TUBES System Ontology: Digitalization of building service systems

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Motivation – „Big Picture“

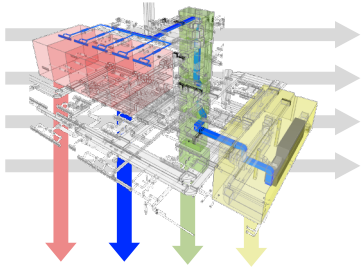
"Live-BIM"
Augmented Reality

Visualisation

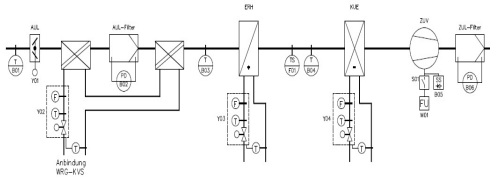
- attributes
- systemtopology
- monitoring data

Control of Operations

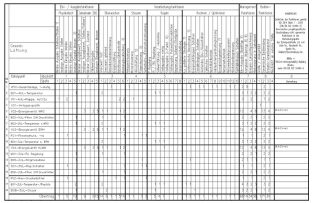
BIM
spatial links



System Diagram
topological links



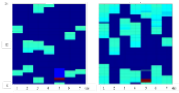
Automation Diagram
functional links



functional lists and diagrams

CAFM
TFM, IFM, ...

Energymonitoring
time series



Building Automation
field & automation layer

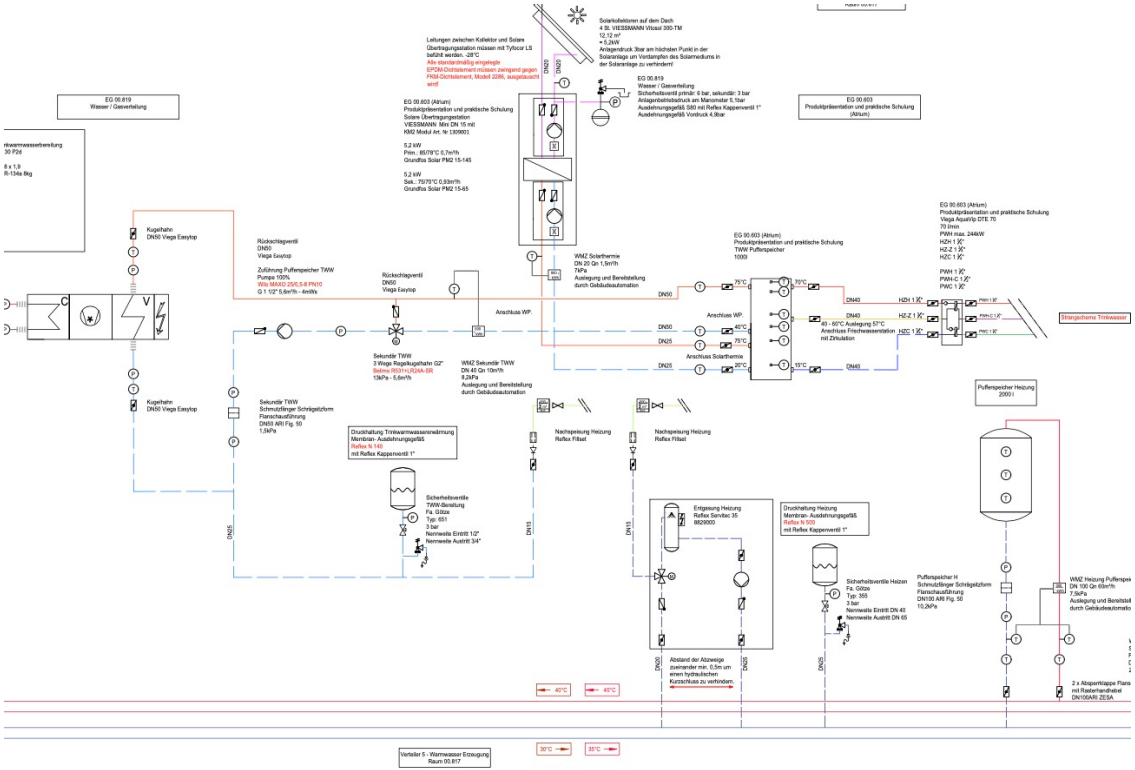
Challenge: Complexity management

Challenge: Complexity management

Can these questions be answered?

- How many building service systems are in the model?
- Which building service systems are included?
- How are these systems interconnected?
- Are these systems completely modelled?
- etc.

Challenge: Complexity management



Kühlbetrieb
Versorgung der Flächentemperierung, RLT- Geräte, Umluftkühlgeräte, Kleinkälte und Trinkkaltwasserkühlung. 10/16°C

Heizbetrieb
Versorgung der Flächentemperierung, RLT- Geräte,Zohnennacherhitzer und Trinkwarmwassererzeugung. 40/30°C

Nur Kältemaschine
Kühlung über die Kältemaschine ohne Vorkühlung wenn die Rückkühler eine Vorlauftemperatur über 14°C liefern

Kältemaschine + Vorkühlung
Kühlung über die Kältemaschine mit Rücklaufabsenkung/ Vorkühlung der Kältemaschine wenn die Vorlauftemperatur des Rückkühlers 2K unter der Rücklauftemperatur des Kaltwassers sekundärseitig liegt.

Freie Kühlung
Kühlung ohne Wärmepumpe wenn die Vorlauftemperatur des Rückkühlers unter 8,0°C liegt und Abnahmeleistung gedeckt ist.

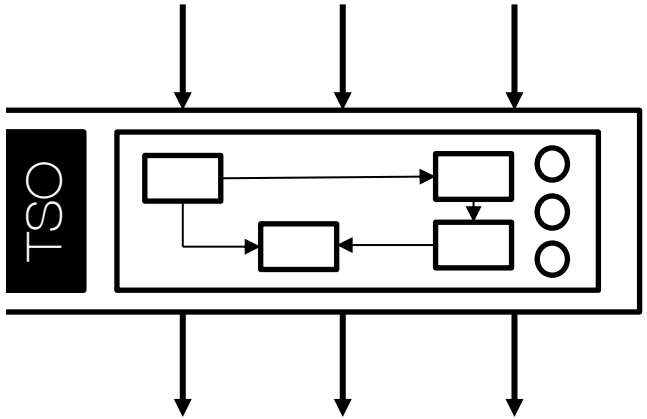
What is a System?

A system is a model of a whole which is isolated from the world or a supersystem, which may consists of interconnected components or sub-systems and has attributes such as inputs, outputs and states.

hierarchical concept

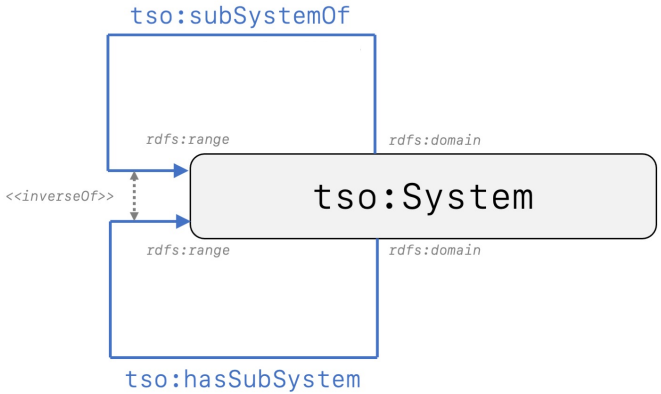
structural concept

functional concept



Hierachichal concept

A system is a model of a whole which is isolated from the world or a supersystem…



Structural concept

A system is a model of a whole […] which may consists of interconnected components or sub-systems …

Whats the difference between a system and a component?

Component vs. System

A system is a model of a whole which is isolated from the world or a supersystem, which may consists of interconnected components or sub-systems and has attributes such as inputs, outputs and states.

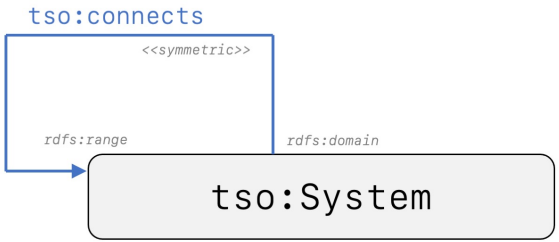
A component is a model of a whole which is isolated from the world or a supersystem, which may consists of interconnected components or sub-systems and has attributes such as inputs, outputs and states. The boundary which isolates the component from the world is defined by the manufacturer with regards to the product aspect.

Components describe the product-related view at aggregated functional aspects in one entity with a given boundary by the manufacturer.

A component can be described as a system.

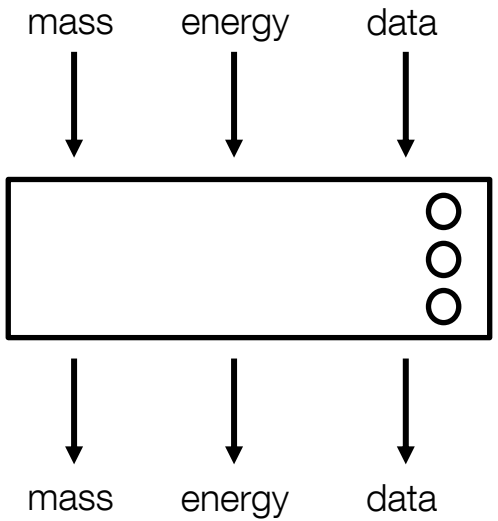
Structural concept

A system is a model of a whole […] which may consists of interconnected components or sub-systems …



Functional concept

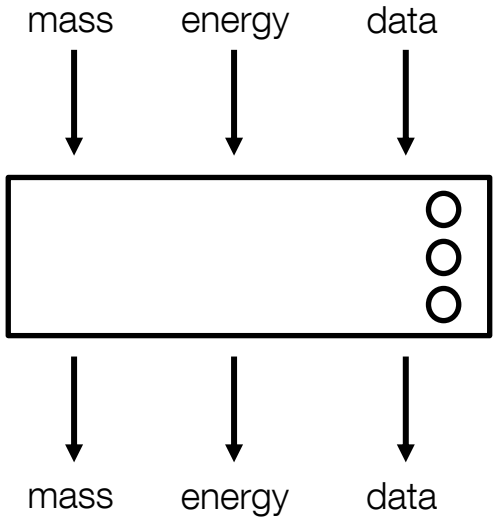
A system is a model of a whole […] which has attributes such as inputs, outputs and states.



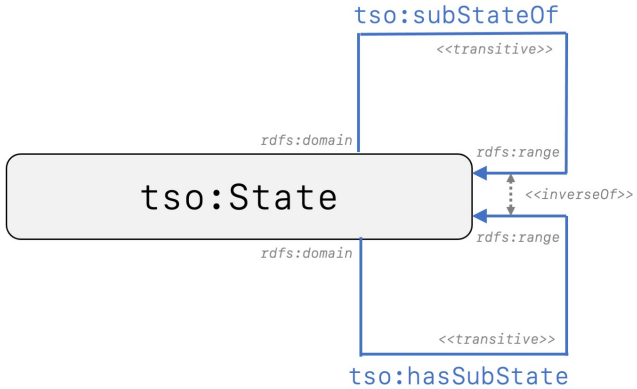
- mass
  - fluid
    - liquid
    - gas
  - solid
- energy
  - thermalEnergy
  - electricalEnergy
  - mechanicalEnergy
- data

Functional concept

A system is a model of a whole […] which has attributes such as inputs, outputs and states.



A state defines the internal condition of a planned or abstract system. This includes specific aspects as on, off, open or closed as well as general aspects such as outdoor-air-operation, mixed-air-operation or heating-operation.



Functional concept

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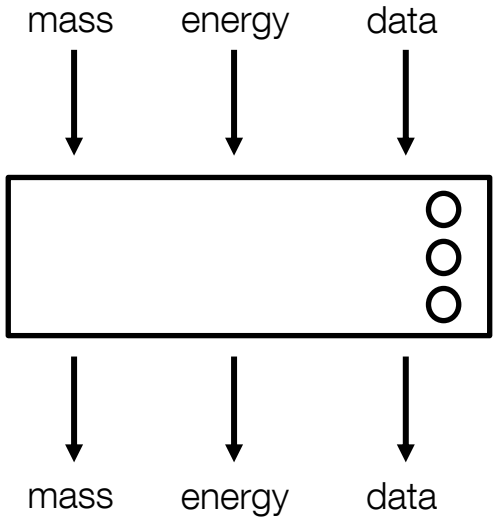
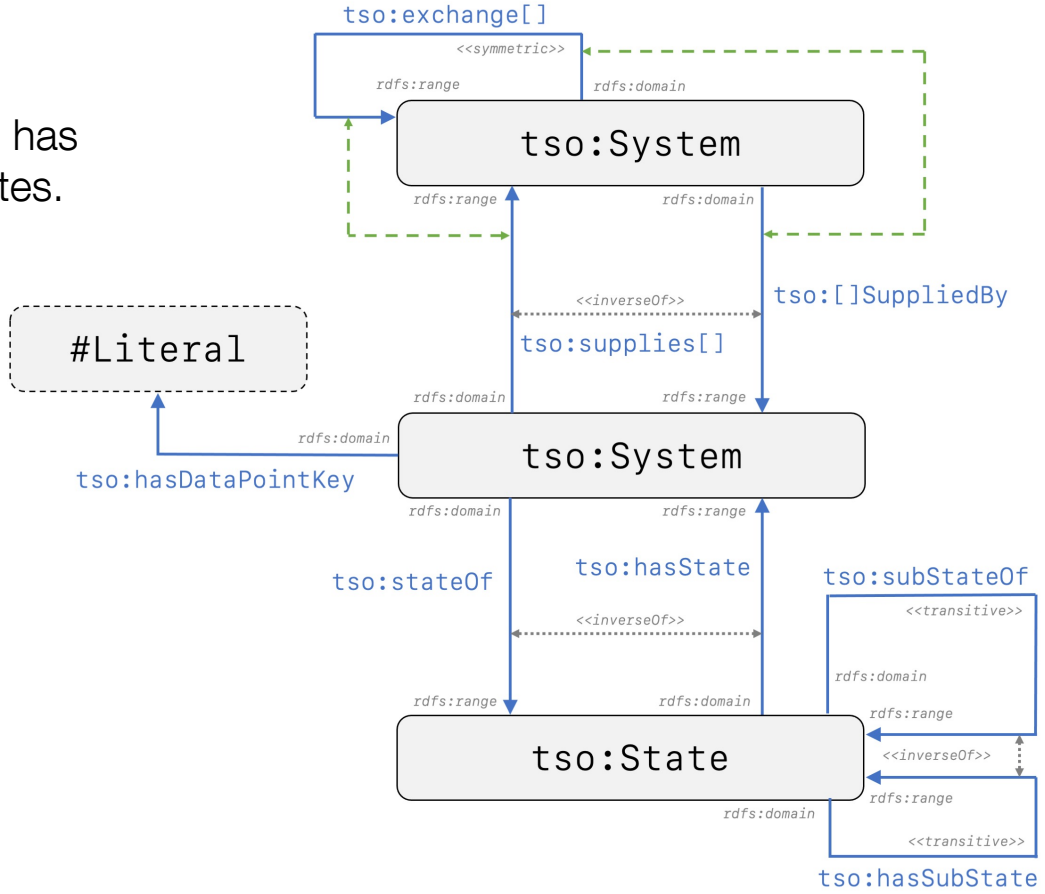
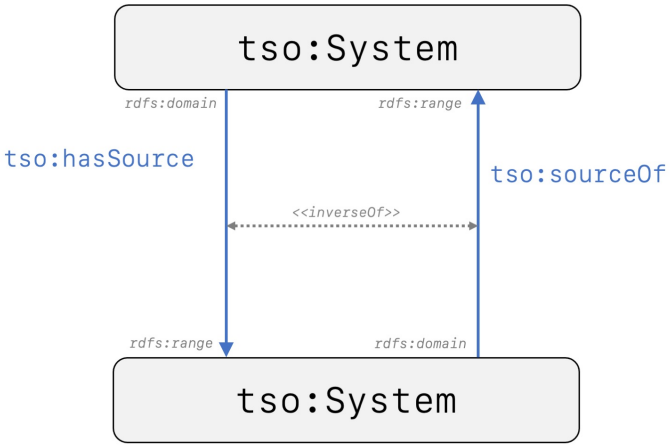
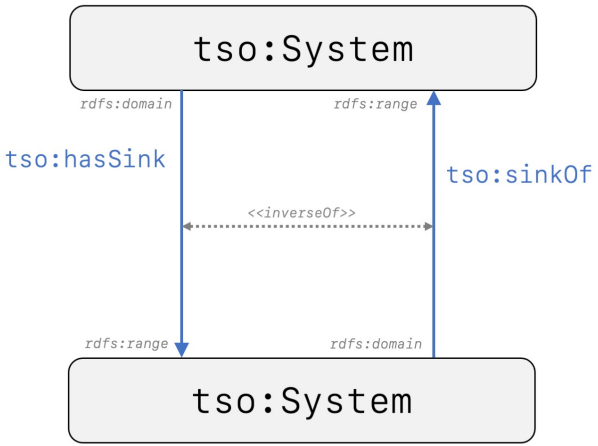




Source and sink of systems

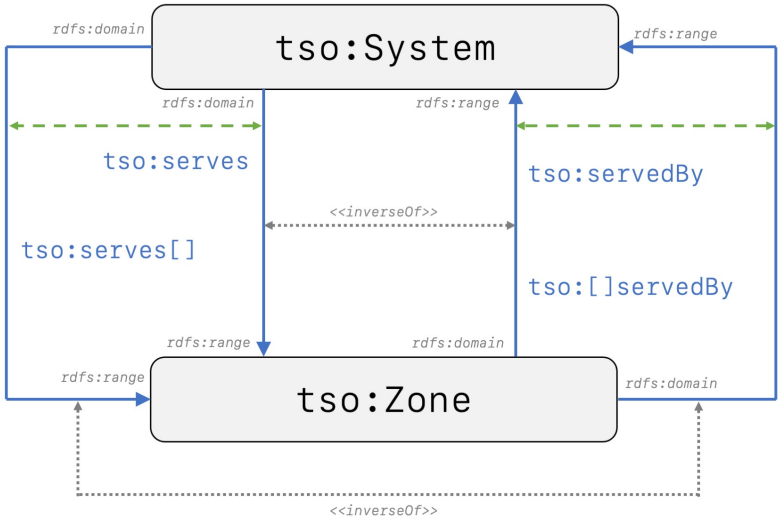




What about spatial elements?

A zone is a part of the physical world or a virtual world that is inherently both located in this world and has a 3D spatial extent. (bot:Zone)

- Zones are served by tso:System
- A tso:System can serve multiple zones
- Zones do not exchange mass, data or energy between each other
- tso:serves can be further detailed to describe „what“ is served



What about spatial elements?

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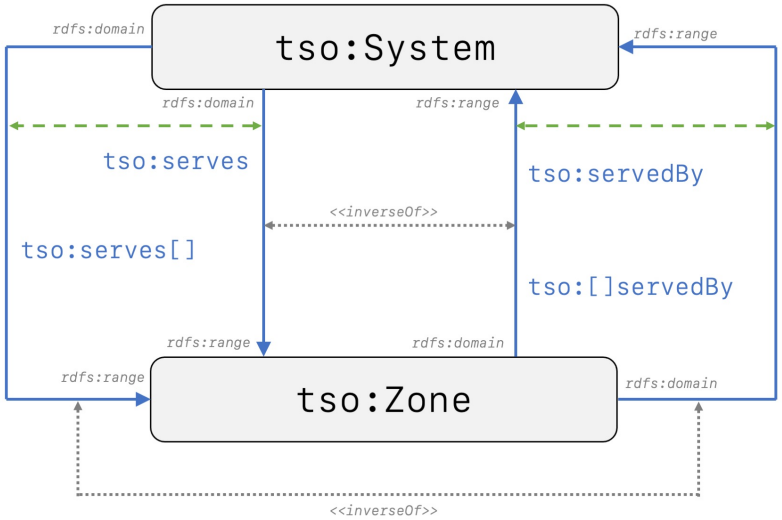
- mass
  - fluid
    - liquid
    - gas
  - solid
- energy
  - soundEnergy
  - electricalEnergy
  - thermalEnergy
  - lightEnergy
  - mechanicalEnergy
- data



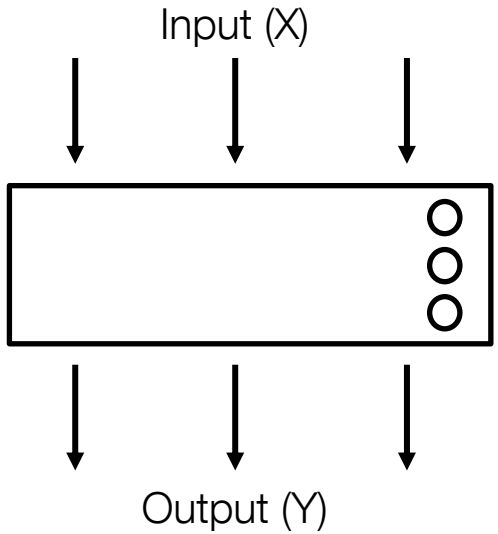
Classification of systems

A system can be classified be the overall function or the technical solution by which the function is fullfilled.

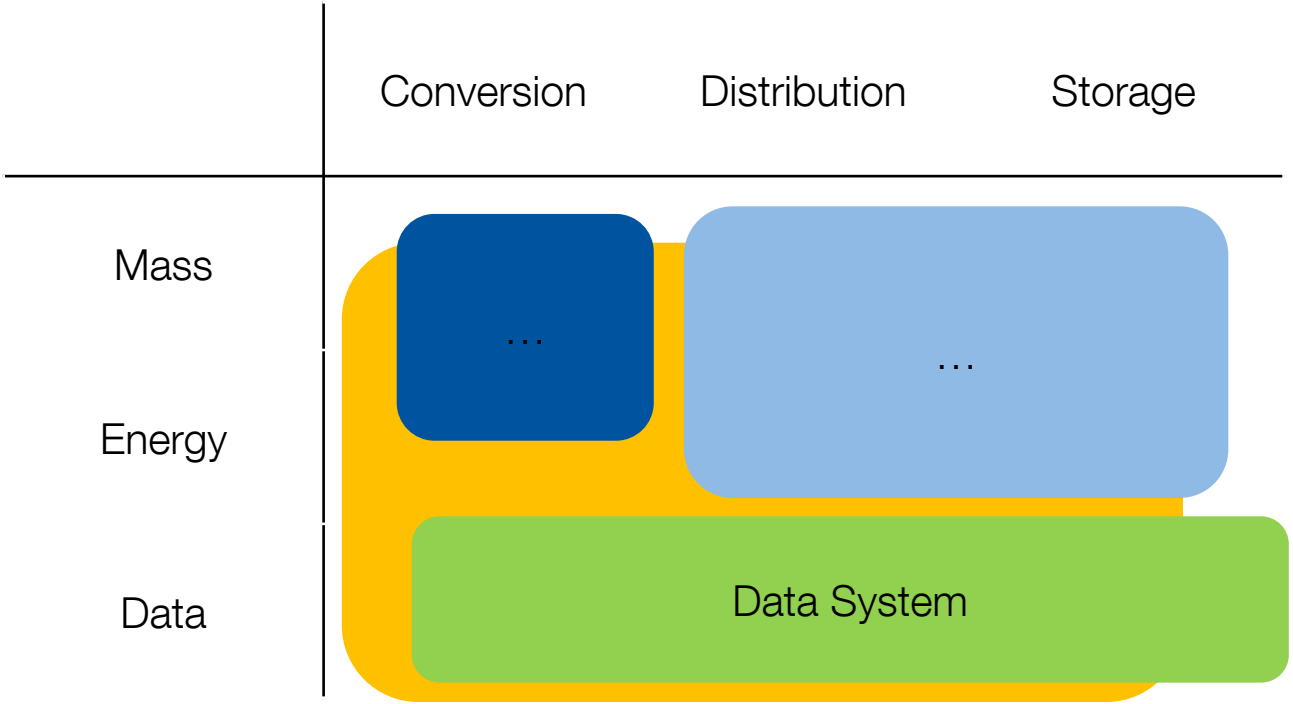
Classification of systems – Technical Solution

A system can be classified be the overall function or the technical solution by which the function is fullfilled.

- X = Y, SX = SY, TX ≠ TY:
  - StorageSystem
- X = Y, SX ≠ SY, TX = TY:
  - DistributionSystem
- X ≠ Y
  - ConversionSystem



Classification of systems – Functional System

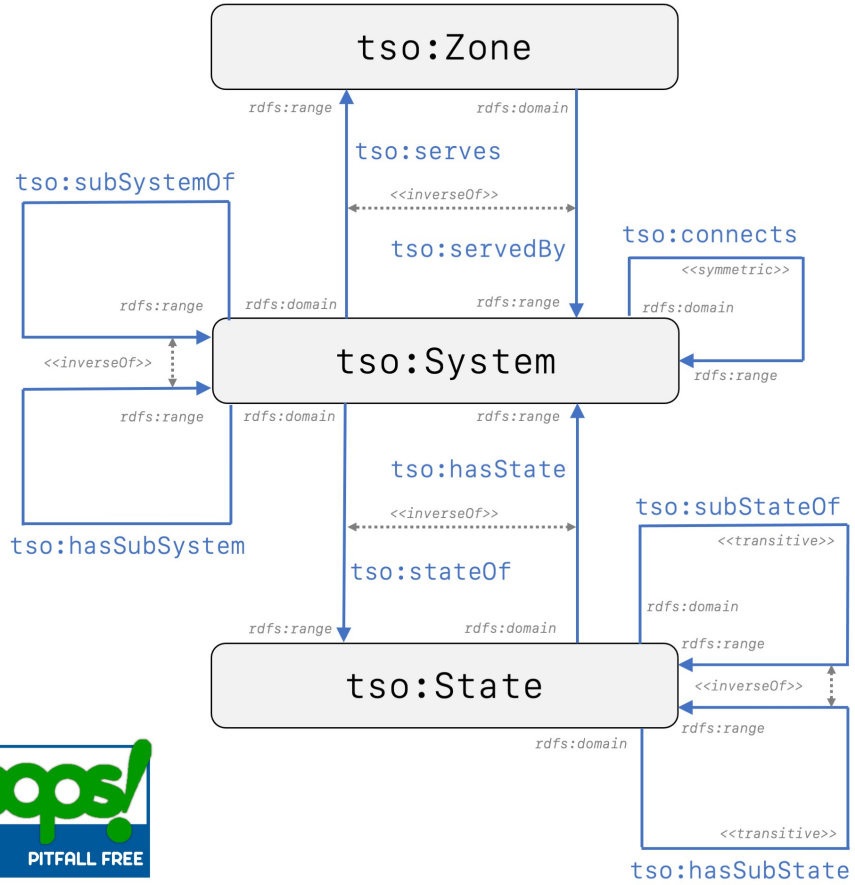


Classification of systems

Functional Systems	Technical Systems	Components
HeatingSystem	ConversionSystem	
CoolingSystem	- EnergyConversionSystem	
VentilationSystem	- FlowConversionSystem	
SanitarySystem	DistributionSystem	
FluidSystem	- SupplySystem	Classification based on IFC
DrainageSystem	- ReturnSystem	
SafetySystem	StorageSystem	
ElectricalSystem		
DataSystem		
AutomationSystem		

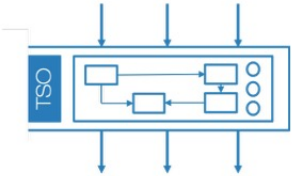
Overview

- Namespace: https://w3id.org/tso#
- Ontology IRI: https://w3id.org/tso/v0.2/tubes
- Documentation: https://rwth-e3d.github.io/tso
- 21 Classes
- 67 Object Properties
- 1 Datatype Properties
- Alignments to BOT, SAREF, BRICK & IfcOWL



Documentation

TUBES System Ontology



The namespace for TSO terms is http://w3id.org/tso# and the suggested prefix is tso

View the Project on GitHub
RWTH-E3D/tso

This project is maintained by RWTH-E3D

Hosted on GitHub Pages — Theme by orderedlist

Uses

The scope of the TUBES System Ontology is to explicitly define the topology of interconnected building service system and their components. As a lightweight ontology it has a strong alignment to other ontologies within the W3C community and aims to provide the means to link information at data level within the AEC industry.

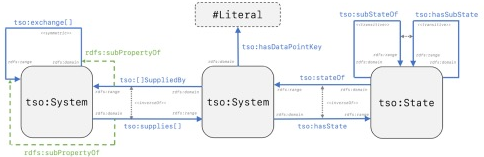
A persistent URI namespace for the TUBES System Ontology (tso) will be provided by W3ID at https://w3id.org/tso.

Documentation

The latest version of TSO is provided in Turtle, RDF/XML and JSON-LD format. Extensive documentation is also available.

Concept

The three main classes of the TUBES System Ontology are *tso:System*, *tso:Zone* and *tso:State*. A *tso:Zone* is defined as a part of the physical world or a virtual world that is inherently both located in this world and has a 3D spatial extent. It has a strong alignment to the zone concept of the Building Topology Ontology. The inverse object properties *tso:serves* and *tso:servedBy* define relationships linking systems and zones to describe that a zone is served by a system, respectively a system serves a zone. *tso:locatedIn* and *tso:contains* define relationships to describe that a system is located in a zone, respectively a zone contains a system. *tso:State* defines the planned internal condition of a component or abstract system. To link a state to a system, respectively a system to a state, the inverse properties *tso:stateOf* and *tso:hasState* are defined. A *tso:System* is a model of a whole which is isolated from the world or a supersystem, which may consists of interconnected components or subsystems and has attributes such as inputs, outputs and states. Within this definition there are three concepts with are further detailed in the following.



Alignments

Within the W3C linked building data ecosystem several alignments are proposed. Currently, these are available:

- for Building Topology Ontology (BOT) as AlignmentBOT
- for Building Topology Ontology (SAREF) as AlignmentSAREF for the core ontology and additional files for AlignmentSAREF4BLDG as well as AlignmentSAREF4SYST
- for Smart Energy Aware Systems (SEAS) as AlignmentSEAS

Examples

Examples for the use of TSO are provided for the DigitalHub and CUBE projects.

- DigitalHub v0.2
- CUBE v0.2

Contacts

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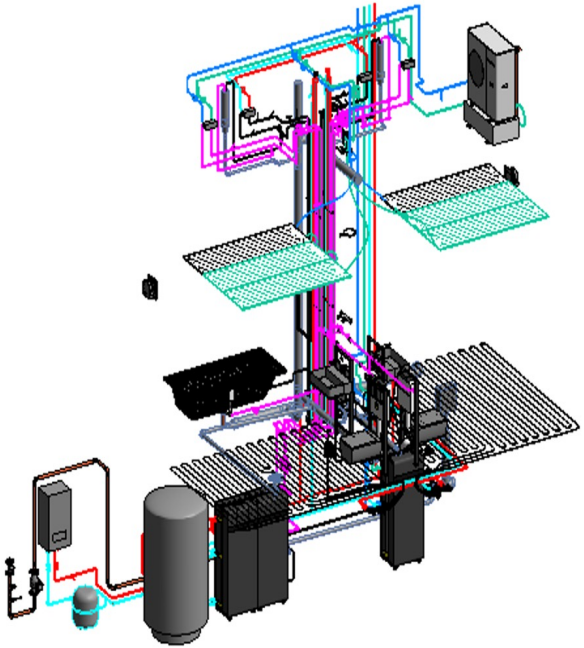
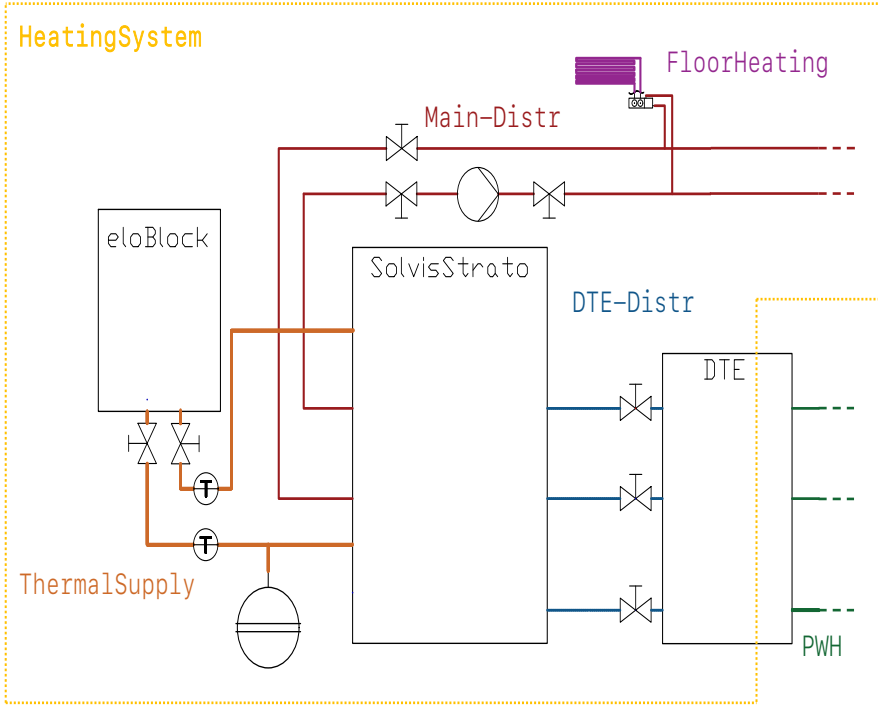
- Dominik Schlütter schluetter@e3d.rwth-aachen.de

Use-Case: ViegaCUBE





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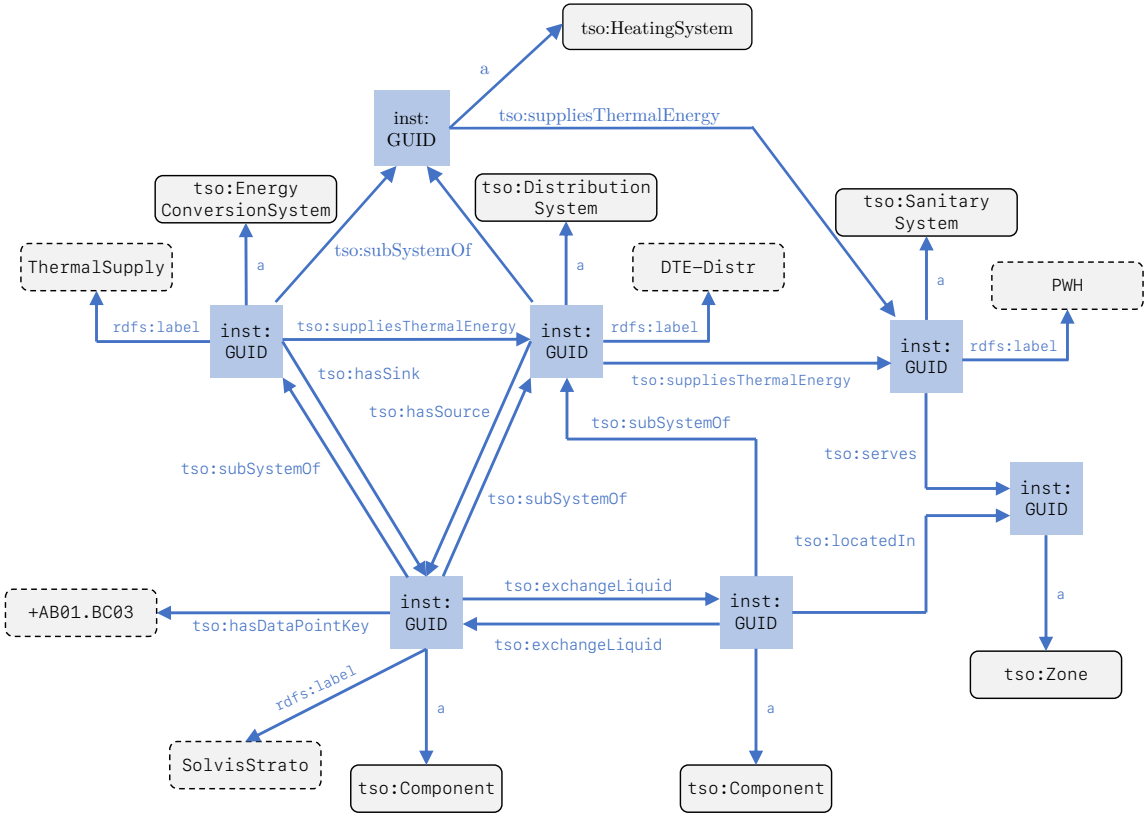
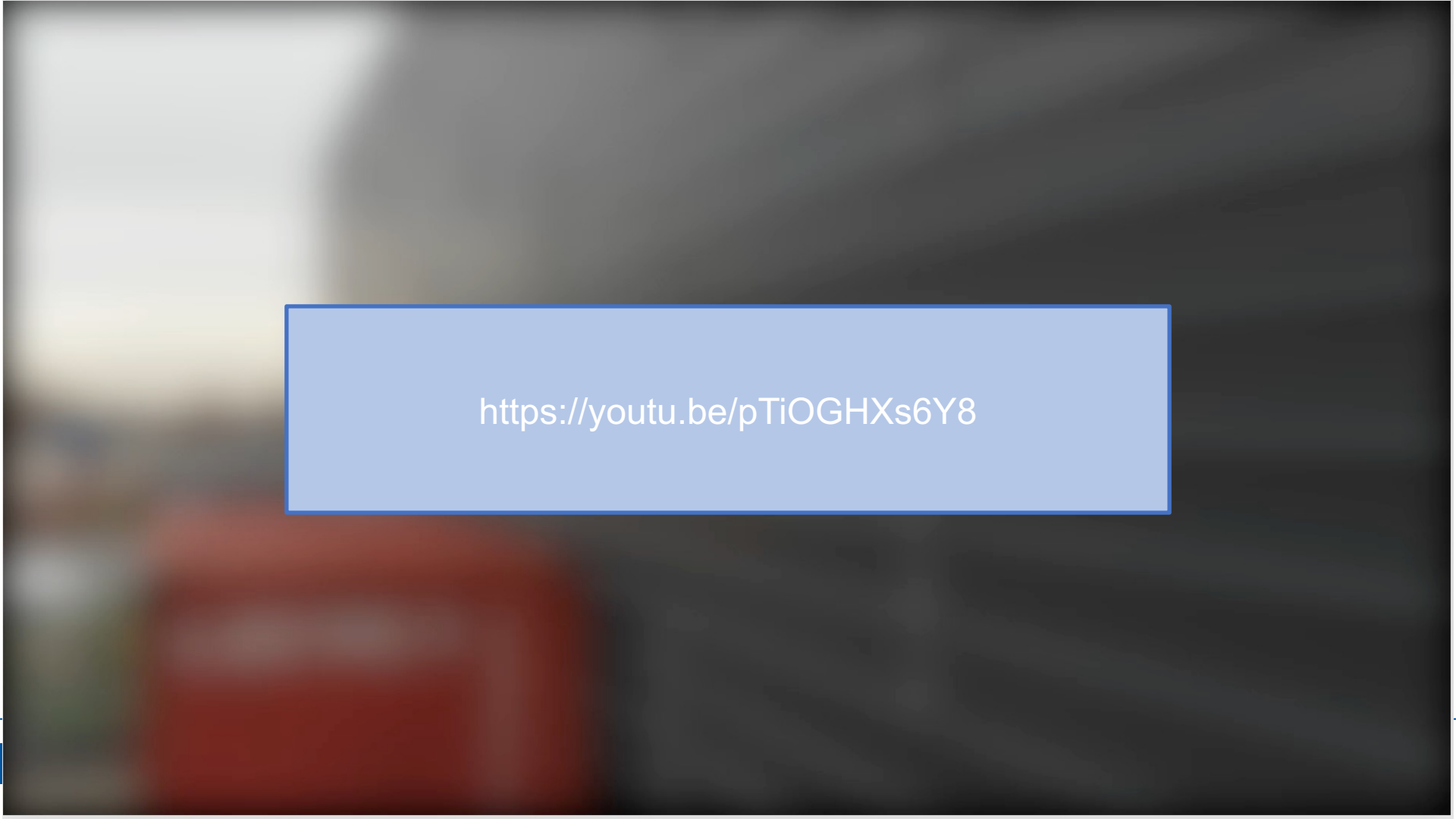
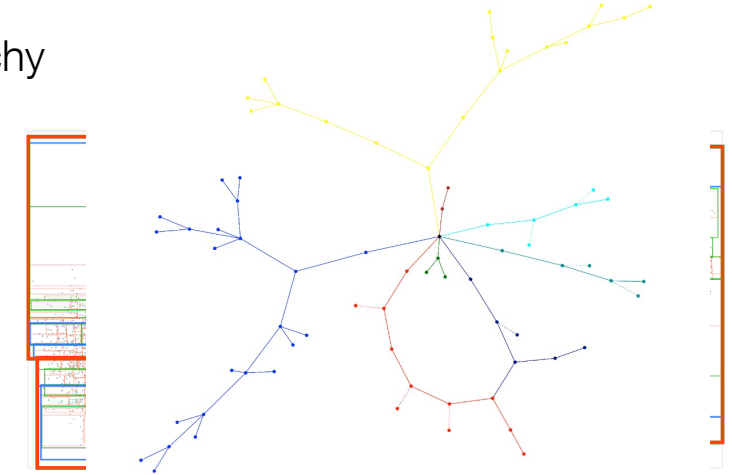



https://youtu.be/pTiOGHXs6Y8

Topology Extraction – IFC2TSO

- Topological links via IfcDistributionPort and Spatial links via the geometric representation and the location of objects
- Implementation of a spatial tree using the geometric positioning of the DistributionPorts and corresponding elements to match unassigend ports
- Graph algorithms to identify systems and their hierarchy based on their topological connection and the exchange of flow
- Aggregation of nodes by the number of neighbours and their value to lower the complexity



Future Work

- Implementation of TSO in the real-world project Viega World
- Integrate sub-properties of tso:subSystemOf to explicitly model the hierarchy of systems and add the class tso:IntegratedSystem as a sub-class of tso:System
- Revise the conversion pipeline IFC2TSO and add support for multiple *.ifc files
- Dynamic web-based visualisation of the system diagrams based on TSO (in split screen view with the BIM model)

Q&A