TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik Institut für Angewandte Informatik, Professur Technische Informationssysteme

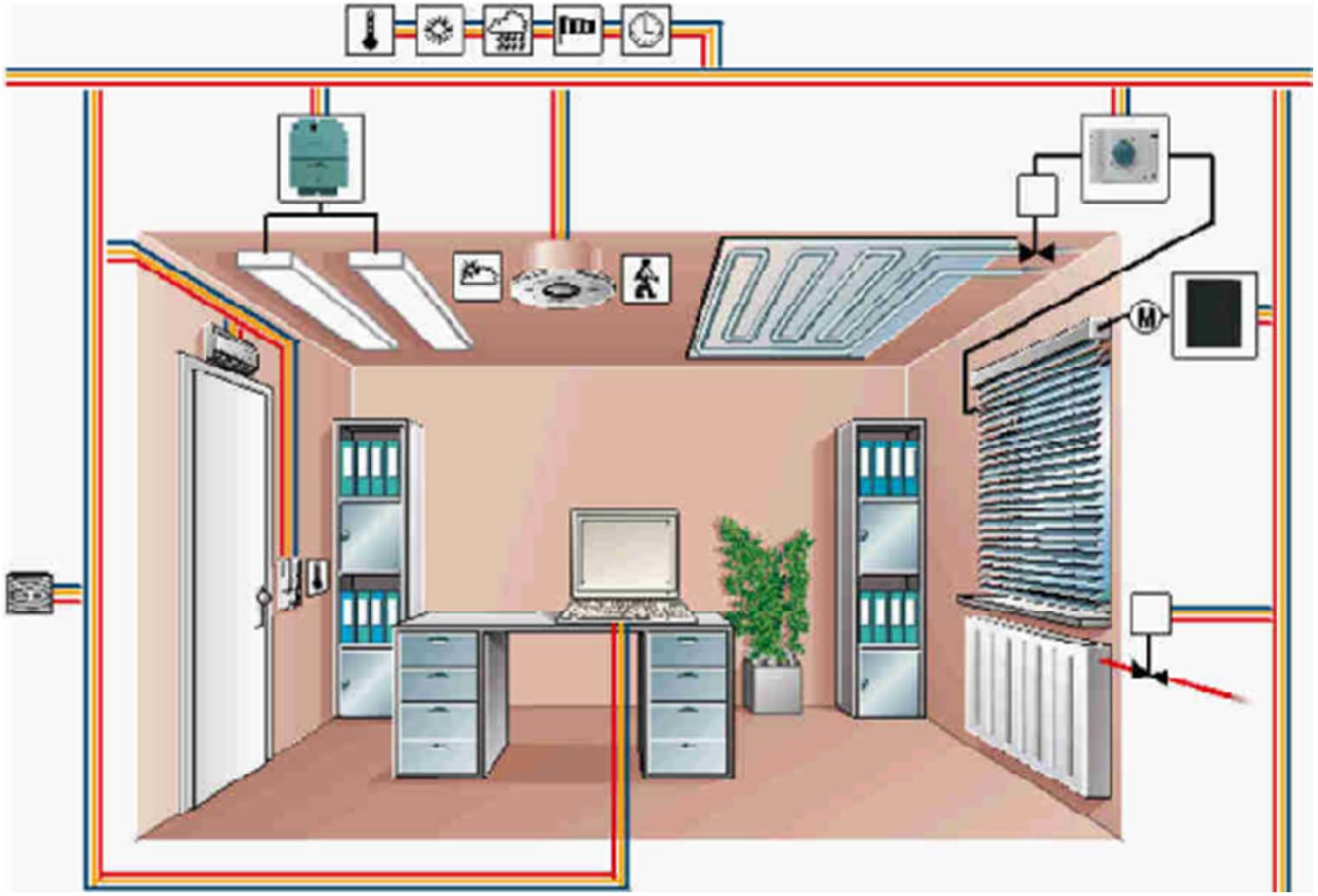
Interoperability: Advantages, Problems and Solutions

Prof. Dr.-Ing. habil. Klaus Kabitzsch

Dresden, 2018-05-29

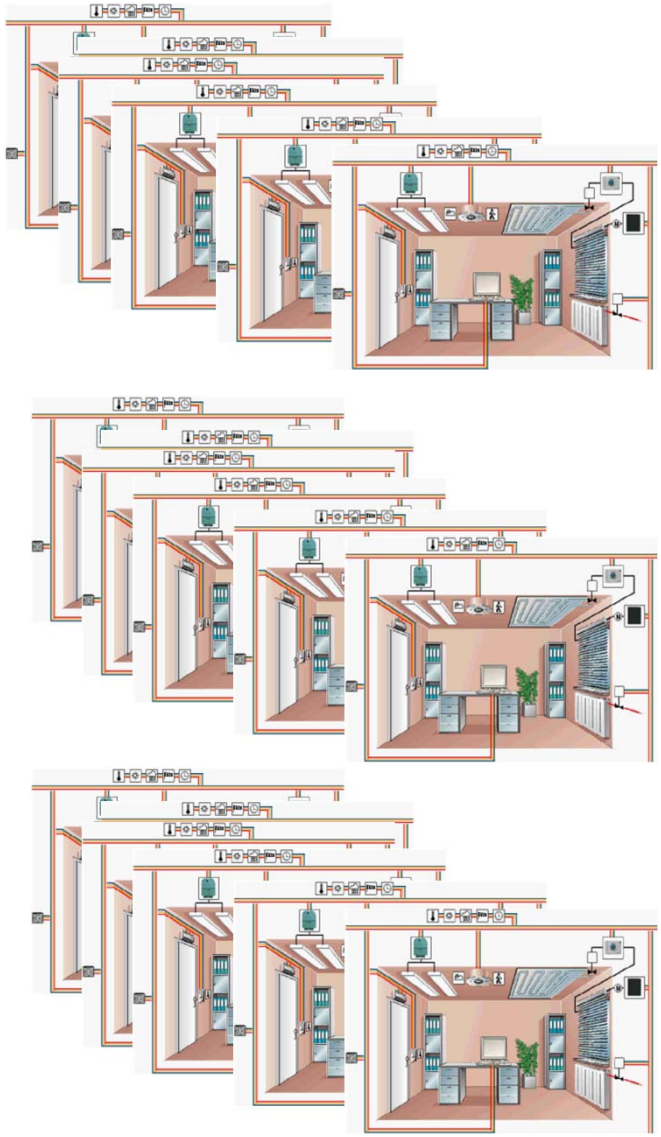
Complexity and Economy

Complexity in Intelligent Rooms



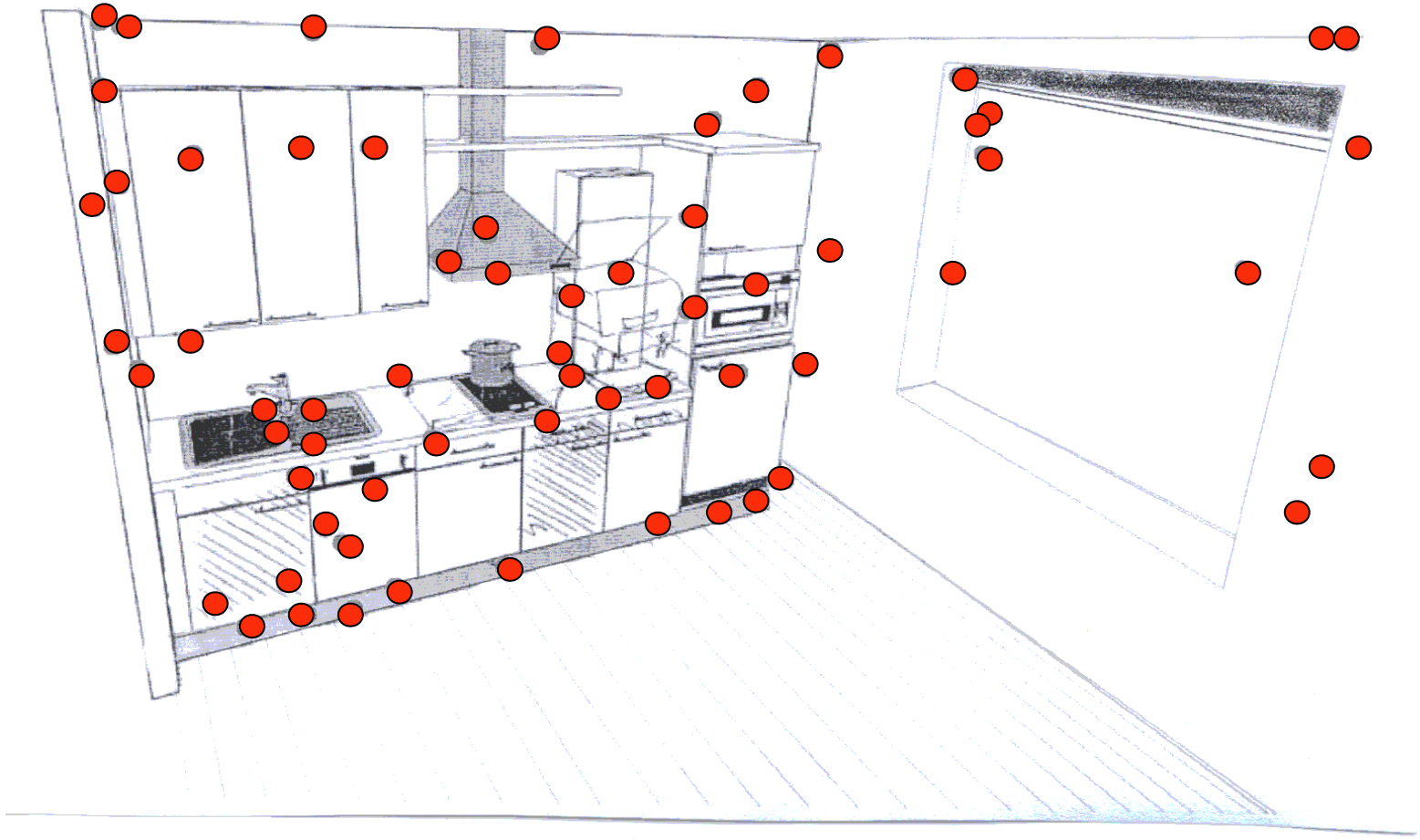
One room – many networked components

Complexity in Intelligent Buildings



One building - many networked rooms

Complexity in the Future

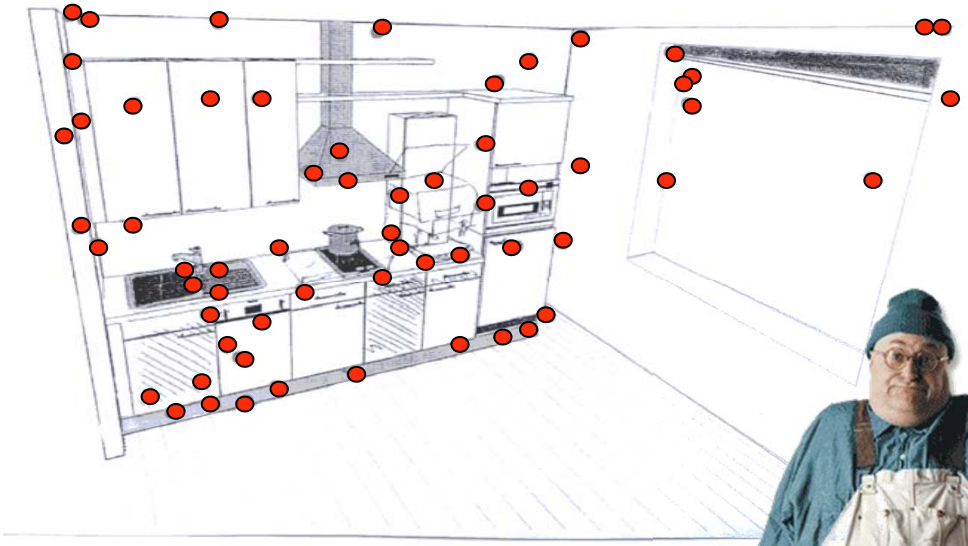


Internet of things vision – much more networked components

Complexity in the Future

WHO can design it –
and HOW to design it ?

Complexity in the Future



WHO can design it –
and HOW to design it ?

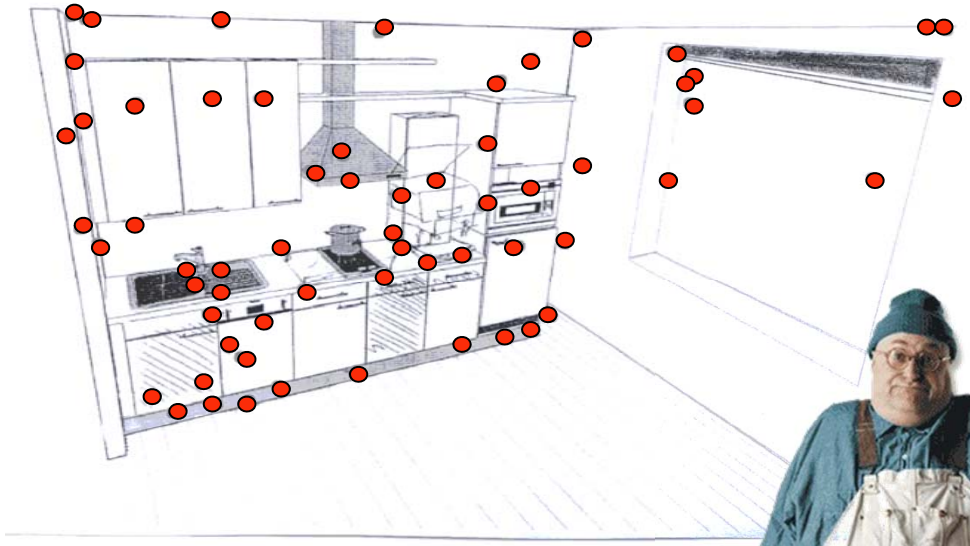
WHO ?

Computer Scientists ?
Craftsmen ?
Customers / Clients ?
Self-X ?

HOW ?

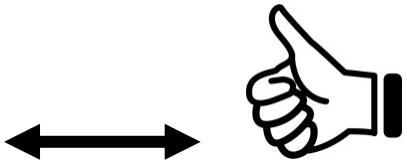
Programming line per line ?
Composition of Components ?
Self-X ?

Complexity in the Future



WHO can design it – and HOW to design it ?

Cost



Quality

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HOW ?

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Composition of Components ?
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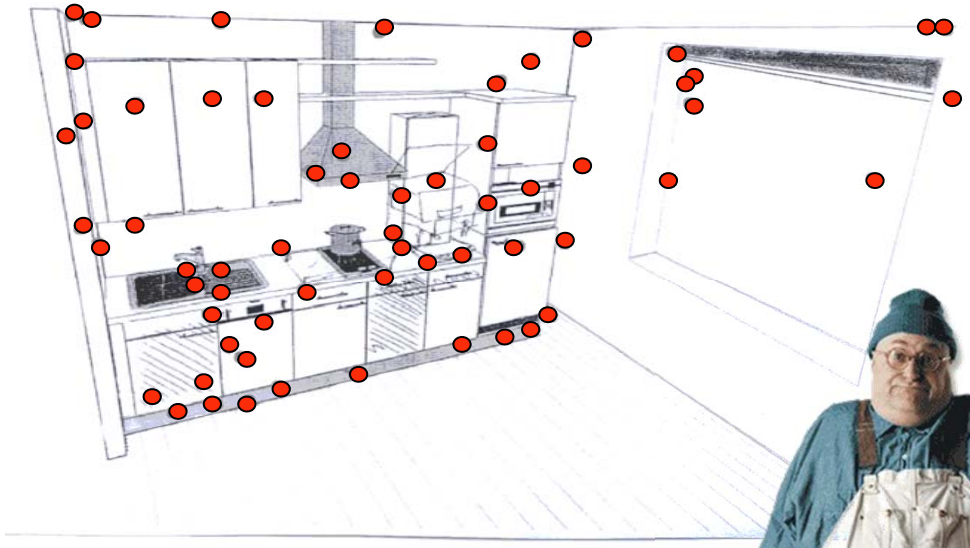
Complexity in the Future



WHO can design it – and HOW to design it ?

Cost

Quality

WHO ?

Computer Scientists ?
Craftsmen ?
Customer / Client ?
Self-X ?

Combination of different people: collaborative workflow

HOW ?

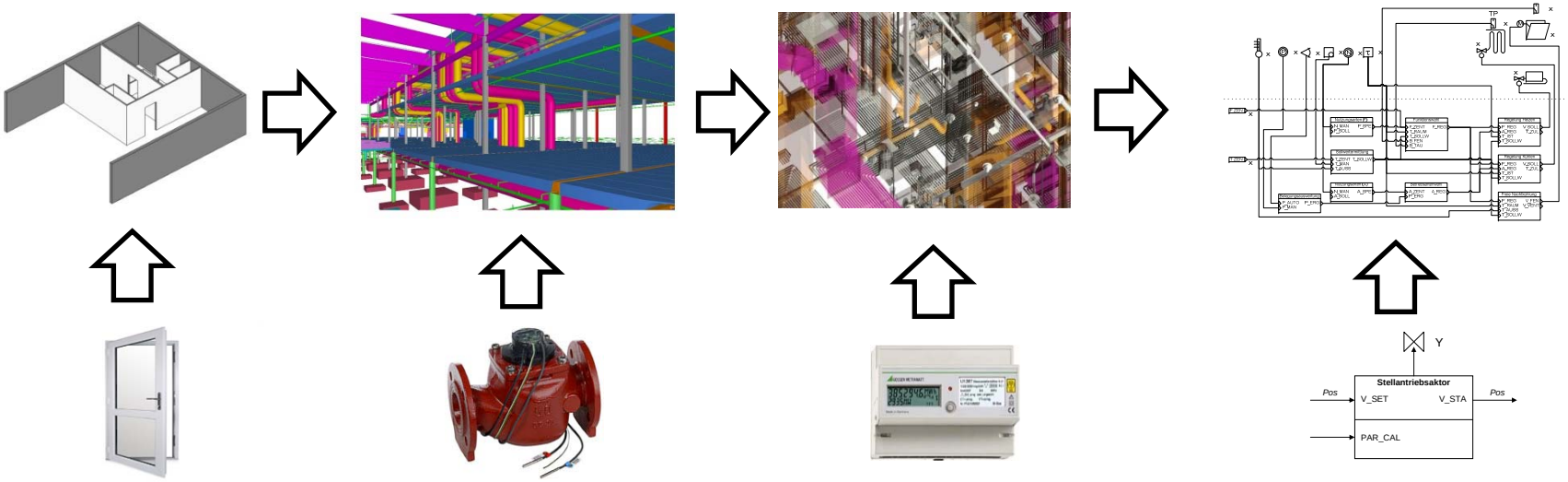
Programming line per line ?
Composition of Components ?
Self-X ?

Combination: „prefabrication and re-use“

Prefabrication and Re-Use

Prefabrication, Re-Use = Component Assembly

Whole buildings and their digital twins (BIM / IFC)



Construction
IFC
ISO 16739

HVAC
VDI 3805
ISO 16757

Hardware
eCl@ss
IEC 61360 / ISO 13584

Software
VDI 3813/14/12
{ISO 16484}

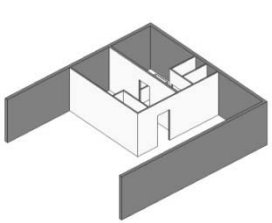
Prefabricated components: from electronic catalogues

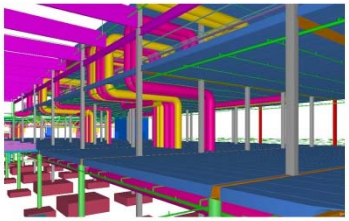
Prefabrication, Re-Use = Component Assembly

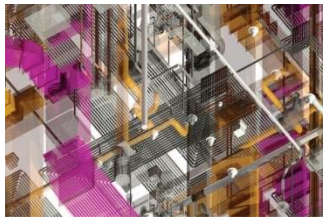
Geometry , Materials

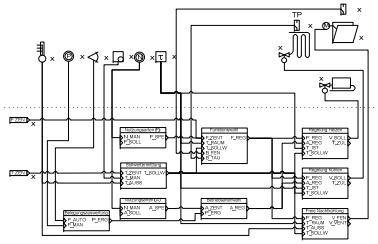
Flows , Causalities

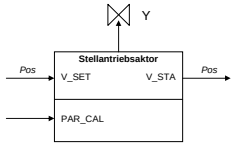
Whole buildings and their digital twins (BIM / IFC)











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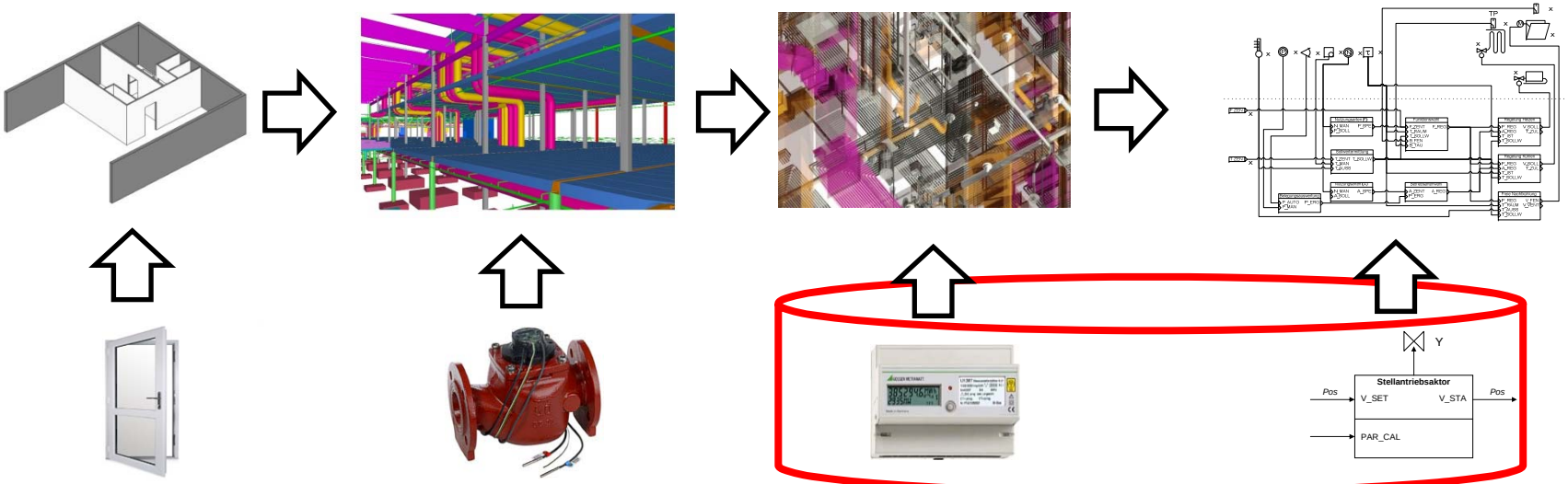

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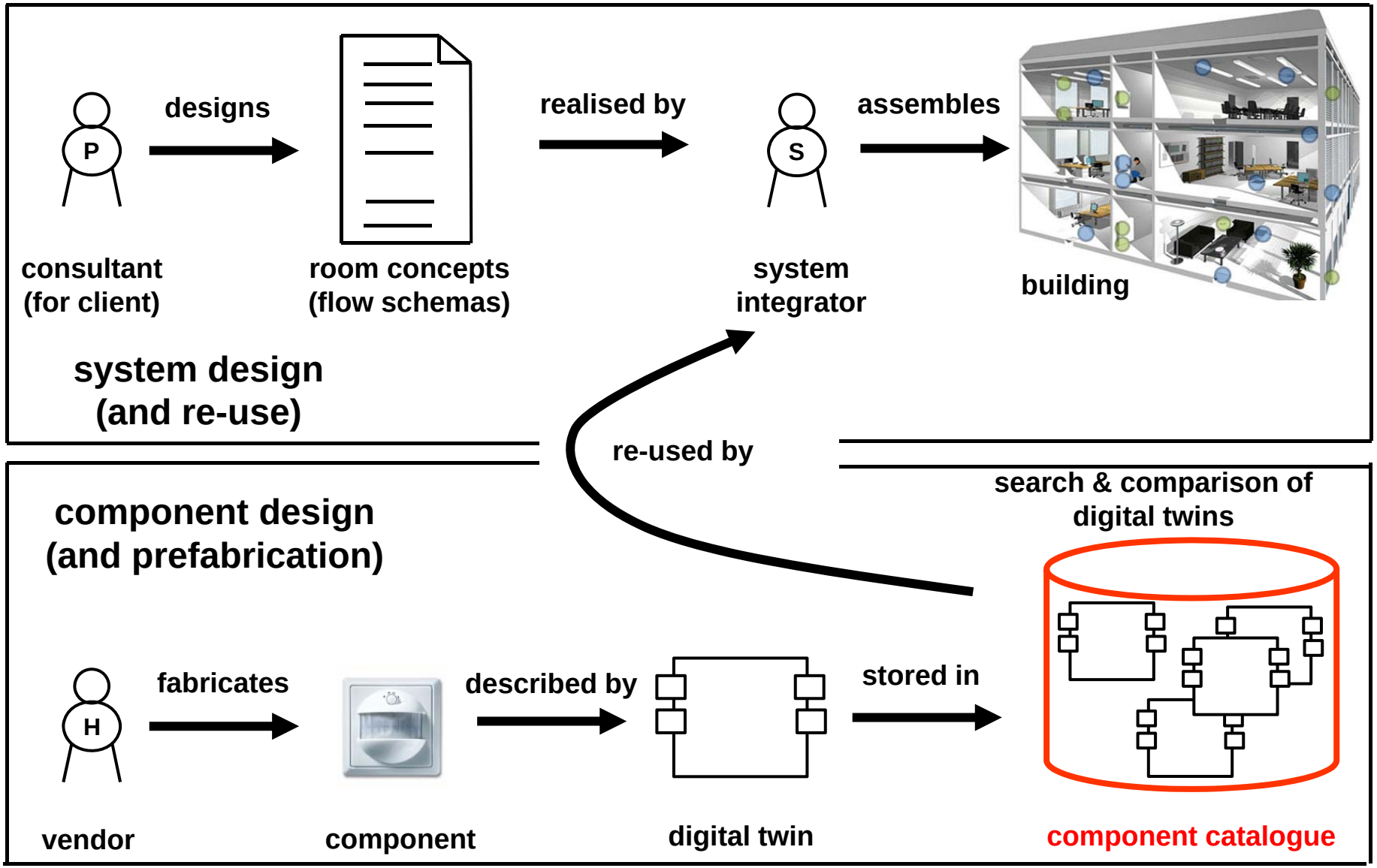
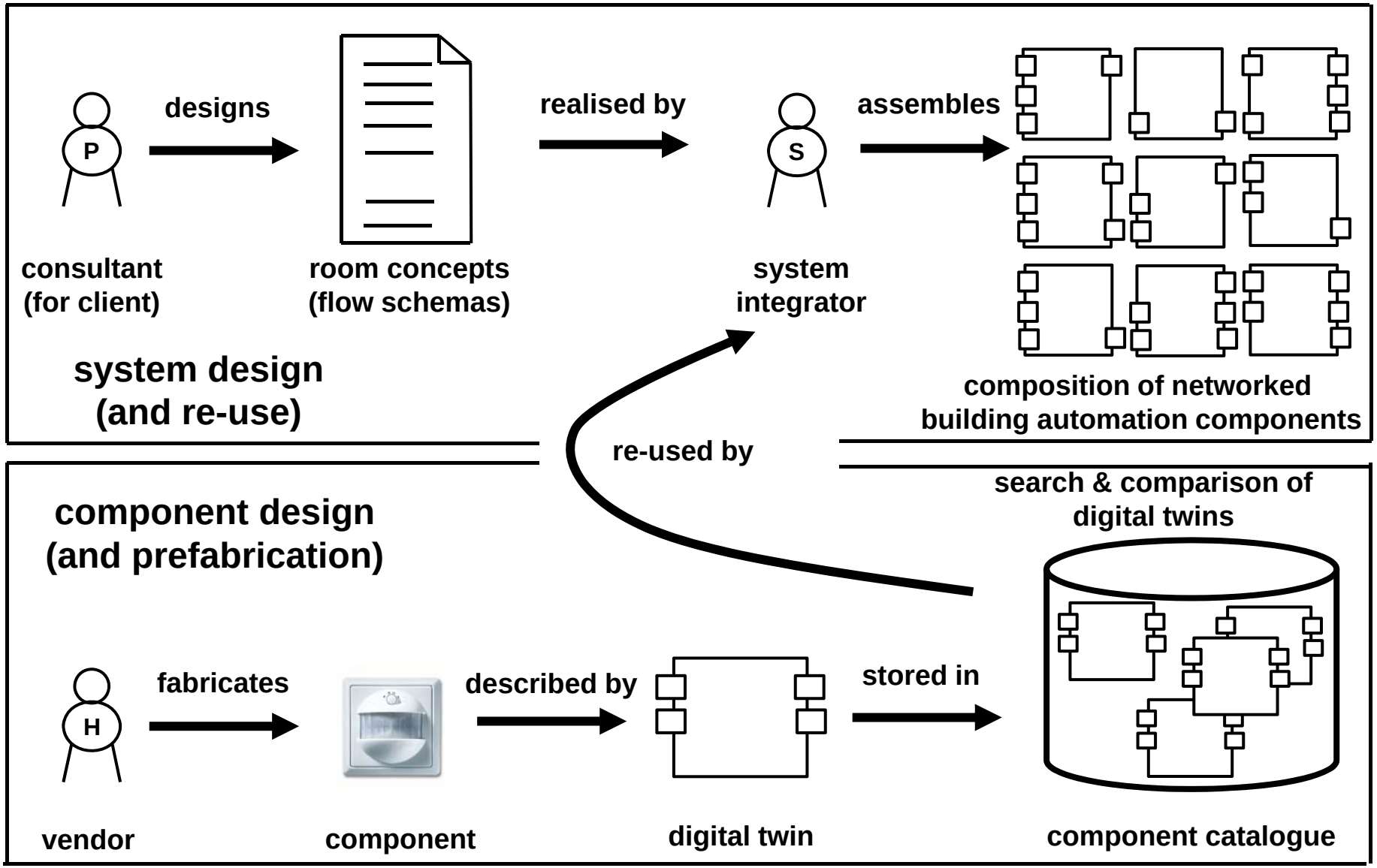


Prefabrication, Re-Use = Component Assembly



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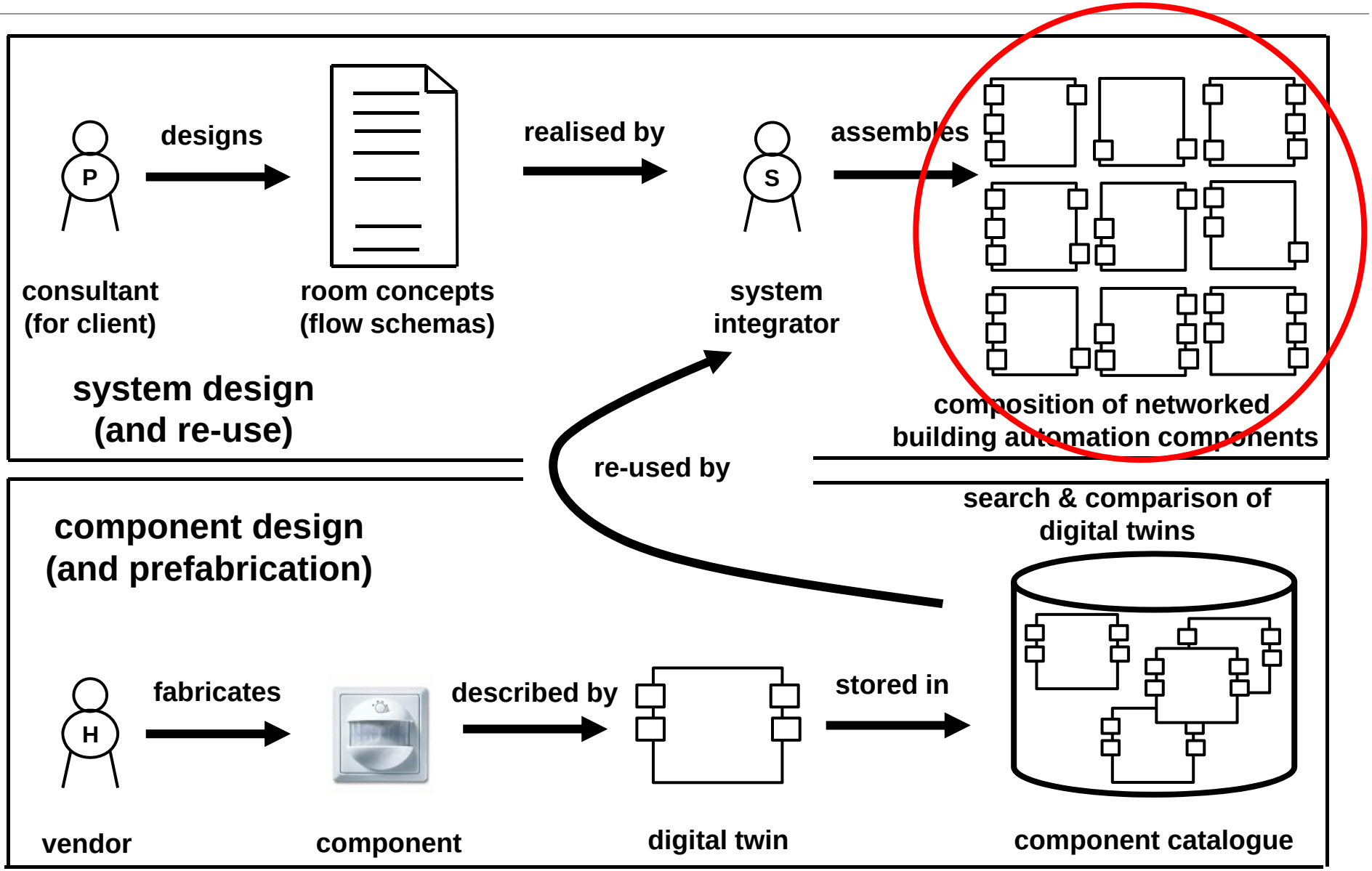
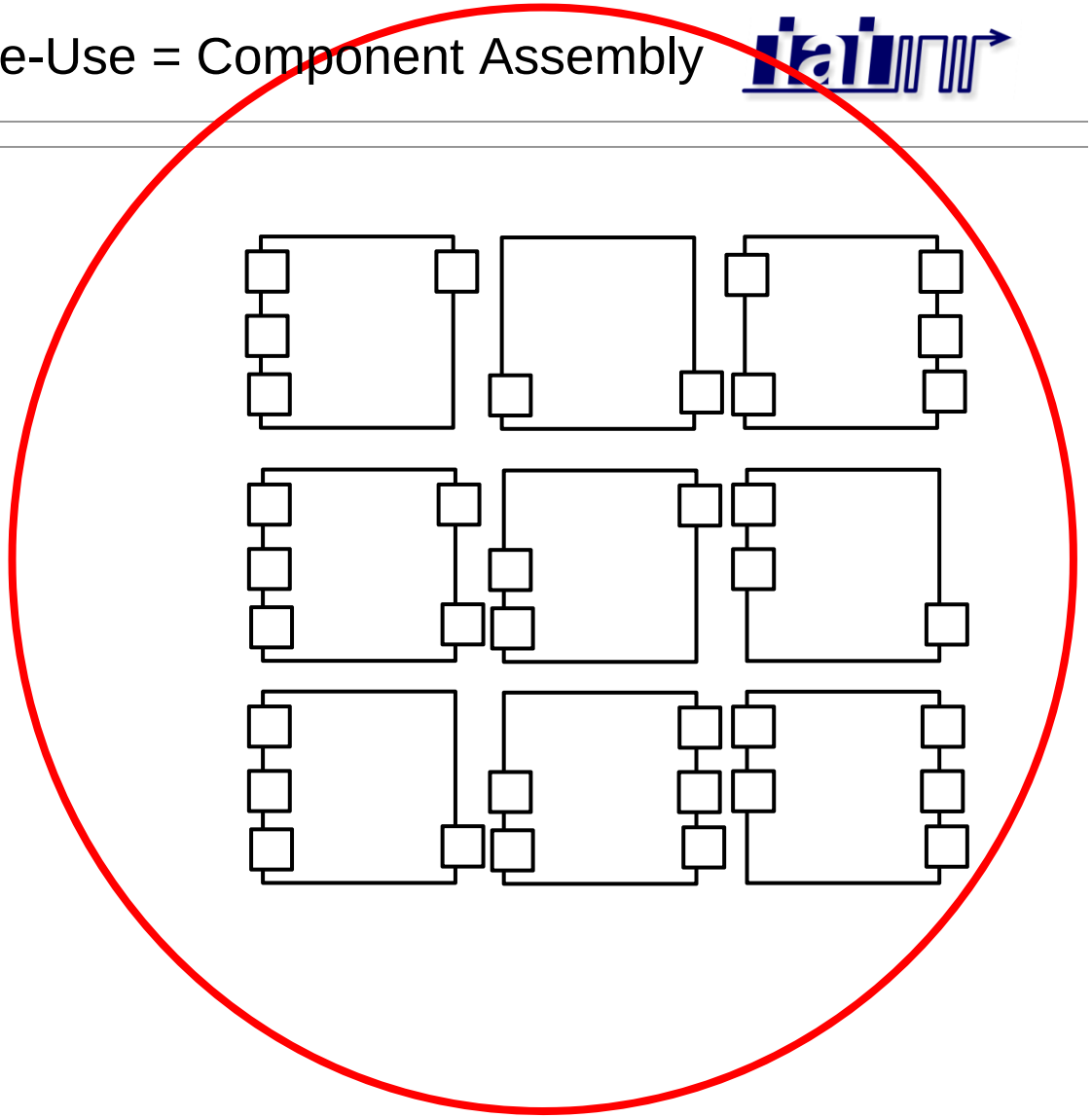


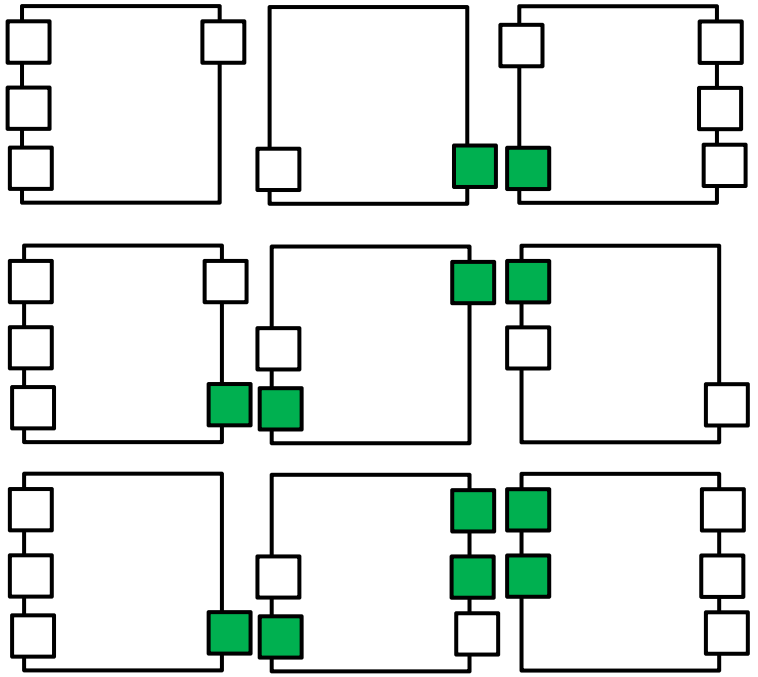
Prefabrication, Re-Use = Component Assembly

composition of networked
building automation components



Prefabrication, Re-Use = Component Assembly

Some good data connections

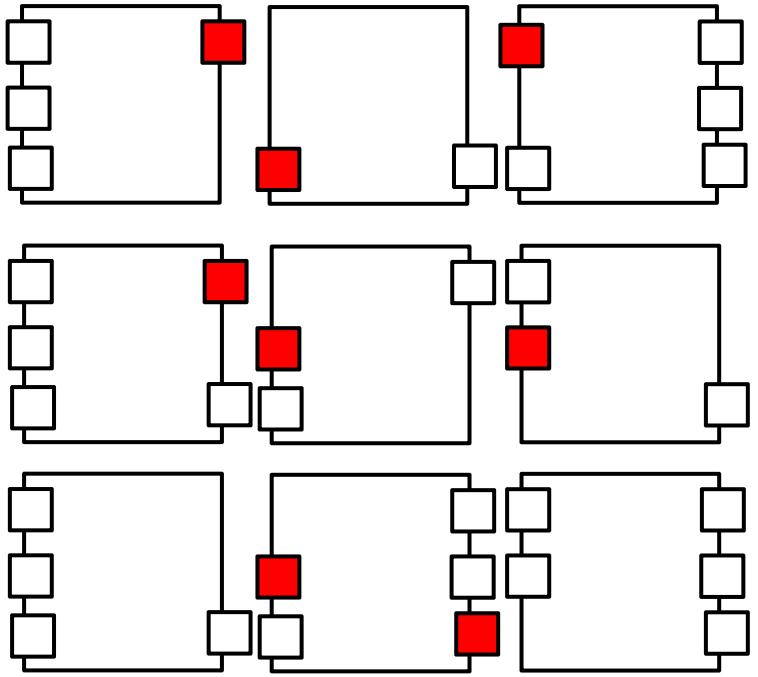


Prefabrication, Re-Use = Component Assembly

Missing or insufficient data connectors

→ Needed data flow impossible

→ Needed automation functions impossible



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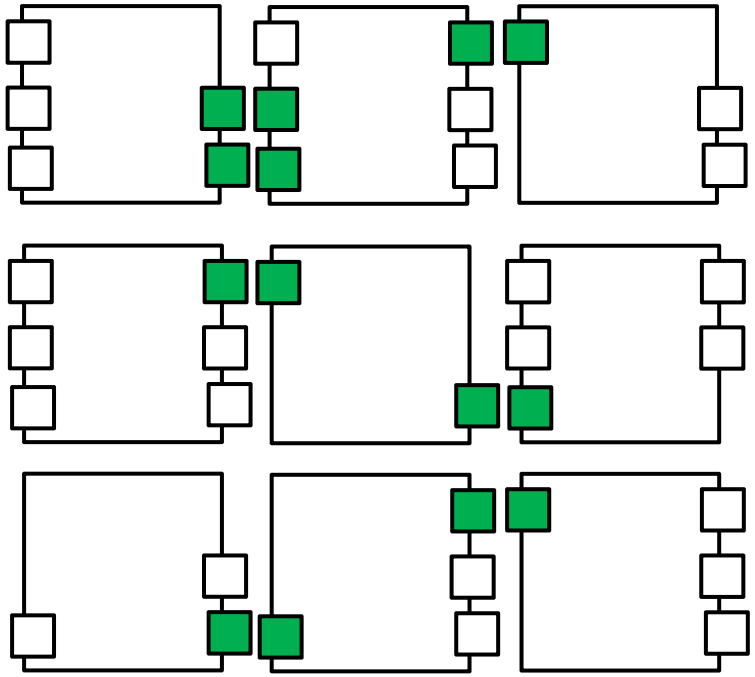

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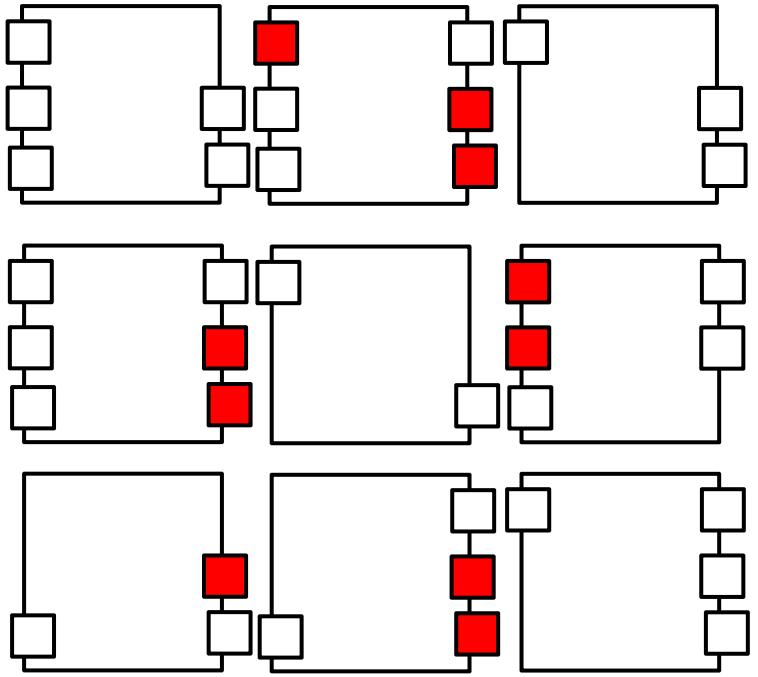

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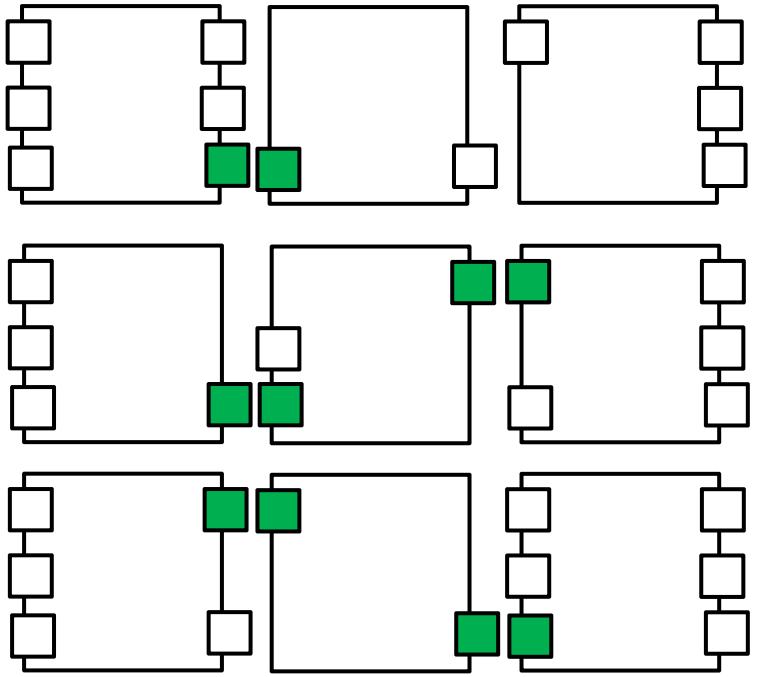

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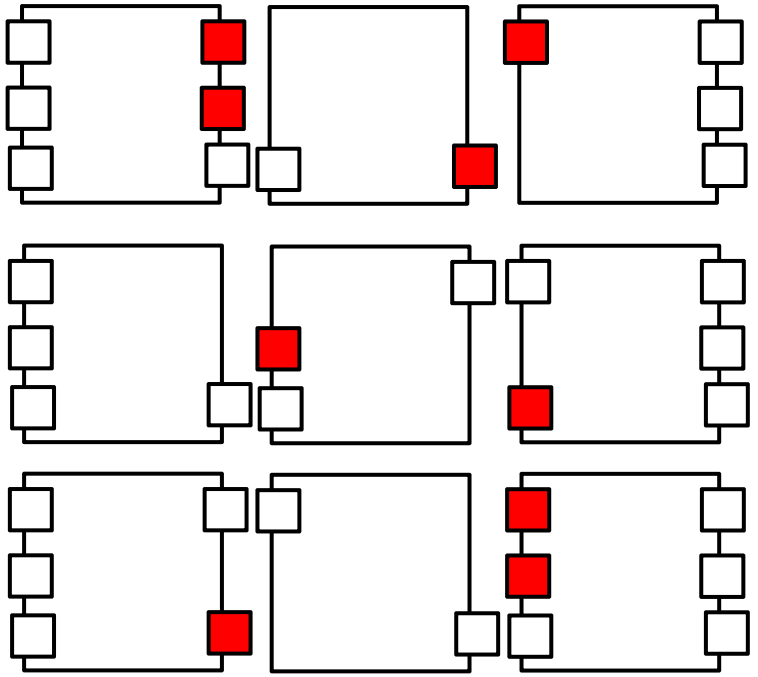

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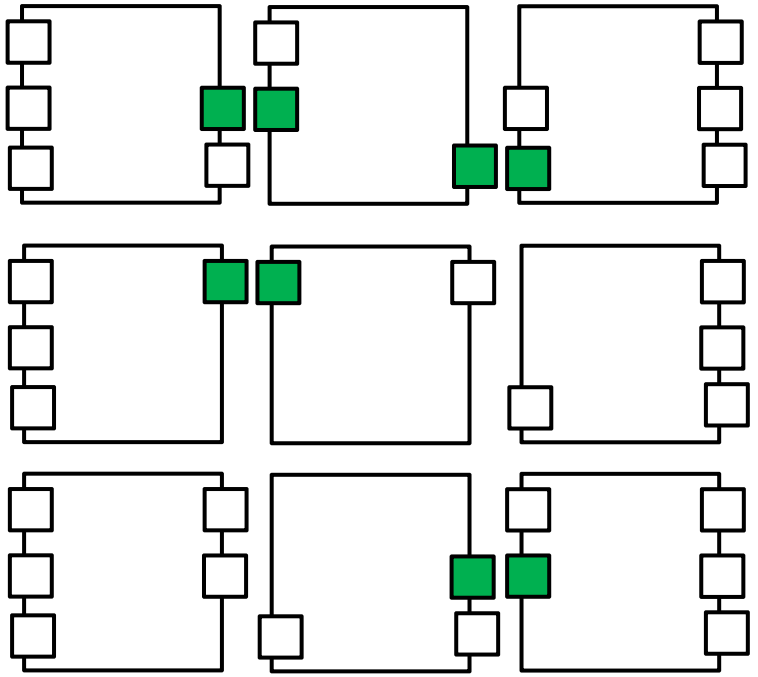

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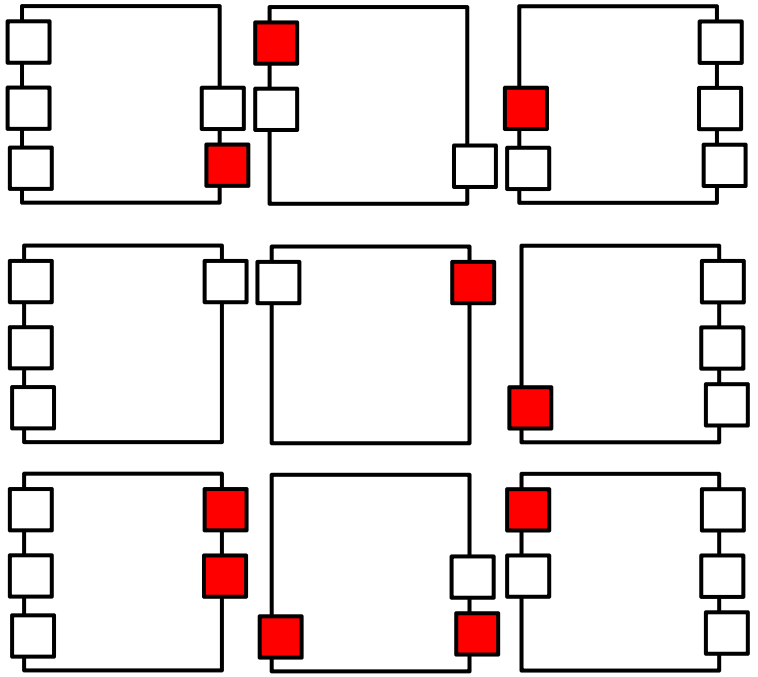

Prefabrication, Re-Use = Component Assembly

Missing or insufficient data connectors

→ It‘s like a puzzle !

→ Millions of combinations
(exponential complexity)

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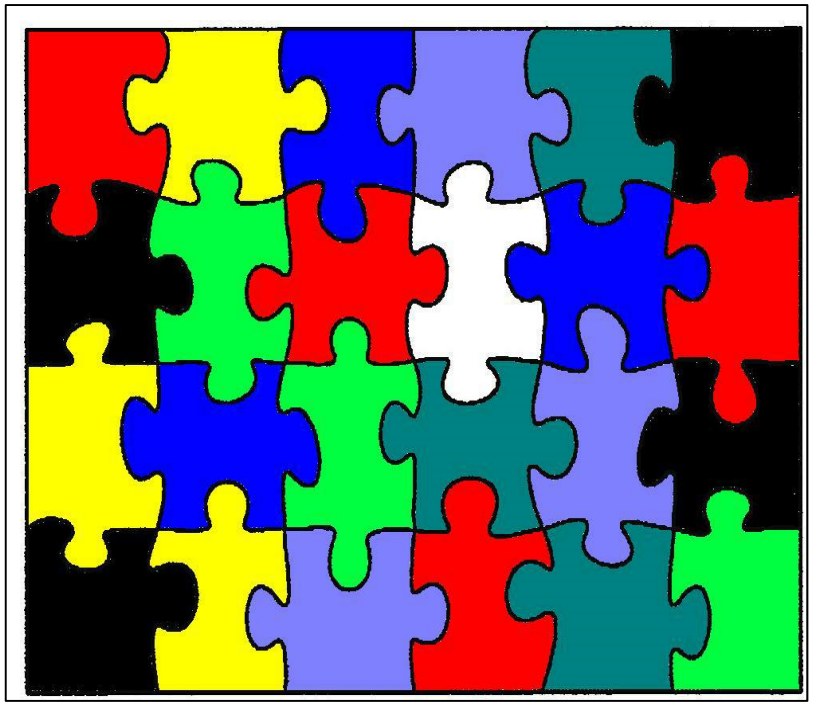
→ Needs long time to find a solution

→ Sometimes impossible to find a solution



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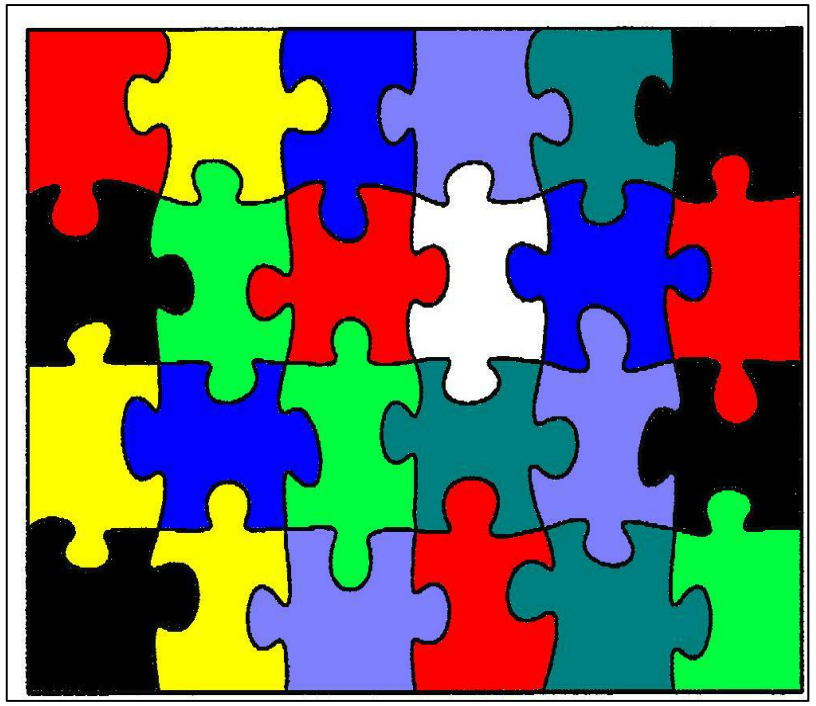


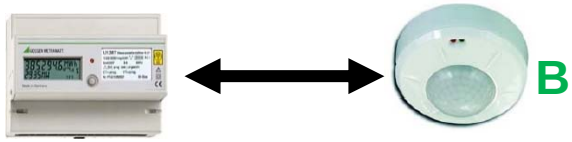
Interoperability

Interoperability of Components

Definition:

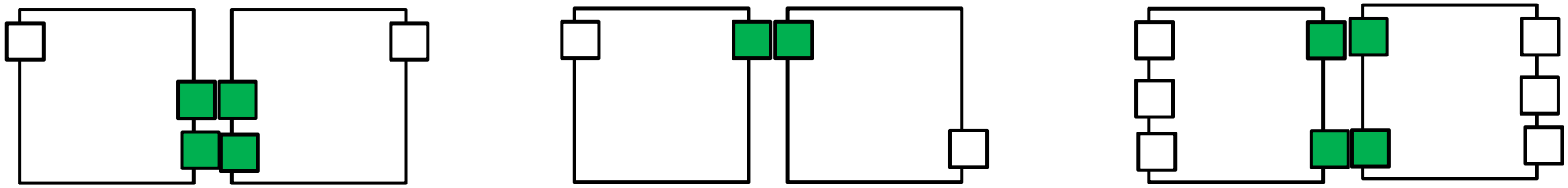
Two (or more) Components are **interoperable**, if they are able to work together in defined functions without additional effort for design or adaptation (unless produced by different vendors).

bilateral (A - B) or multilateral

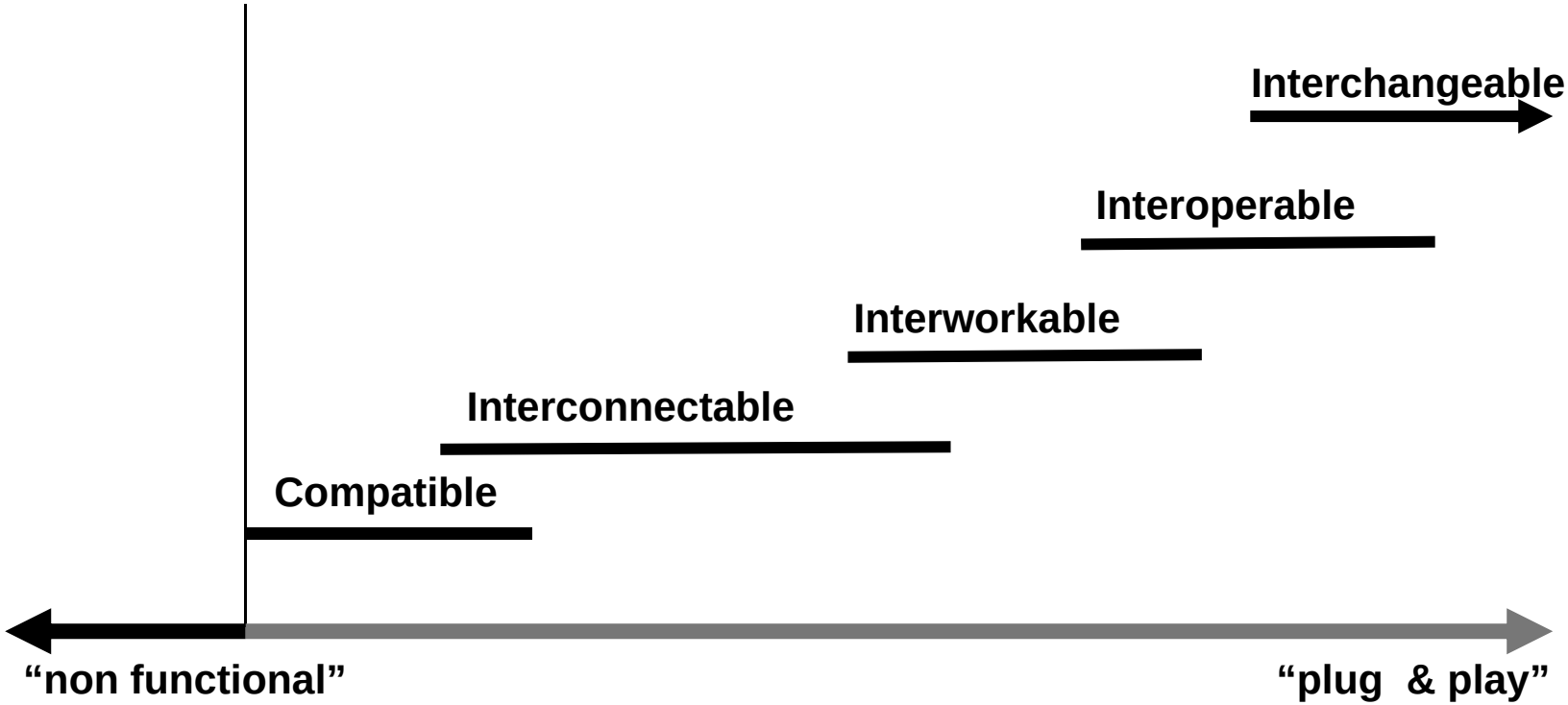


in a defined environment

in defined functions



Hierarchy of Preconditions for Fitness



Preconditions - what must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
Dynamic Behavior					eq.
Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
Lay. 7 Data Structures			eq.		
Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

Guarantee by . . .

- Knowledge
- Information
- Data
- Signal

Design

Trans-formation

Standar-disation

Preconditions - what must be equal?

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Guarantee by . . .

- Knowledge
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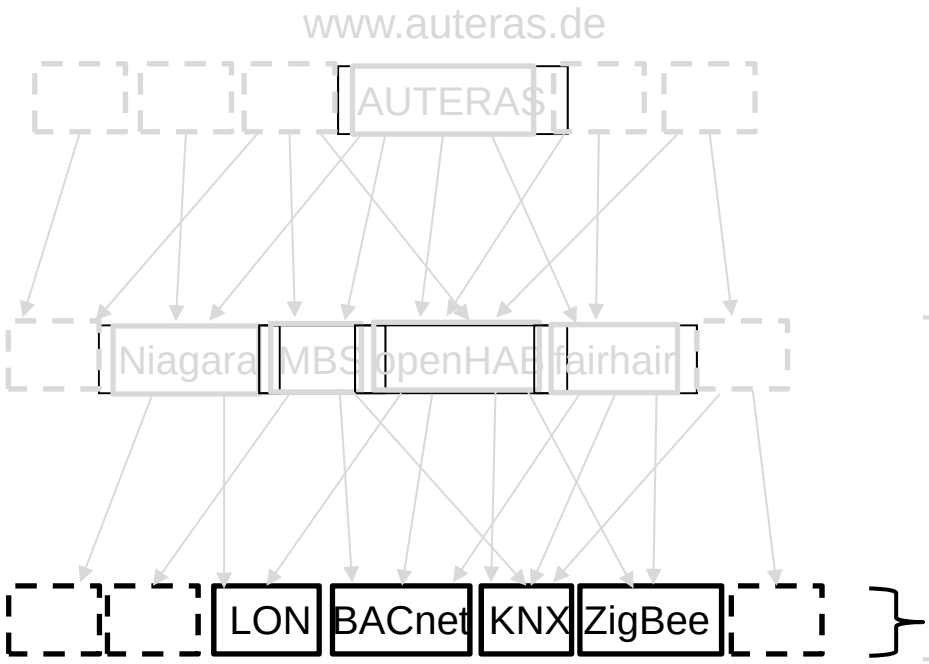
How to guarantee the preconditions?



Layer 1 - „8“
Interoperable by design
(discovery, selection, composition)

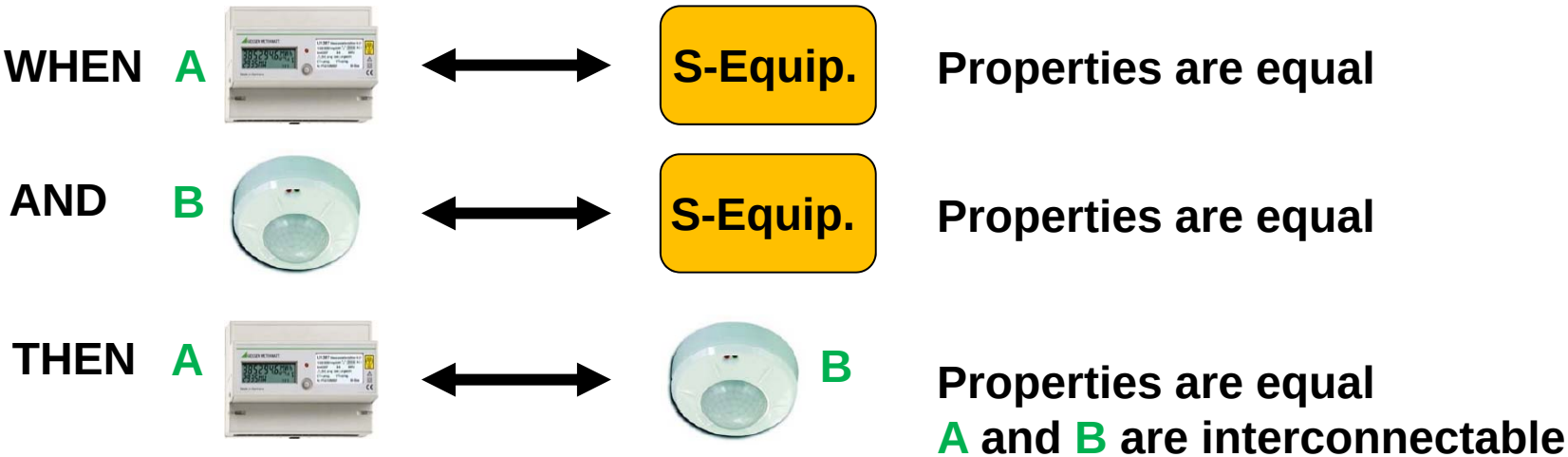
Layer 1 - 7
Interworkable by transformation
(middleware)

Layer 1 - 6
Interconnectable by standardisation
(conformance test & certification)

Conformity of Components

Definition:

A component C is conform to a standard S, if all properties of C are equal to S. This can be evaluated by a comparison with a “standard equipment” during a conformance test and confirmed by a certificate



Preconditions - what must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
Dynamic Behavior					eq.
Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
Lay. 7 Data Structures			eq.		
Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

Knowledge

Information

Design

Data

Signal

Guarantee by . . .

Trans-formation

Standar-disation

Preconditions - what must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
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Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
Lay. 7 Data Structures			eq.		
Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

Knowledge (Dynamic Behavior, Lay. 8) – Information (Lay. 7 Basic Semantics) – Design (Knowledge + Information)

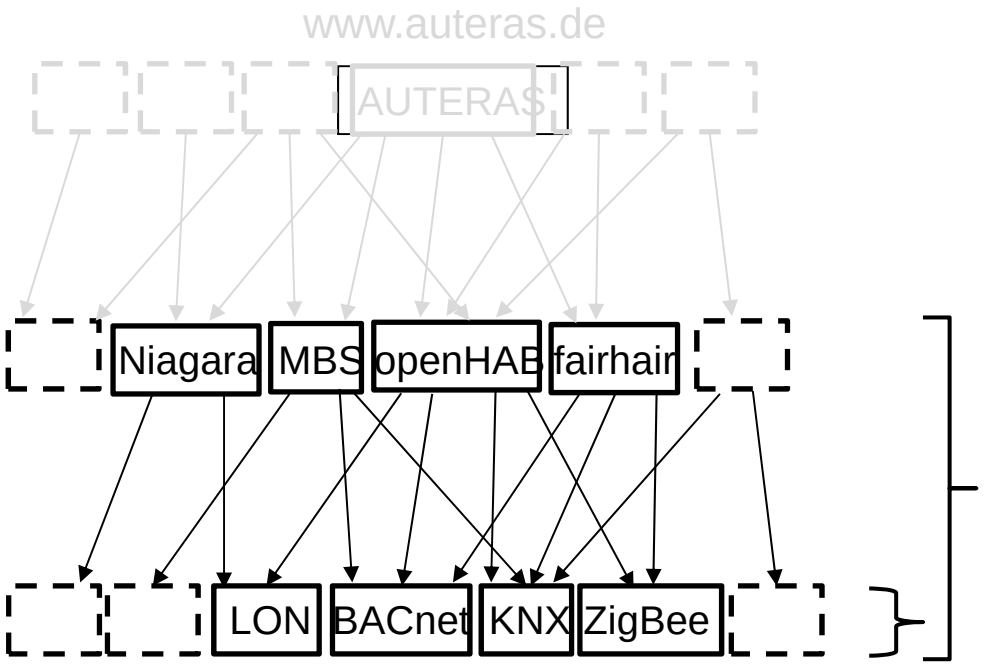
Data (Lay. 7 Data Structures, Layer 3 - 6) – Signal (Layer 1 - 2)

Guarantee by . . .

Trans-formation (Data)

Standar-disation (Signal)

How to guarantee the preconditions?



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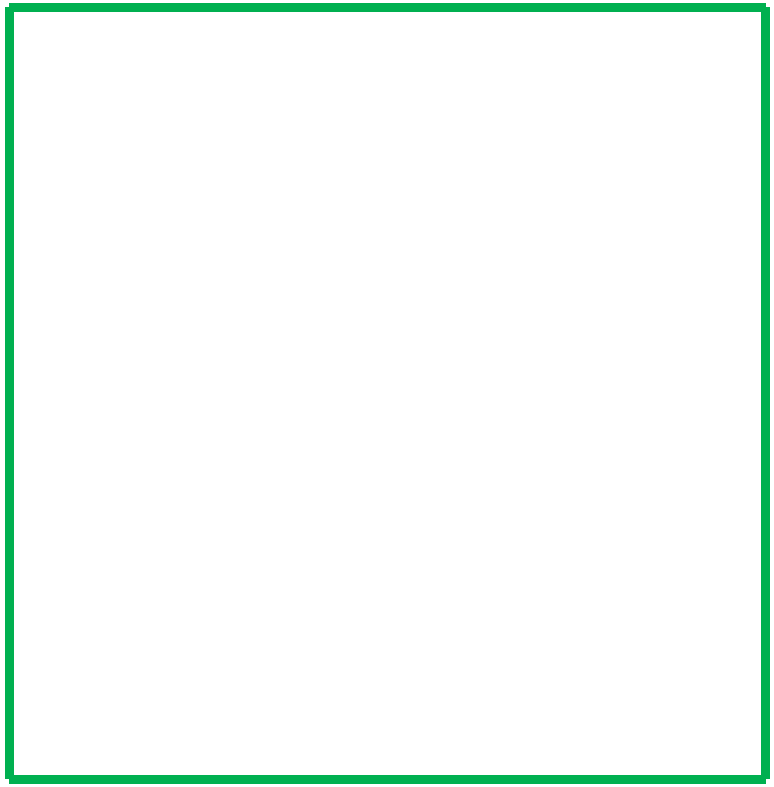
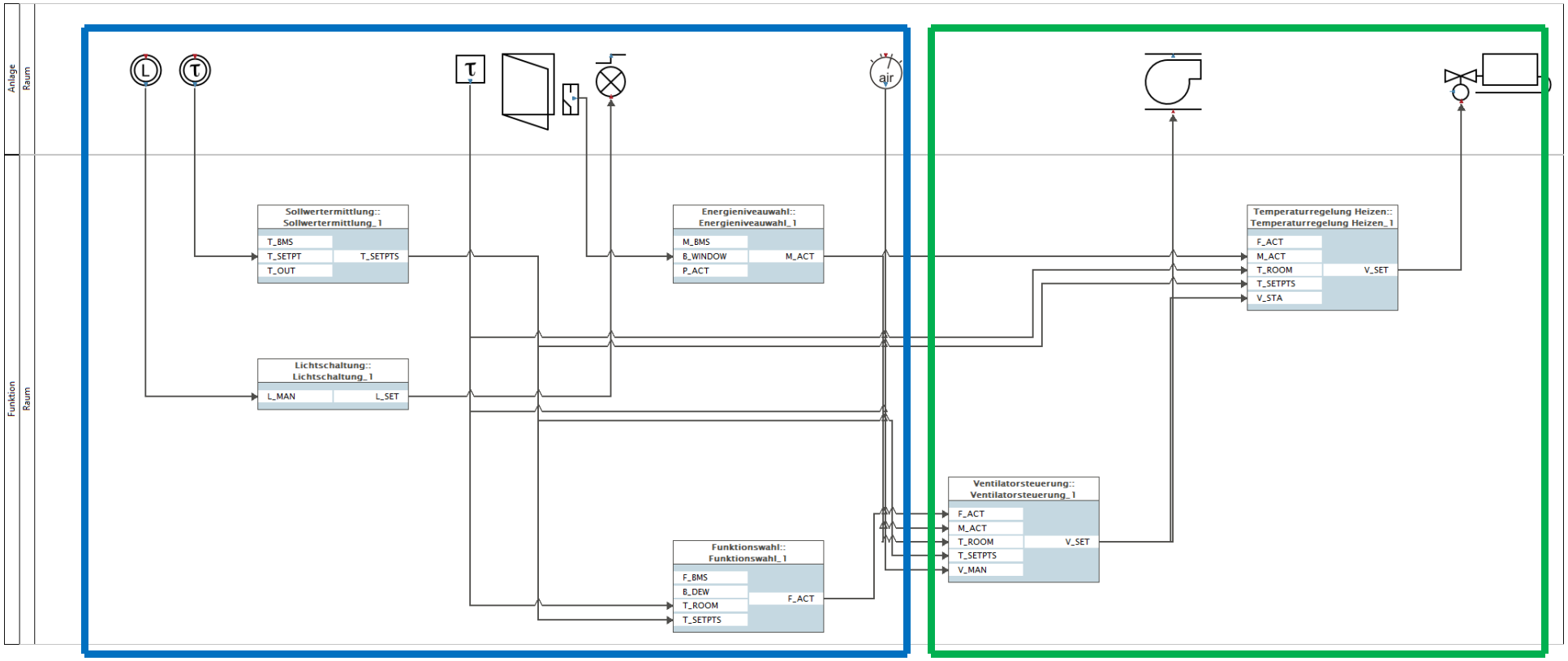
Preconditions - Interworkable

Component A in network 1



Component B in Network 2

Preconditions - Interworkable

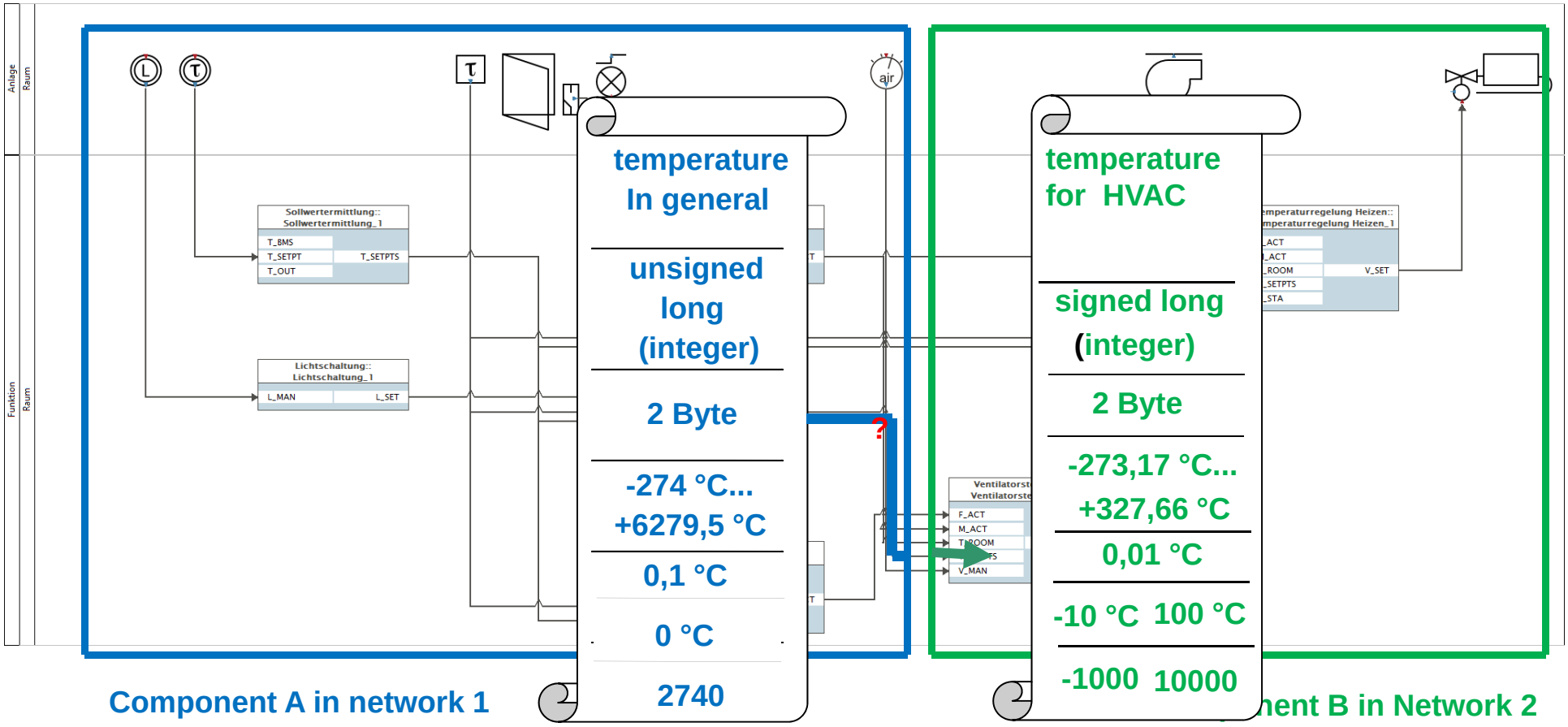


Component A in network 1

Component B in Network 2

All crossing „information arrows“ between both components are part of the network interface

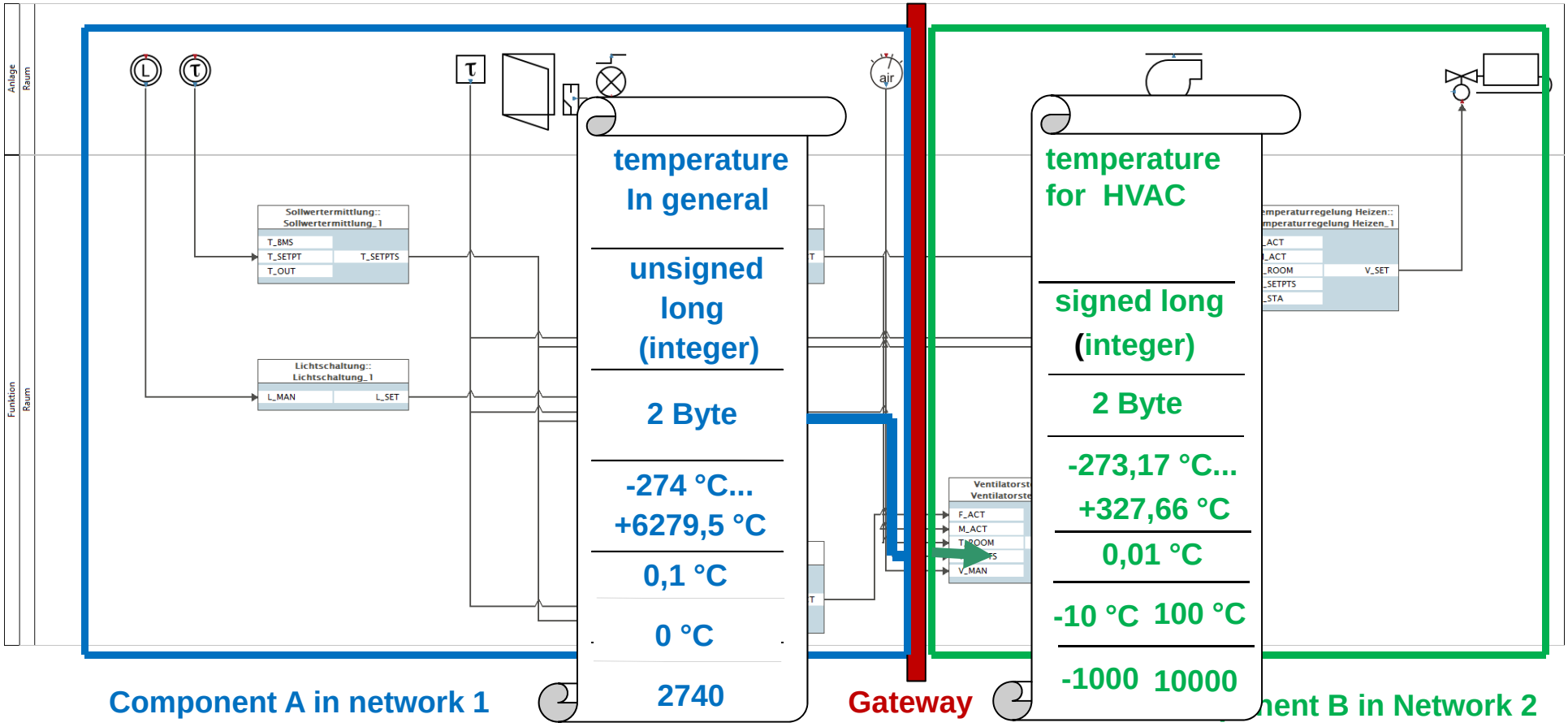
Preconditions - Interworkable



All crossing „information arrows“ between both components are part of the network interface

Different data structures on both sides of the interface

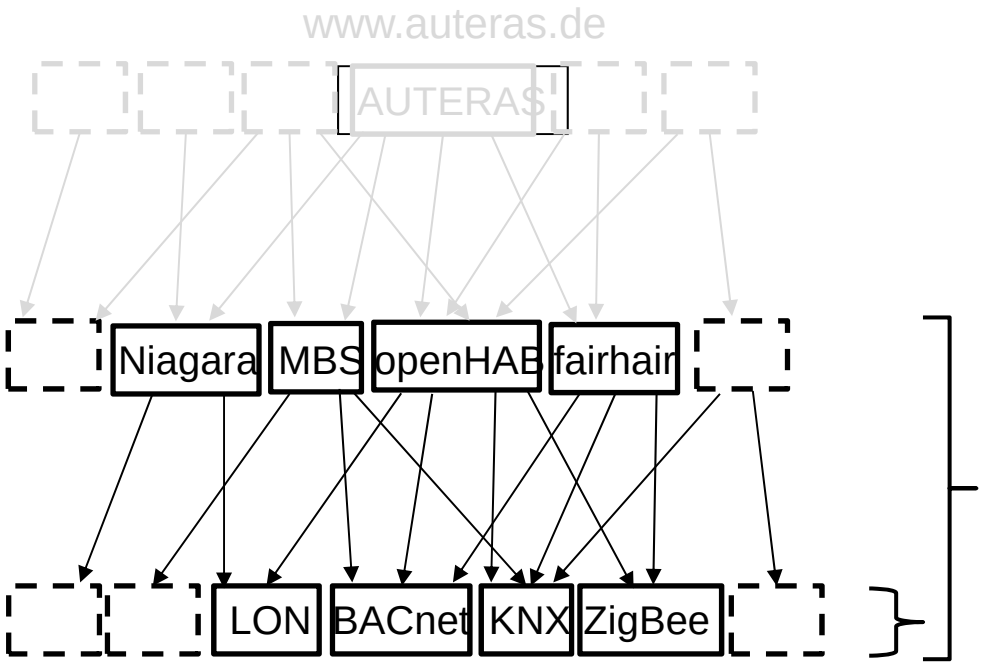
Preconditions - Interworkable



All crossing „information arrows“ between both components are part of the network interface

Transformation of different data structures by the gateway

How to guarantee the preconditions?



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(middleware)

Layer 1 - 6
Interconnectable by standardisation
(conformance test & certification)

Semantics

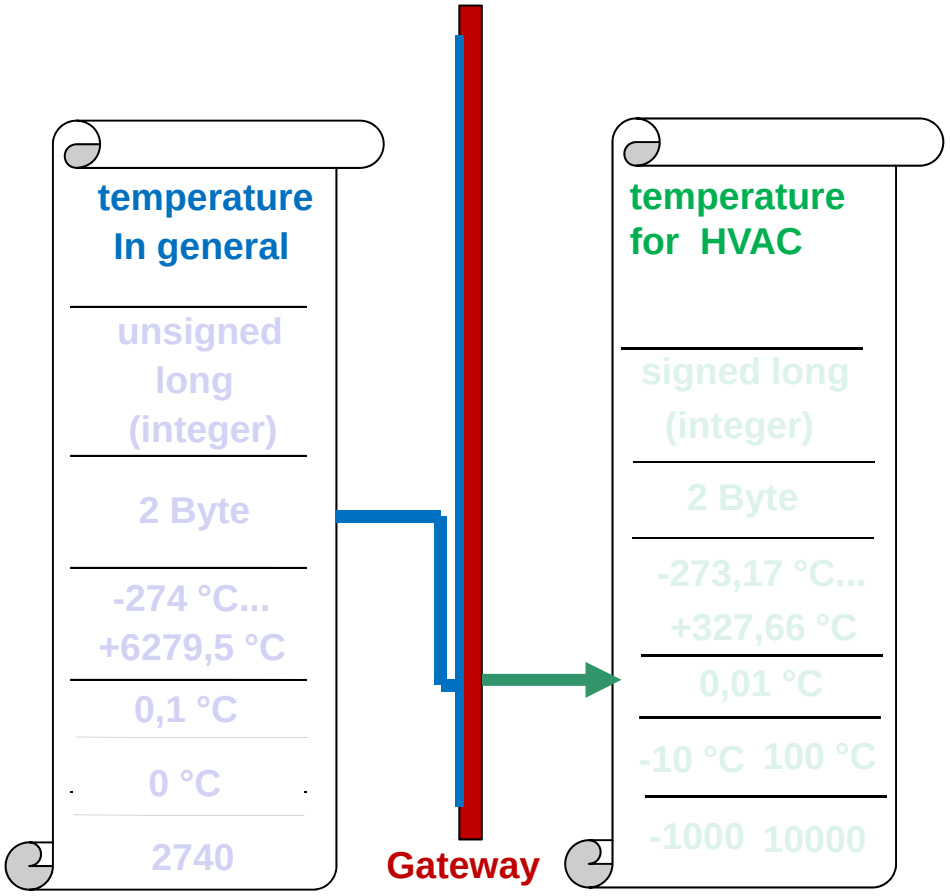
Preconditions - what must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
Dynamic Behavior					eq.
Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
Lay. 7 Data Structures			eq.		
Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

Guarantee by . . .

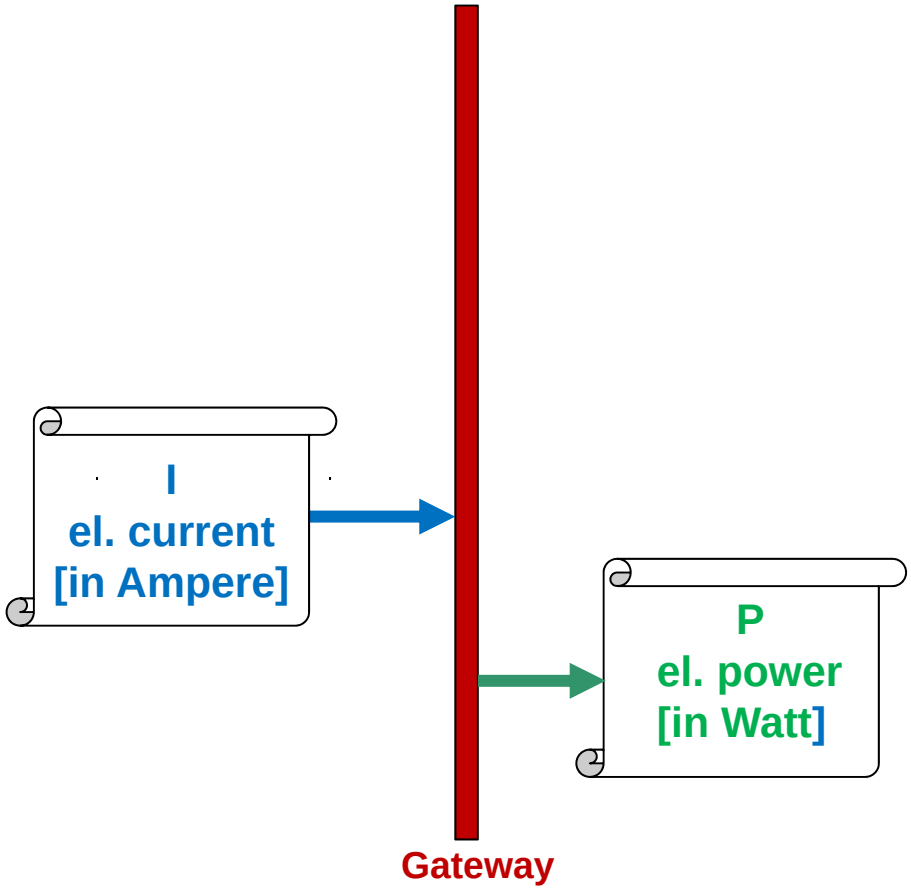
- Knowledge (Dynamic Behavior, Lay. 8 Applic. Semantics) } Design (Knowledge, Information)
- Information (Lay. 7 Basic Semantics)
- Data (Lay. 7 Data Structures, Layer 3 - 6) — Trans-formation
- Signal (Layer 1 - 2) — Standar-disation

Same Basic Semantics



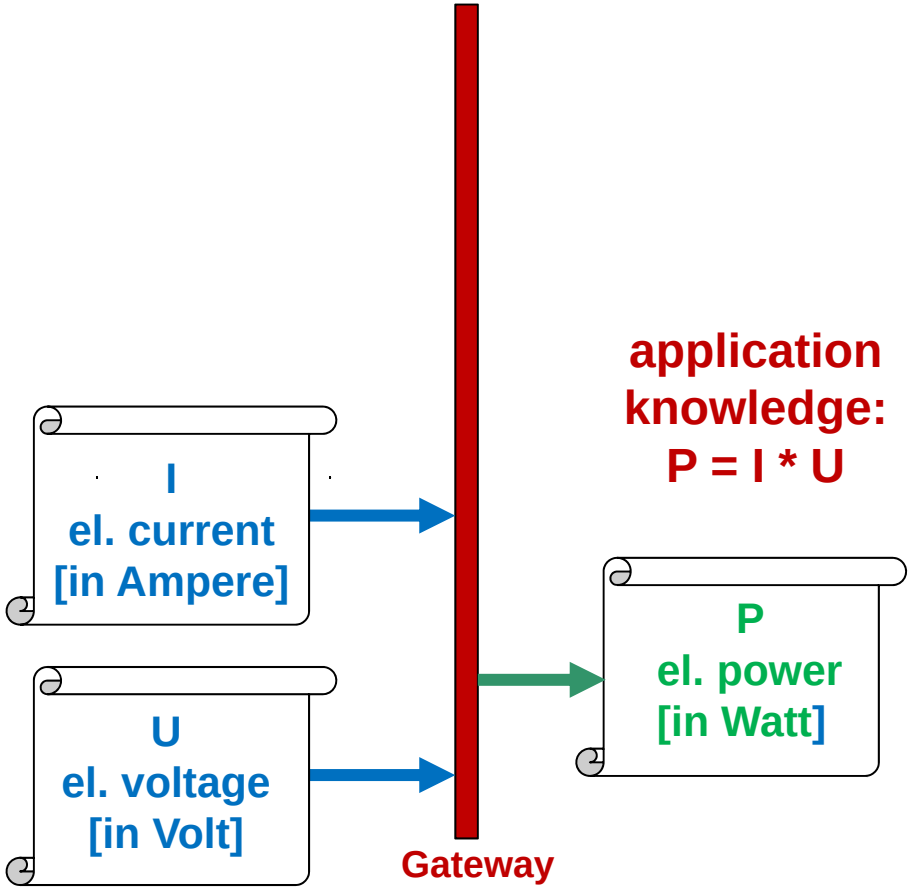
In the last example this precondition was fulfilled:
Same basic semantics (temperature) on both sides
→ transformation by a gateway is possible

Different Basic Semantics



In this example the precondition is NOT fulfilled:
Different basic semantics (current, power) on both sides
→ transformation by a gateway is impossible

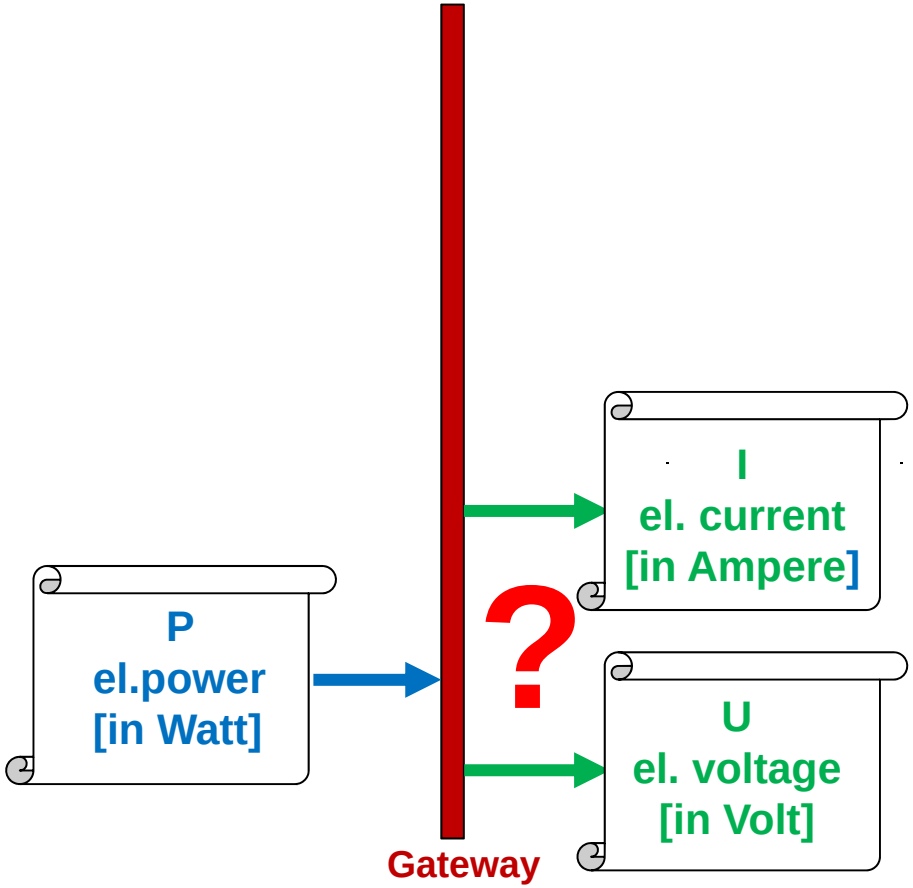
Different Basic Sem. – But Knowledge



In this example the precondition is NOT fulfilled:
Different basic semantics (current, power, voltage) on both sides
→ transformation by a gateway is impossible

→ But semantic transformation by „application background knowledge“ is possible

Different Basic Sem. & Insufficient Knowledge



In this example the precondition is NOT fulfilled:
Different basic semantics (current, power, voltage) on both sides
→ transformation by a gateway is impossible

→ missing „application background knowledge“ → semantic transformation is impossible

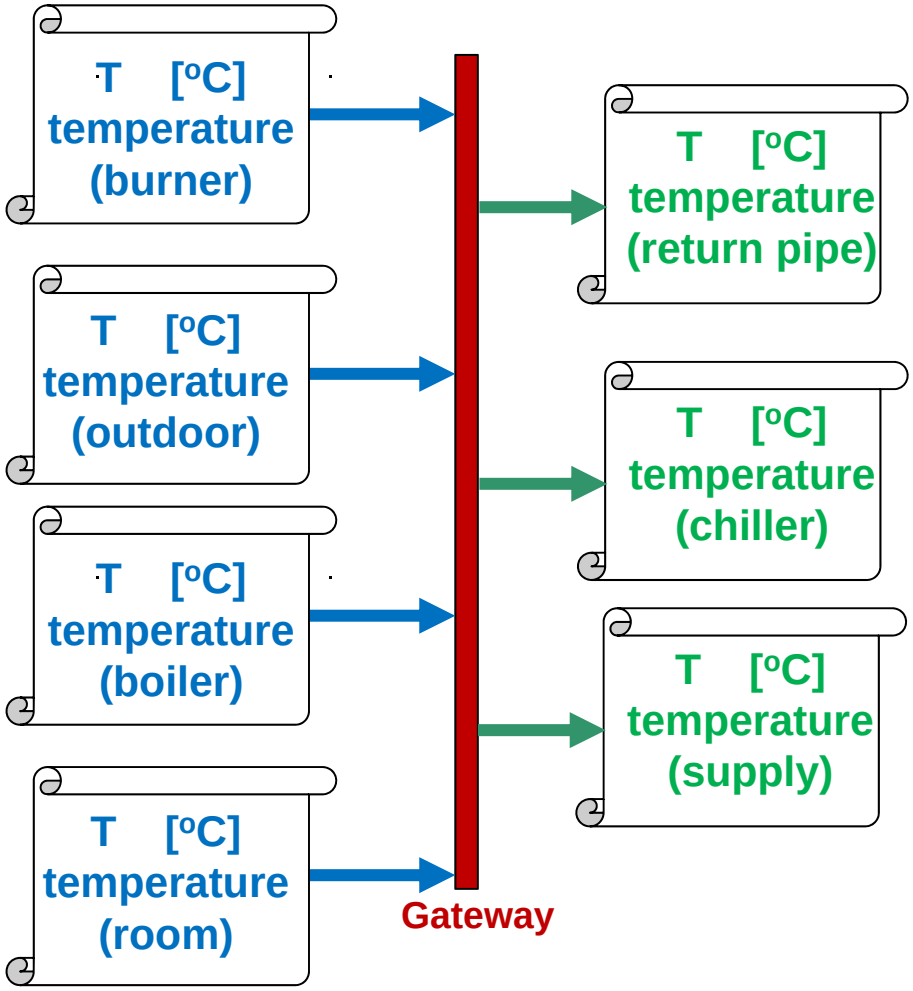
Preconditions - what must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
Dynamic Behavior					eq.
Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
Lay. 7 Data Structures			eq.		
Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

Guarantee by . . .

- Knowledge
- Information
- Design
- Data
- Trans-formation
- Signal
- Standar-disation

Same Basic Sem. – Different Application Sem.



All information of same basic semantics type (temperature [°C],
But coming from different locations → different application semantics
→ transformation by a gateway is impossible

Preconditions - what must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
Dynamic Behavior					eq.
Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
Lay. 7 Data Structures			eq.		
Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

Guarantee by . . .

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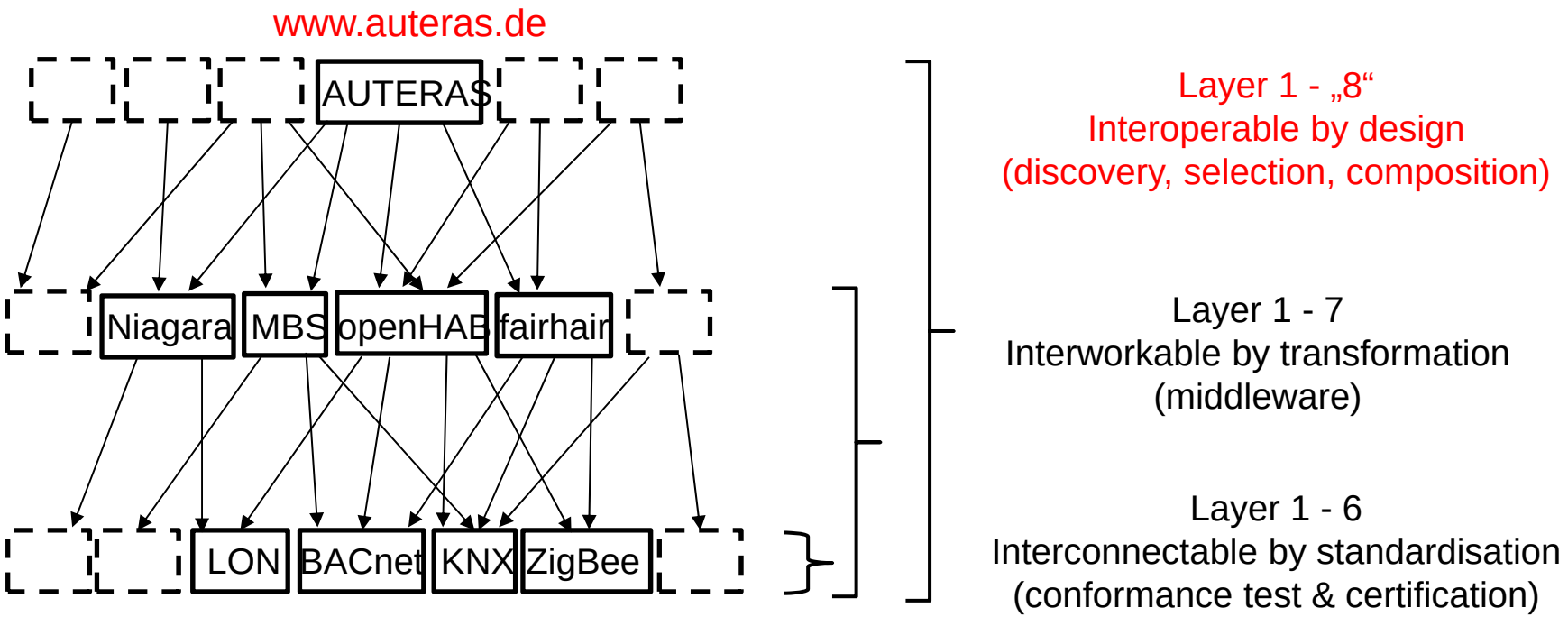
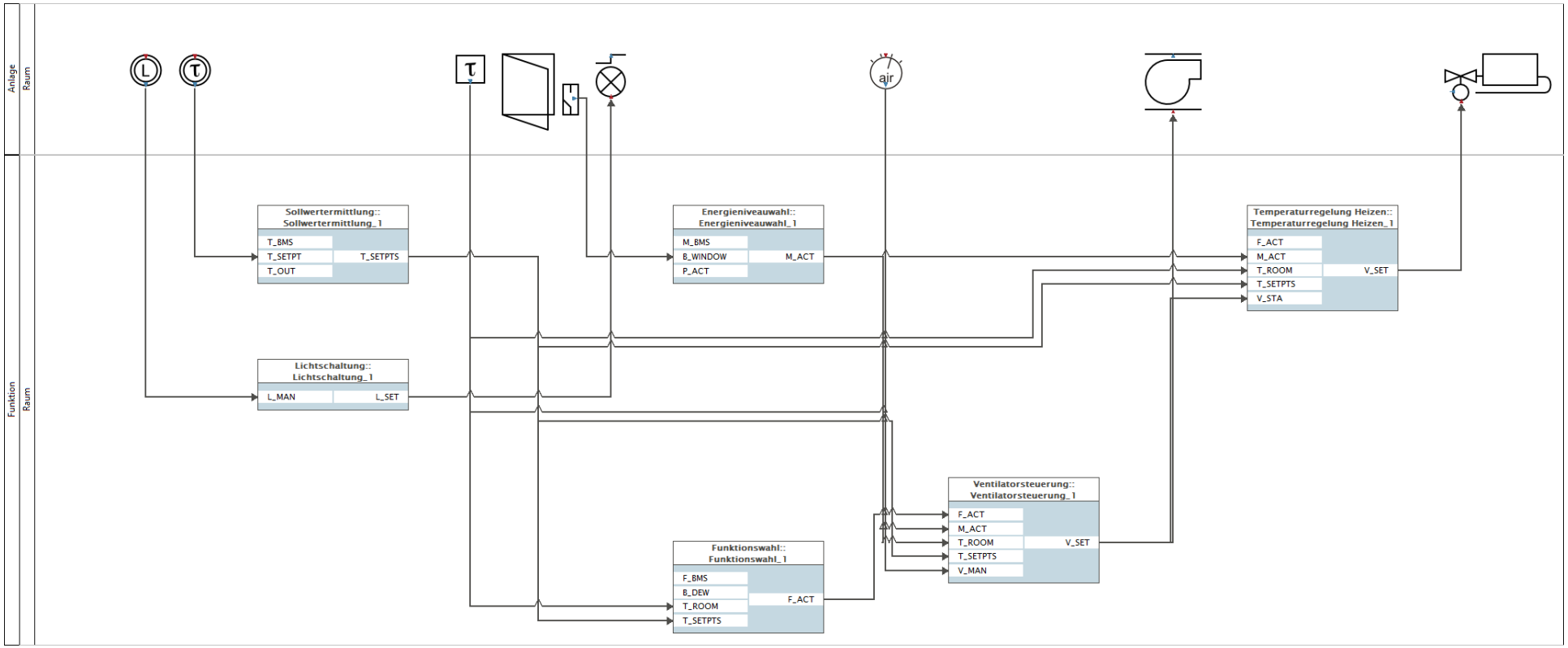
How to guarantee the preconditions?



Semantic Interoperability by Semantic Design

Semantic Design

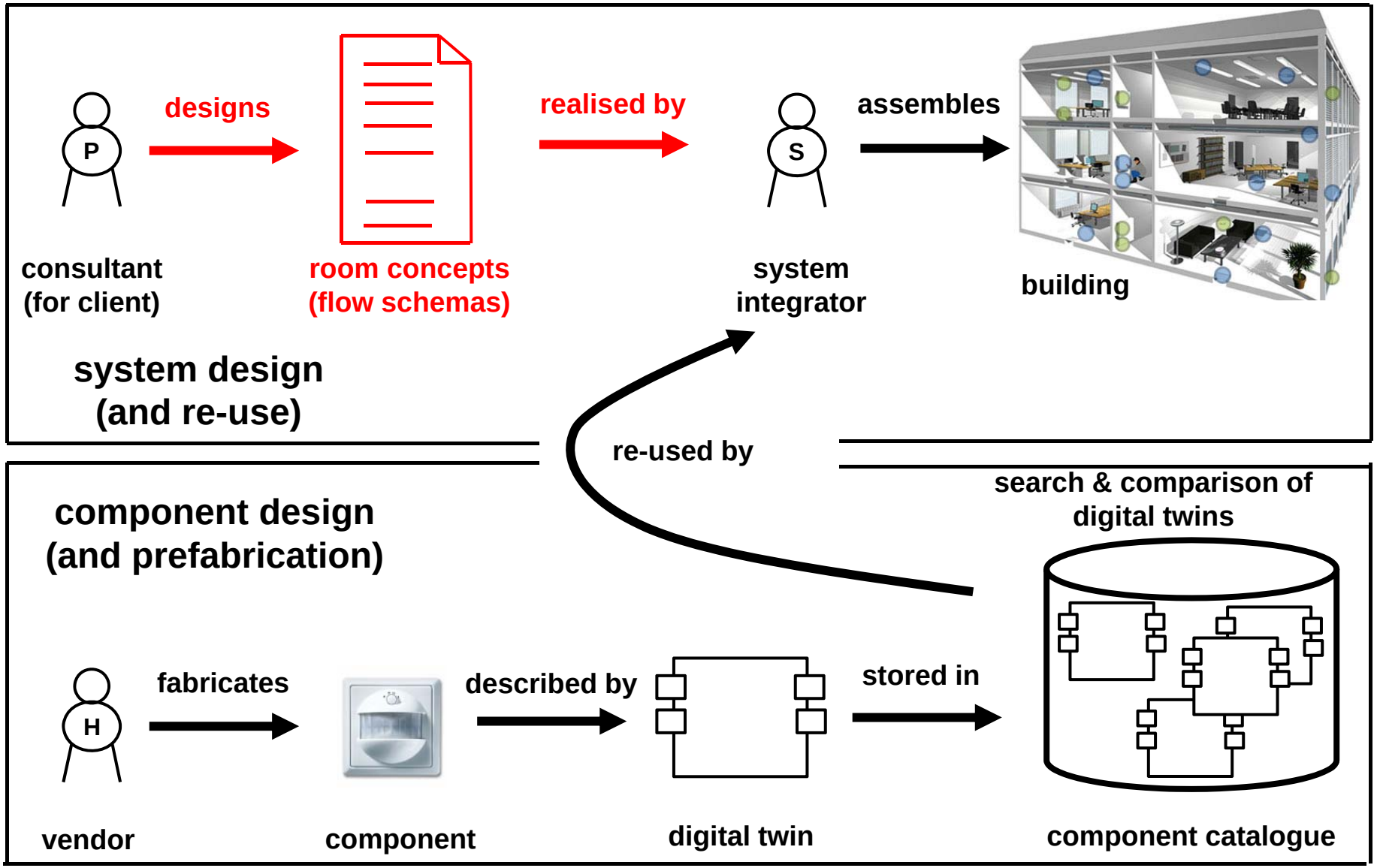


Design of abstract application concept → schema of semantic information flow

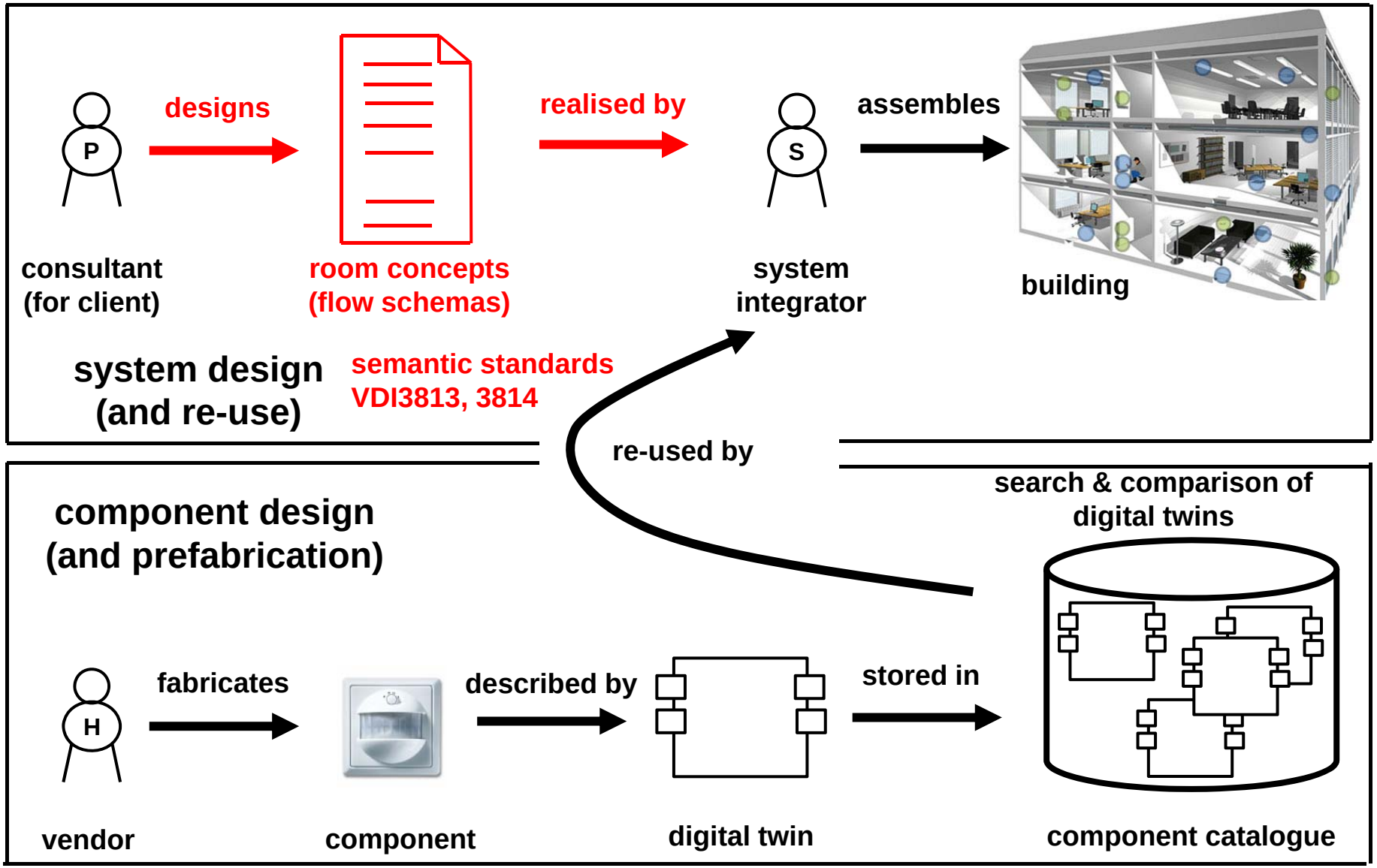
Abstract:

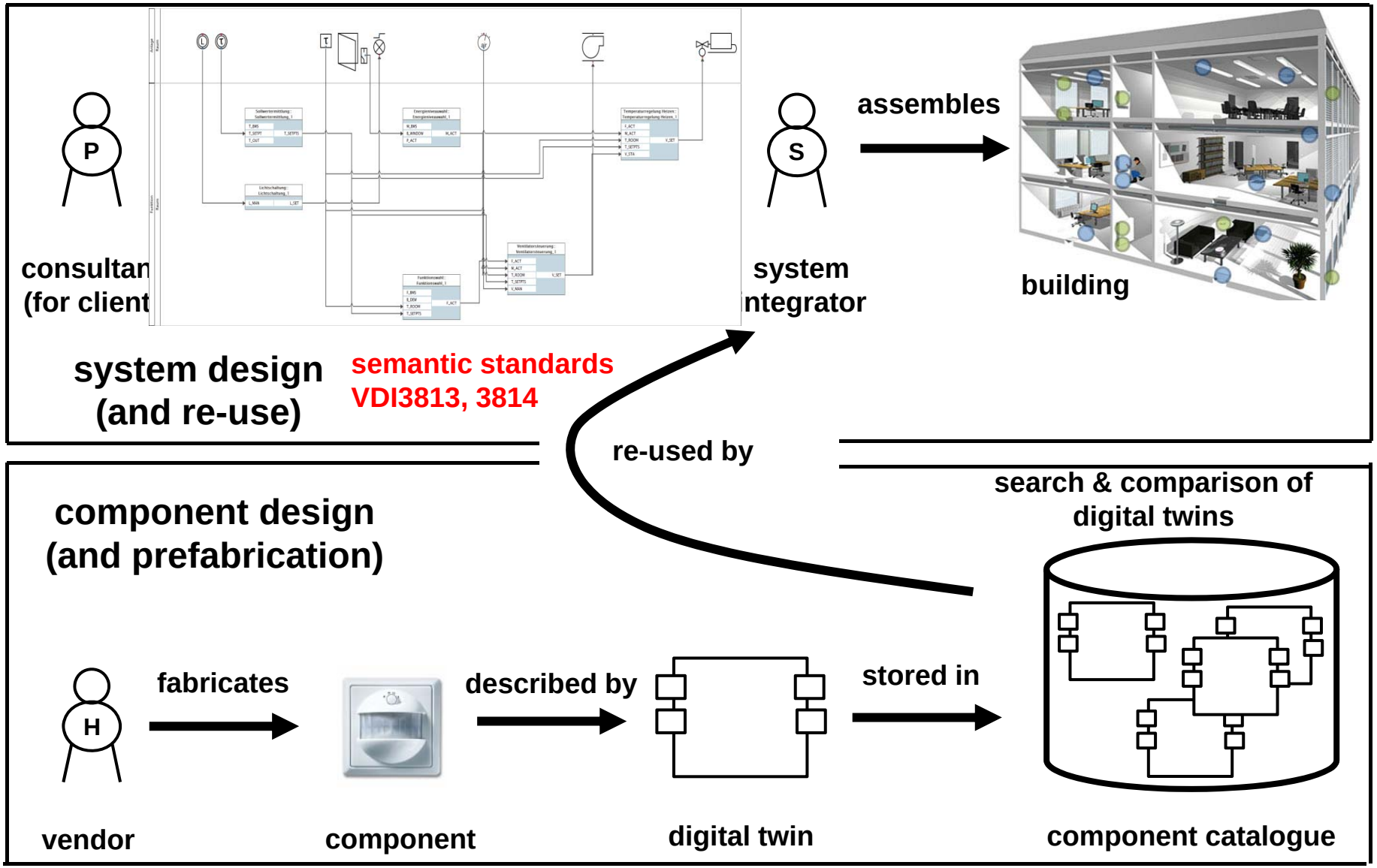
- Neglect implementation (HW, SW, data structures)
- Neglect deployment into components
- Neglect platforms (software, network protocols, interfaces)
- Neglect vendor dependency

Semantic Design

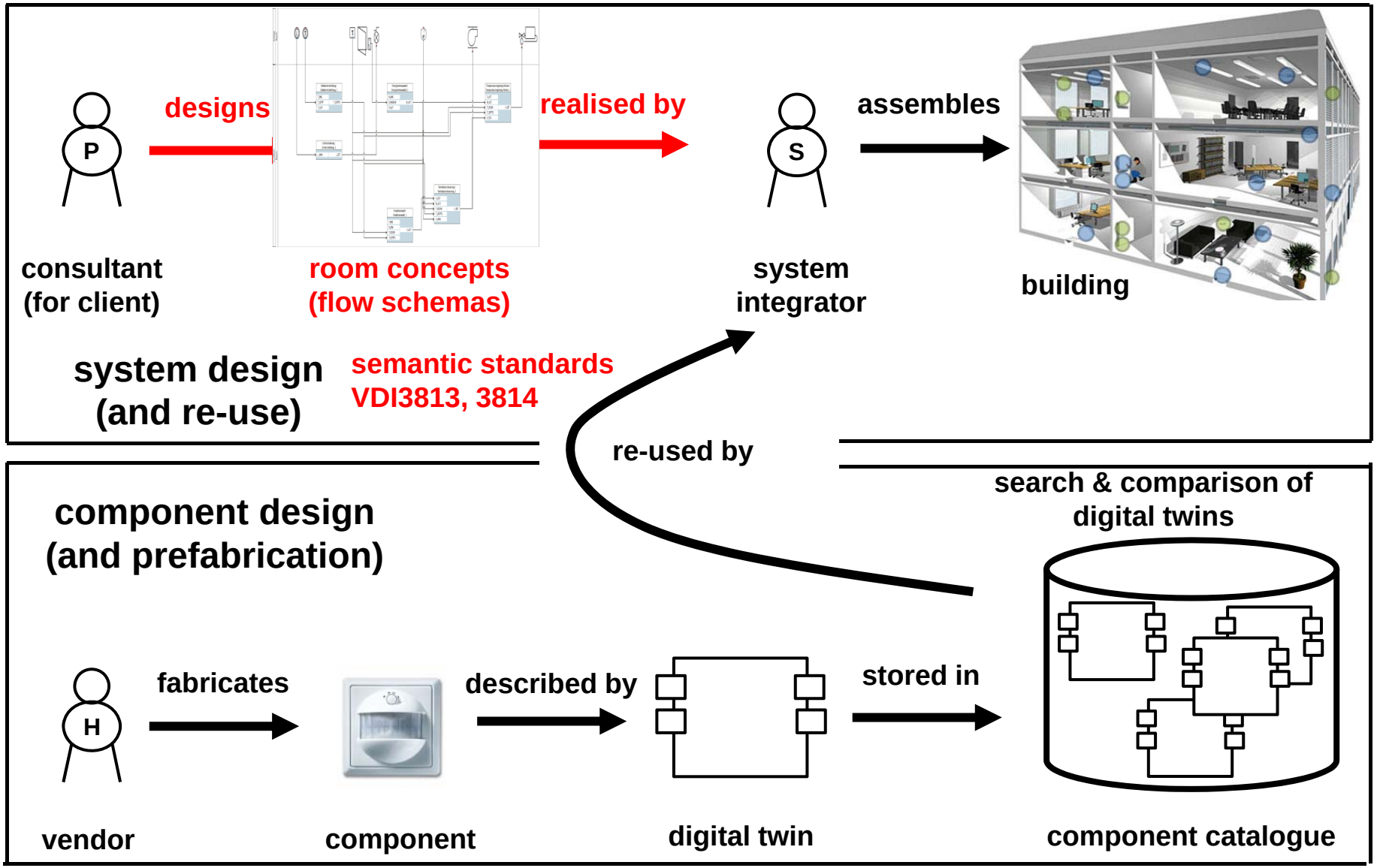


Semantic Design

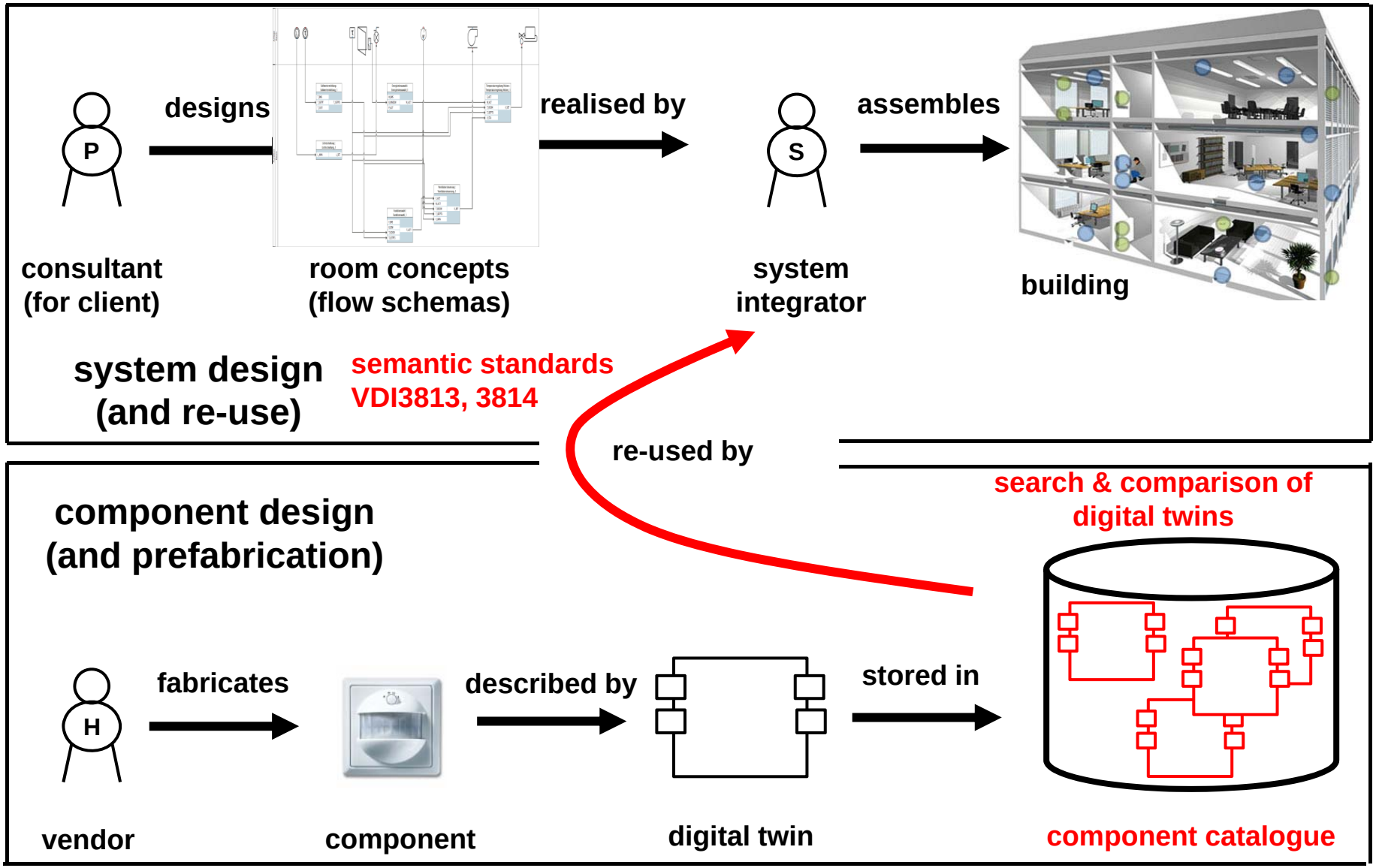



P
consultan
(for client
system design
(and re-use)
semantic standards
VDI3813, 3814
S
system
ntegrator
assembles
building
re-used by
component design
(and prefabrication)
search & comparison of
digital twins
H
fabricates
vendor
component
described by
digital twin
stored in
component catalogue

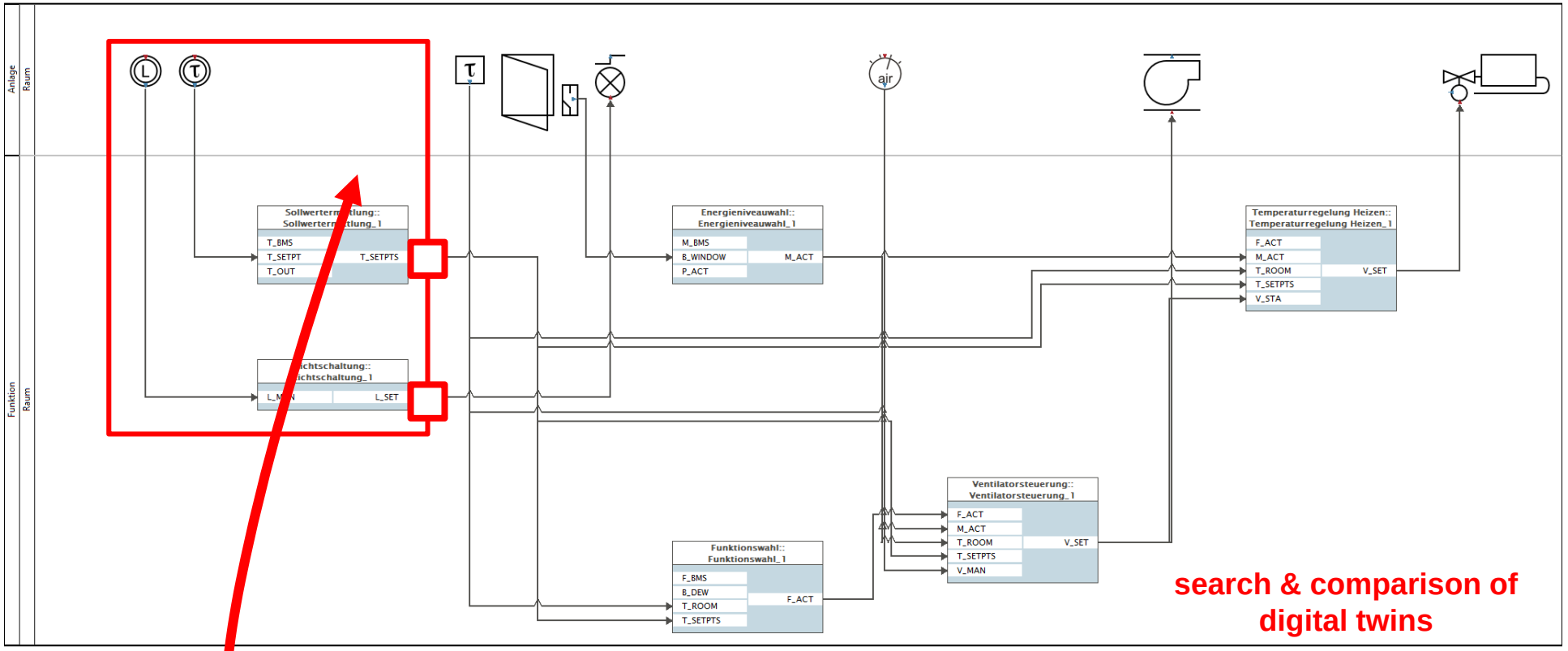
Semantic Design



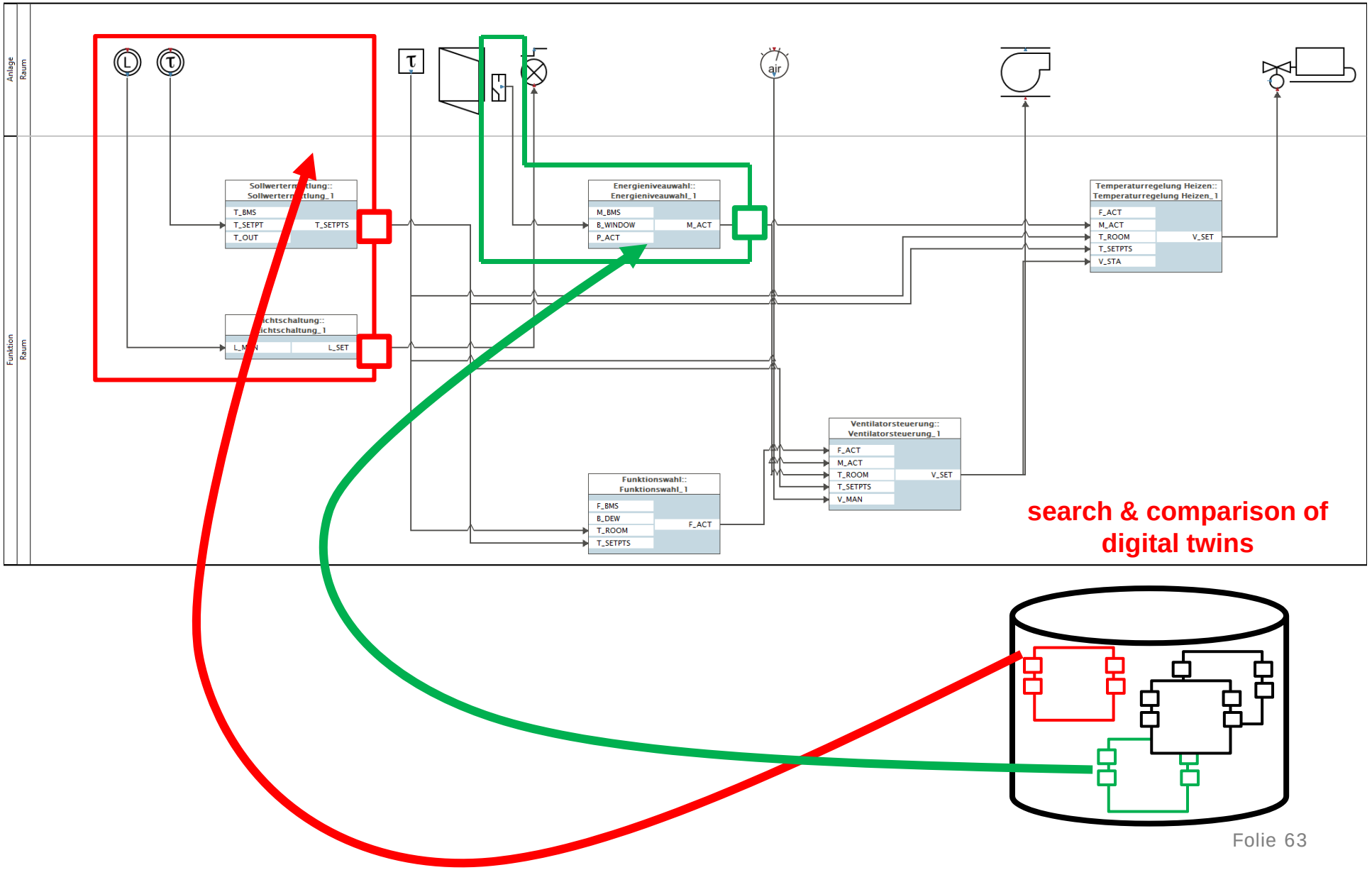
Semantic Puzzle



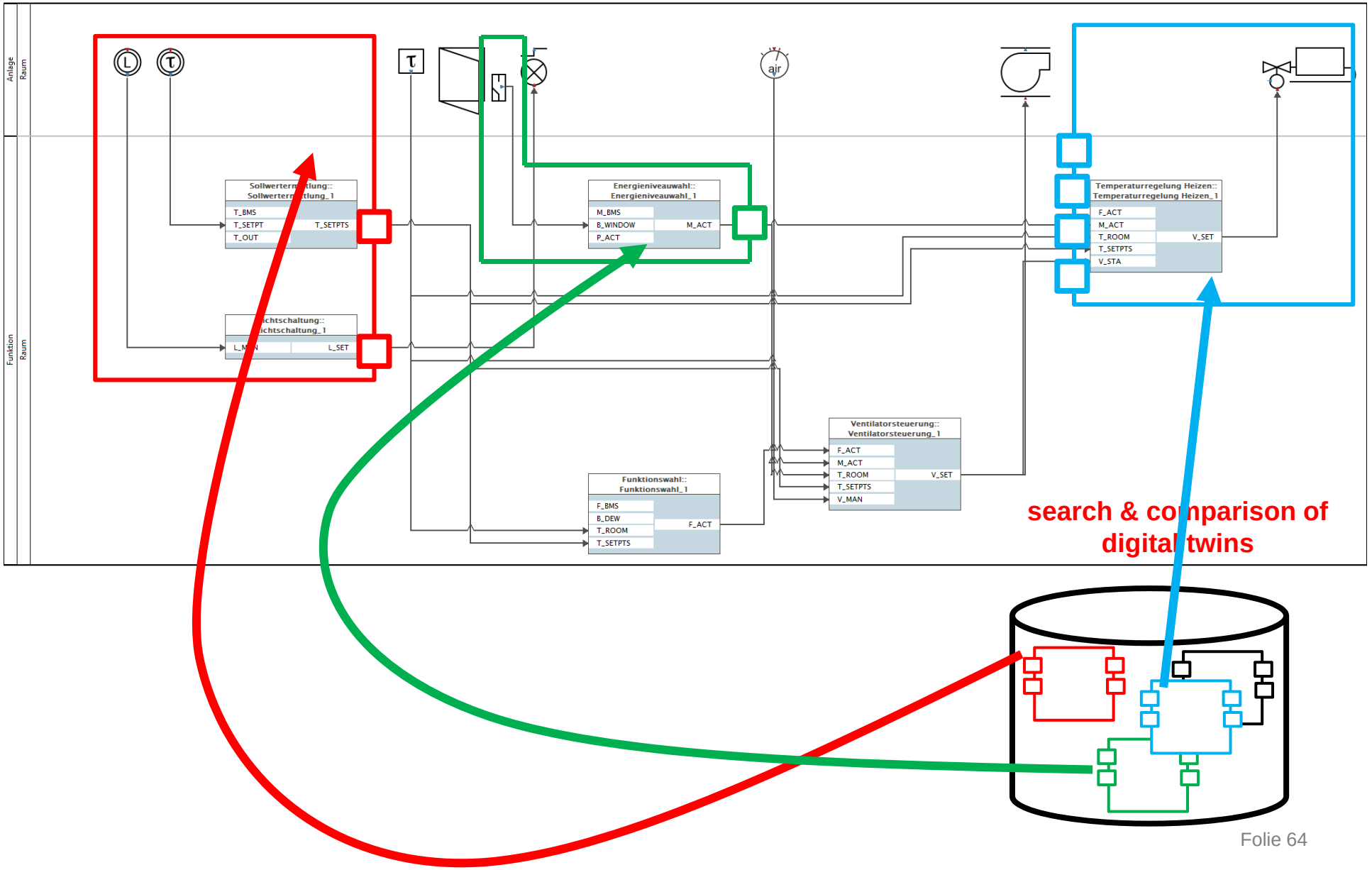
Semantic Puzzle



Semantic Puzzle



Semantic Puzzle



Semantic Puzzle

Search & comparison of digital twins in the catalogue:

→ It‘s like a puzzle !

→ Millions of combinations
(exponential complexity)

Semantic Puzzle

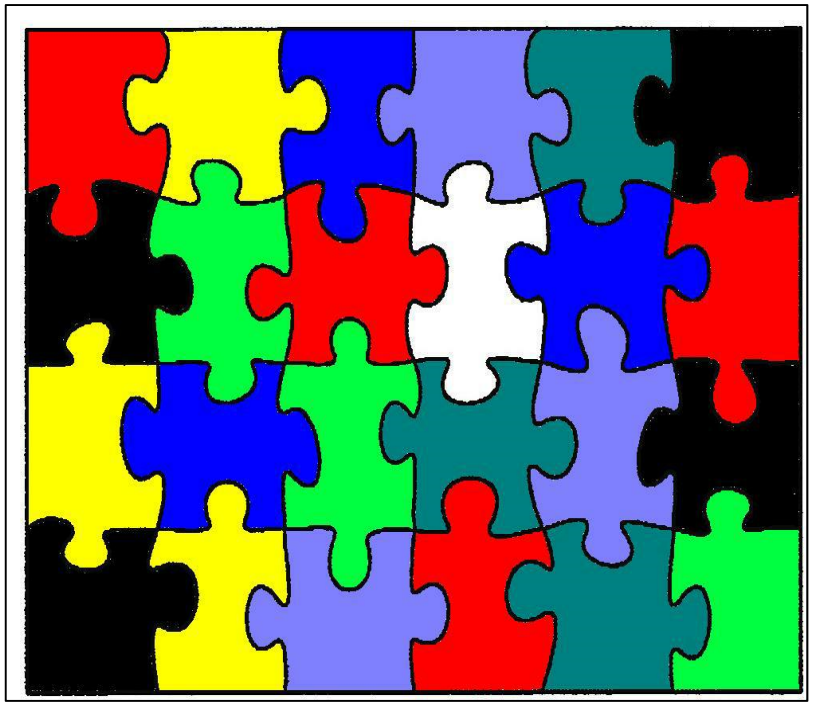
Search & comparison of digital twins in the catalogue:

→ It‘s like a puzzle !

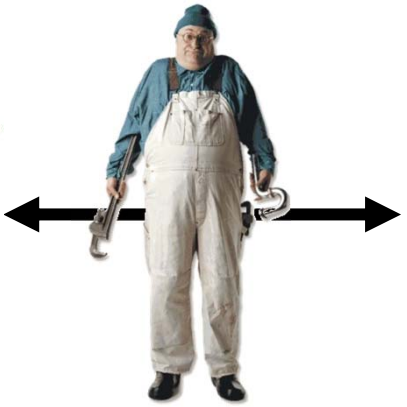
→ Millions of combinations (exponential complexity)

→ Needs long time to find a solution

→ Sometimes impossible to find a solution



Cost



Quality

Interoperable Re-Use without Semantic Puzzle ?

Unified Products

Yes, we can avoid semantic puzzle, if we use:

→ Only a few concepts

→ Unified products
(e.g. from one vendor only)

Yes, if we give up variety / diversity:

→ Only a few concepts sufficient?

→ One solution fits all clients?

Unified Products

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Yes, if we give up variety / diversity:

→ Only a few concepts sufficient?

→ One solution fits all clients?

magic conflict

Cost

Quality

Unified Products

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(e.g. from one vendor only)

Yes, if we give up variety / diversity:

→ Only a few concepts sufficient?

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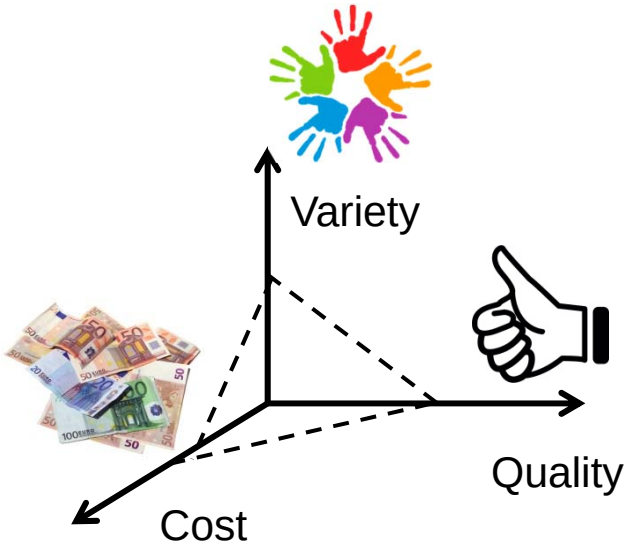

magic triangle

High variety: with puzzle

Low variety: without puzzle

Plug & Play ?

What must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
Dynamic Behavior					eq.
Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
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Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

Guarantee by . . .

- Knowledge
- Information
- Data
- Signal

- Commis-sioning
- Design
- Trans-formation
- Standar-disation

Dynamic behavior:

Parameters for signal filters, parameters for controller tuning, timeout constants, sampling rates etc.

- Depend on real process, plant, location, environment
- Defined during installation, commissioning, operation

→ Prefabrication is impossible

→ All parameters (dynamic behavior) get lost during maintenance (component change)

So far Plug & Play is impossible (a buzzword only) !

What must be equal?

	Com-patible	Inter-connect-able	Inter-work-able	Inter-oper-able	Inter-change-able
Dynamics Behavior					eq.
Lay. 8 Applic. Semantics				eq	
Lay. 7 Basic Semantics				eq.	
Lay. 7 Data Structures			eq.		
Layer 3 - 6		eq.			
Layer 1 - 2	eq.				

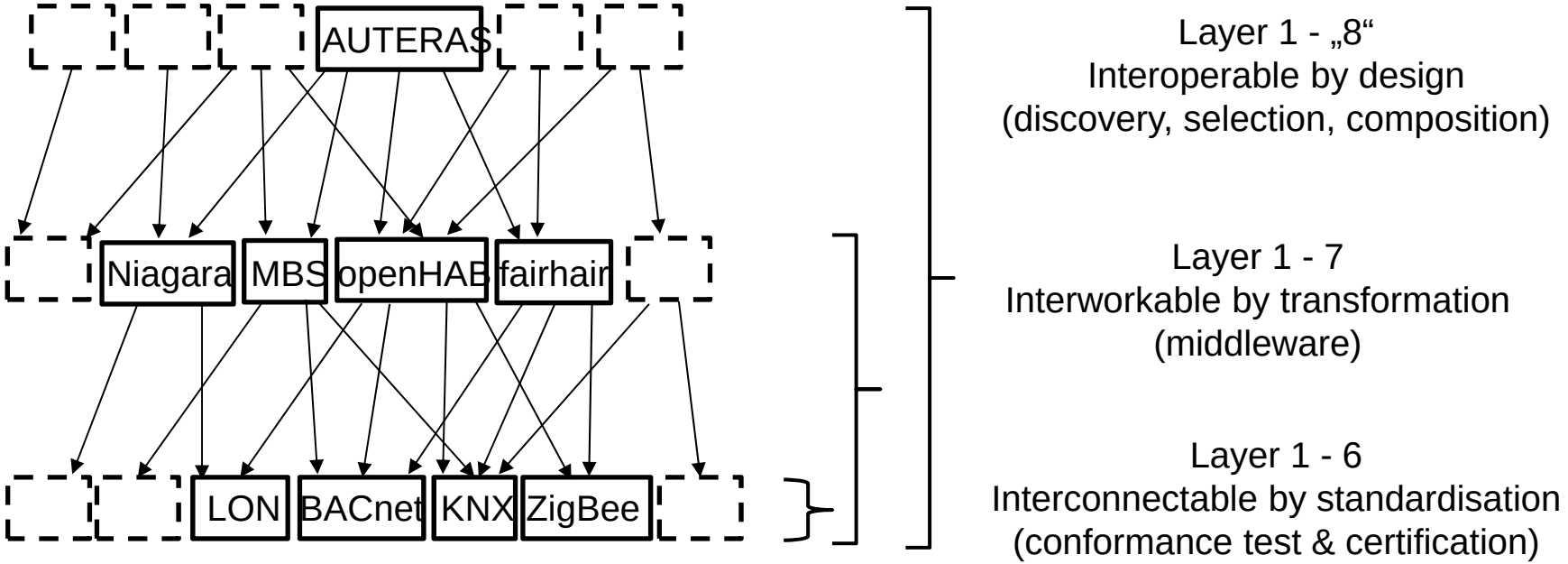
Guarantee by . . .

- Knowledge
  - Commis-sioning
  - Design
- Information
- Data
  - Trans-formation
- Signal
  - Standar-disation

Next Presentations Today

Schedule Today

Now and in the afternoon we have presentations as follows:



Schedule Today

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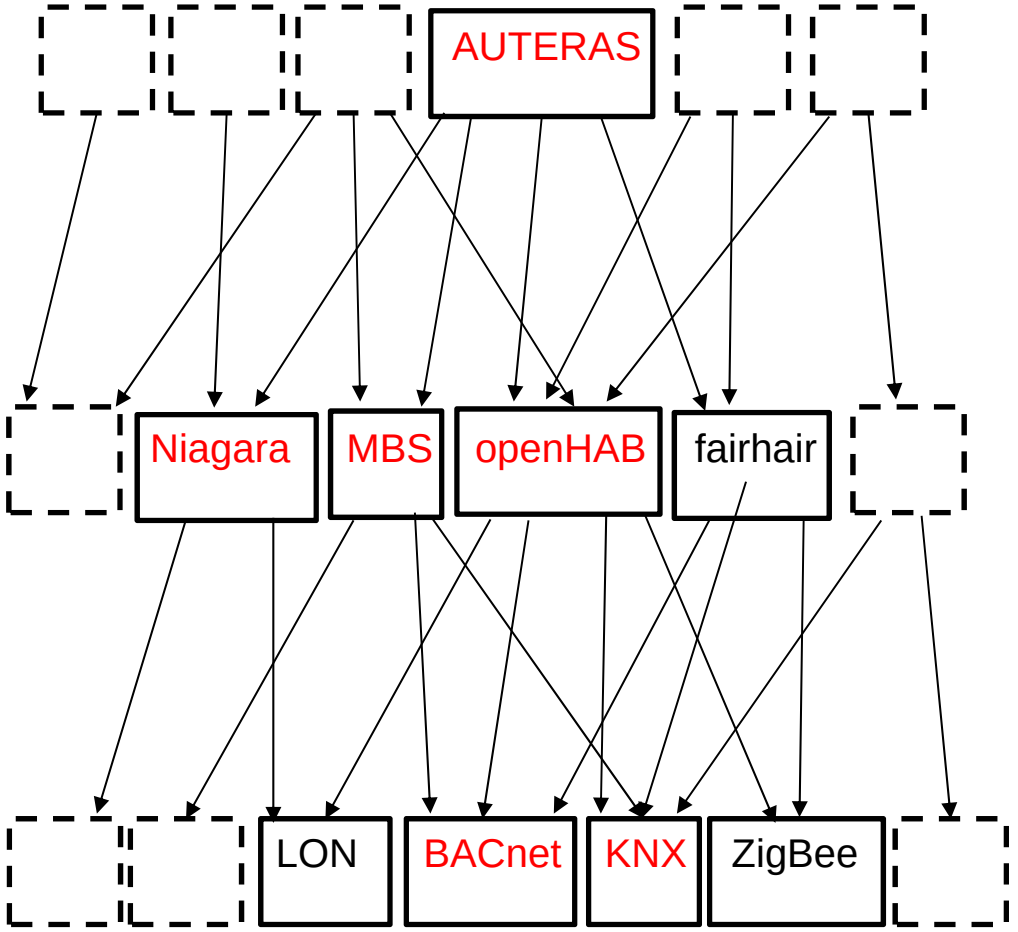


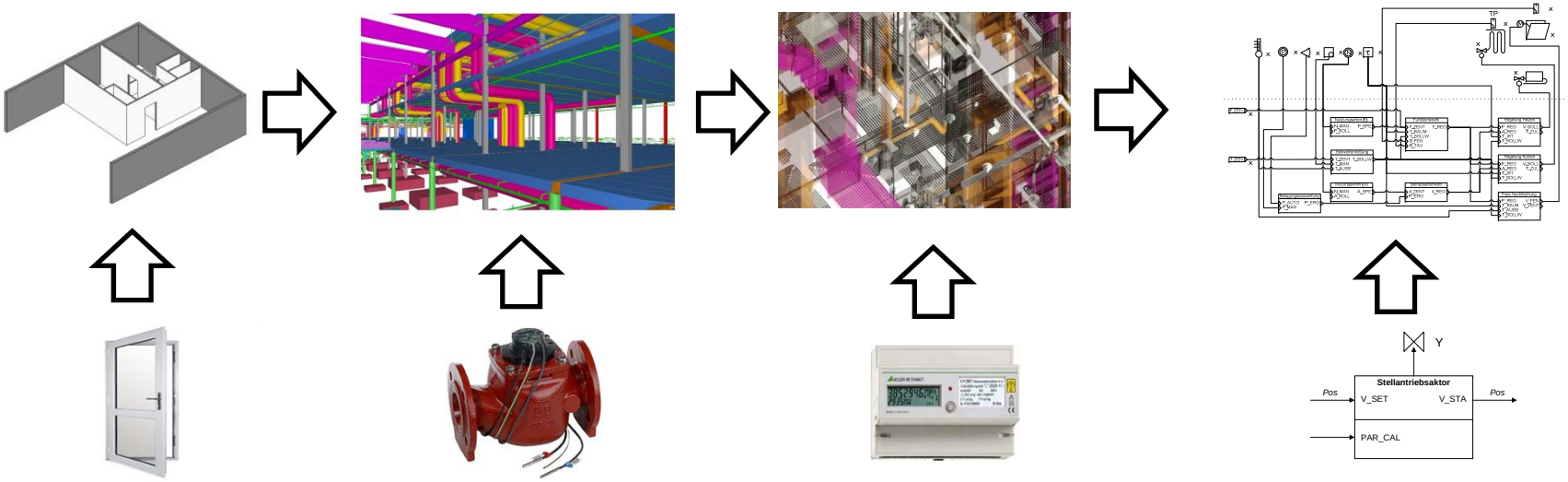
Layer 1 - „8“
Interoperable
by design
(discovery, selection,
composition)

Layer 1 - 7
Interworkable
by transformation
(middleware)

Layer 1 - 6
Interconnectable
by standardisation
(conformance test &
certification)

Collaboration Platform „DesignServiceFlow“ is open for all interested Partners:
http://serviceflow.ga-entwurf.de

Whole buildings and their digital twins (BIM / IFC)



Construction
IFC
ISO 16739

HVAC
VDI 3805
ISO 16757

Hardware
eCl@ss
IEC 61360 / ISO 13584

Software
VDI 3813/14/12
{ISO 16484}

Prefabricated components: from electronic catalogues

TECHNISCHE UNIVERSITÄT DRESDEN

Questions ?

E-Mail: Klaus.Kabitzsch@tu-dresden.de
www: http://tud.de/inf/tis

Collaboration Platform:
http://serviceflow.ga-entwurf.de

Tool: www.AUTERAS.de