Industrial Ontologies @ Siemens

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Semantics and Reasoning

Ontocommons Workshop DORIC-MM 2021

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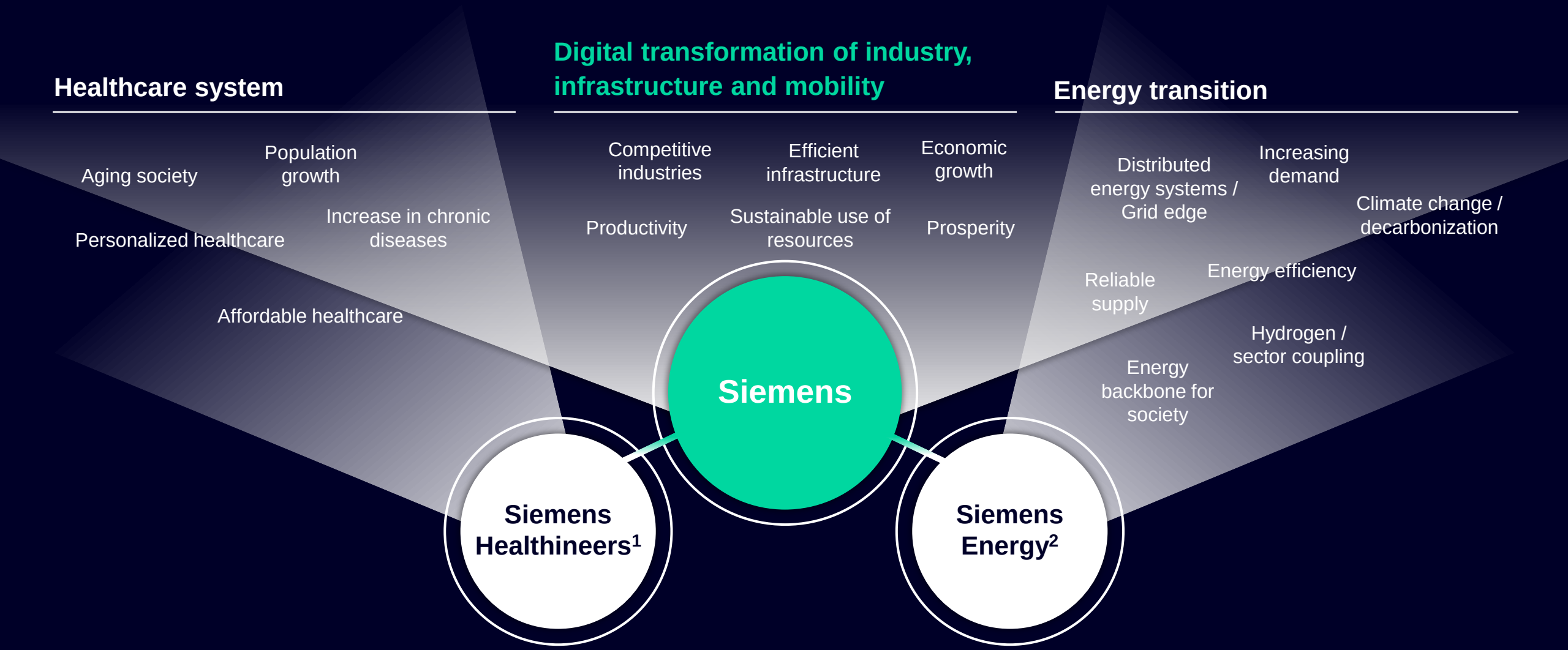
Providing technology solutions to address the greatest challenges of our time



1 Publicly listed subsidiary of Siemens | **2** Publicly listed associate

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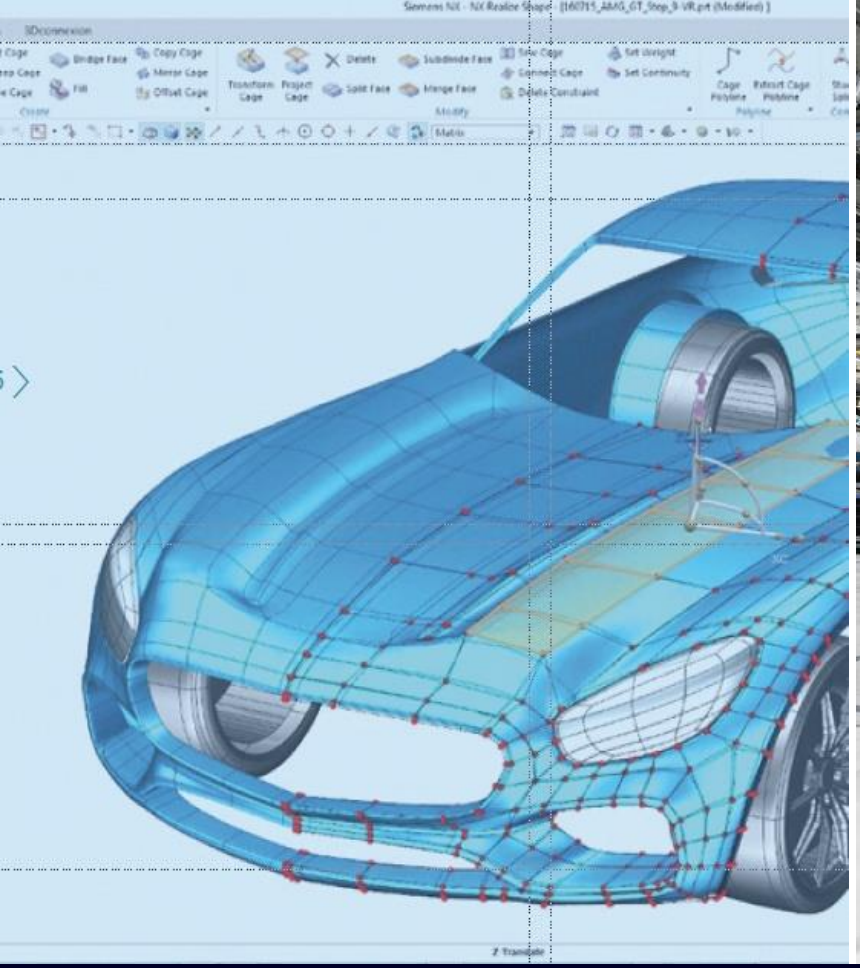

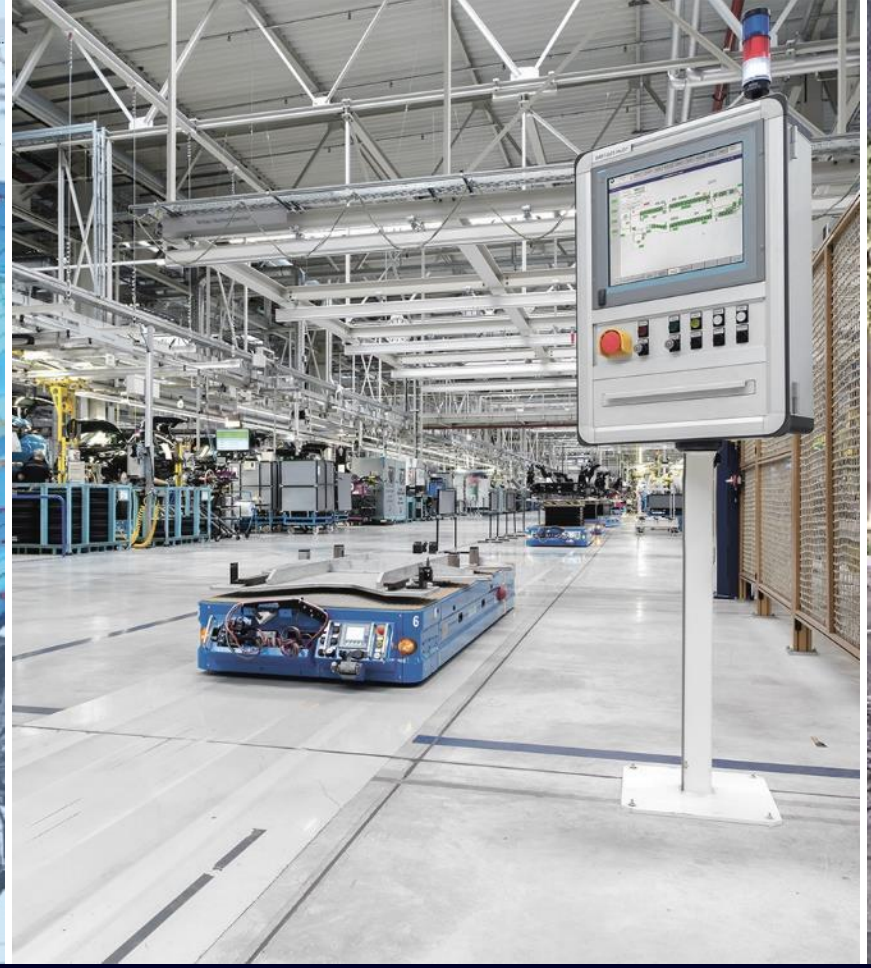

We commute in cars designed with **Siemens software …**

… built in factories running on **Siemens automation …**

… charged by a renewable and decentralized **Siemens smart grid.**

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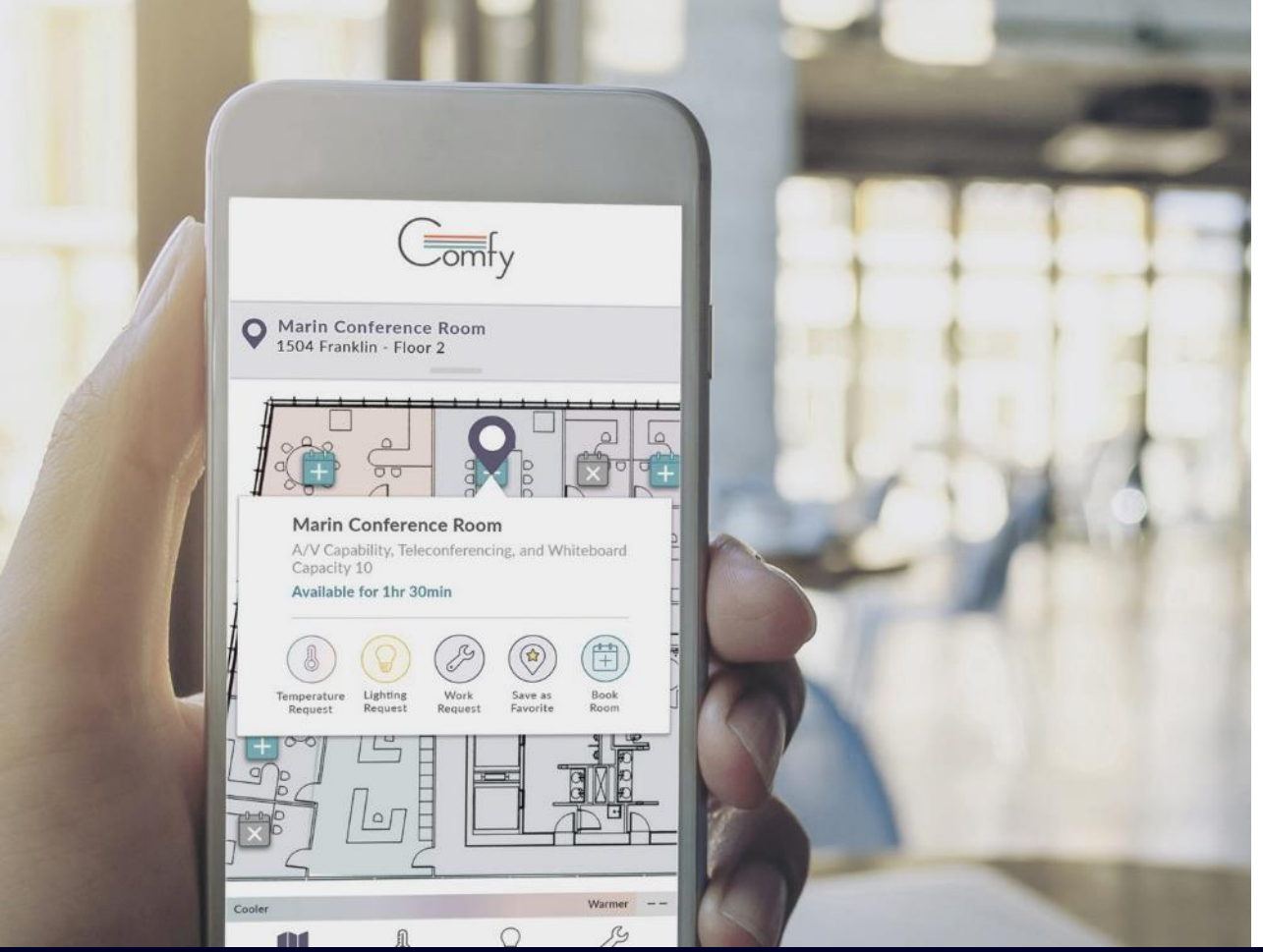

We work in **smart buildings** that keep us comfortable and healthy …

… with a **carbon neutral footprint** that keeps the planet healthy as well.

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We travel on **Siemens trains …**

… and on planes brought to life using **Siemens technology.**

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Example Knowledge Graphs – Siemens Technology drives innovation from world-class research to company-wide adoption

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Milestones

Google

Google Knowledge Graph announced

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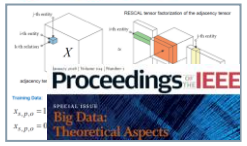
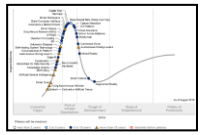


Breakthrough: ML on graphs

Startups & big players entering KG market

Gartner



Gartner add KGs to hype cycle

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Mindsphere SDI adding graph support

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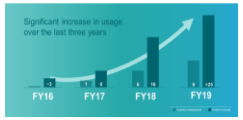

> 30 KG projects,
> 10 productive use
> 6 CCTs

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Shared ontologies

Technology innovation activities

Ontology libraries

Shared & reusable ontologies

Data Strategy

Accelerate adoption & roll-out projects

Business Buy-in

Proof-of-values and competence ramp-up

Cognitive
Deep Learning

Machine Learning on graphs

Funded projects

LarKC Large Knowledge Collider

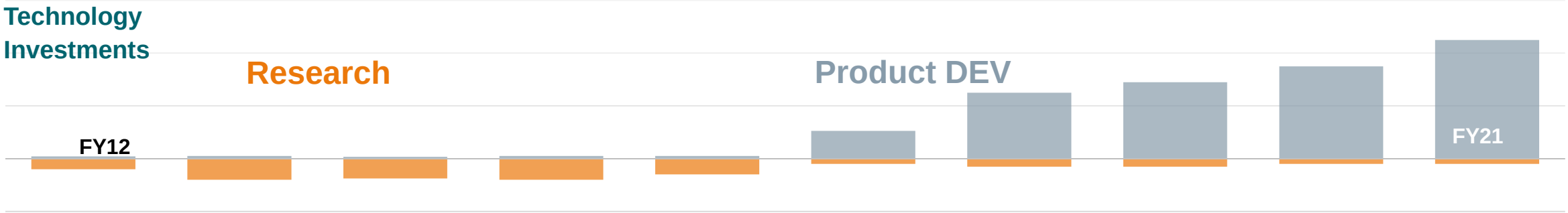
Optique

THESEUS
Neue Technologien für das Internet der Dienste

Knowledge Graphs as data layer on top of SQL Databases

Semantic knowledge graphs & reasoning

Technology Investments



Several Siemens initiatives working towards common, reusable semantic models

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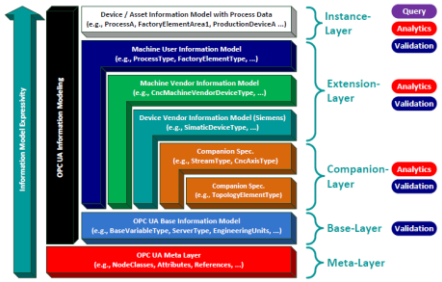
Smart Infrastructure Building Products

Building Technologies Domain Model

- community-based intiative since 2019
- OWL models: Location, Asset, Zones & Functions, ...

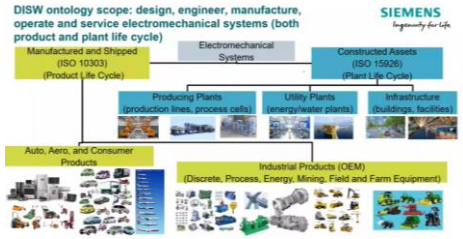
Digital Industries Factory Automation



Plant Data Model

- OWL models generated from UPC UA companions and vendor-specific information models
- engineering models

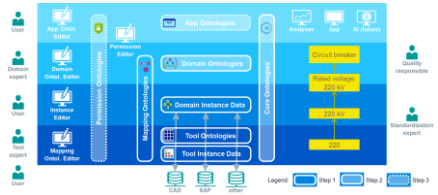
Digital Industries



Digital Industries Cross-Domain Ontology

- new intiative
- scope: product and plant lifecycle

Siemens Energy Gas&Power Transmission



Siemens Energy Transmission Domain Ontologies

- cross-unit intiative since 2020 (meanwhile all BUs)
- support domain experts by a tool set to create high quality ontologies without informatic proficiency

...

Ongoing Initiative: Shared Ontology Guidelines, Upper-Ontology and Siemens-wide Ontology Publication Platform

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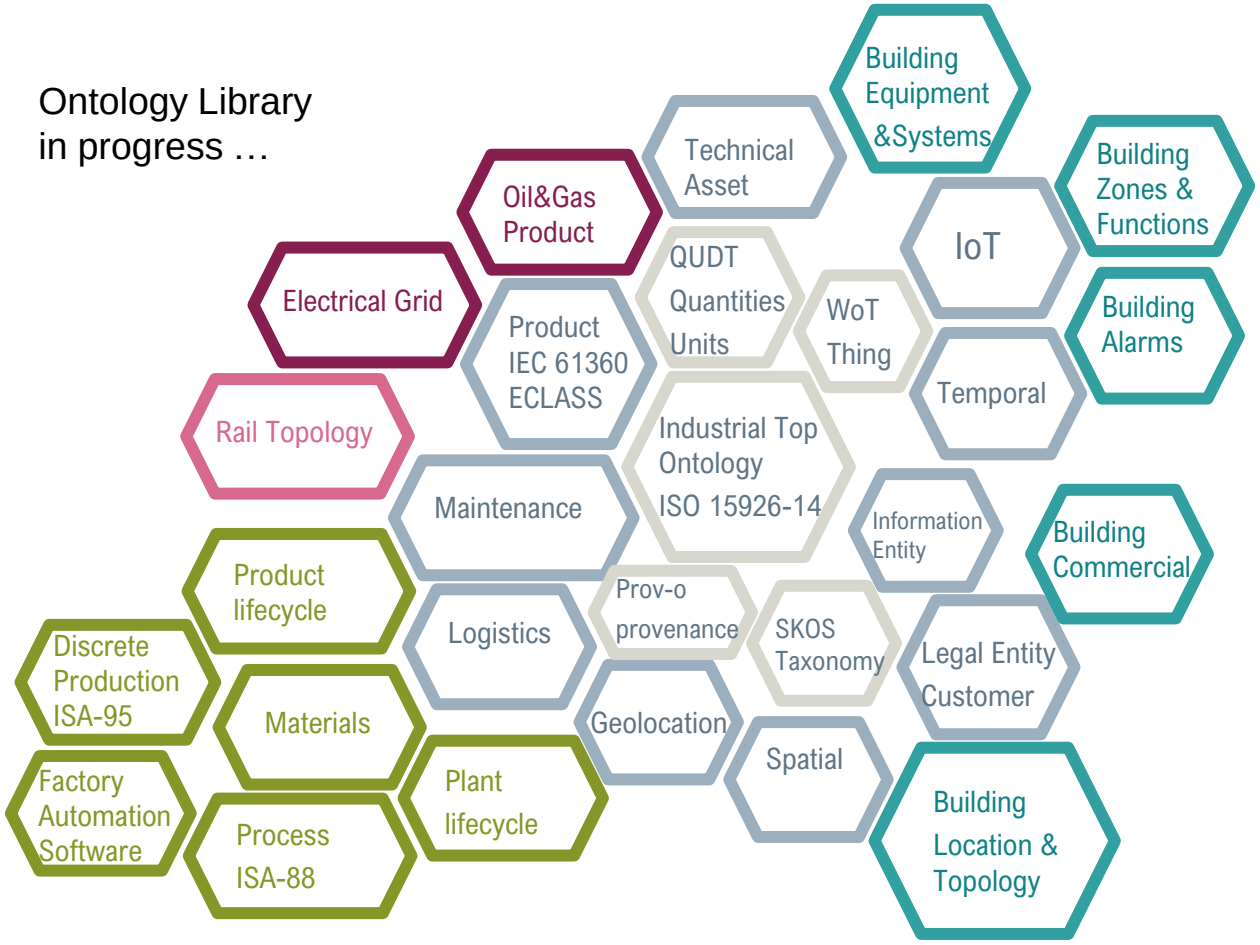
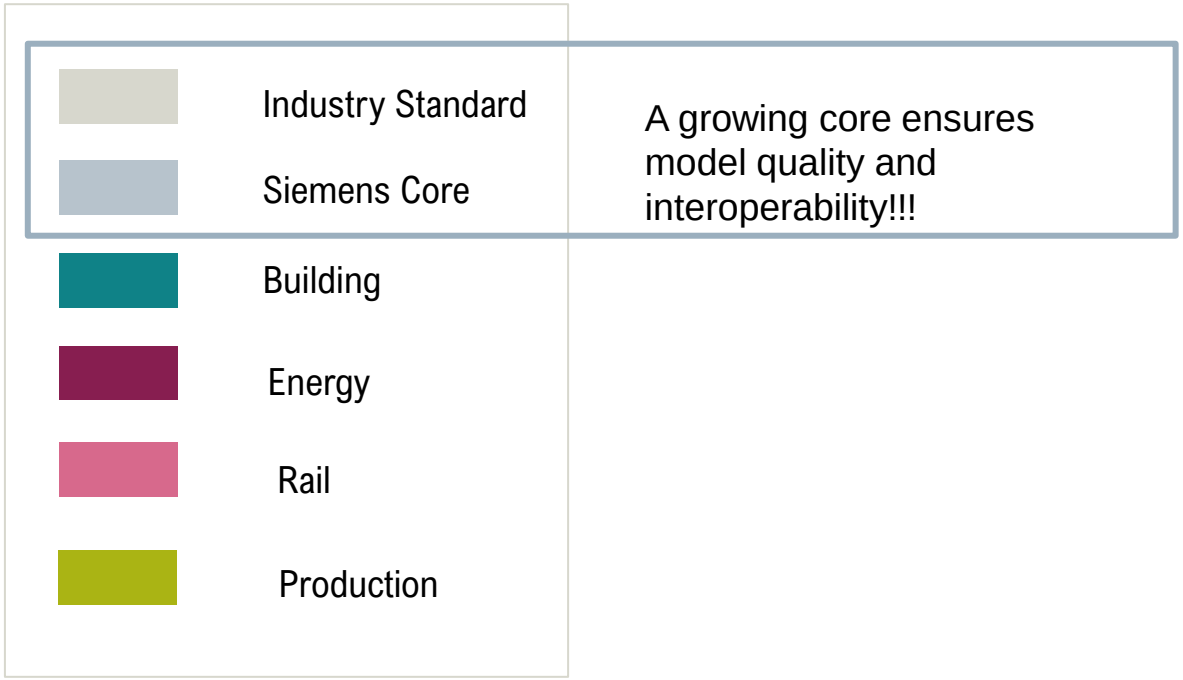
Ontology Library
in progress …





A growing core ensures model quality and interoperability!!!

Ontology Library – Summary Motivation (Why?)

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A library of reusable, Siemens-relevant semantic domain models will …

… reduce modeling efforts

- By encapsulation and model reuse
- By applying semantic best-practice guidelines

… speed-up data integration

- By implementing ETL* for standard data schemas only once
- By integrating isolated standards

… enable product lifecycle integration

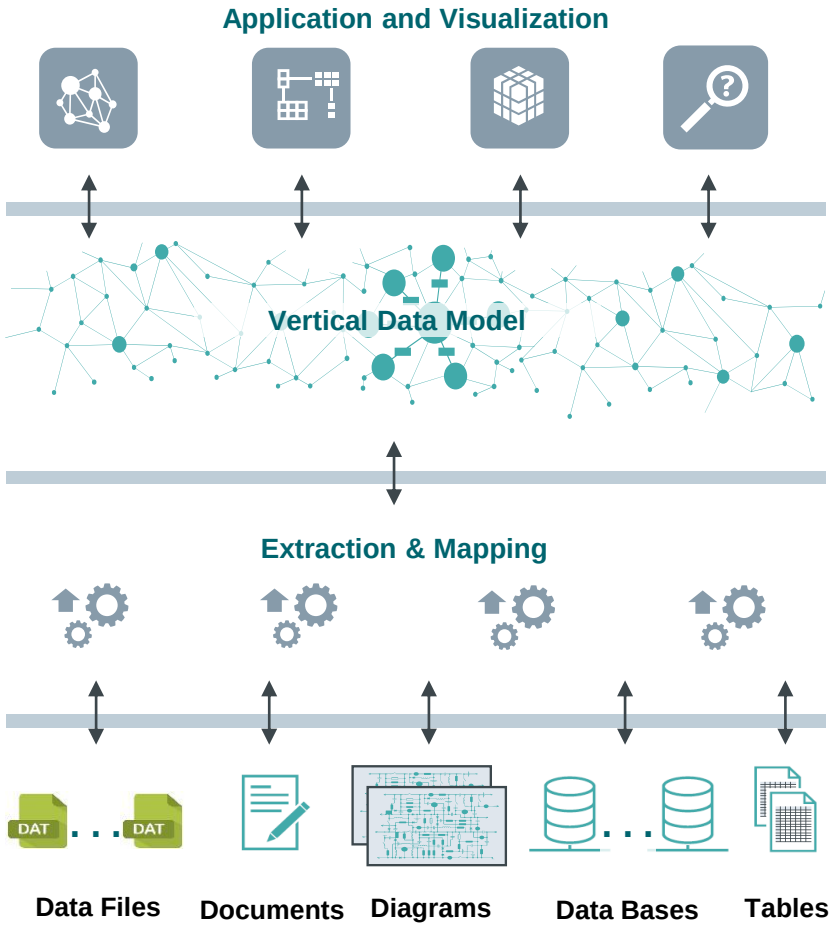
- By providing generic concepts used by various lifecycle processes
- By providing links between lifecycle modules

… enable Siemens platform ecosystem

- Reusable software libraries can be built based on shared models
- Interoperability between different Siemens Business Units and with suppliers as well as customers

ETL*= extract, transform, load data

Shared semantic models help to avoid maintaining an exponentially growing number of bilateral mappings



... **m** apps

... **1** shared model

... **n+m** mappings

... **n** data models

High quality semantic data models that are shared reused across applications

For each application and data source one mapping to the shared model

The basic pillars for building an ontology library: Content, guidelines and community

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Content

- What objects to represent?
- What is the agreed semantics?
- What is common, what specific?

1. Collect and share existing data models
2. Prioritize verticals/standards and propose common core
3. Review and extend core model library

Guidelines

- How do we formalize and document core models?
- How to integrate standards?

1. Agree on language and naming conventions for core models
2. Agree on support for existing standards and tools
3. Provide documentation and tools to facilitate (re-)use

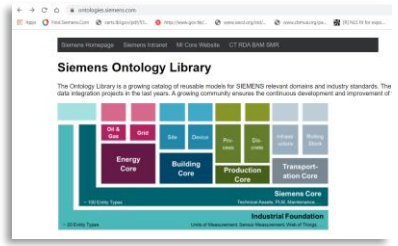
Community

- Who contributes?
- How do we synchronize activities across Siemens?

1. Setup of community and working groups
2. Define processes, IP and owner-ship model for common core
3. Prepare communication and dissemination material

Inner source data models

Ontology Library
Repository &
Publication Platform



Guideline document, Standardization

Top Industrial Ontology
ISO/TR 15926-14

QUDT: Quantities, Units, Dimensions Ontology

CLASS goes OWL/RDF

Regular JF and Working Groups

Learnings

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1. We need a shared upper-level ontology
2. We need to actively contribute to the community efforts outside of Siemens
3. Ontology modeling is hard and takes time
4. We need inference

Learning 1
We need a shared upper-level ontology

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Industrial Top-Level Ontology ISO 15926-14

- Gas&Power Products
- Building technologies
- Factory Automation Software
- Manufacturing Processes/Skills

owl:Thing
- Activity
  - Event
    - PointInTime
    - PeriodInTime
- Aspect
  - Disposition
    - Function
  - Quality
    - PhysicalQuantity
  - Role
- Object
  - FunctionalObject
    - System
  - InformationObject
    - QuantityDatum
      - ScalarQuantityDatum
    - UnitOfMeasure
      - Scale
  - Location
    - Site
    - SpatialLocation
      - PointInSpace
      - RegionInSpace
  - Organisation
  - PhysicalObject
    - Compound
    - InanimatePhysicalObject
      - Phase
      - Stream
    - Organism
      - Person

owl:topObjectProperty
- connectedTo
  - directlyConnectedTo
- creates
- datumUOM
- hasDisposition
  - hasFunction
- hasInstalled
- hasPart
  - hasActivityPart
    - hasActivityBound
      - hasBeginning
      - hasEnd
  - hasArrangedPart
    - hasAssembledPart
    - hasFeature
  - hasFunctionalPart
- hasParticipant
- hasQuality
  - hasPhysicalQuantity
- hasRole
- installedAs
- interests
  - approvedBy
- locatedRelativeTo
  - containedBy
  - contains
- occursRelativeTo
  - after
  - before
    - causes
- participantIn
- partOf
  - activityPartOf
    - activityBoundOf
      - begins
      - ends
  - arrangedPartOf
    - assembledPartOf
    - featureOf
  - functionalPartOf
- realizedIn
- representedBy
  - qualityQuantifiedAs
- roleOf

- Currently mainly used to ensure the quality of modeling!
- In future, it will enable better interoperability

GIST

- Digital Industries

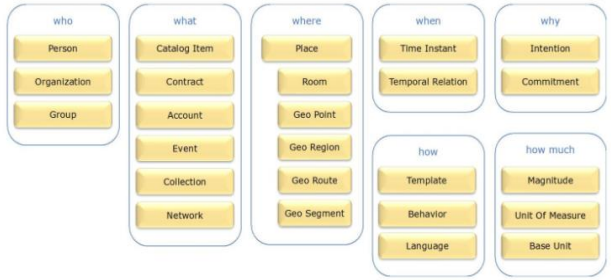
Cross-Domain Ontology

- Alignement with ISO 15926-14 planned

gist

semantic arts

Open source OWL Ontology with business/industry relevant terms



Learning 2
We need to actively contribute to the community efforts outside of Siemens

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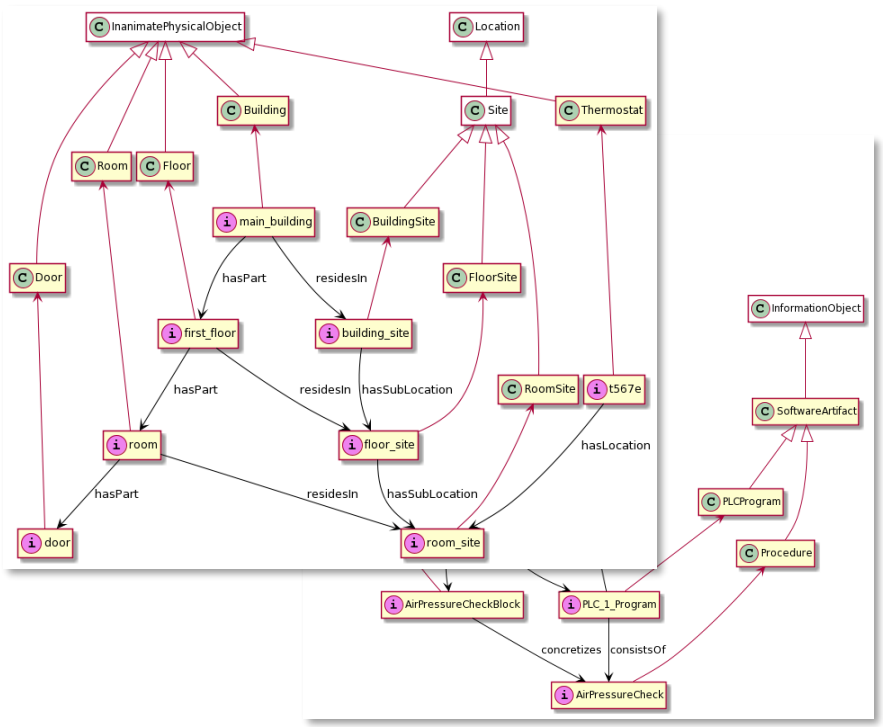
Contributed to ISO 15926-14 via JIP READI



Contributing to QUDT

After reviewing several unit ontologies, we found QUDT most suitable for Siemens use cases.

- Compliant with IEC/ISO 80000 units
- Includes all known systems of units/quantities
- Includes unit conversions
- Cross referencing to UCUM, UN/ECE, and CDD (IEC 62720) unit codes

Active development supported by Siemens researchers

- Siemens colleagues contributed 600 units and cross-references to IEC 62720 and UN/ECE
- Continuous support and exchange

Contributing to ECLASS goes OWL/RDF

- Siemens (DI) and Siemens Energy (GP) is a member of a cross-company intitative (together with Schneider Electric and others) that has developed a first draft of ECLASS in OWL
- Alignement with Siemens representatives in IOT-relevant standards ongoing

Learning 3
Ontology modeling is hard and takes time

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Finding people with the right competencies is hard!

- Data scientists understand OWL, but do not understand the domain and usually do not even want to understand it in depth
- Domain experts know the domain but do not understand OWL
- None of them understands upper ontologies ☺

What about re-using and contributing to existing open-source industrial ontologies?

- First problem: there are few of them and usually do not provide what is required by the use case
- Second problem: there are several incompatible ones for the same domain
- Third problem: in order to re-use or contribute you first have to build up experience and expertise yourself

What can be done?

- Training, coaching, building an ontology modeling community within Siemens
- Enabling domain experts to model the knowledge with tools which guide to create and maintain compatible models whitout informatic proficiency
  - Use templates (e.g. OTTR*) in the backend to abstract away from OWL and higher-level ontologies
  - Generate SHACL automatically

OTTR*=Reasonable Ontology Templates (https://ottr.xyz/)

Learning 4
We need inference

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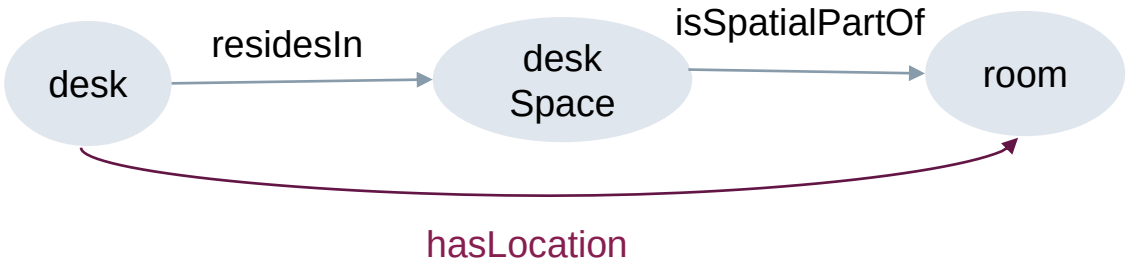
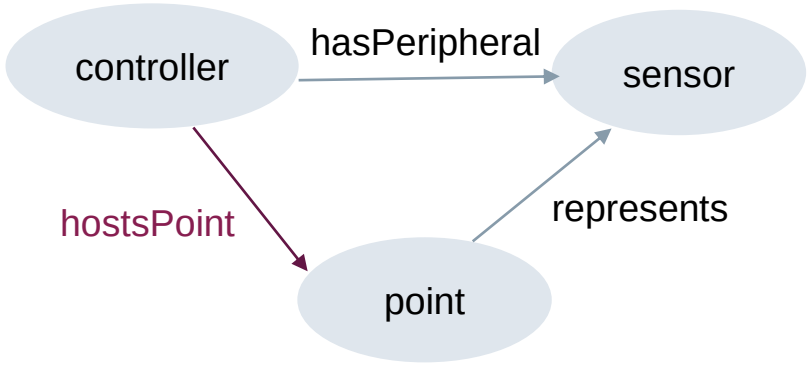
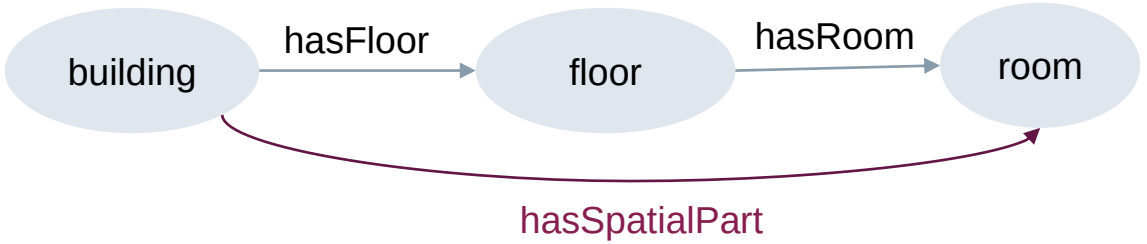
- This seems to be obvious considering OWL is the chosen formalism
- However, most OWL ontologies we use currently are weekly axiomatized because the curent focus is rather on representation and less on reasoning
- As our knowledge graphs grow and the use-cases to be supported require different model granularity, it is slowly becoming clear that inference is needed!
- Problem: Widely-adopted graph databases such as Neptune do not support inference as of now.







Thank You!

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