



Institut Mines-Télécom

SAREF4SYST

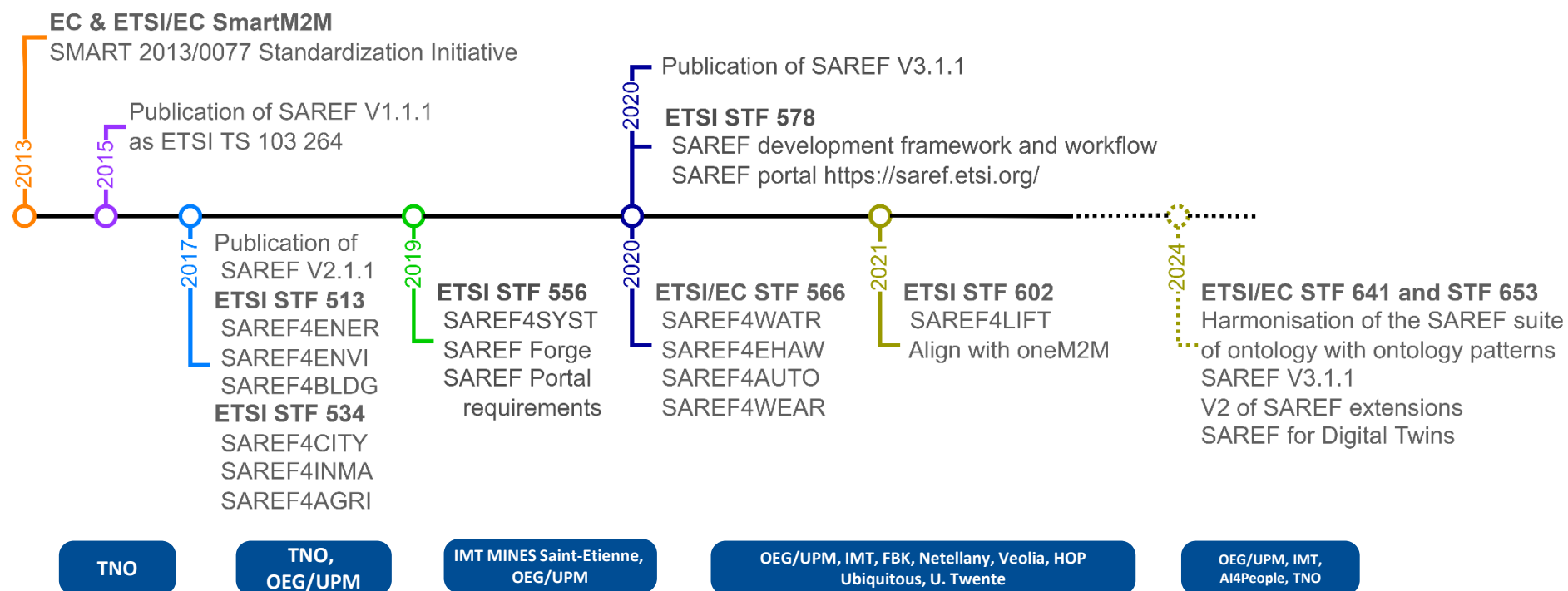
a SAREF Reference Ontology Pattern for Representing Systems and their Interconnections

Maxime Lefrançois

<http://maxime-lefrancois.info/>

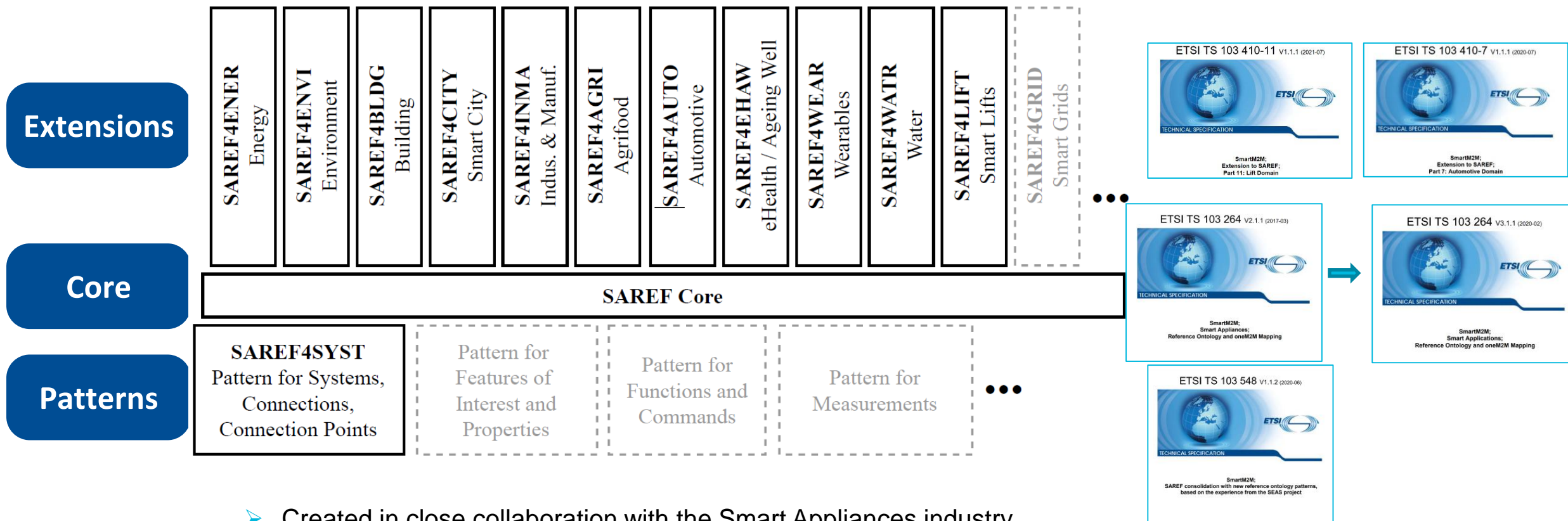
IMT – MINES Saint-Étienne – Institut Henri Fayol –
LIMOS UMR 6158

Smart Applications REference ontology (SAREF).



- Created in close collaboration with the Smart Appliances industry,
- Funded by EC and ETSI task forces, governed by SmartM2M

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- Created in close collaboration with the Smart Appliances industry,
- Funded by EC and ETSI task forces, governed by SmartM2M
- A set of versioned ontologies, published in ETSI Technical Specification documents
- Documentation published at <https://saref.etsi.org/>
- Development framework and workflow specified in ETSI TS 103 673

Daniele, L., den Hartog, F., & Roes, J. (2015). Created in close interaction with the industry: the smart appliances reference (SAREF) ontology. In *Formal Ontologies Meet Industry: 7th International Workshop, FOMI 2015, Berlin, Germany, August 5, 2015, Proceedings 7* (pp. 100-112). Springer International Publishing.

García-Castro, R., Lefrançois, M., Poveda-Villalón, M., & Daniele, L. (2023). The ETSI SAREF ontology for smart applications: a long path of development and evolution. *Energy Smart Appliances: Applications, Methodologies, and Challenges*, 183-215.

TR 103 549: Guidelines for consolidating SAREF with new reference ontology patterns -> TS 103 548: SAREF reference ontology patterns

ETSI TR 103 549 V1.1.1 (2019-07)



SmartM2M;
Guidelines for consolidating SAREF with
new reference ontology patterns,
based on the experience from the ITEA SEAS project

- Analysis of the modularization and factorization potential of SAREF
- Suggested SAREF reference ontology patterns (features of interest and properties, functions and commands, etc.)
- Issues in SAREF Core V2.1.1

ETSI TS 103 548 V1.1.2 (2020-06)

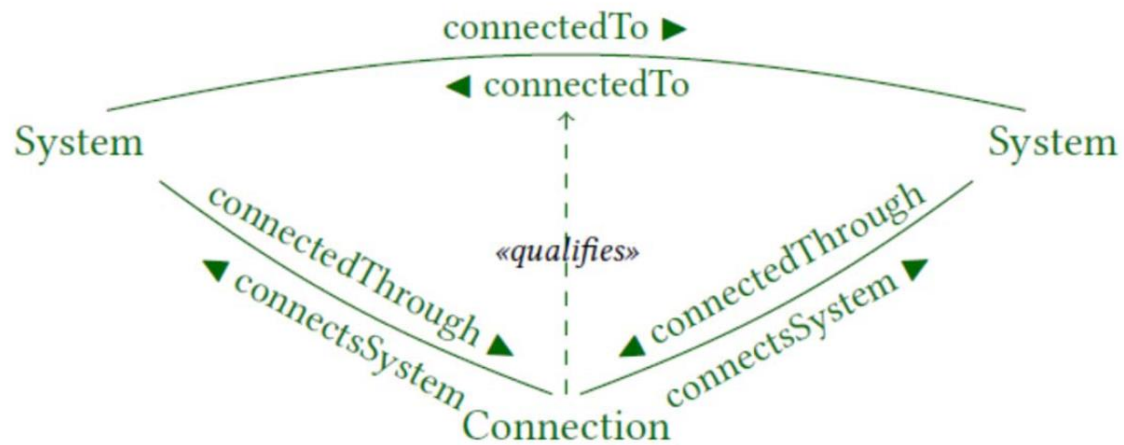


SmartM2M;
SAREF consolidation with new reference ontology patterns,
based on the experience from the SEAS project

- One first pattern: SAREF4SYST
- (and major revision V3.1.1 of SAREF Core)
- (and dev framework and workflow presented Wed.)

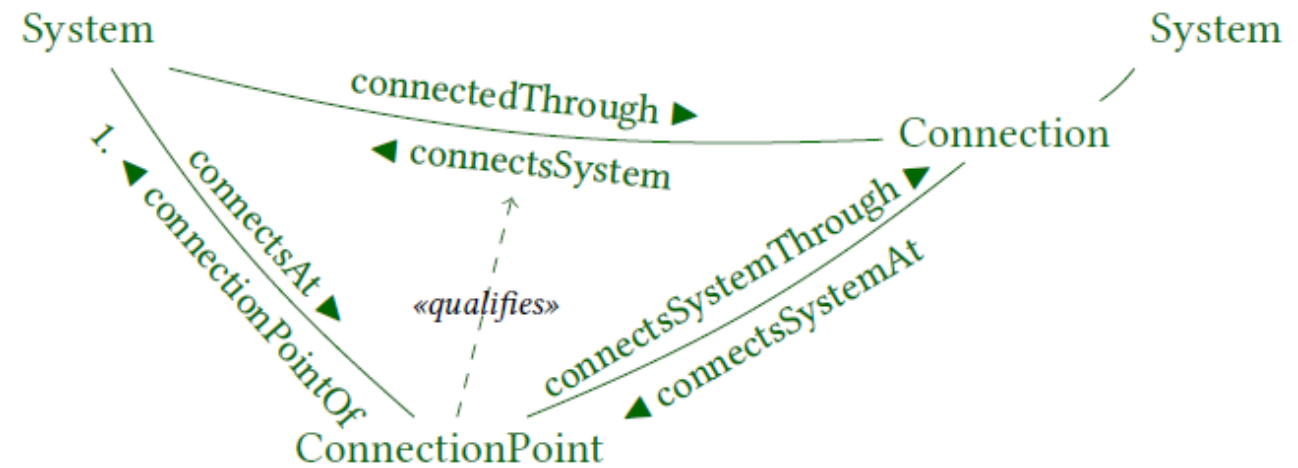
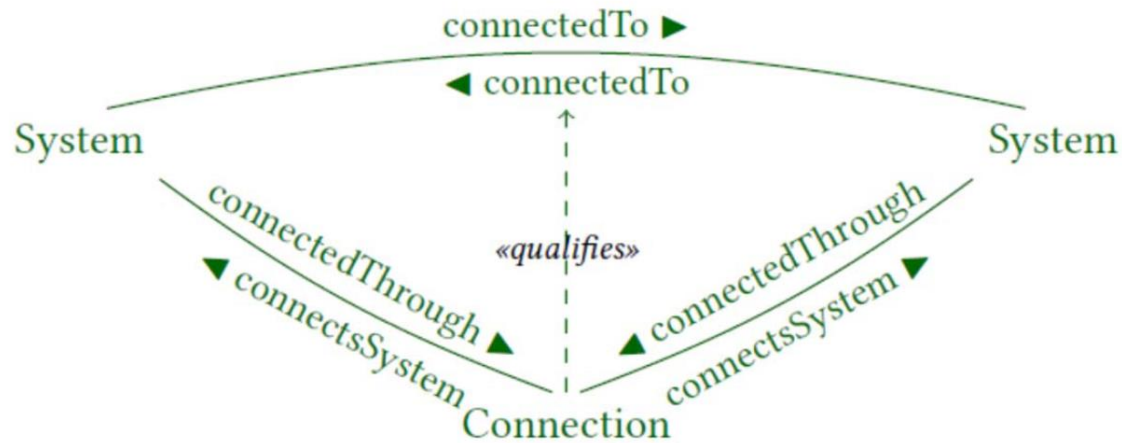
SAREF4SYST: Systems, connections, connection points

Published as the **SAREF4SYST** ontology pattern
Pattern for Systems,
Connections of systems,



SAREF4SYST: Systems, connections, connection points

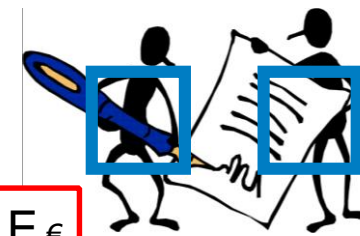
Published as the **SAREF4SYST** ontology pattern
Pattern for Systems,
Connections of systems,
and Connection Points of these systems at which they connect



SAREF4SYST: Systems, connections, connection points

Qualify **systems**

- ✓ The environment in a specific place
- ✓ A building, a room
- ✓ An appliance
- ✓ A set of appliances
- ✓ A business partner



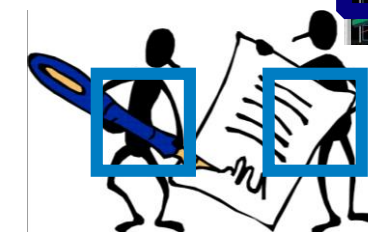
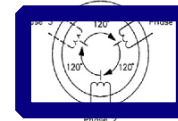
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Qualify their **connection points**

- ✓ Wall, window, ceiling
- ✓ Plug, Socket
- ✓ Offer, demand



SAREF4SYST: Systems, connections, connection points

Qualify **systems**

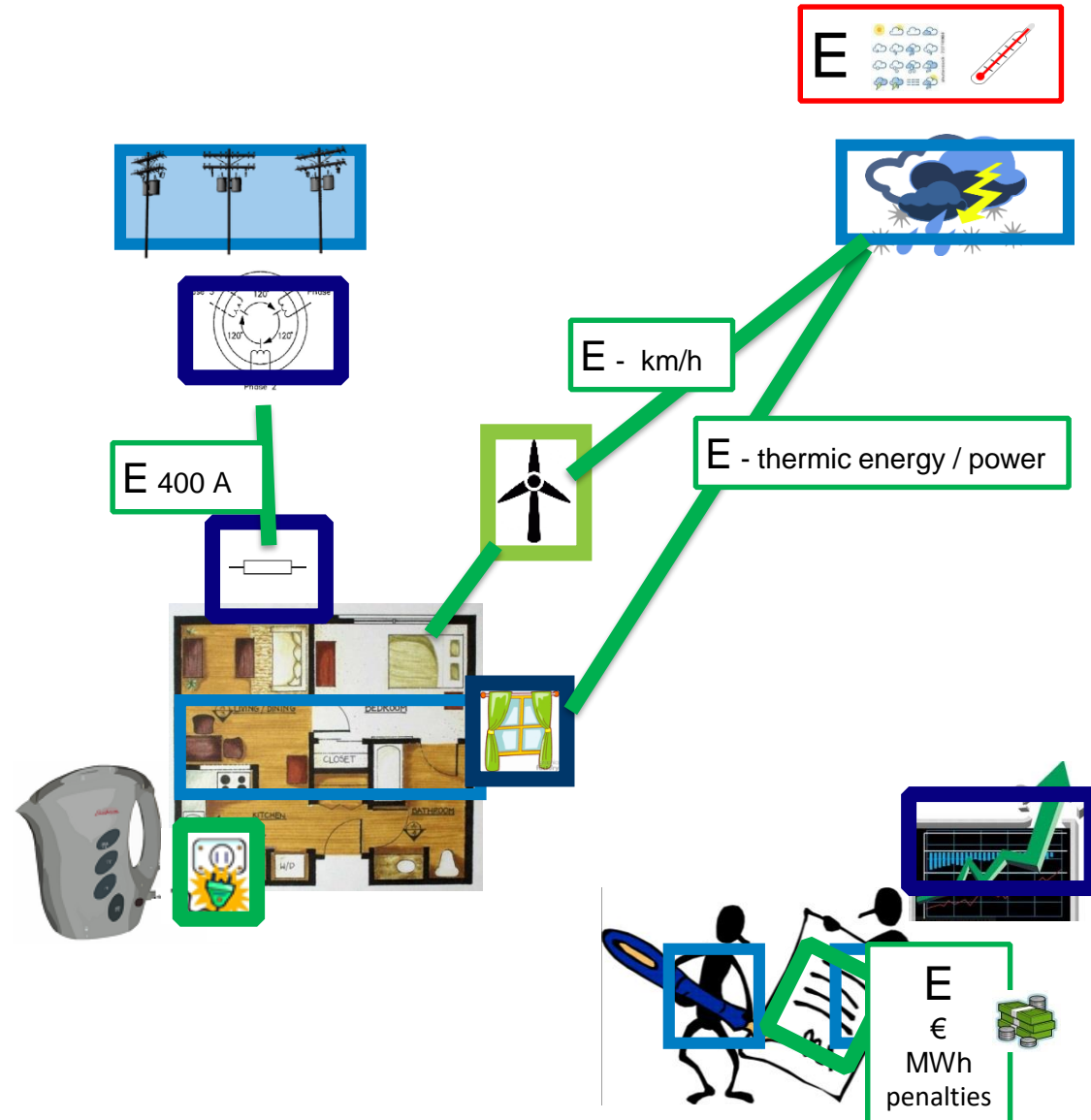
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Qualify their **connection points**

- ✓ Wall, window, ceiling
- ✓ Plug, Socket
- ✓ Offer, demand

Qualify the **connections** between these systems (flows)

- ✓ Electric energy flows
- ✓ Water volume/ thermic energy / light flows



Use case: Smart Energy

A specific system

A specific type of connection

- Electric power systems can exchange electricity with other electric power systems.
The electric energy can flow both ways in some cases (from the Public Grid to a Prosumer), or in only one way (from the Public Grid to a Load).
- Electric power systems can be made up of different sub-systems.
- Generic sub-types of electric power systems include producers, consumers, storage systems, transmission systems.
- The properties that are relevant for these systems include power production, consumption, energy stored.
- These properties may be measured or acted on by IoT devices.

Use case: Smart Energy

A specific system

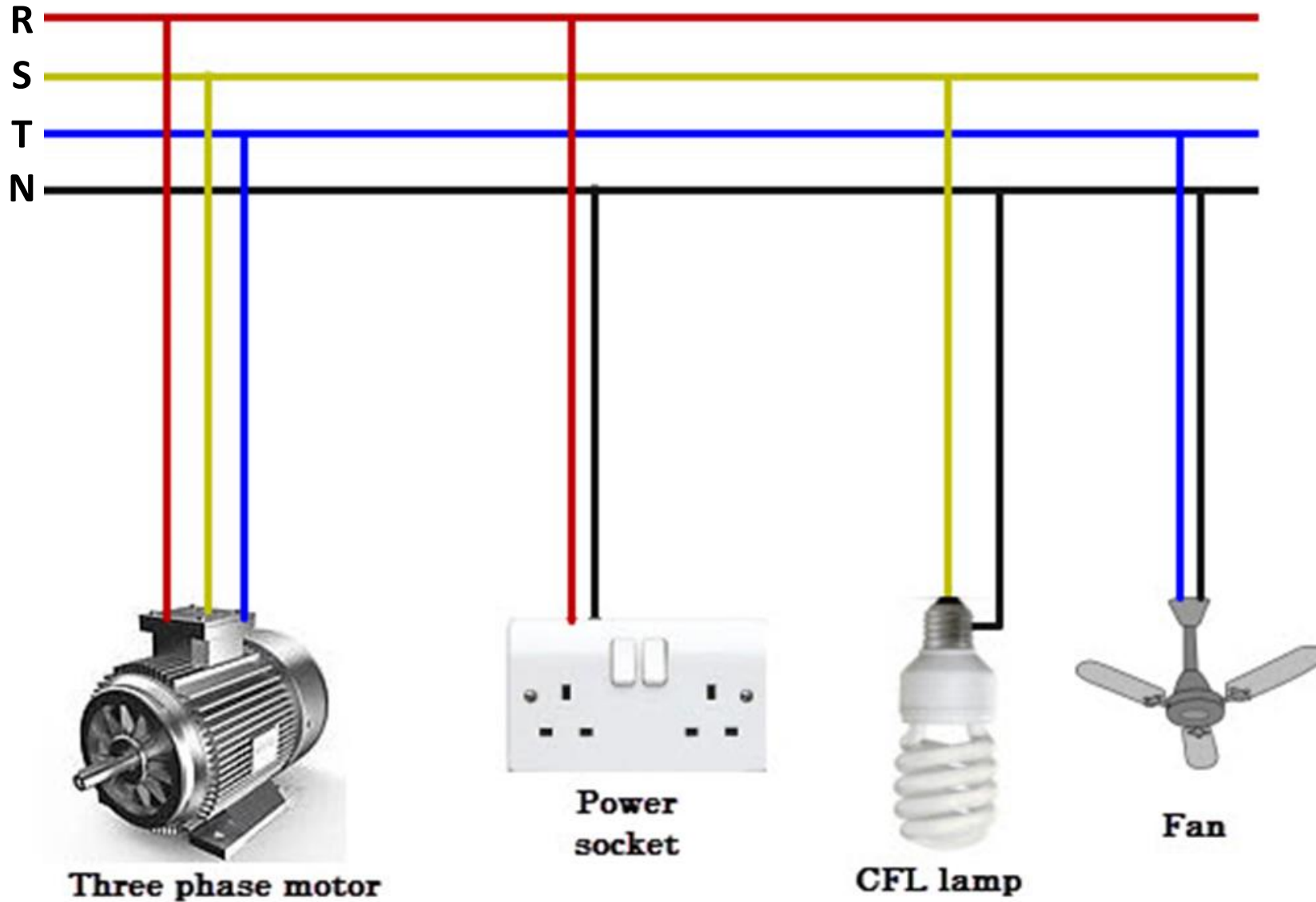
A specific type of connection point

- Electric power systems may be connected one to another through electrical connection points.
- An Electric power system may have multiple connection points (Multiple Winding Transformer generally have one single primary winding with two or more secondary windings).
- Generic sub-types of electrical connection points include plugs, sockets, direct-current, single-phase, three-phase connection points.
- The properties that are relevant for these connection points include voltage, resistance, conductance, reactance, susceptance, and can be measured between two wires of the connection points.

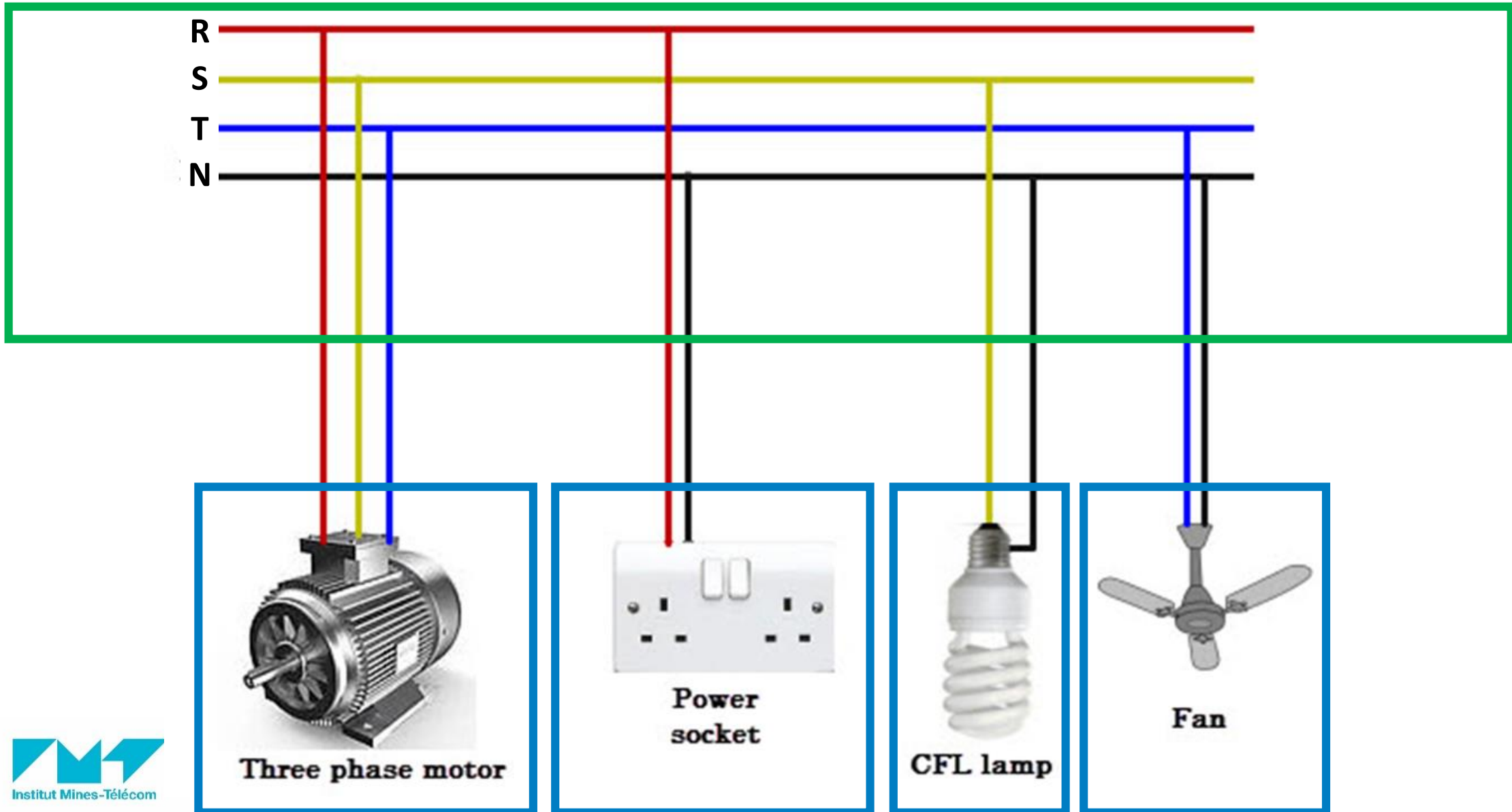
Use case: Smart Energy

- An Electrical connection may exist between two Electric power systems at two of their respective connection points.
- Generic sub-types of electrical connections include Single-phase Buses, Three-phase Buses.
- A single-phase electric power system can be connected using different configurations at a three-phase bus (RN, SN, TN types).
- The properties that are relevant for a three-phase electric bus include voltage between the different wires R, S, T, N (R-to-N, S-to-N, R-to-S, etc.).
- IoT devices can be used to measure and control this voltage at different points of the grid.

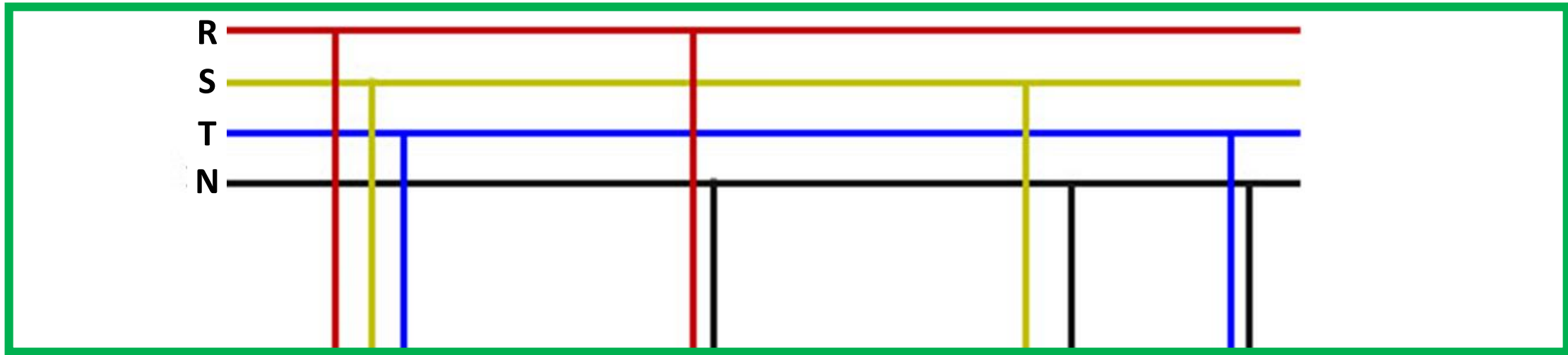
Use case: Three-phase power grid



ThreePhasePowerBus



ThreePhasePowerBus

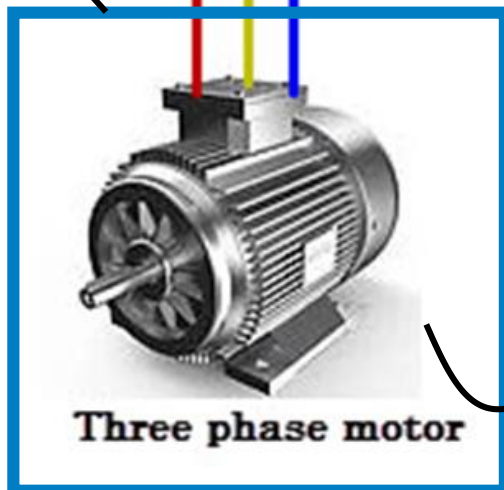


connectedInTriangleThrough
≡ connectsSystem

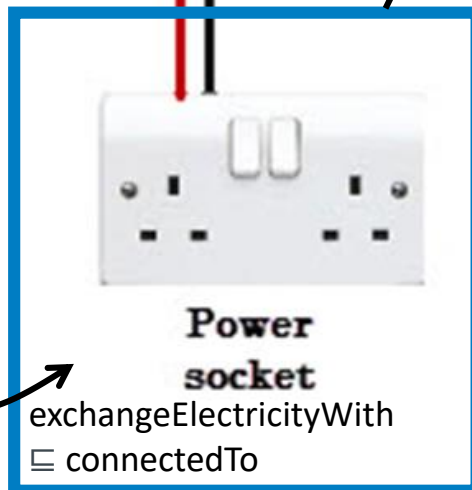
connectedInRNThrough
≡ connectsSystem

connectedInTNThrough
≡ connectsSystem

Motor



Three phase motor



Power socket

exchangeElectricityWith
≡ connectedTo



CFL lamp



Fan

ThreePhasePowerBus

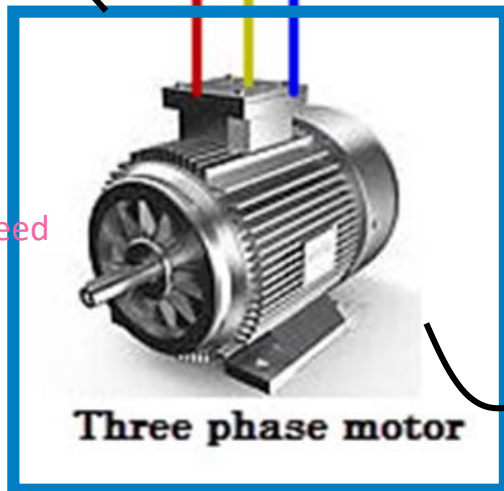


connectedInTriangleThrough
 ≡ connectsSystem

connectedInRNTThrough
 ≡ connectsSystem

Motor

power
 rotationSpeed
 torque
 on/off

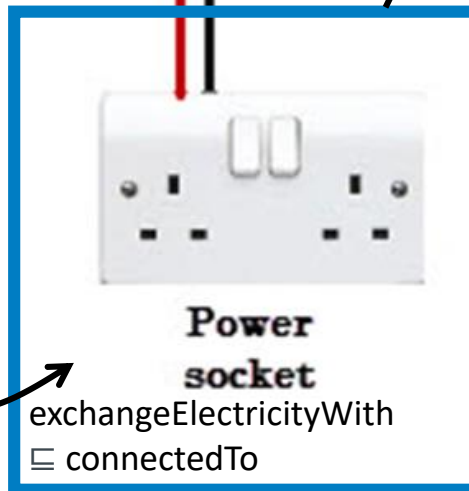


PowerSocket

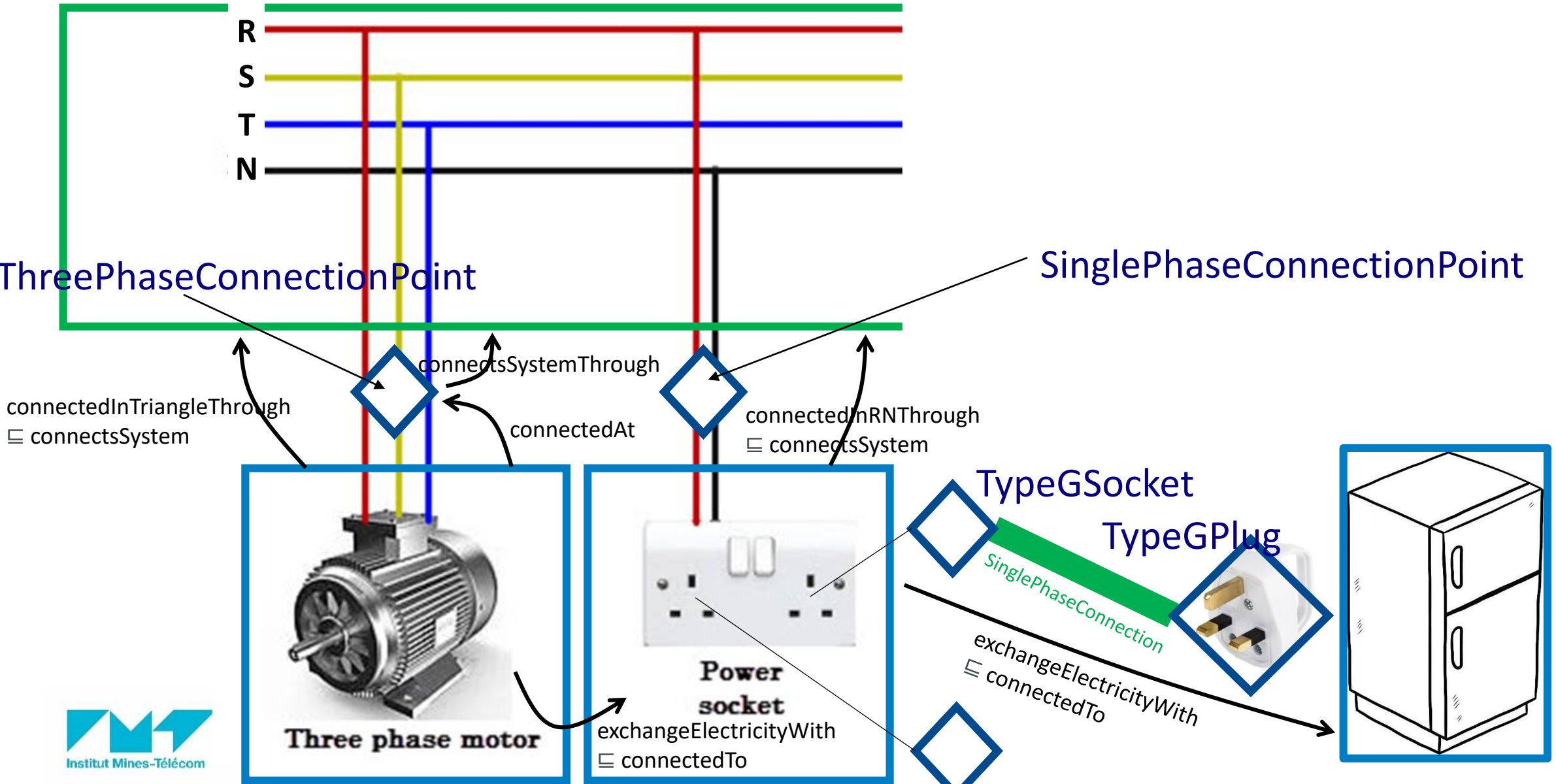
voltage?*

current?*

*NO



ThreePhasePowerBus



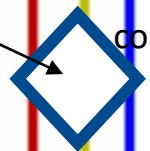
ThreePhasePowerBus

RNVoltage
SNVoltage
TNVoltage
RSVoltage
STVoltage
TRVoltage



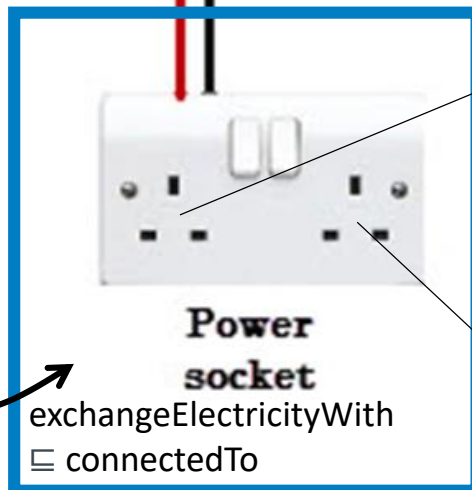
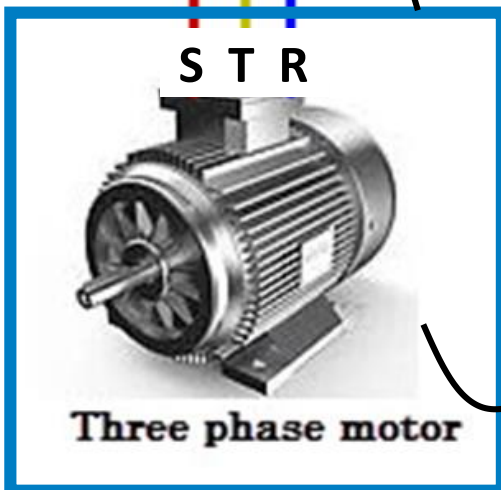
ThreePhaseConnectionPoint

RNVoltage
SNVoltage
TNVoltage
RSVoltage
STVoltage
TRVoltage
rCurrent
sCurrent
tCurrent
RSResistance
STesistance
TNResistance
...



connectsSystemThrough

connectedAt



exchangeElectricityWith

connectedTo

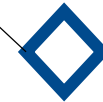
SinglePhaseConnectionPoint

phaseWireCurrent
(convention: >0 if it enters the system)
neutralWireCurrent
(convention: <0 if it leaves the system)
phaseToNeutralVoltage
phaseToNeutralResistance
...



TypeGSocket

phaseWireCurrent
(convention: >0 if it enters the system)
neutralWireCurrent
(convention: <0 if it leaves the system)
phaseToNeutralVoltage



TypeGSocket

phaseWireCurrent
(convention: >0 if it enters the system)
neutralWireCurrent

ThreePhasePowerBus

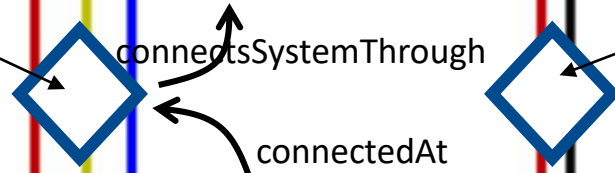
RNVoltage
SNVoltage
TNVoltage
RSVoltage
STVoltage
TRVoltage



As a matter of fact, here
 $bus.RNVoltage = socket.phaseToNeutralVoltage$
 $bus.RSVoltage = motor.STVoltage$
 $bus.STVoltage = motor.TRVoltage$
 $bus.TRVoltage = motor.RSVoltage$
 $motor.sCurrent + socket.phaseWireCurrent + \dots = 0$
 ...

ThreePhaseConnectionPoint

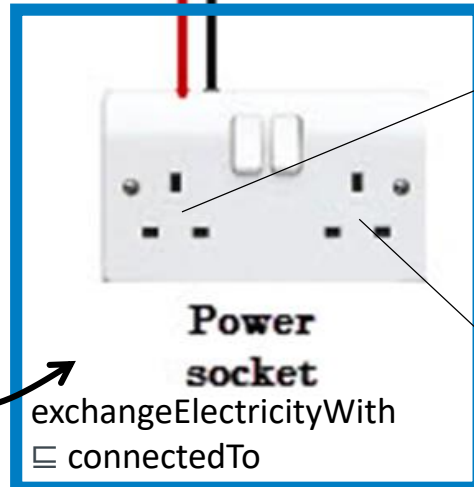
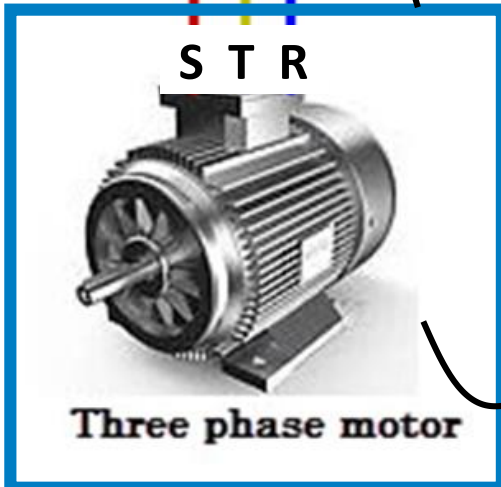
RNVoltage
SNVoltage
TNVoltage
RSVoltage
STVoltage
TRVoltage
rCurrent
sCurrent
tCurrent
RSResistance
STesistance
TNResistance
...



connectsSystemThrough
connectedAt

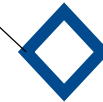
SinglePhaseConnectionPoint

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 neutralWireCurrent
 (convention: <0 if it leaves the system)
 phaseToNeutralVoltage
 phaseToNeutralResistance
 ...



TypeGSocket

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 (convention: >0 if it enters the system)
 neutralWireCurrent
 (convention: <0 if it leaves the system)
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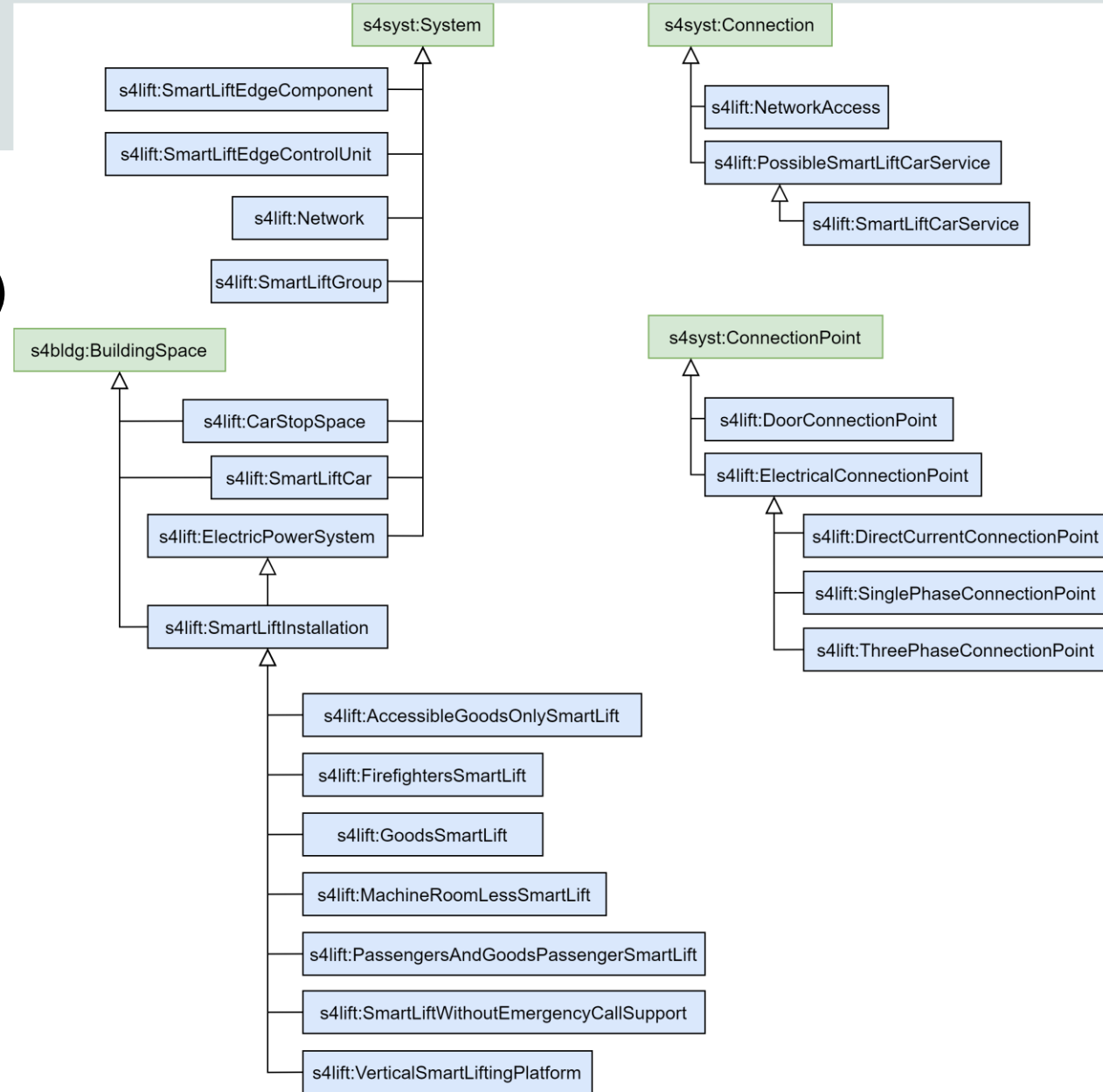
TypeGSocket

phaseWireCurrent
 (convention: >0 if it enters the system)
 neutralWireCurrent

exchangeElectricityWith
connectedTo

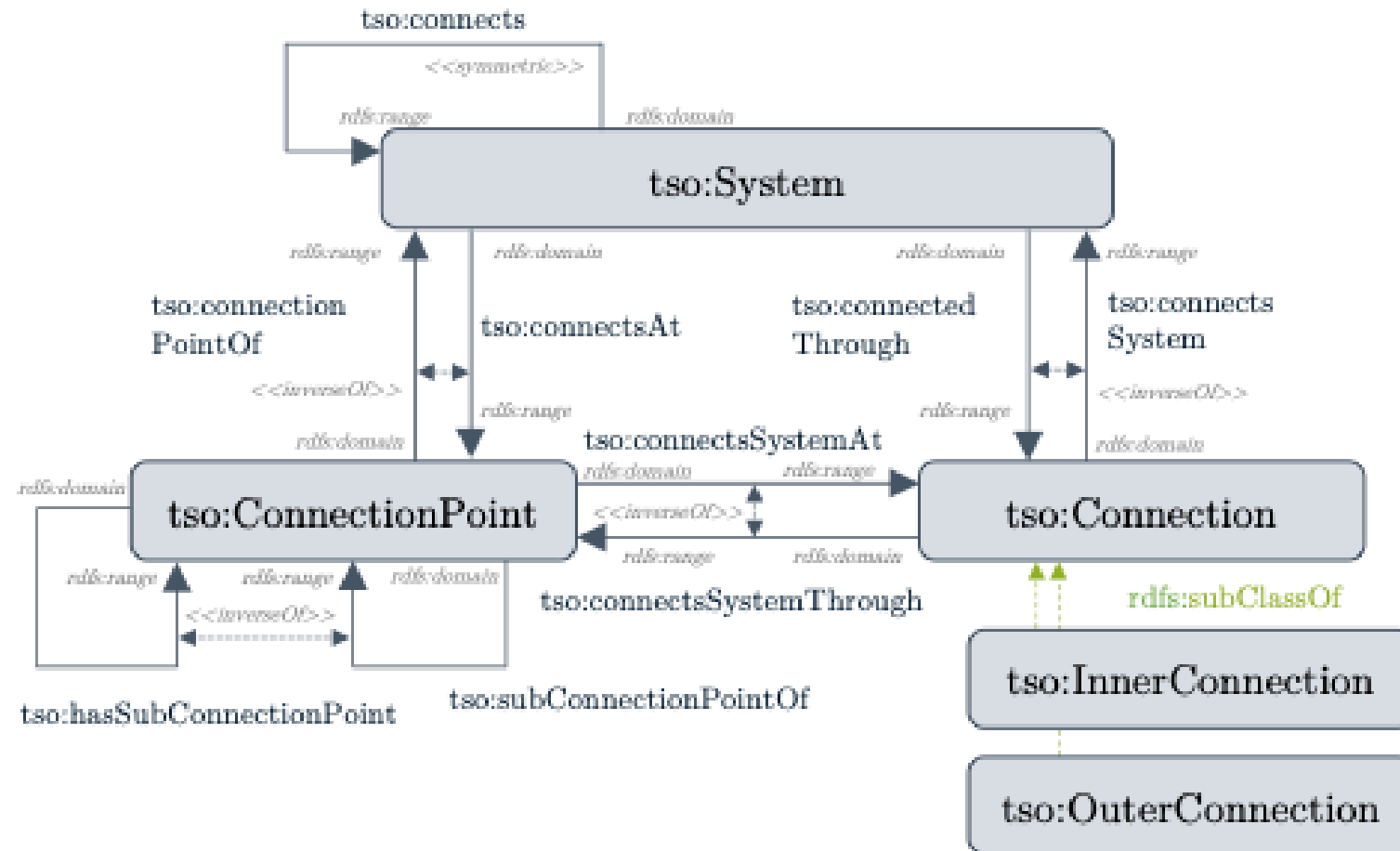
Uptake

In SAREF extensions (ex SAREF4LIFT)



Kukkonen et. Al. (2022a, 2022b)

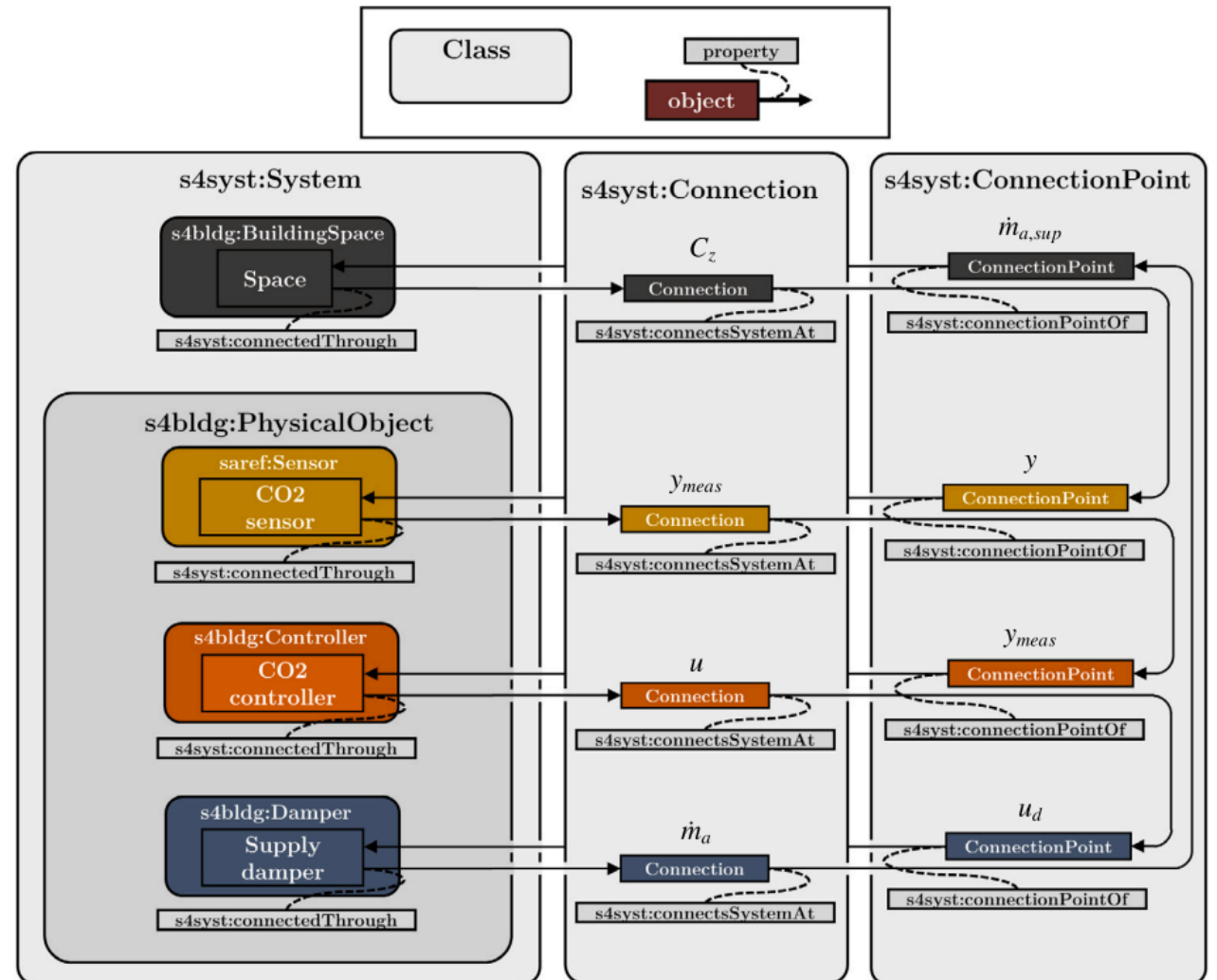
TUBES System Ontology and Flow System Ontology



Uptake

Bjørnskov and Jradi (2022)

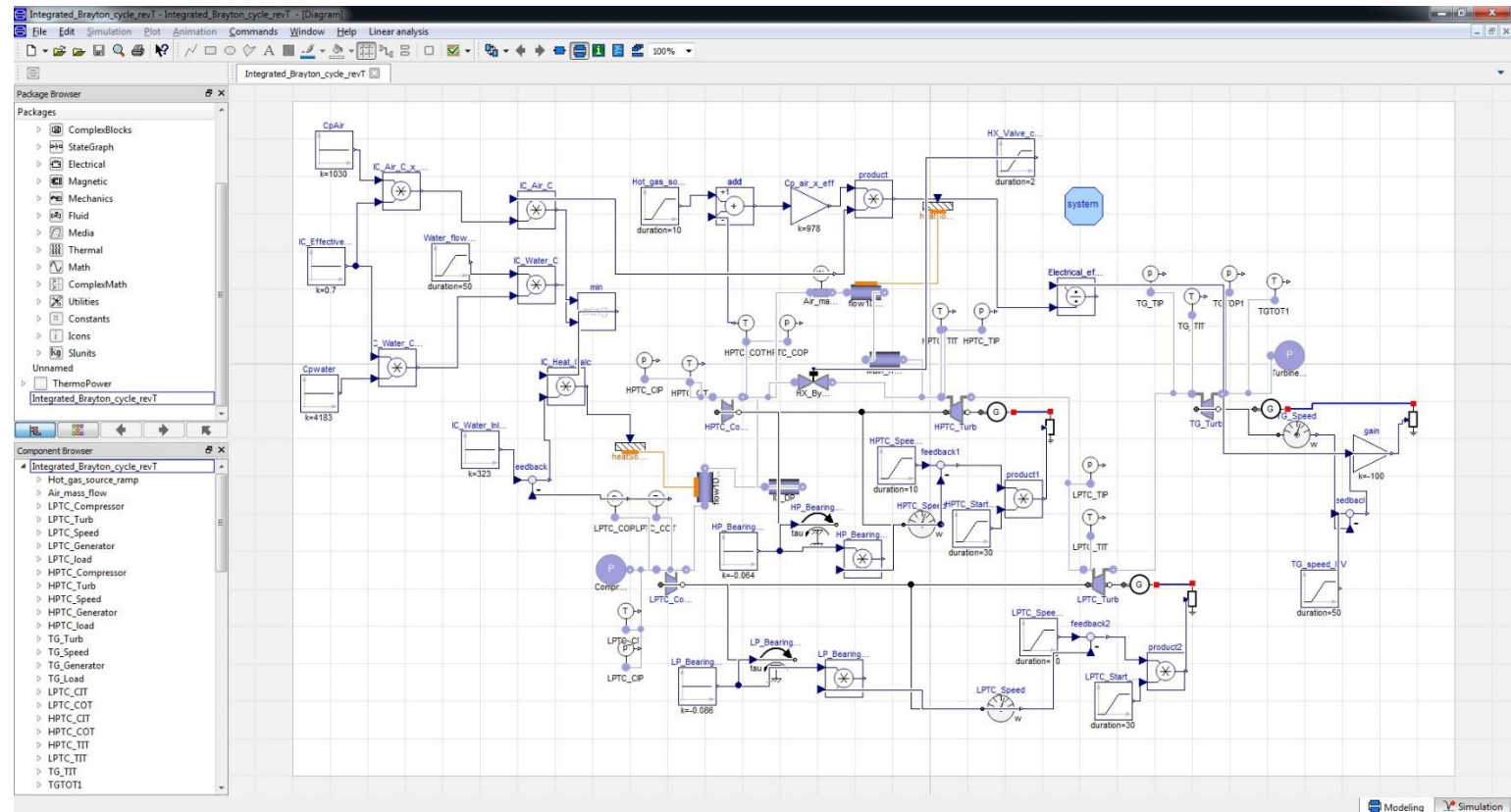
Simulation of interconnected systems in a Building DT



Uptake

Roxin et. al. (2021)

Investigating Potential Alignments between Modelica Standard Library and SAREF Ontologies



Other modeling discrepancies in SAREF

- Extensions were developed independently by different teams of experts
- Sometimes different modelling decisions were made
- There exist modelling discrepancies in SAREF

Examples:

- No agreement in extensions about what properties actually represent, and how properties are modeled
- Extensions introduce classes that should be part of SAREF Core
- Different extensions introduce the notion of “ID”, with different names and in different ways

Full list of issues at <https://labs.etsi.org/rep/saref/saref-portal/-/issues>

TR 103 549 and TR 103 781: Studies for SAREF ontology patterns

-> TS 103 548: SAREF reference ontology patterns

- Report on the modularization and factorization potential of SAREF suite using reference ontology patterns.
- List identified modelling discrepancies in SAREF Core and extensions, along with proposals to homogenize the modelling.
- Describe a set of core ontology patterns and how they can be used as a basis for future normative work in TC SmartM2M

ETSI TR 103 549 V1.1.1 (2019-07)



SmartM2M;
Guidelines for consolidating SAREF with
new reference ontology patterns,
based on the experience from the ITEA SEAS project

ETSI TR 103 781 V1.1.1 (2023-09)



SmartM2M;
Study for SAREF ontology patterns and
usage guidelines

ETSI TS 103 548 V1.1.2 (2020-06)



SmartM2M;
SAREF consolidation with new reference ontology patterns,
based on the experience from the SEAS project

ETSI TS 103 548 V1.2.1 (2024-XX)



SmartM2M;
SAREF reference ontology patterns

Conclusions

- ✓ First reference ontology pattern for SAREF
- ✓ Useful in many engineering domains
- ✓ Core ontology + guidelines to extend the 3 classes and 9 properties
- ✓ ETSI TS 103 548 - <https://saref.etsi.org/saref4syst> - <https://saref.etsi.org/sources/saref4syst>
- ✓ Ongoing work in ETSI Task Forces to define more patterns

