Chair of Computational Modeling and Simulation
School of Engineering and Design
Technical University of Munich

Advanced Process Representation for Semi-Automated Linking between Construction Schedules and IFC Files

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Chair of Computational Modeling and Simulation

Technical University of Munich

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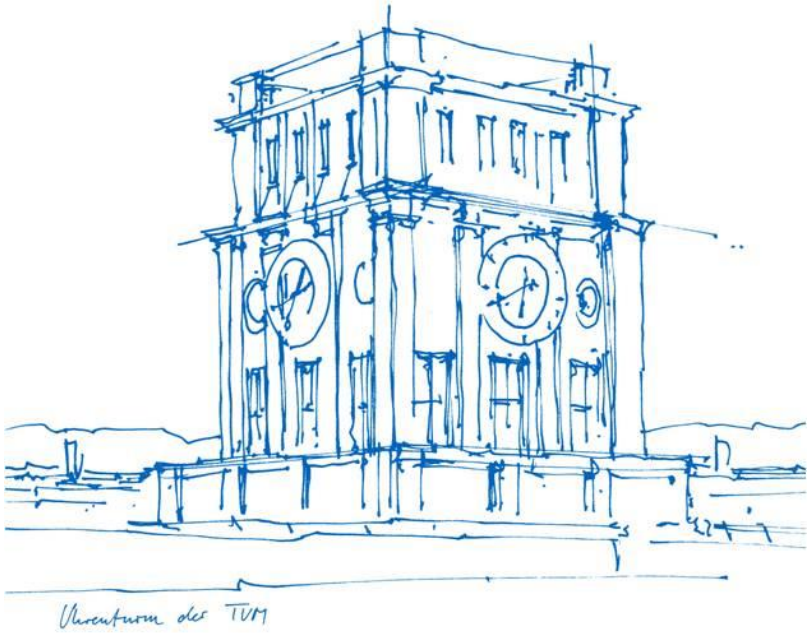


Problem Statement and Goal

Schedule exchange:

- XML and spreadsheet-based
- Difficulties in interpretation arise from:
  - Project management software
  - Language
  - Project-specific abbreviations
  - Scheduling methodology

→ Loss of information

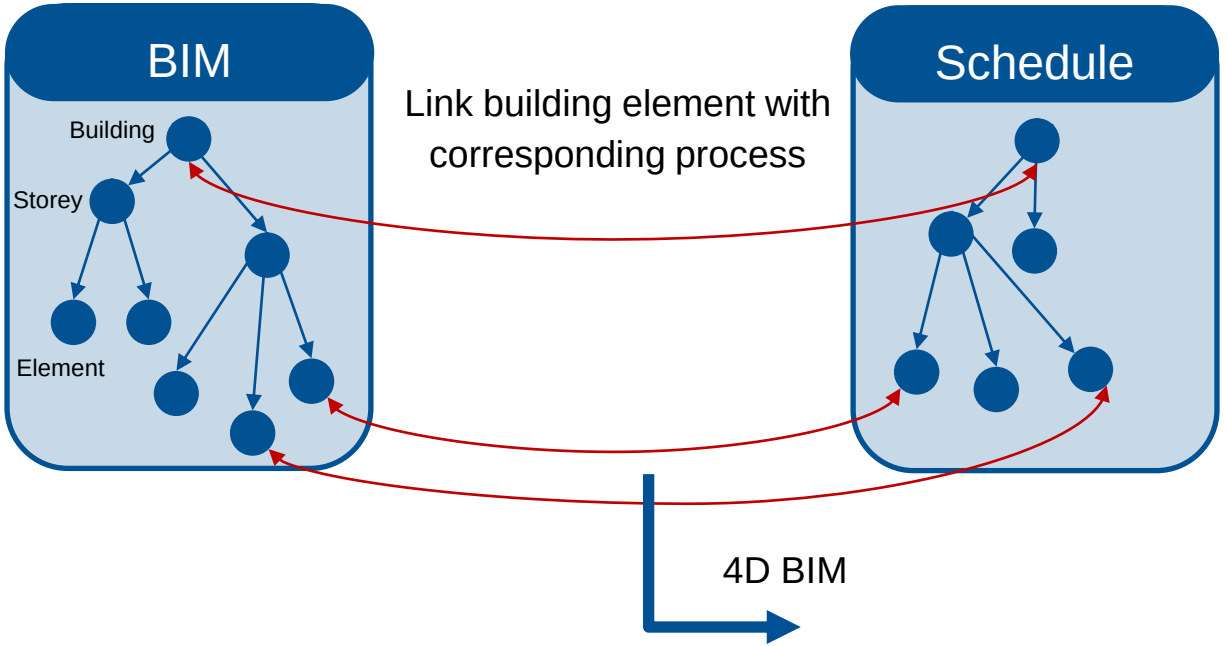
Goal:

- Automated interpretation of schedules
- Understand process dependencies

Task Name	Parent	Is Leaf Task	Location ID	Location
Kellarin sähköhyllyt	80833987	FALSCH	3560546	B - 01 - kerro
Lämpörungot ja patterit + käyttövesiputket	80833987	WAHR	3560533	B - 0K - Kerros K
Lämpörungot ja patterit + käyttövesiputket	80833989	FALSCH	3560546	B - 01 - kerros 1
Asuntojen kaapelointi	80833987	WAHR	3560533	B - 0K - Kerros K
Asuntojen kaapelointi	80833988	FALSCH	3560547	B - 02 - kerros 2
Lämpörungot ja patterit + käyttövesiputket	80833989	FALSCH	3560547	B - 02 - kerros 2
Asuntojen kaapelointi	80833988	FALSCH	3560548	B - 03 - kerros 3
Ääniloukkumuotit	80833993	FALSCH	3560546	B - 01 - kerros 1
Ääniloukkumuotit	80833993	FALSCH	3560547	B - 02 - kerros 2
Lämpörungot ja patterit + käyttövesiputket	80833989	FALSCH	3560548	B - 03 - kerros 3
IV-hajotukset	80833987	WAHR	3560533	B - 0K - Kerros K
IV-hajotukset	80833999	FALSCH	3560546	B - 01 - kerros 1
Rappaus / Talo A>POHJOINEN	81841613	FALSCH	4132858	B - - Talo B
Asuntojen kaapelointi	80833988	FALSCH	3560549	B - 04 - kerros 4
Lämpörungot ja patterit + käyttövesiputket	80833989	FALSCH	3560549	B - 04 - kerros 4
IV-hajotukset	80833999	FALSCH	3560547	B - 02 - kerros 2
Asuntojen kaapelointi	80833988	FALSCH	3560550	B - 05 - kerros 5
Lämpörungot ja patterit + käyttövesiputket	80833989	FALSCH	3560550	B - 05 - kerros 5
IV-hajotukset	80833999	FALSCH	3560548	B - 03 - kerros 3

Linking IFC and Schedule

Created in BIM-authoring tool



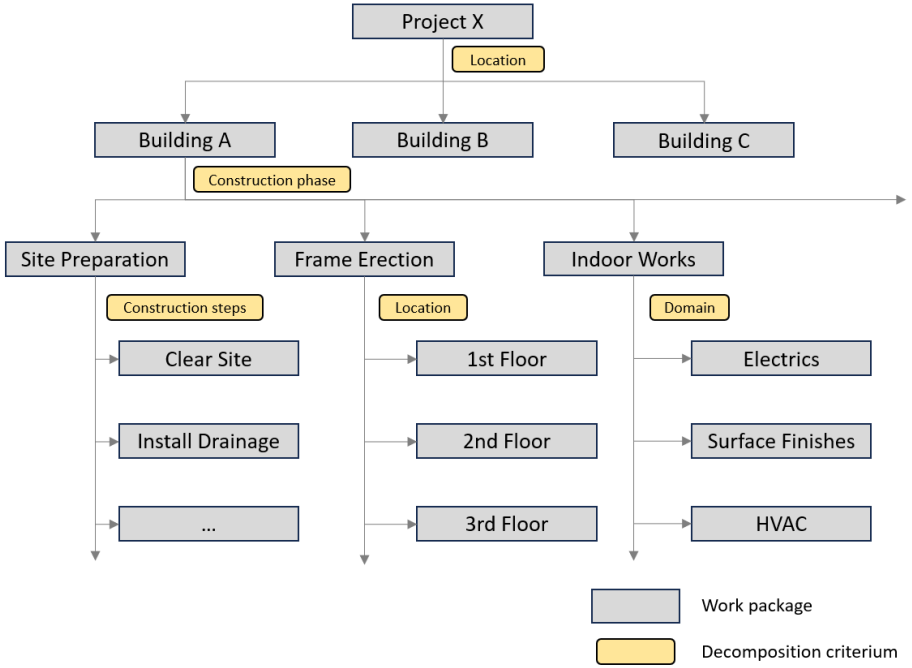
Created in project management software

https://youtu.be/5A6RyltDtn8?si=zgBExkDKEXISNkRK

Work Breakdown Structures

- Systematical breakdown of construction project into manageable parts
- Level of detail can be selected for every work package individually
- Dependent on organizational structure of the project and its individual partners

Decomposition criteria are essential to interpret the meaning of individual work packages



Process Decomposition Criteria

- Analysis of schedules of 8 past and ongoing real-world construction projects
- Manual identification of the used process decomposition criteria
- Additional guidance through construction-related classification systems (OmniClass, UniClass, etc.)

→ 9 categories of decomposition criteria

Criterion	Examples	Percentage used
Phase	earth works, frame errection	1.00
Production method	precast, cast-in-place	0.13
Construction step	place formwork, pour concrete	1.00
Location	building, storey, room	1.00
Element	wall, column, slab	0.75
Discipline / domain	plumber, electrician, painter	0.88
Equipment	crane, excavator, concrete mixer	0.25
Material	wood, tiles, concrete, steel	0.25
Property	diameter, width, height, load-bearing	0.38

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Data Schemata for Process Modeling

Main Requirements:

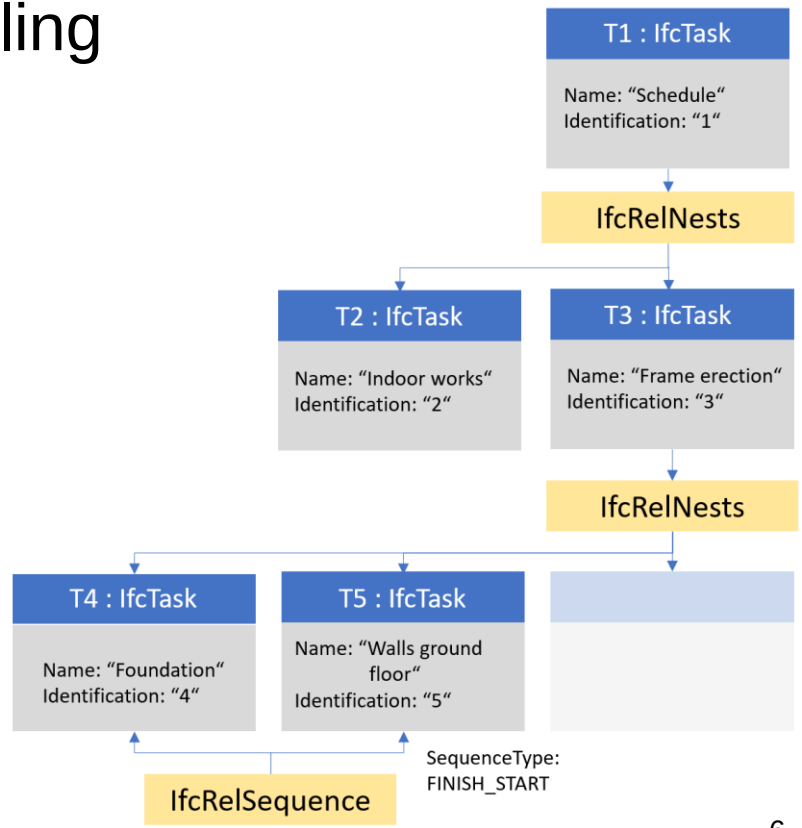
- Decomposition criteria
- Process dependencies

Existing Schemata:

- IFC / ifcOWL
- DiCon
- CTO
- IoC
- DTC

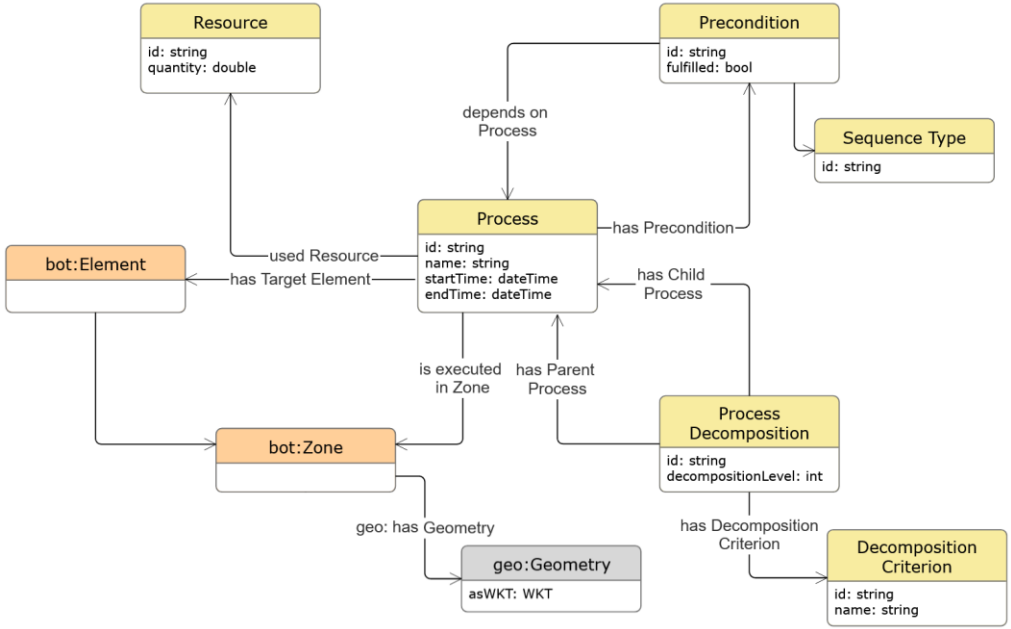
Limitations:

- Only some of them cover process dependencies (start-start, end-start, etc.)
- Most of them cover only a generic process decomposition (e.g. IfcRelNests)



Construction Schedule Ontology (CSO)

- **Process** as central class
- **Decomposition criterion** (+ 9 individuals)
- **Process preconditions** with **sequence types** (start-start, start-end, end-start, end-end)
- **Resources:** worker, equipment, formwork, materials, etc.
- Reuse of **BOT** for building-related aspects
- **GeoSPARQL** used for representation of geometry (optional usage)



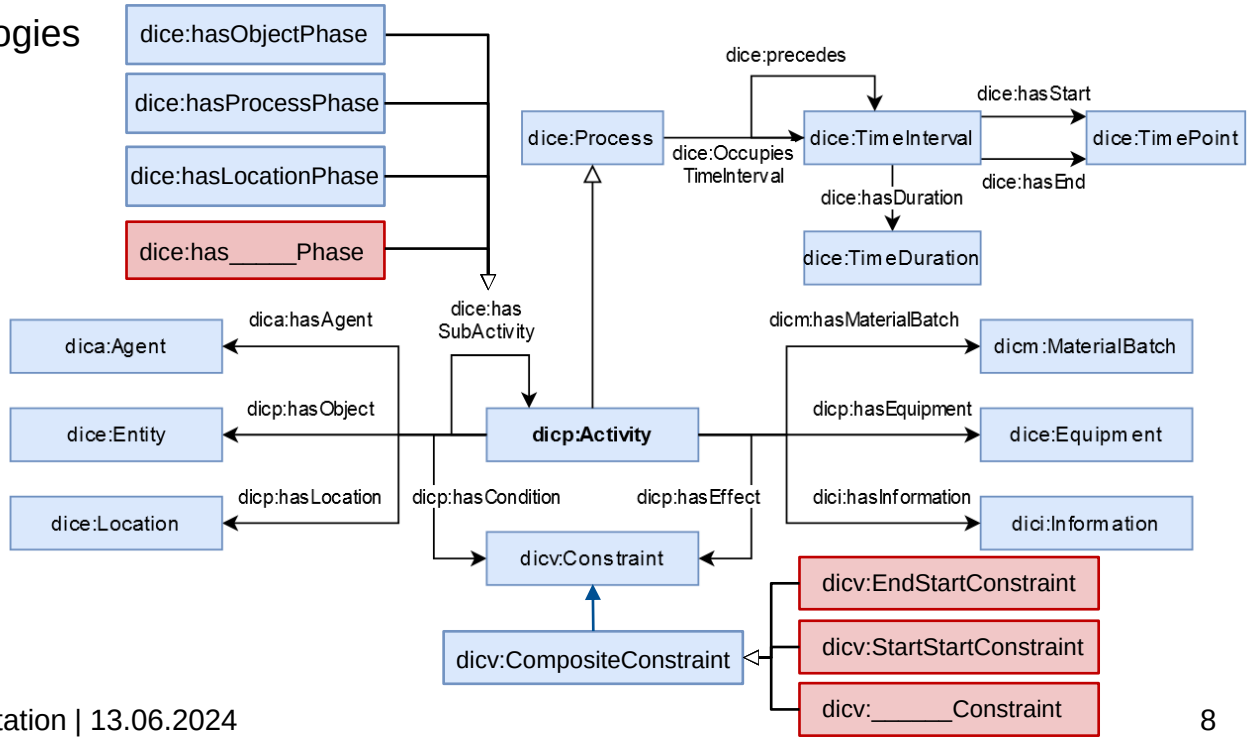
Integration into Existing Ontologies

Integration with the following ontologies can be achieved with little effort:

- DiCon
- CTO
- IOC
- ifcOWL

Changes required for DiCon:

- Add 6 sub-properties for dice:hasSubActivity
- 4 subclasses of dicv:CompositeConstraint for process sequences



Case Study – Linking IFC and Schedule

Spanish construction project of a hospital building

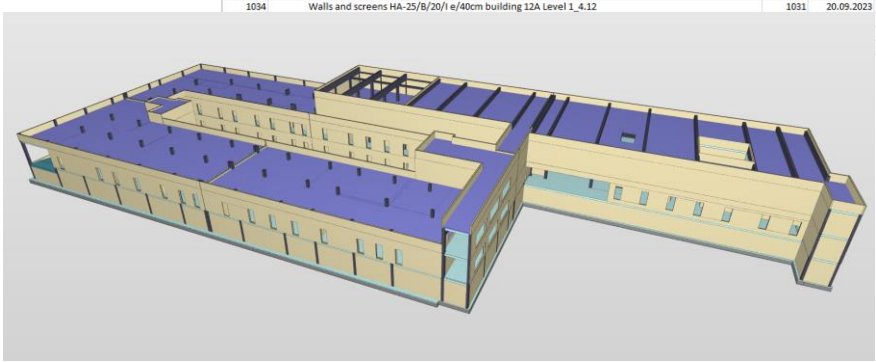
Available planning information:

- IFC file
- Schedule as Excel export (Primavera)
- Manually added decomposition criteria

Graph setup:

- IFCtoLBD Converter
- xBIM for extraction of further IFC information
- Newly implemented schedule converter

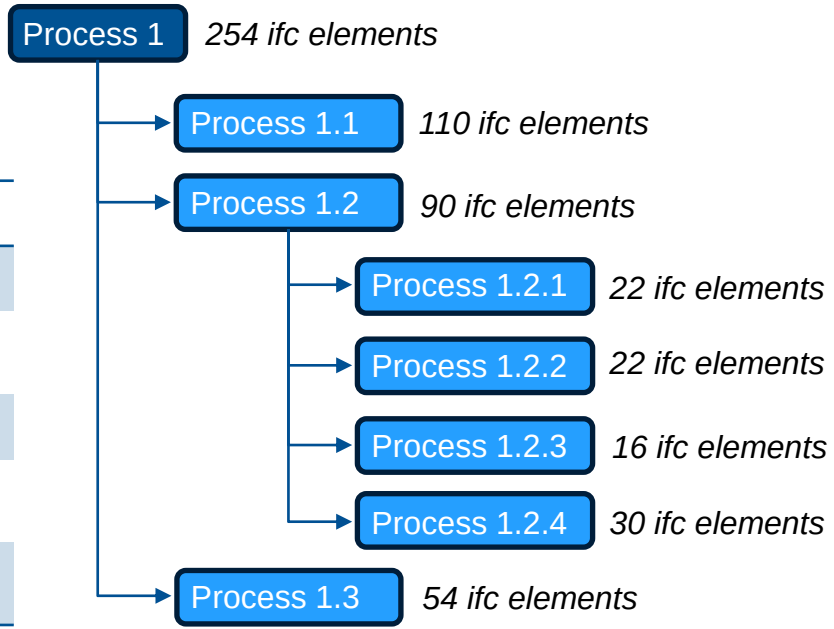
ID	Name	Parent	Start	End	Preconditions	inBIM	Criterium
999	Building 12A	0	03.03.2023	01.07.2024		true	Phase
1000	Shell construction	999	03.03.2023	10.04.2024		true	Phase
1001	Preparation works	1000	03.03.2023	04.10.2023		false	
1002	Foundation and structure	1000	19.03.2023	13.12.2023	1001	true	Phase
1003	Foundation and structural walls	1002	19.03.2023	08.09.2023		true	ConstructionStep
1005	Shallow foundation	1003	19.03.2023	09.08.2023		true	ConstructionStep
1006	Lump sum to justify calculation and execution of canopy foundations for all buildings	1005	19.03.2023	23.07.2023		false	
1007	Shallow foundation for building 12A	1005	23.07.2023	09.08.2023	1006	true	
1009	Retaining walls	1003	30.07.2023	08.09.2023	1005	true	Element
1010	Continuous footing and (wall) struts HA-25/B/20/IIa building 12A	1009	30.07.2023	16.08.2023		true	
1012	Concrete wall e/40cm Level 0_0.00 building 12A	1009	17.08.2023	28.08.2023	1010	true	
1014	Concrete and structural beams	1002	10.08.2023	13.12.2023	1003	true	Material
1015	Concrete structure	1014	10.08.2023	13.12.2023		true	Element
1017	Columns	1015	10.08.2023	13.12.2023		true	Location
1018	Execution of pillars building 12A Level 0_0.00	1017	10.08.2023	01.09.2023		true	
1020	Execution of pillars building 12A Level 1_4.12	1017	20.09.2023	10.10.2023	1025	true	
1022	Execution of pillars building 12A Level 2_8.12	1017	31.10.2023	21.11.2023	1027	true	
1024	Slabs and stairs	1015	04.09.2023	07.12.2023		true	Location
1025	Solid slabs including staircase building 12A Level 0_0.00	1024	04.09.2023	19.09.2023	1018,1032	true	
1027	Solid slabs including staircase building 12A Level 1_4.12	1024	11.10.2023	30.10.2023	1020,1034	true	
1029	Solid slabs including staircase building 12A Level 2_8.12	1024	02.11.2023	21.11.2023	1022,1036	true	
1031	Walls and screens	1015	10.08.2023	30.11.2023		true	Location
1032	Walls and screens HA-25/B/20/I e/40cm building 12A Level 0_0.00	1031	10.08.2023	01.09.2023		true	
1034	Walls and screens HA-25/B/20/I e/40cm building 12A Level 1_4.12	1031	20.09.2023	10.10.2023	1025	true	
				08.11.2023	1027	true	
				13.11.2023	1015	true	Element
				13.11.2023		true	



Case Study – Filtering Criteria

- Traversal of process hierarchy
- Application of filtering operations dependent on the process decomposition criterion

Criterion	Filtering
Element	beo:BuildingElement subclasses
Location	bot:Building, bot:Storey, bot:Space, bot:Zone
Phase / Construction Step / Method	No immediate filtering
Property	Values of datatype properties of beo:BuildingElement nodes
Equipment / Discipline / Material	Type of resource assigned to process

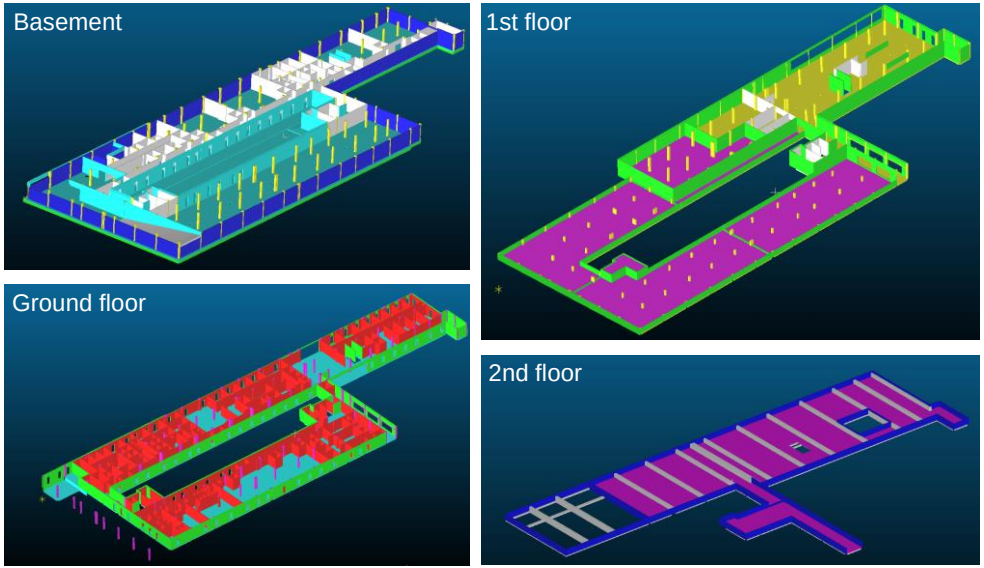


Case Study - Results

- Filtering operations applied to all processes
- Building elements linked with processes

- Elements colored according to their corresponding process for visualization purpose

Challenge:
- Load-bearing and non-load-bearing walls only distinguishable by their material



Conclusion

- Identification of **process decomposition criteria**
- Well-defined **representation of processes** and their dependencies
- Semi-automated **linking of schedule and IFC elements**

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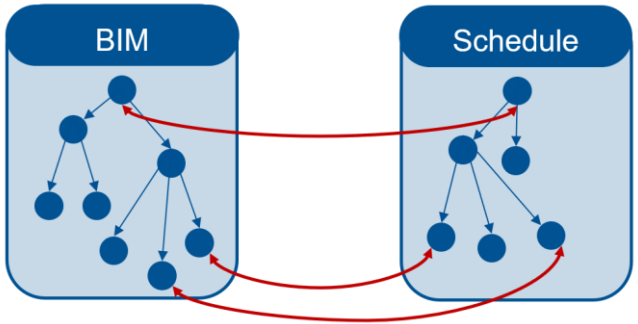
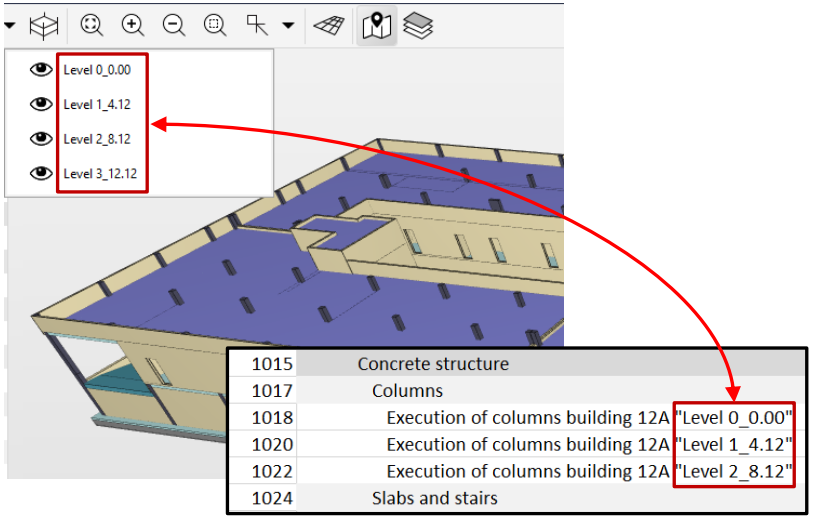


Limitations

- Similar naming used in the schedule and IFC file
- Use of project-specific abbreviations
- Mismatch between granularity of the schedule and IFC file (automated splitting of IfcBuildingElements not covered)
- Manual effort to assign decomposition criteria



Future Work - Other Applications

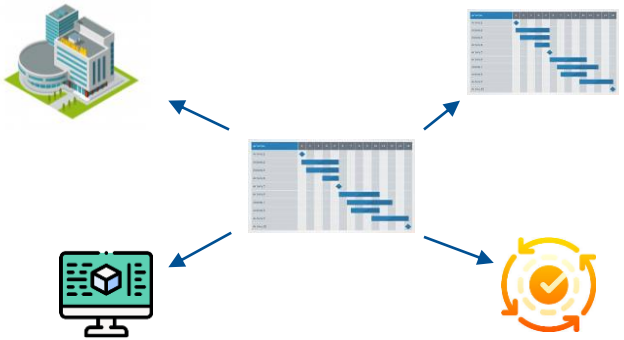
Future Work:

- Natural Language Processing
- Integrate CSO into an existing ontology
- Investigate on subclasses for decomposition criteria

Other Applications:

Automated schedule interpretation

- Integration into simulation systems
- Coordination between contractor and subcontractor
- Schedule consistency checks



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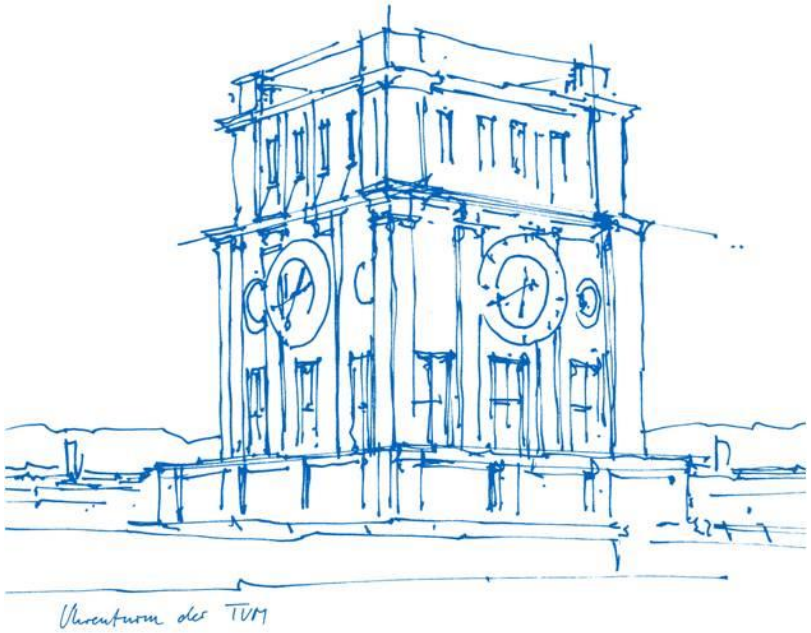


Classification Systems in Construction

Many national and international classification systems:

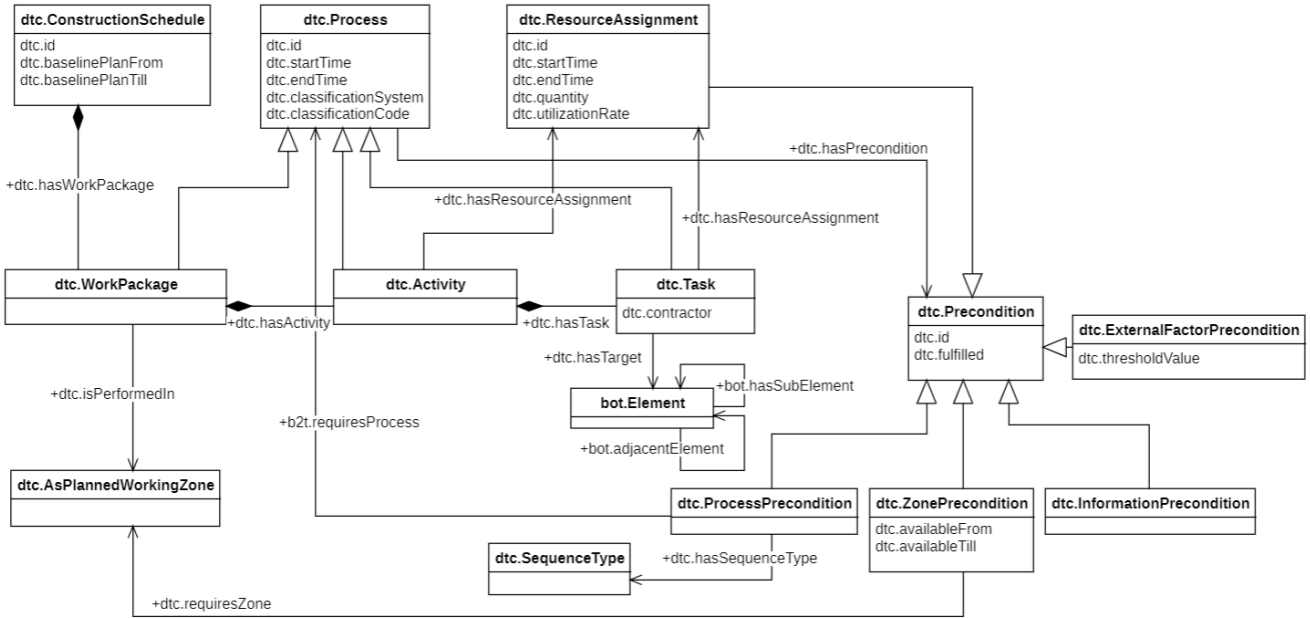
- MasterFormat
- Uniformat
- Omniclass
- CoClass
- ISO 12006-2
- ISO 81346-12

Helpful in defining decomposition criteria

ISO 12006-2	ISO 81346-12	OmniClass	CoClass	CCS	UniClass
Information		Information		Documents	Forms
Products	Components	Products Materials	Components	Components	Products
Agents		Disciplines Roles		Documents	Agents
Aids		Tools		Equipment	Tools Equipment
Management		Services		Documents	Project Management
Processes		Phases		Documents	Phases
Complexes			Complexes		Complexes
Entities		By Functions By Forms	Entities	Entities	Entities Activities
Built Spaces	Spaces	By Functions By Forms	Spaces	Built Spaces User Spaces	Spaces Locations
Elements	By Function By Technics	Elements	By Functions By Technics	By Functions By Technics	Functions Systems
Work Results		Work Results	Production		
Properties		Properties	Properties Landscape	Classes	Properties CAD

Data Schemata for Process Modeling

Digital Twin Construction Ontology (DTC):



Data Schemata for Process Modeling

Internet of Construction Ontology (IOC):