)



Objective: Explicit & Reusable MM-Information

Objective: Provide explicit and reusable Multi-Model Information

- Provide a Data Schema for Multi-Models to allow Creation of generic Multi-Model Tools (e.g. Linking- and Filter-Strategies)
- Specified Serialization Format for neutral Data Exchange including Elementary Models and the Links between their Elements



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Objective: Explicit & Reusable MM-Information

Identified Requirements:

1. There must be a schema of a multi-model which is generic by the meaning of domain unaware
2. The schema must be concrete by the meaning of allowing the ad hoc creation of valid multi-model instances
3. The schema must be able to store (possibly semantic orthogonal) domain models
4. The stored domain models must not be modified
5. References between elements of domain models must be persistable and restorable.
6. Those references are binary up to n-ary
7. The schema must be extensible and adaptable (allow to create converters)
8. There must be a standard implementation which supports instantiation and manipulation of conform multi-model instances
9. There must be a standard serialization format for multi-model instances

Approach: The Generic Multi-Model

Definition (Elementary Model, EM)

An Elementary Model is an exchangeable instance of a data model with a delimited domain and an appointed semantic.

Definition (Link Model, LM)

A Link Model is a serializable instance of a data model with a schema that stores references between elements of different Elementary Models.

Definition (Multi-Model, MM)

A Multi-Model is a serializable composite of a set of Elementary Models *E* and a possibly empty set of Link Models having elements of *E* as subject.

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Approach: The Generic Multi-Model

Schema

- Ecore Model, Eclipse Modeling Framework (EMF)
- Default XML-Serialization

Constraints

- Defined for Consistency
- Not shown here

Meta-Data Information

- For yet unspecified Information
- Key Value Pairs

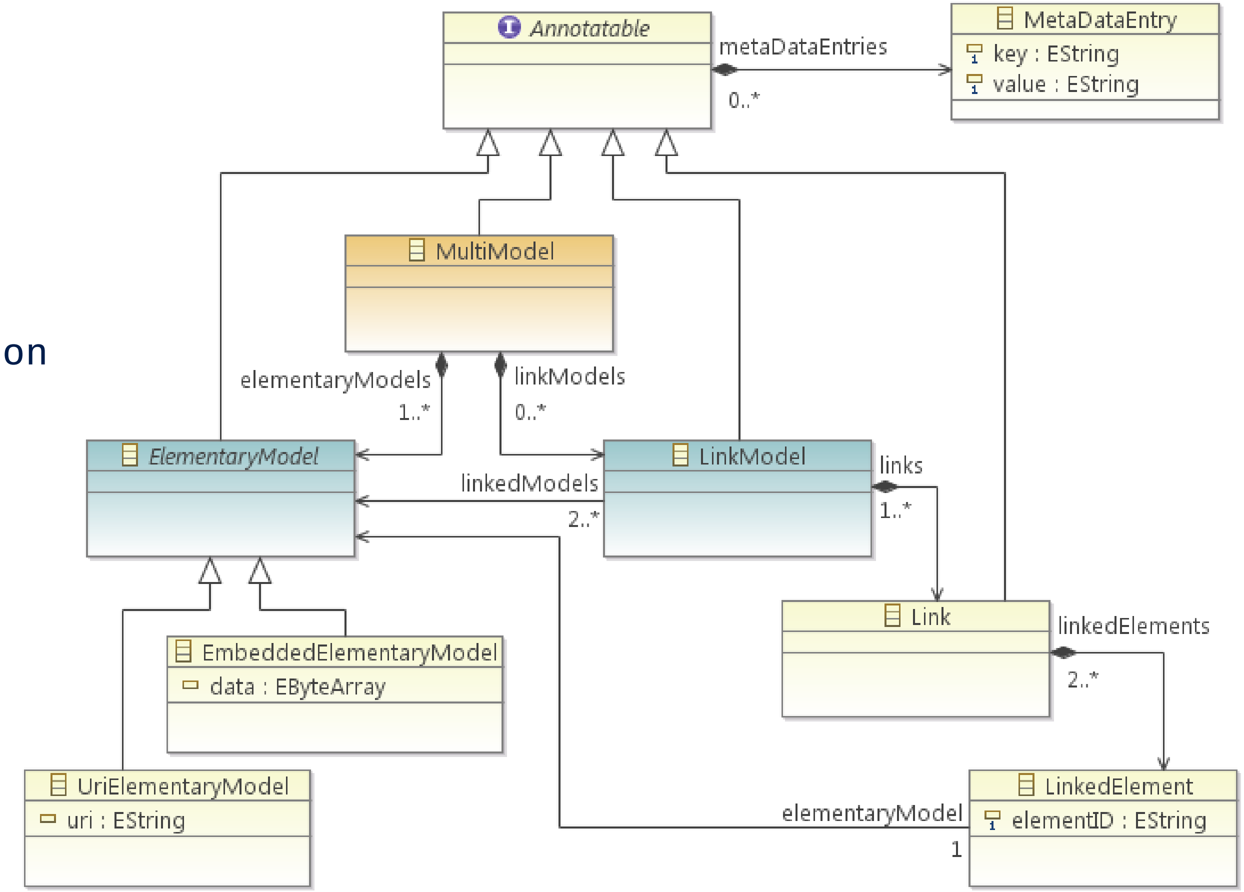
Elementary Models

- Embedded or
- Referenced by URI

Links

- n Elements of m Models
- ID-based

Class Diagram



Approach: The Generic Multi-Model

ID-based Linking - Methods for Identifying Elements without ID

1. Generate and set IDs according to the Elementary Model’s Directive
   Meta-Data: *cib.model.generatedID = TRUE*
2. Add ID to Serialization if supported by Format (e.g. XML or JSON)
   Meta-Data: *cib.model.artificialIDAttribute = <added ID attribute name>*
3. Use Primary Keys of Models stored in Relational Databases as native ID-Substitute
   Meta-Data:
   cib.linkedElement.artificialID.rdb.pk.db = <database name>
   cib.linkedElement.artificialID.rdb.pk.schema = <db schema name>
   cib.linkedElement.artificialID.rdb.pk.table = <db table name>
   cib.linkedElement.artificialID.rdb.pk.column = <db column name>

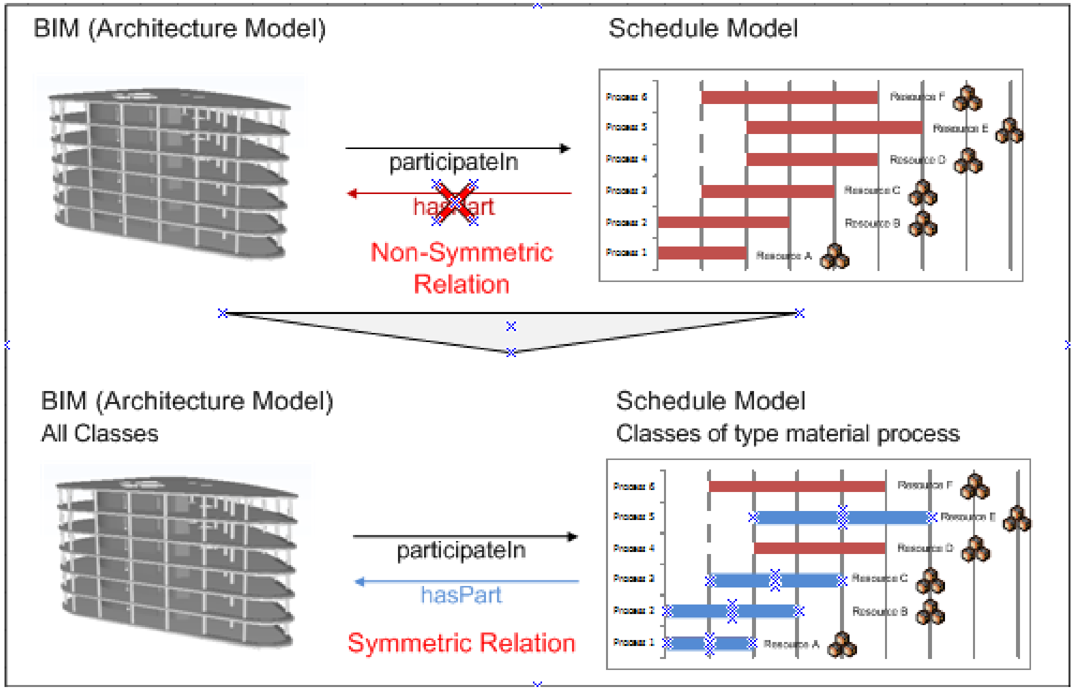
Methods providing potentially unexact or inconsistent Results

4. Use Feature Path as ID-Value
   e.g. *Root->Building->Roof*
5. Use Collection Index as ID-Value
   e.g. *Root[0]->Building[1]->Wall[17]*
6. Use a Query as ID-Value
   e.g. *building.name=`garage` && wall.height > 3.5*

Approach: The Generic Multi-Model

Operational Link Type Specification

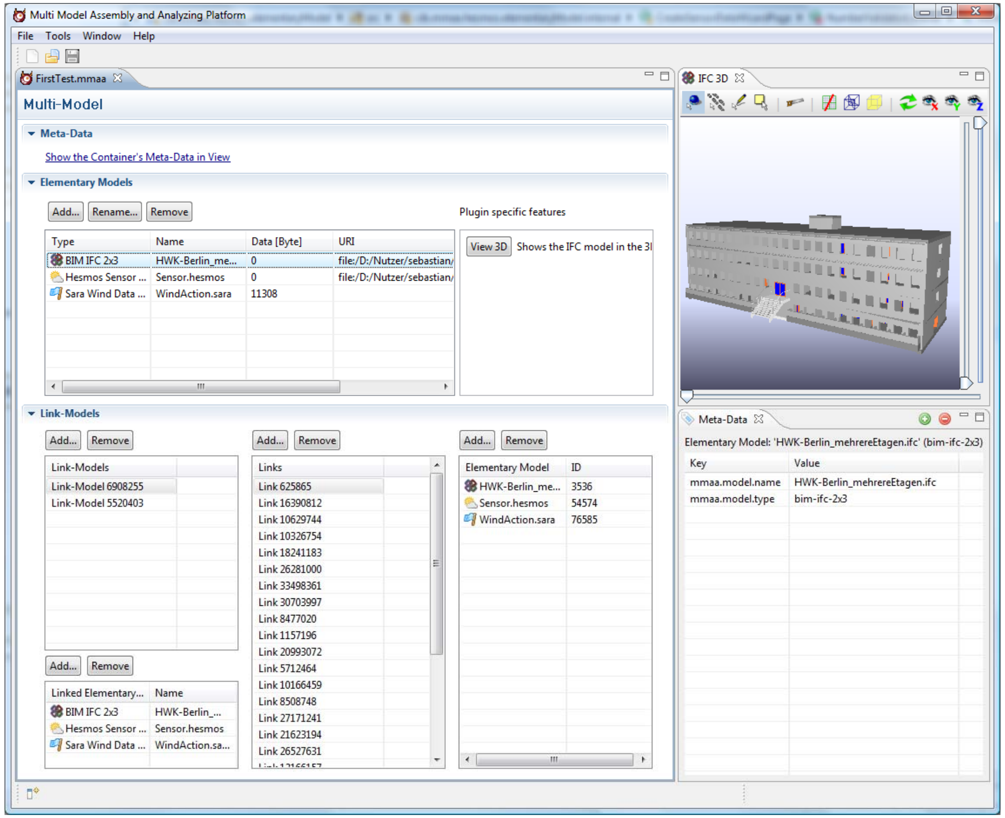
- Describe the Meaning of Links at varying Degrees of Abstraction
- Aim at Improving Coherence of Models
- Encoded as Meta-Data-Entry for Multi-Model-, Link Model- and Link-Instances
- Content: structural and / or semantic Information
- Hierarchical Concept of overwriting Priorities from General to Object specific Link Types



Application and Adoption Examples

Prototypic Implementation within the Multi-Model Assembly and Analyzing Platform (M2A2, TU Dresden)

- Creation and Inspection of Generic Multi-Model Instances
- MM-Validation by proposed Constraints
- Domain-Views for 5 EM Types
- Plugin-Mechanism for Extensions



Type	Name	Data [Byte]	URI
BIM IFC 2x3	HWK-Berlin_me...	0	file:/D:/Nutzer/sebastian/
Hesmos Sensor ...	Sensor.hesmos	0	file:/D:/Nutzer/sebastian/
Sara Wind Data ...	WindAction.sara	11308	

View 3D Shows the IFC model in the 3I

Link-Models
Link-Model 6908255
Link-Model 5520403

Linked Elementary...	Name
BIM IFC 2x3	HWK-Berlin_...
Hesmos Sensor ...	Sensor.hesmos
Sara Wind Data ...	WindAction.sa...

Links
Link 625865
Link 16390812
Link 10629744
Link 10326754
Link 18241183
Link 26281000
Link 33498361
Link 30703997
Link 8477020
Link 1157196
Link 20993072
Link 5712464
Link 10166459
Link 8508748
Link 27171241
Link 21623194
Link 26527631

Elementary Model	ID
HWK-Berlin_me...	3536
Sensor.hesmos	54574
WindAction.sara	76585

Elementary Model: 'HWK-Berlin_mehrereEtagen.ifc' (bim-ifc-2x3)

Key	Value
mmaa.model.name	HWK-Berlin_mehrereEtagen.ifc
mmaa.model.type	bim-ifc-2x3

Application and Adoption Examples

HESMOS – out of the box usage

- Energy Efficiency Simulation and Lifecycle Management
- Provisional Elementary Models and Multi-Model Data Exchange
- Out of the box usage of Generic Multi-Model

MEFISTO-Container

- Controlling, Simulation and Leading of Construction Projects
- 7 defined Elementary Model Types (Domains)
- Dedicated Meta-Data-Model describing Quality of Data
- Compressed Archive Format including Files and Folders
- Artificial IDs for Schedule- and Specification-Model
- Converter from/to Generic Multi-Model to use Generic tools in M2A2

Conclusion

Summary

- Explicit, ID-based Links between Domain Models
- Bottom Up Approach, Task specific and loose Coupling
- Meta-Data Mechanism; Several Predefinitions for structural and semantic Description
- Data Schema is generic: (Construction) Domain unaware
- Data Schema is extensible & ready for use out of the Box
- XML-Serialization for neutral Data Exchange

- Just one of many potential solutions
- Responsibility for Link Interpretation and Domain Semantics is deferred to

Outlook

- Provide Methods for (Semi-) automated Linking
- Provide Multi-Model-Filter Methods

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Questions?

Thank You

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