Knowledge Graphs in the Real World

How Industry 4.0 Use Cases Benefit from Using Semantic Technologies

Daniel Herzig-Sommer
Dr.-Ing., COO metaphacts GmbH
Summer school AI Technologies, July 25, 2023

Agenda

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- Intro
- “Knowledge Graphs in the real world” - Industry use cases
- Technology stack
- Metaphactory
- Deep Dive – How Industry 4.0 use cases benefit from KGs
- Demo
- Summary

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Unlocking the value of your data with knowledge graphs

Company Snapshot

- metaphacts GmbH
- Founded in 2014
- Headquartered in Walldorf, Germany
- International team across multiple locations
- Independent software vendor. Part of *Digital Science*
- **metaphactory** – Knowledge Democratization Platform

How do we make decisions?

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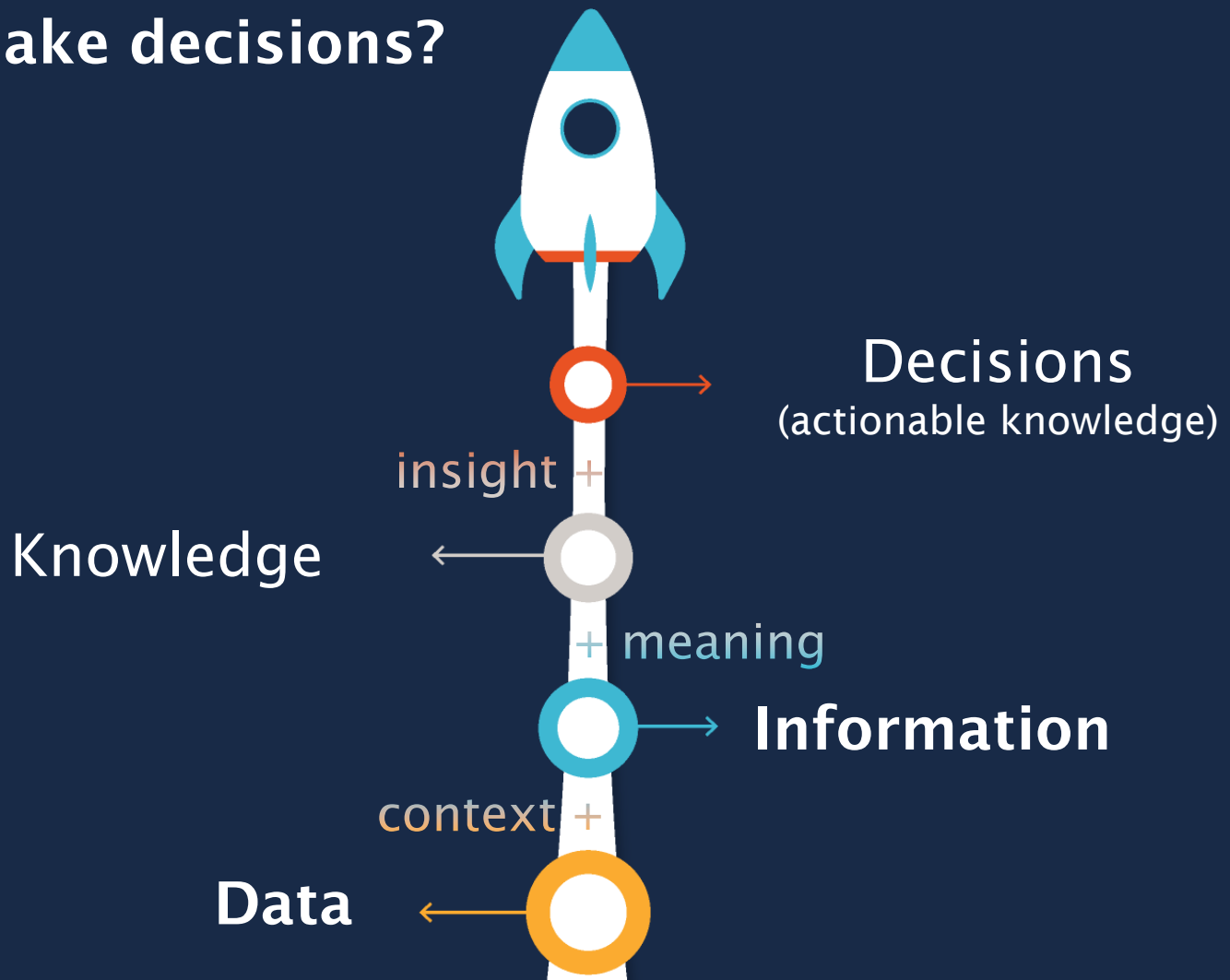

Some metaphacts customers

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SIEMENS energy

BOSCH

Boehringer Ingelheim

NLB | National Library Singapore

SIEMENS

BKW

SCHAEFFLER

Swiss Art Research Infrastructure

SANOFI

FOODIE
FARM-ORIENTED OPEN DATA IN EUROPE

sapa

Agriculture and Agri-Food Canada

For details on other customers please visit:
metaphacts.com/company/customers

References from Engineering & Manufacturing

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Smart Manufacturing Planning & Execution

SIEMENS

- ✓ AI-based knowledge graph application for automated, skill-based allocation of machines to production requests
- ✓ Cost & time savings by supporting planners & line operators in validation of manufacturing plans
- ✓ Enables realization of low-volume orders

Read more »

Materials Science Knowledge Graph

BOSCH

- ✓ Smart business application for material research & development
- ✓ One-stop knowledge hub for materials and chemical component information
- ✓ Meaningful & actionable insights surfaced through a user-friendly interface

Read more »

Turbine Spare Parts Management

SIEMENS energy

- ✓ Smart and targeted maintenance of spare parts of large gas turbines
- ✓ Preventive maintenance resulting in reduced turbine downtimes
- ✓ Increased business user and customer satisfaction
- ✓ Savings of thousands of hours on manual effort

Read more »

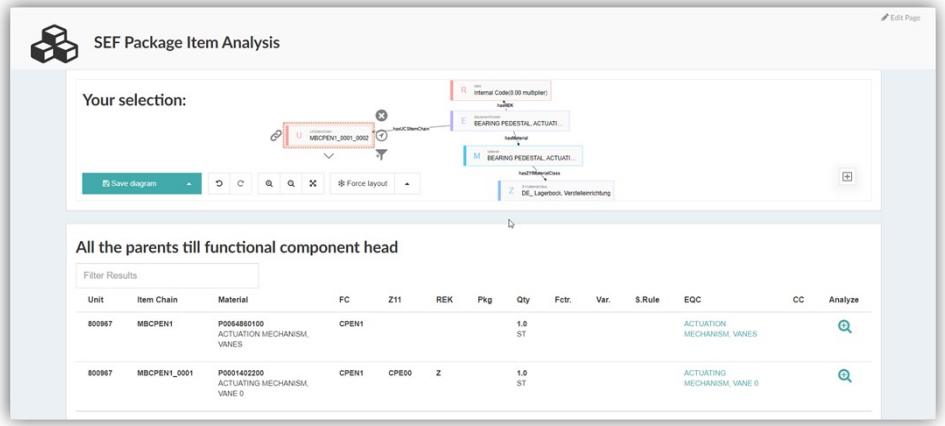
Other customers in this sector

BKW

SCHAEFFLER

Engineering & Manufacturing Demo

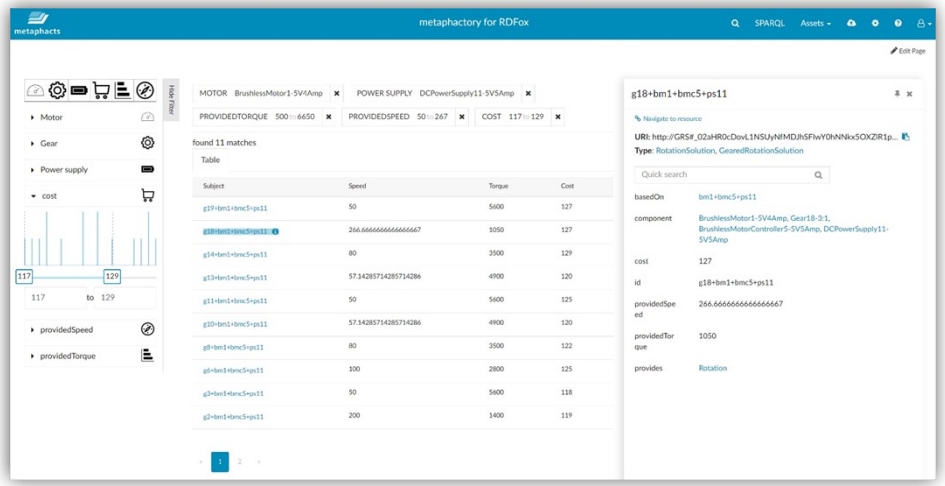
Turbine Spare Parts Management



Application developed by

SIEMENS energy

Configuration Management Demo



Developed together with

Oxford Semantic Technologies

References from Pharma & Life Sciences

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Omics Data Management

Boehringer Ingelheim

- ✓ One-stop knowledge hub for gene expression data helping data stewards in bridging the gap between business and IT
- ✓ Bioinformaticians benefit from intuitive exploration of gene sequencing data for specific diseases and time frames

Watch now »

Clinical Analytics & Informatics Dashboard

American multinational pharmaceutical corporation

- ✓ Intelligent dashboard providing an integrated view over a data mesh of proprietary & public data sources
- ✓ Accelerated & optimized drug discovery & development through contextualized data & reasoning

Watch now »

Drug Development & Drug Repurposing

Swiss multinational healthcare company

- ✓ Target discovery dashboard connecting & transforming proprietary & public information into explicit knowledge
- ✓ Data scientists, immunologists & systems biologists gain access to actionable insights for drug discovery & repurposing

Read more »

Enterprise Data Fabric

American multinational biopharmaceutical company

- ✓ Portal for shared business data with well-defined meaning & linkages
- ✓ Users gain insights on dependencies between functions & processes, spanning the entire value chain from research & clinical trials, to production, marketing & distribution

Watch now »

Omics Data Management Demo

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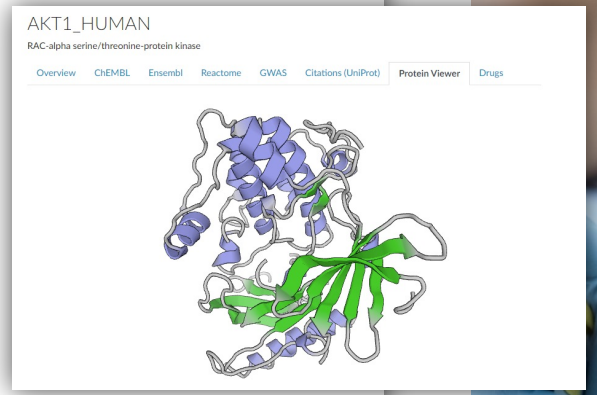
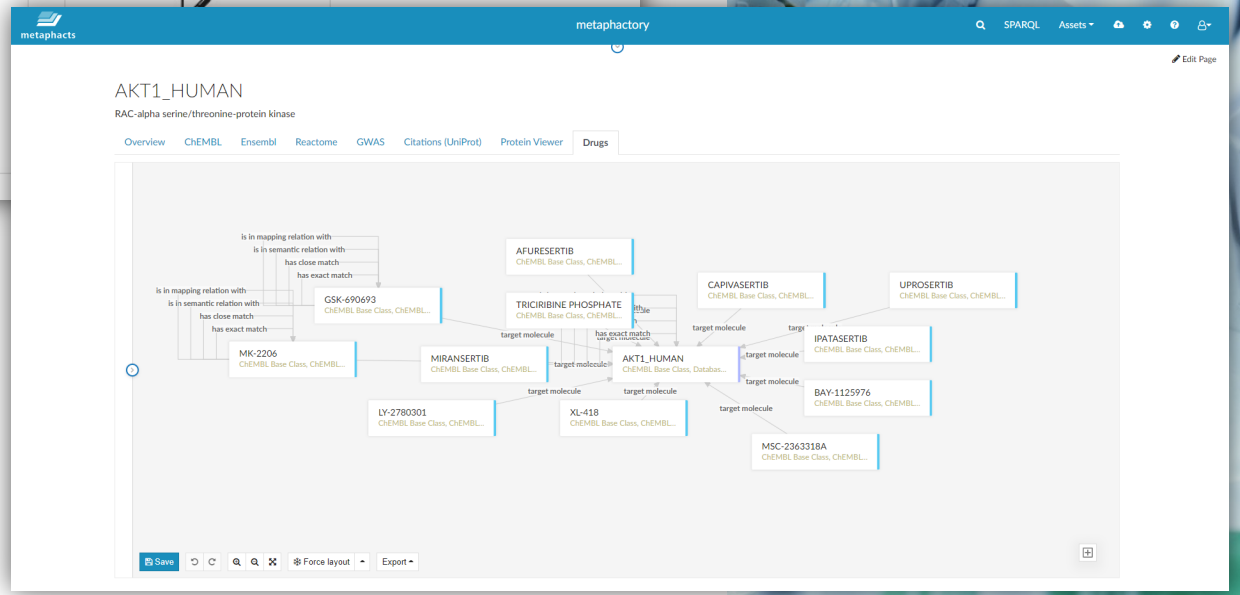


Enter search term here

Protein	Gene	Disease
192655	24536	39863



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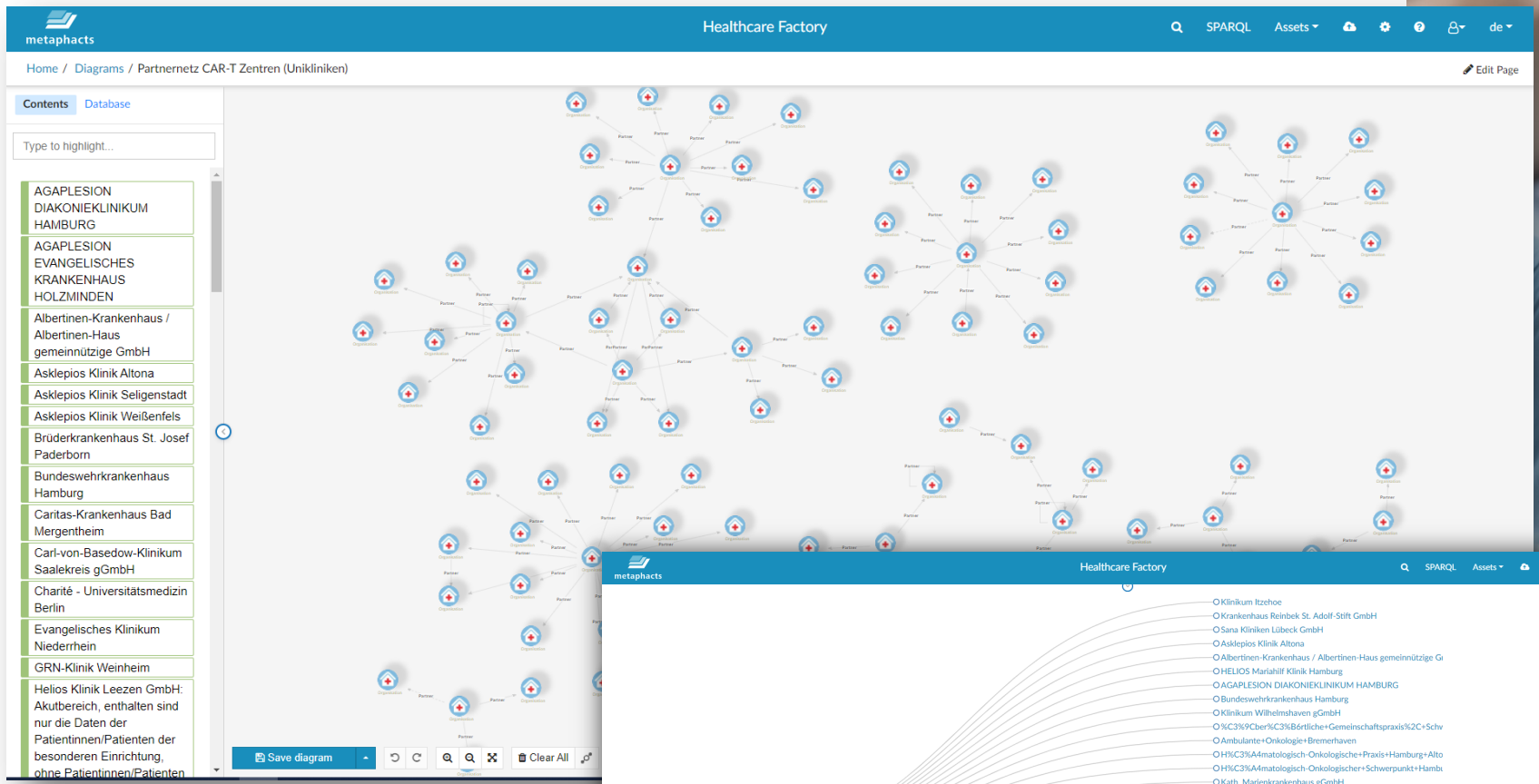
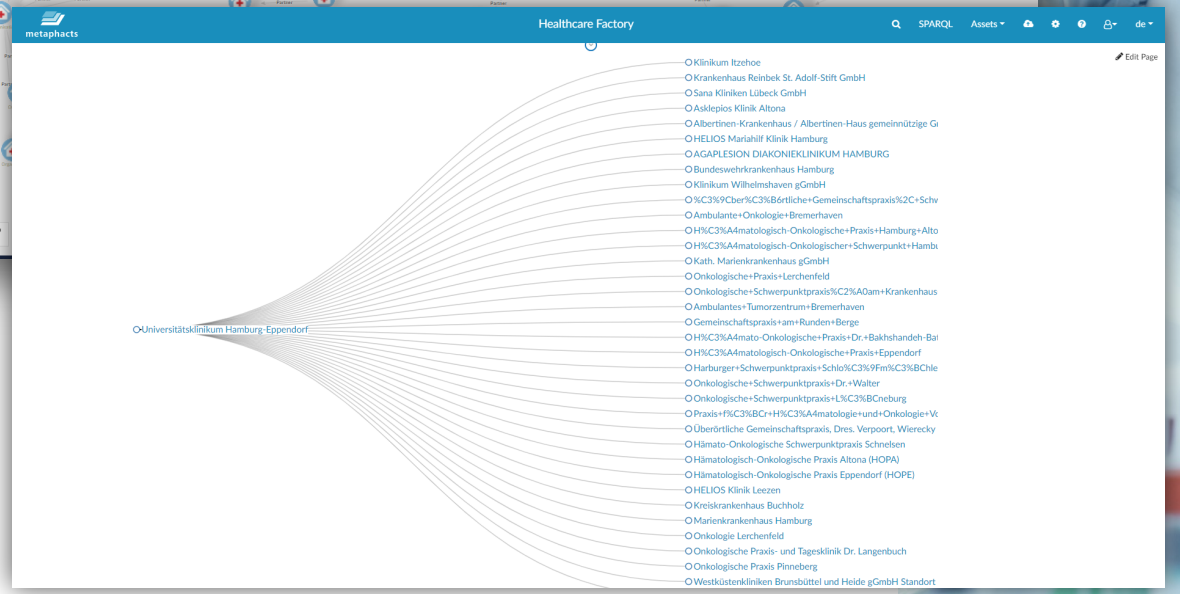
Market Access Demo





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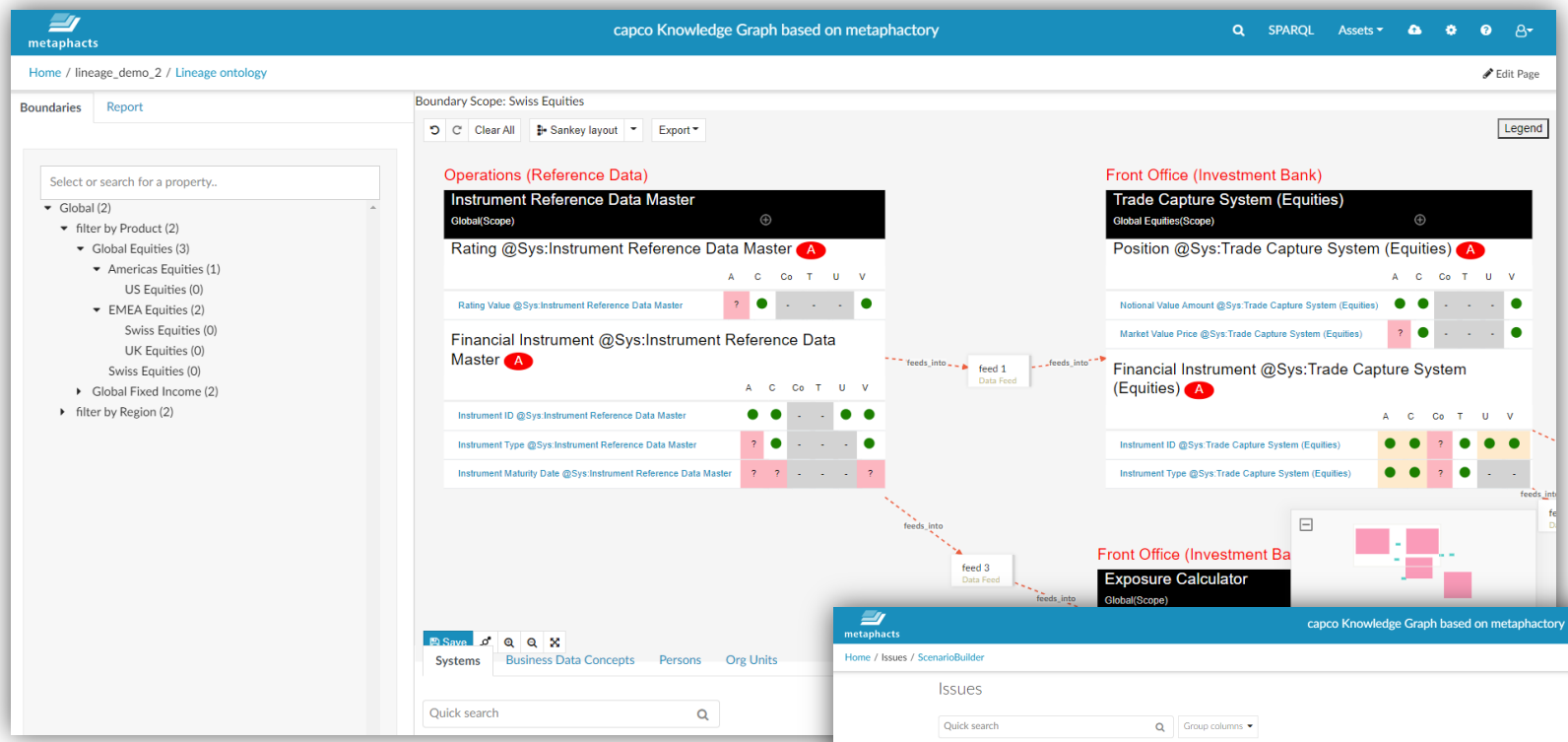
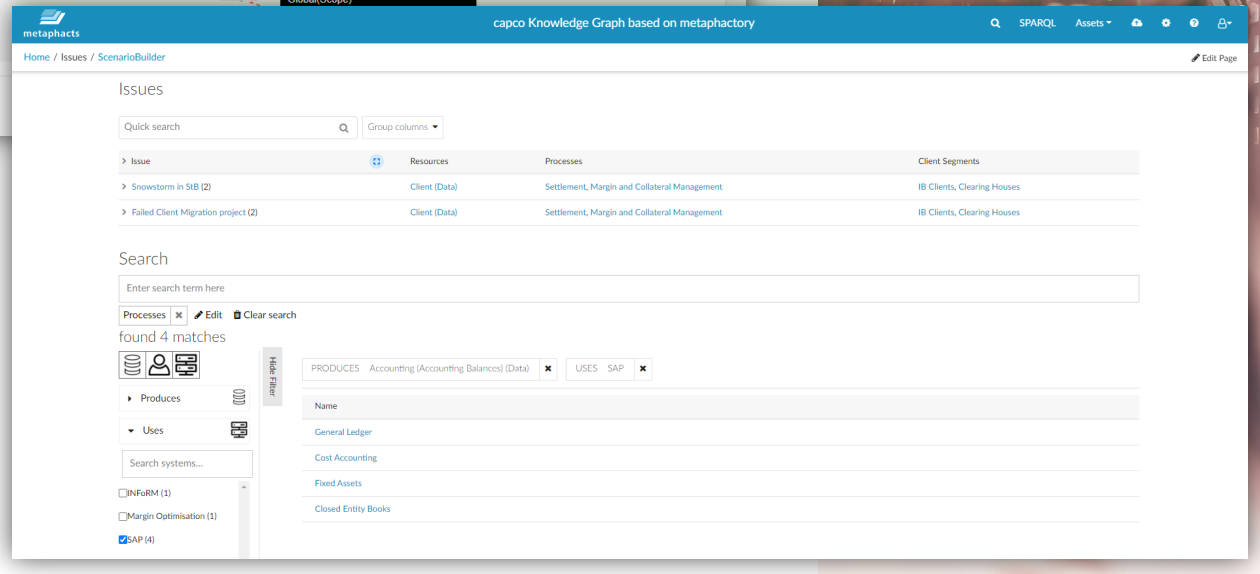
HEALTHCARE FACTORY

Data Lineage & Digital Twin Demo





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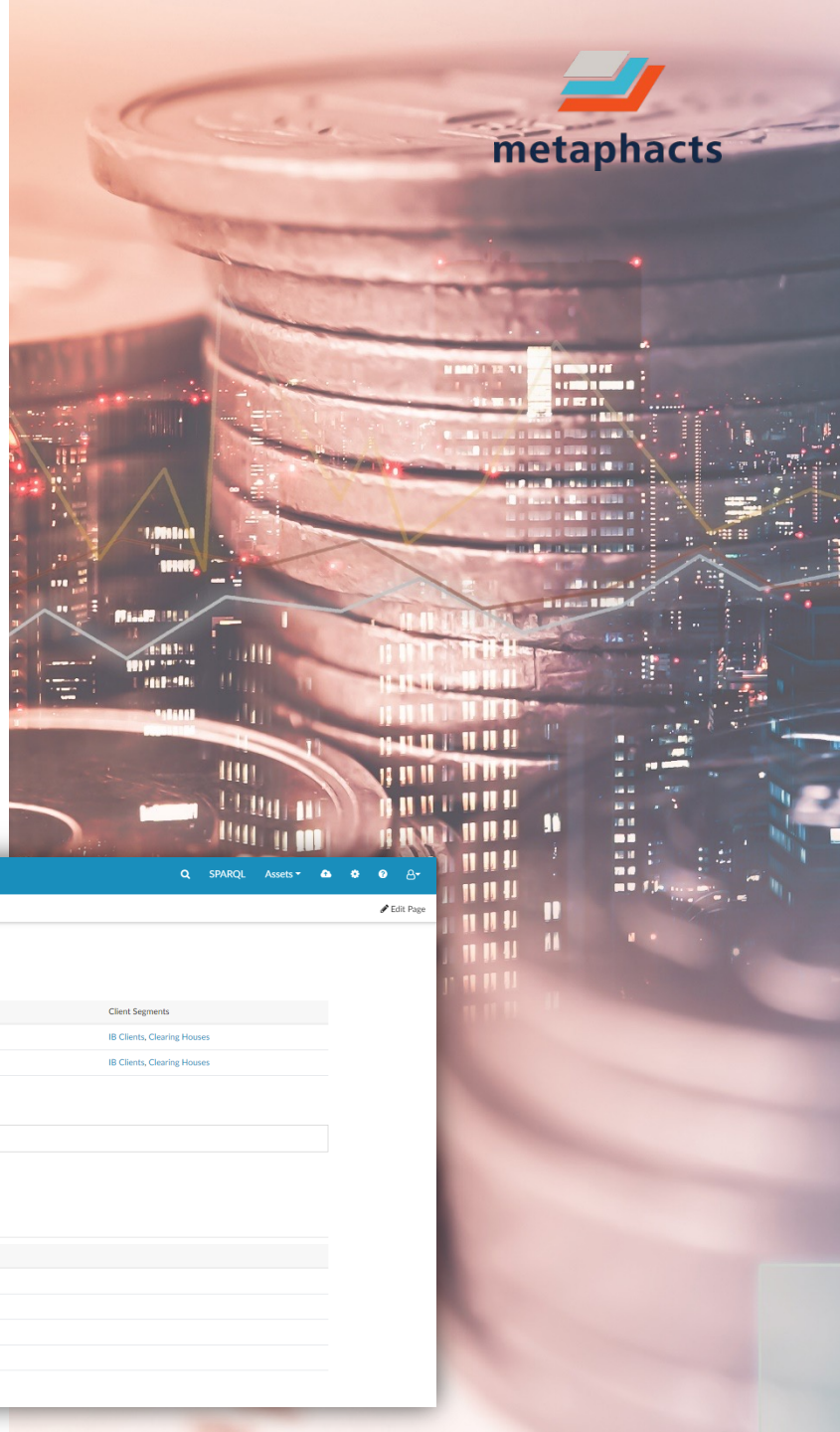

Principles for unlocking the value of data

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Findable

- Unique and persistent identifiers
- Rich metadata
- Unique identifiers in metadata
- Indexed data repositories

Accessible

- Retrievability through standard communication protocols
- Protocols are open, free & universally implementable
- Authentication
- Persistent metadata

Interoperable

- Use of standard data models
- Vocabularies & taxonomies
- Linked metadata

Reusable

- Metadata have multiple attributes
- Usage license
- Provenance information
- Community standard

Adapted from: Mark D. Wilkinson et al., Comment: The FAIR Guiding Principles for scientific data management and stewardship (2016)

Platform based on open standards

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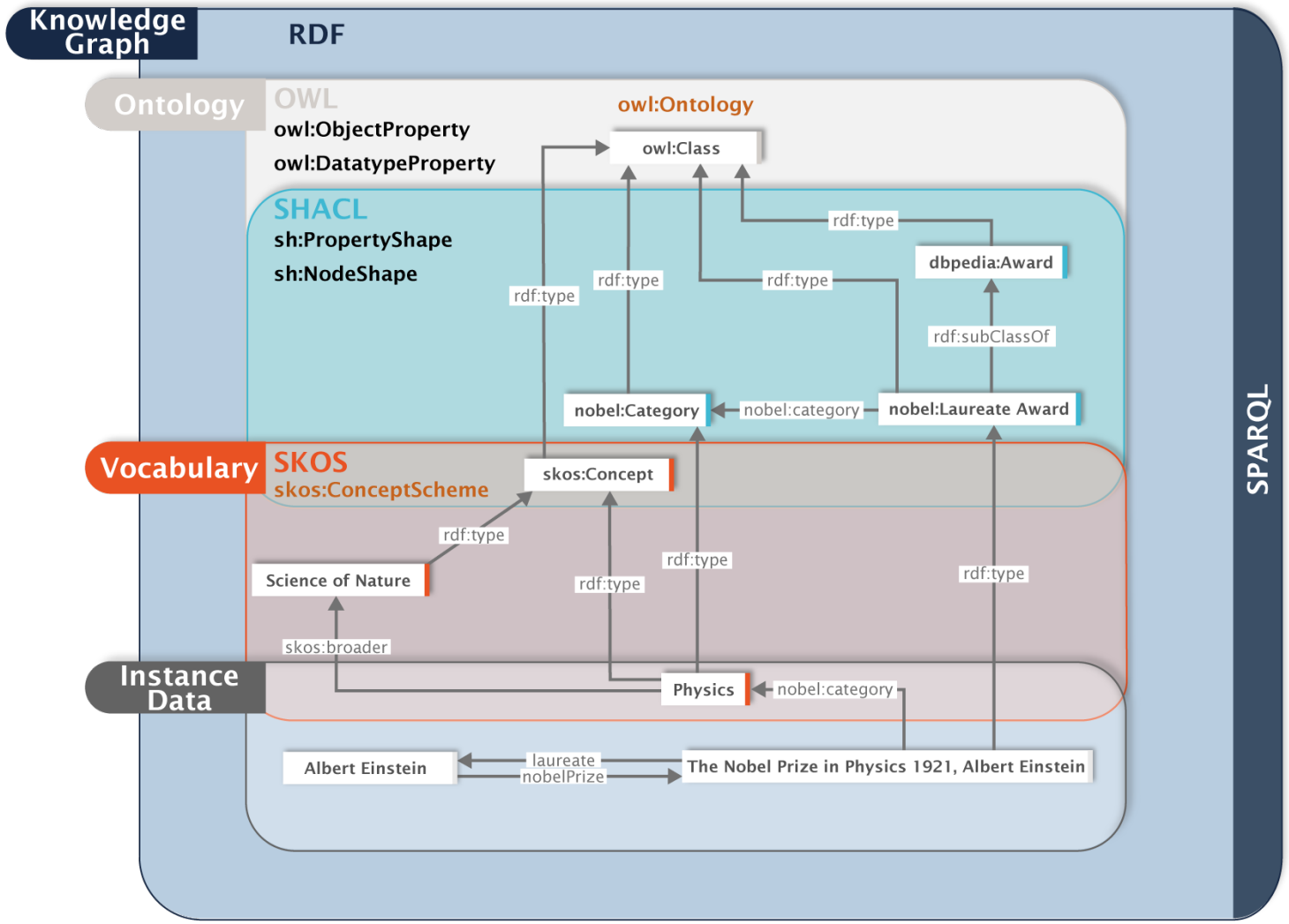
Graph Data Model	Vocabularies	Ontology Language	Rules & Constraints	Query Language
Linked Data Platform	Web Components	HTML Templates	Java Backend	REST APIs

FAIR
Findable Accessible Interoperable Reusable

Connecting the ontologies, vocabularies & instance data



metaphactory knowledge graph approach - Layering of open W3C semantic knowledge graph standards as utilized & applied by metaphactory

Benefits

- Interlink ontologies & vocabularies to support reuse while separating management & governance tasks
- Improve stakeholder communication, asset documentation & governance
- Enable model-driven applications with e.g., auto-suggestions in semantic forms, runtime validation of user interaction, hierarchical facets in search, etc.
- Ensure data quality by running checks & validations against business logic

The semantic layer explained

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Knowledge Management

Knowledge Publishing, Discovery & Consumption

Knowledge-driven Applications

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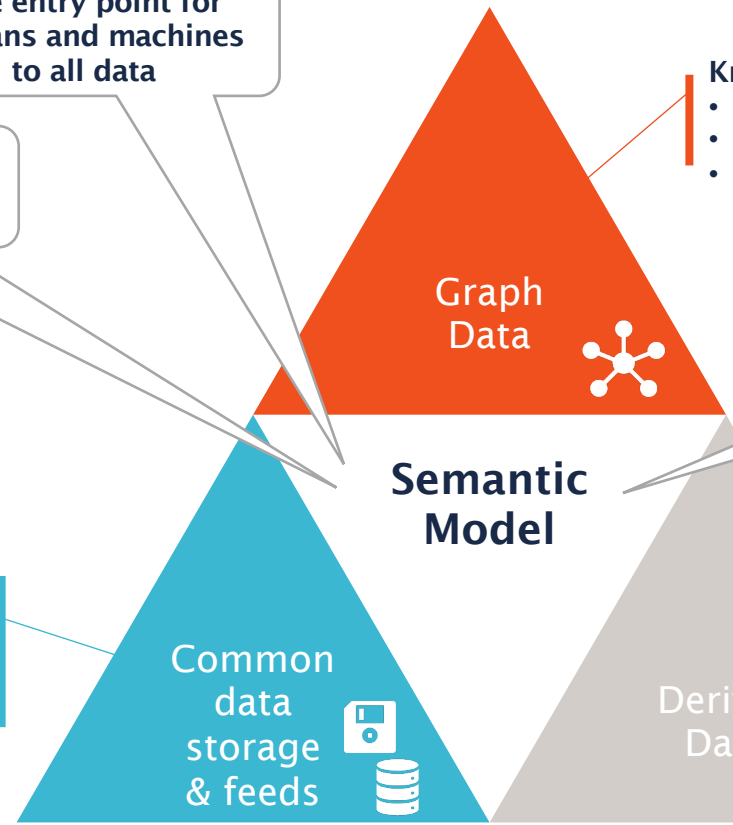
One entry point for humans and machines to all data

Describe and integrate all data

Enable reusability across use cases & projects



Knowledge Graph
- Metadata to describe other data
- Highly connected data directly maintained here
- URIs to link “each data point” uniquely

Common Data Storage & Data Feeds
- Siloed RDMS
- File storage / Document stores
- Data archive
- Data lake
- Data warehouse
- Data feeds (sensor data, stock price,..)

Derived Knowledge
- Learned via AI/ML
- Inferred and reasoned from the Knowledge Graph
- Computed from raw data

metaphactory accelerates knowledge graph adoption

metaphacts

Improve data literacy across the enterprise

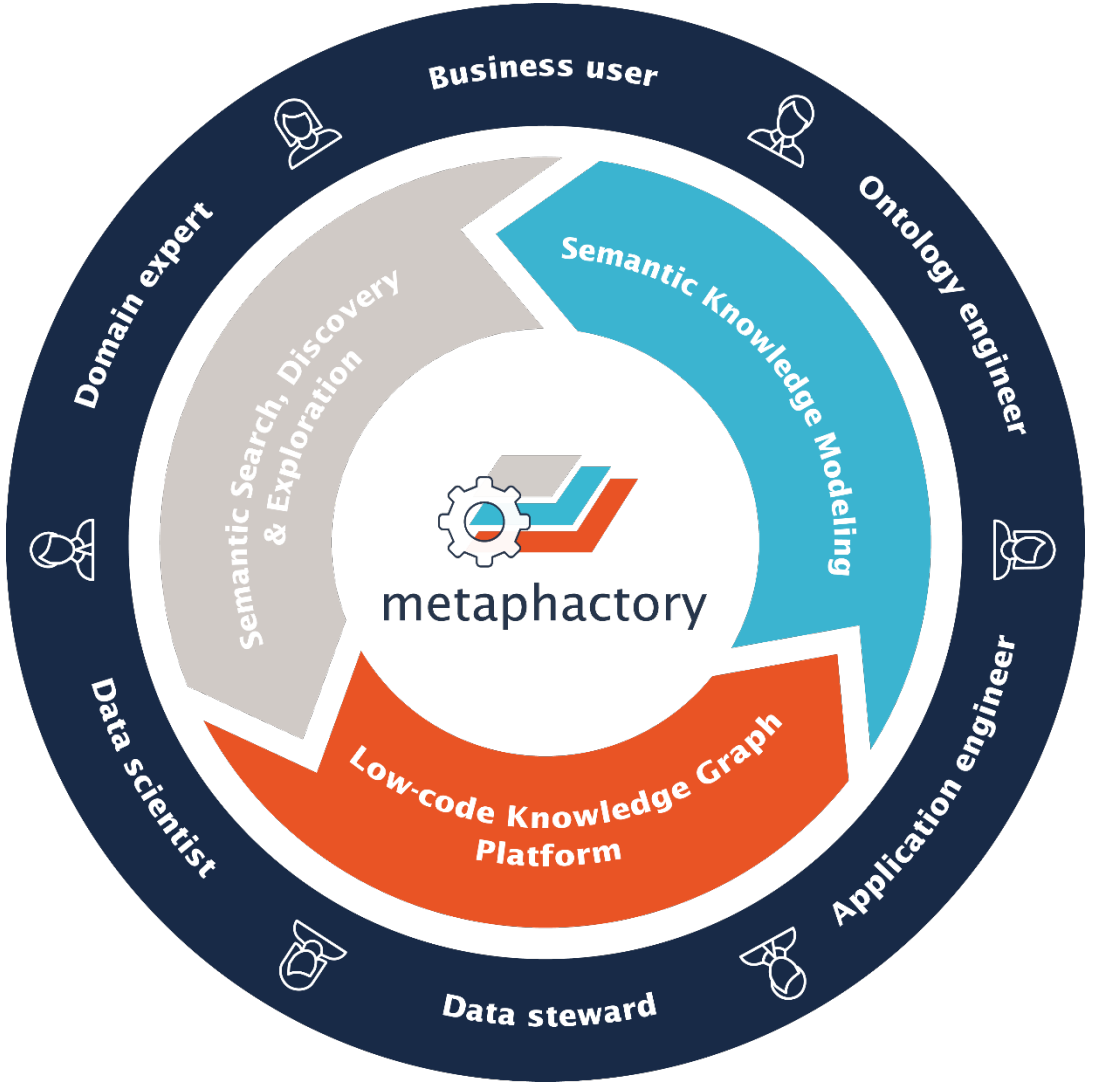
- Out-of-the-box, intuitive interfaces for searching, browsing & exploring your Knowledge Graph

Capture hidden expert knowledge in your knowledge model

- Visual ontology modeling for domain experts & business users; Taxonomy & Dataset management

Build Knowledge Graph applications to match your enterprise requirements

- Low-code approach to building custom interfaces that enable business-user interaction with the Knowledge Graph



metaphactory – Knowledge Democratization Platform

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KNOWLEDGE GRAPH MANAGEMENT

Visual authoring, visualization, versioning & cataloging of ontologies, vocabularies, datasets & queries

Data validation, provenance & lineage

END-USER ORIENTED INTERACTION

Abstracted view

One-stop knowledge hub

Intuitive UI for knowledge discovery, exploration, analytics, editing

KNOWLEDGE GRAPH APPLICATION BUILDING

Low-code platform

Powerful template engine

Large library of Web components

Easy customization

DATA INTEGRATION & FEDERATION

Unified view on distributed and heterogenous data sources: graph databases, relational databases, REST APIs, machine learning algorithms

Transparent SPARQL federation

MIDDLEWARE SERVICES

Dynamic data-driven REST APIs based on queries

Role-based access control

Lookup & Reconciliation

Tableau – Web Data Connector Endpoint

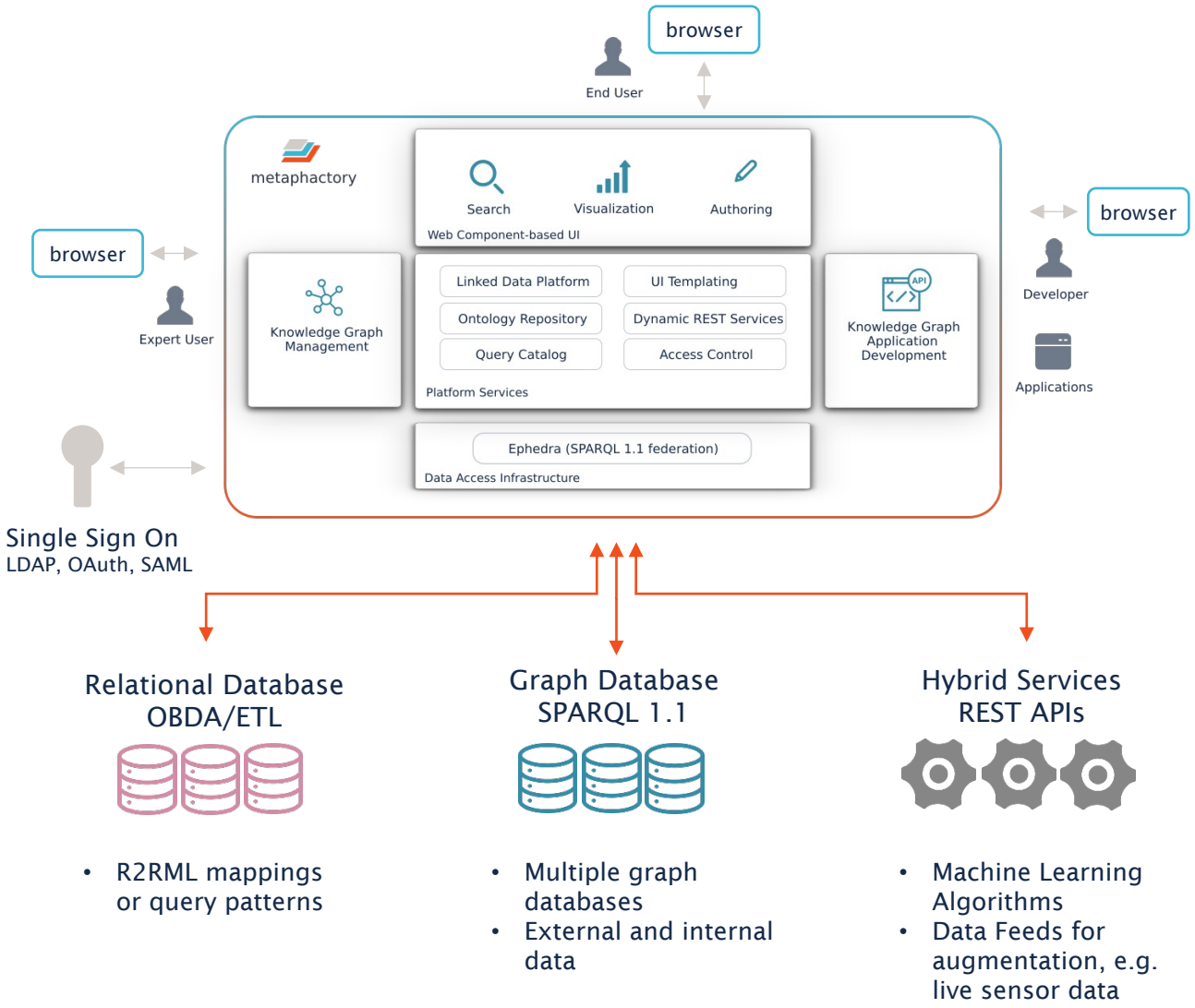
W3C®

Run anywhere

git

FAIR: Findable Accessible Interoperable Reusable

Enterprise Knowledge Graphs Span Multiple Data Spaces



- R2RML mappings or query patterns

- Multiple graph databases
- External and internal data

- Machine Learning Algorithms
- Data Feeds for augmentation, e.g. live sensor data

Advantages of Enterprise Knowledge Graphs

- Unlock isolated data silos
- Query across data sources
- 360˚ view on data

Ephedra – metaphactory's federation engine

Virtual and materialized integration of multiple data sources

- Graph databases
- Relational databases
- Compute services
- REST APIs

Building the knowledge graph

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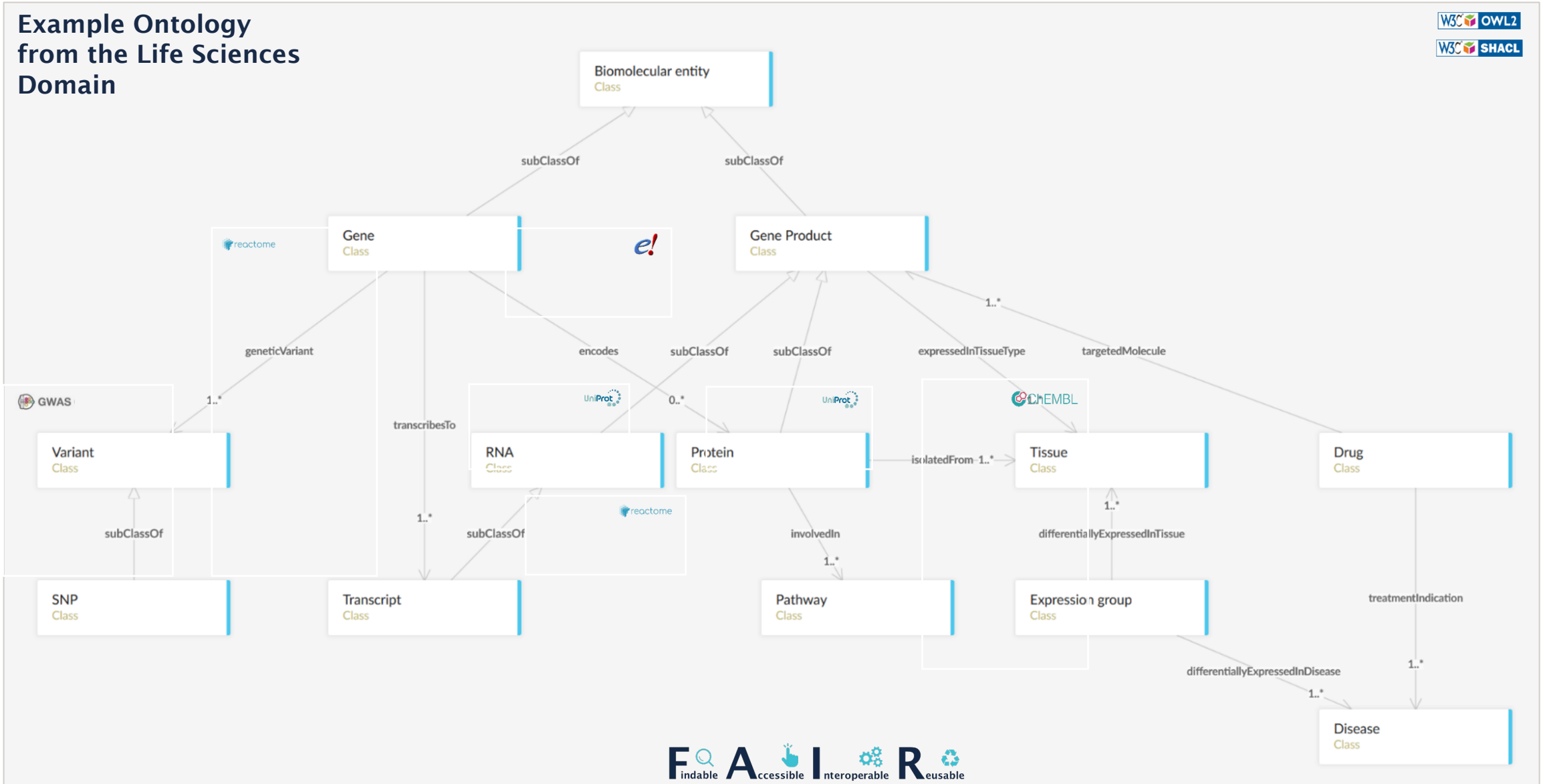
Example Ontology from the Life Sciences Domain



Empowering end users to consume knowledge

Low-code Platform

- Declarative, data-driven Web components
- Ontology-based templating
- Fully configurable to end-user requirements (UI/UX)
- Customized UI for a familiar look & feel
- Support for agile project setup with iterative approach to match end-user expectations
- Very fast data-to-interface iterations possible (rapid prototyping)

How Industry 4.0 Use Cases Benefit from Using Semantic Technologies

Smart Manufacturing at Siemens with KGs

Creating a production plan:

- Choosing the right tools (skills)
- Aligning them in a processes
  - Compatibility of tools
  - Sequence of production steps
  - Availability of materials

→ Requires experts to create a production plan (time, knowledge, setup costs). Only worth for large batches

Can this be automated?
Can we make this smart?

Download the full case study on our website

Smart Manufacturing at Siemens Technology

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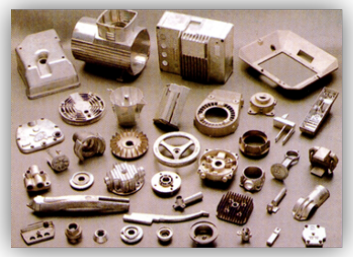

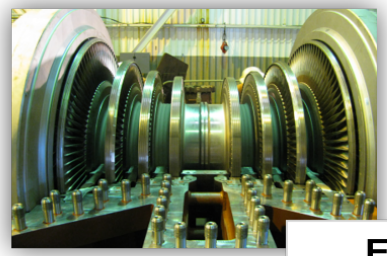

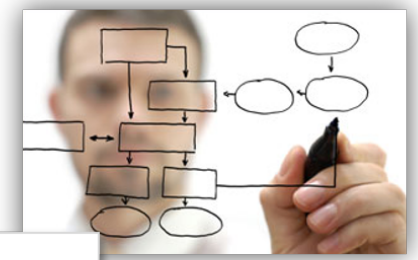

Ontology for Representing Digital Twins of Technical Machinery – Equipment, Material & Processes

Interactive skill matching

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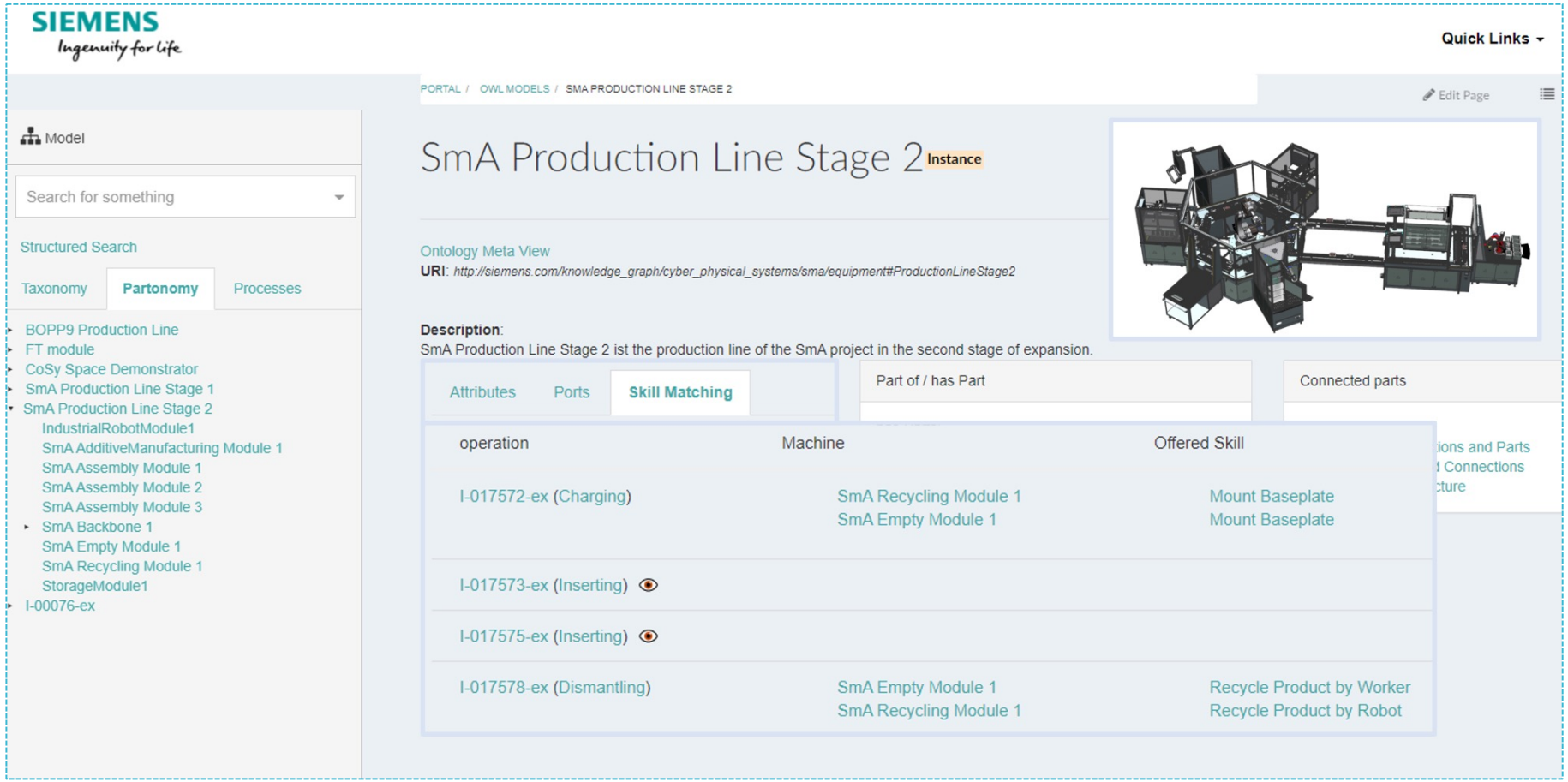
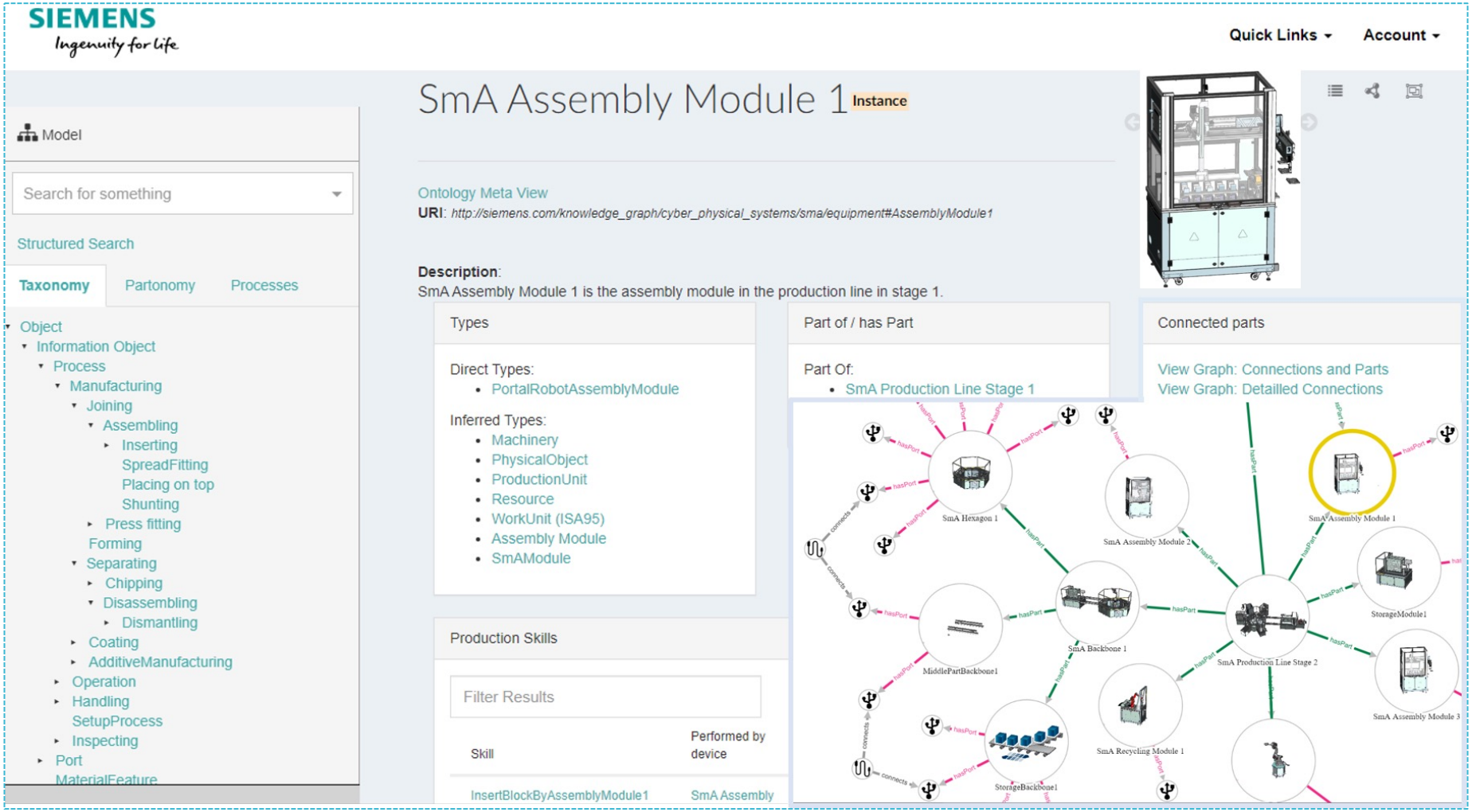


Interactive skill matching of production operations against the skills of a production line

Visualization of manufacturing knowledge in metaphactory



Visualization of manufacturing knowledge in metaphactory for user interaction and transparency over the knowledge graph

Smart Manufacturing at Siemens Technology

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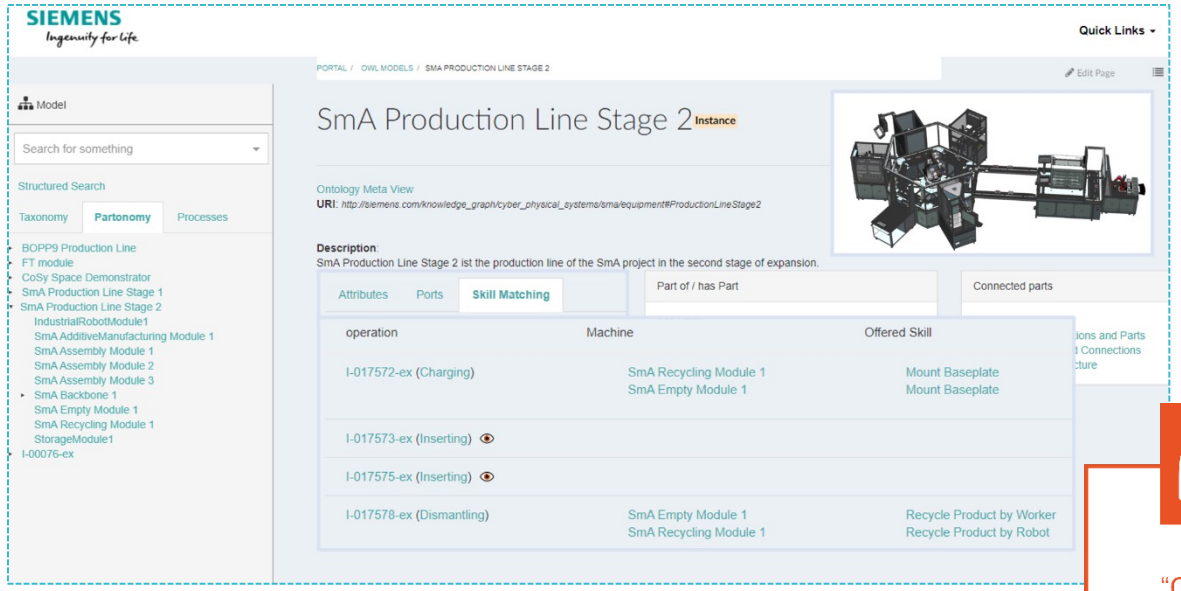
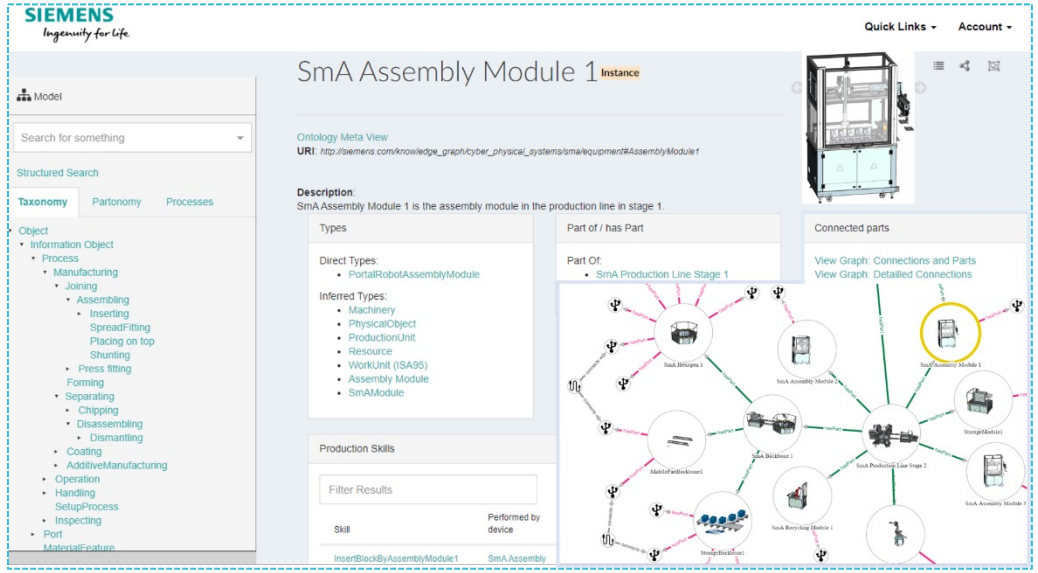




"ONE OF THE REASONS WE CHOSE METAPHACTS WAS BECAUSE OF THEIR EXPERTISE WITH CREATING AND MANAGING ENTERPRISE KNOWLEDGE GRAPHS AND BUILDING TAILORED APPLICATIONS ON-TOP."

Steffen Lamparter
Head of Research Group on
Semantics and Reasoning
Siemens Corporate Technology

EXECUTIVE SUMMARY

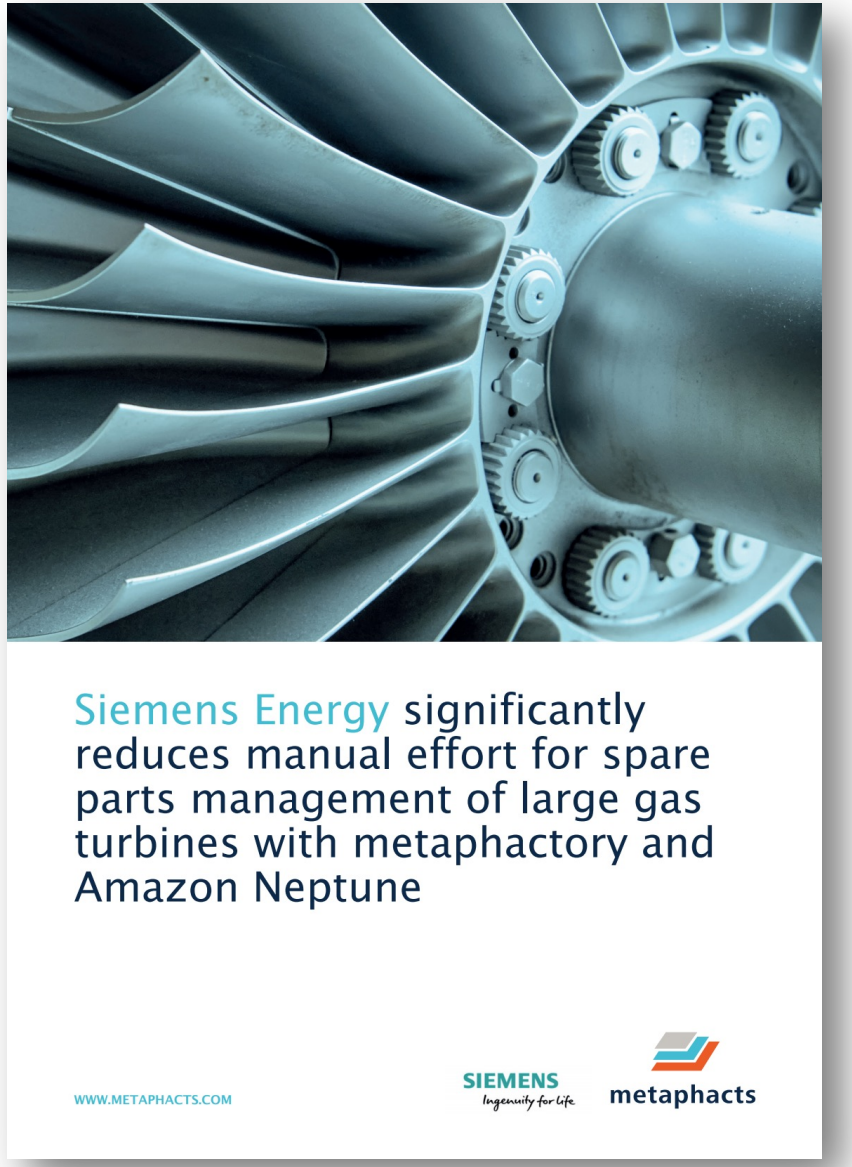
Smart Manufacturing Planning and Execution

- **Manufacturing Knowledge Graph** to capture heterogeneous data sources and expert knowledge
- **AI-based knowledge graph application** to automate the allocation of suitable production equipment
- **Reduced number of plans** human manufacturing planners need to review from approx. 1,400 to just 40
- Feasible and affordable realization of **low-volume orders**

Turbine Spare Part Management at Siemens Energy

- Turbines are complex engineering products
- Individually tailored to a customer use case
- Heterogeneous digital representations of turbine configurations and a multitude of customer-specific spare parts catalogs and maintenance packages

- Downtimes are costly



Turbine Spare Part Management at Siemens Energy

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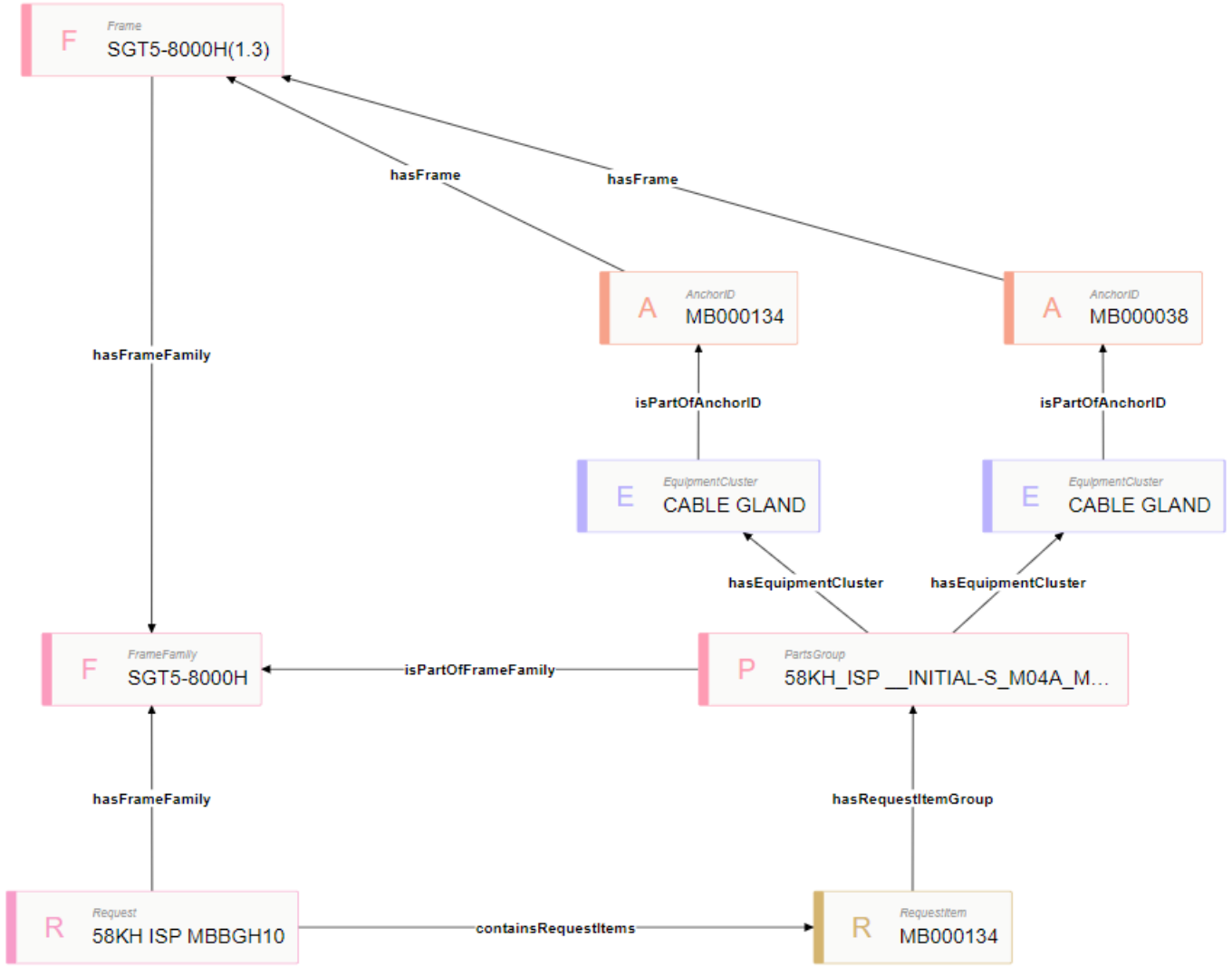

Excerpt of the Knowledge Graph showing a request item and connected resources

Turbine Spare Part Management at Siemens Energy

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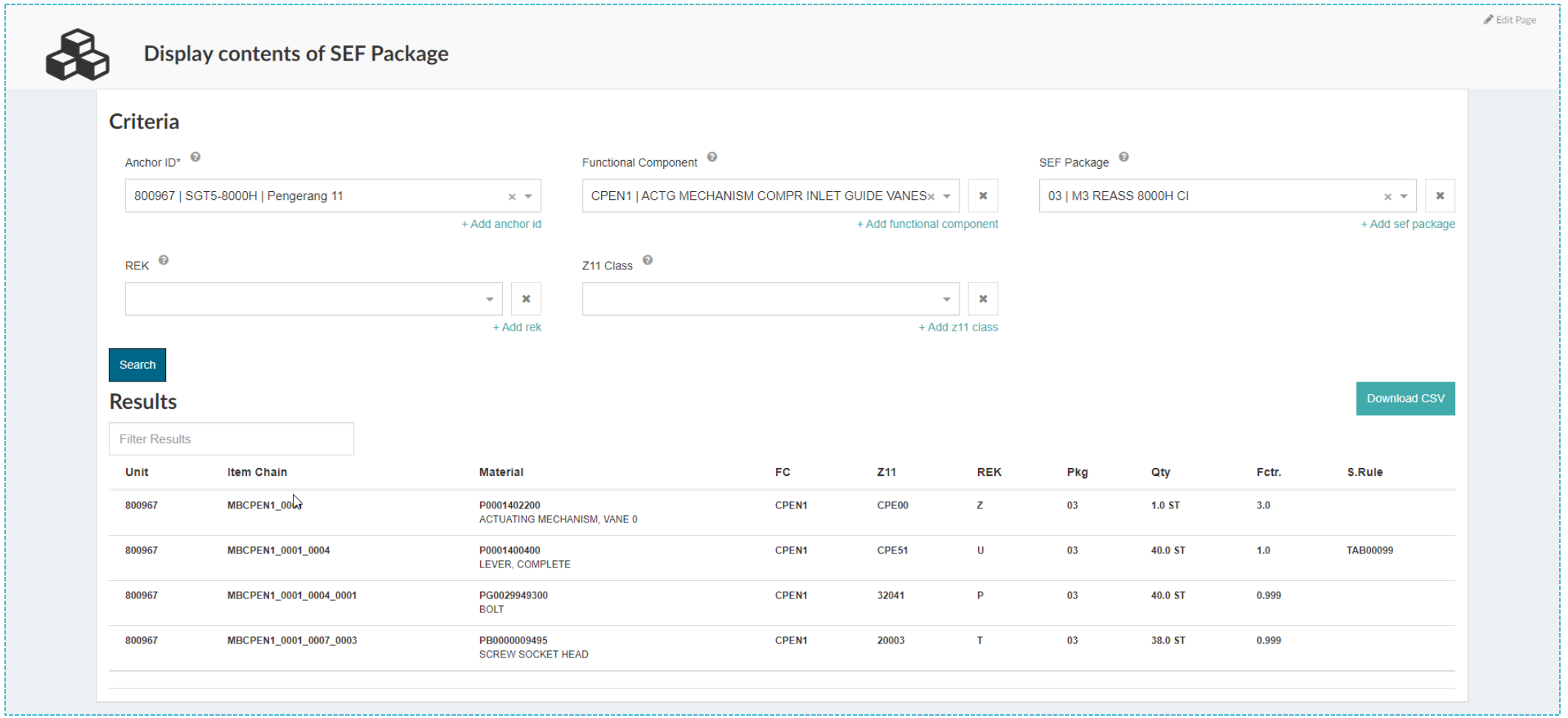

Intuitive end-user search interface across the fleet of large gas turbines

Turbine Spare Part Management at Siemens Energy

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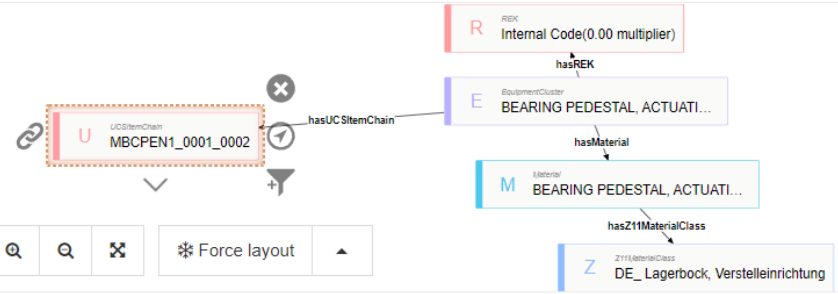
Edit Page

SEF Package Item Analysis

Your selection:



Save diagram | Force layout

All the parents till functional component head

Filter Results

Unit	Item Chain	Material	FC	Z11	REK	Pkg	Qty	Fctr.	Var.	S.Rule	EQC	CC	Analyze
800967	MBCPEN1	P0064860100 ACTUATION MECHANISM, VANES	CPEN1				1.0 ST				ACTUATION MECHANISM, VANES		
800967	MBCPEN1_0001	P0001402200 ACTUATING MECHANISM, VANE 0	CPEN1	CPE00	Z		1.0 ST				ACTUATING MECHANISM, VANE 0		

Visual exploration of spare parts

Live sensor data integration with the Knowledge Graph

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Real-time Live Sensor Data Retrieved via Federation and Virtually Integrated with the Knowledge Graph

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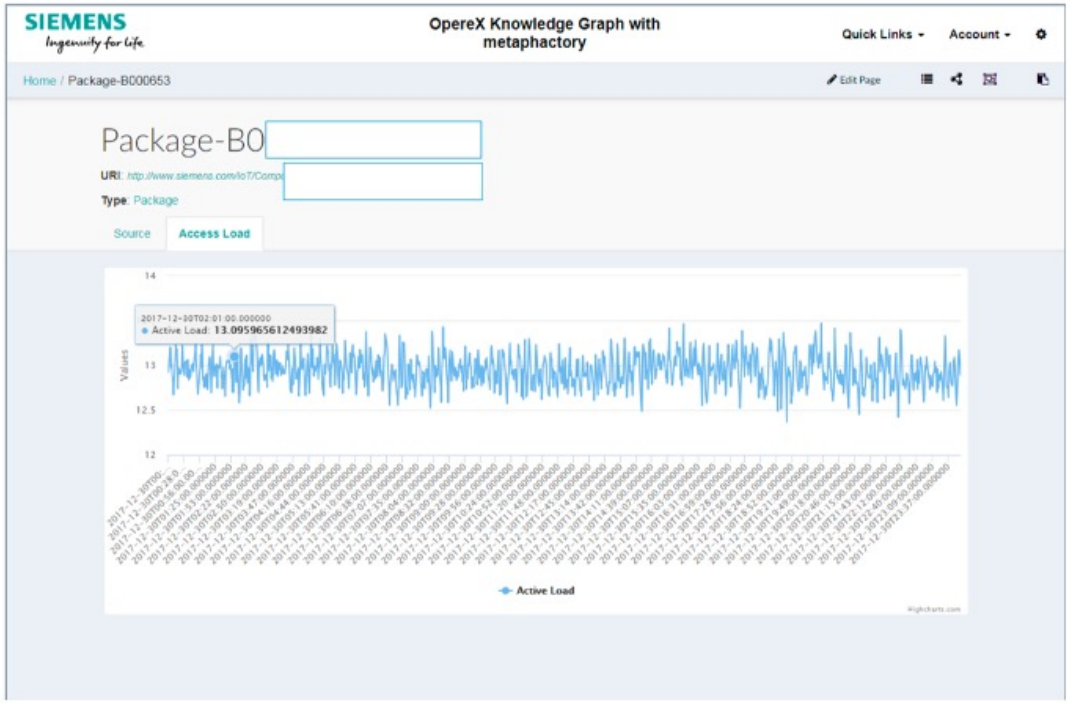

Ephedra Federation

- External time-series data is virtually integrated with the Knowledge Graph
- End users have one integrated view
- Siemens Mindsphere

Hubauer, Thomas, Steffen Lamparter, Peter Haase, and Daniel Markus Herzig.
"Use Cases of the Industrial Knowledge Graph at Siemens." In *ISWC (P&D Industry)*. 2018.

Turbine Spare Part Management at Siemens Energy

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SIEMENS
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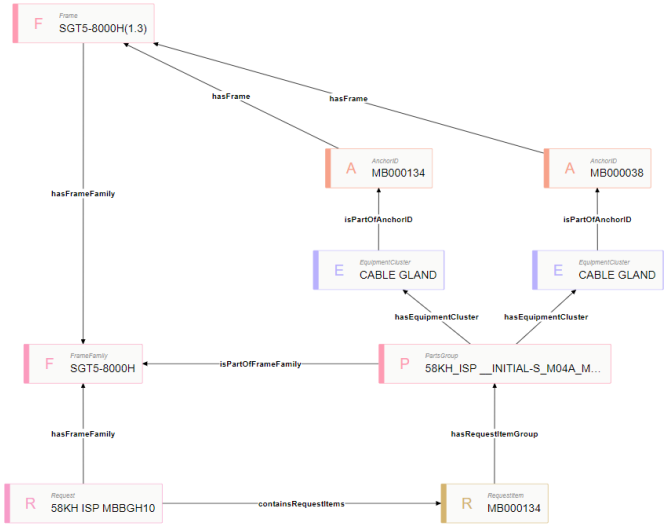
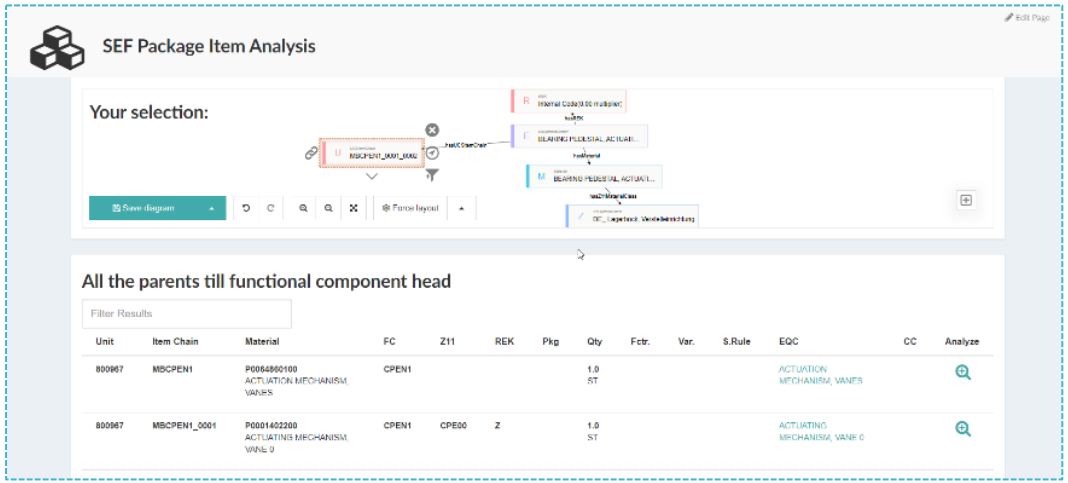
> "THE KEY ADVANTAGE OF METAPHACTORY WAS THAT WE COULD EASILY VISUALIZE OUR DATA DURING DEVELOPMENT FOR EARLY FEEDBACK FROM THE BUSINESS ALLOWING FOR DATA QUALITY IMPROVEMENTS, AND FAST AND TARGET-FOCUSED DEVELOPMENT OF OUR DATA MODEL AND APPLICATION."
>
> **Paul Zolnowski**
> Section Lead- Post Documentation, Siemens Energy





EXECUTIVE SUMMARY

Goal: Smart and targeted maintenance of spare parts of large gas turbines

Challenge: Heterogeneous digital representations of turbine configurations and a multitude of customer-specific spare parts catalogs and maintenance packages

Solution: Knowledge Graph driven application for fleet-wide analysis of turbine configurations and spare parts

Results:

- Shorter time to market of the business solution through rapid application development
- Efficient identification and management of spare parts, resulting in higher productivity and yearly time savings of up to 1,500 hours
- Increased business user and customer satisfaction

DEMO

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- We support research!
  - Ask for an edu instance or academic license

- https://metaphacts.com/get-started
  - Request a demo instance, runs for two weeks
    or get a docker image and run it on your laptop

metaphactory trial

metaphacts

- **https://metaphacts.com/get-started**
- **Get a docker image** and run it on your laptop
- **Also available on** aws marketplace

Control over your graph database choice

metaphactory is validated on: Stardog, Ontotext GraphDB, Amazon Neptune, Blazegraph DB, Franz Inc. AllegroGraph, MarkLogic, Oracle Spatial and Graph, OpenLink Virtuoso, RDFox, and AnzoGraph.

Tutorials to get you started included

Immediate access after registration

14-day trial period

Full & exclusive control over your instance

Bring your own data or use our tutorial dataset

Free support during the trial period

Join us!

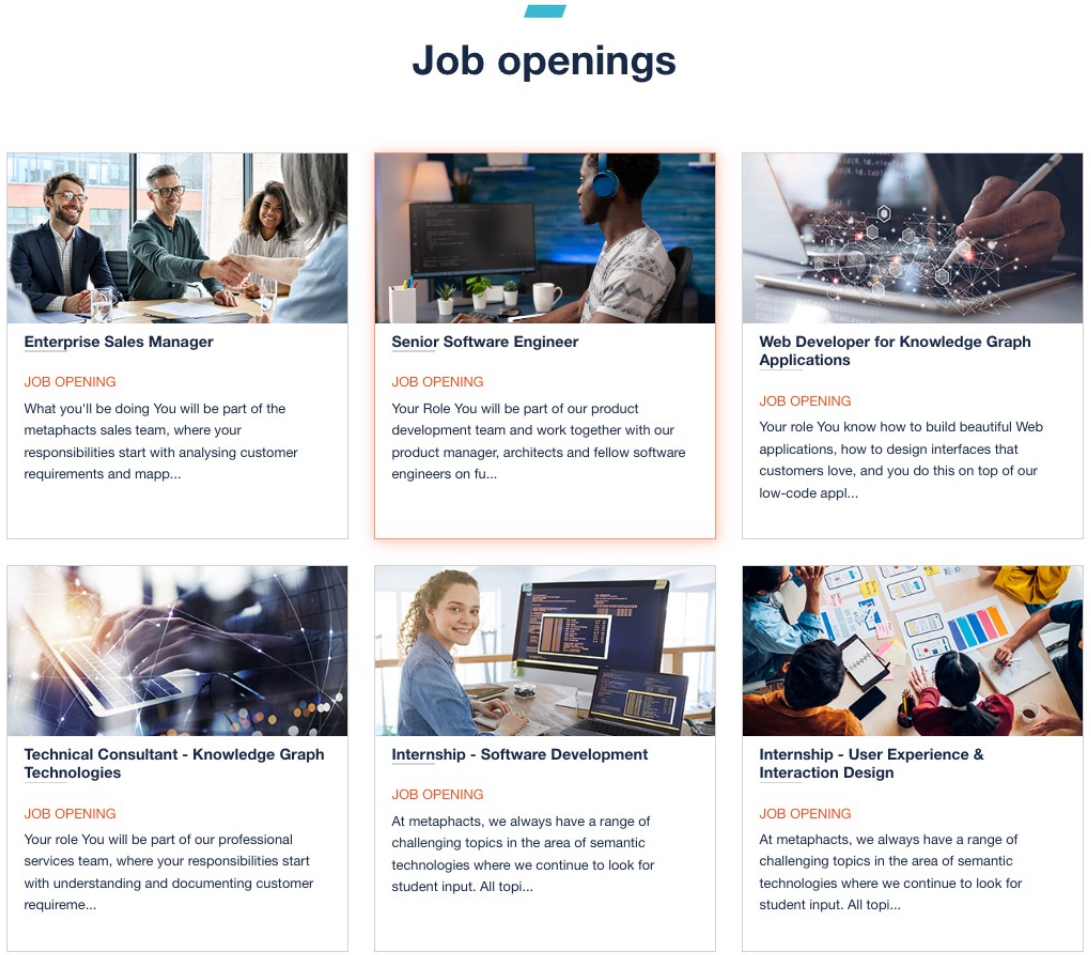
While in academia

- Internships on selected topics
- Theses and disseration topics
- Cooperations in research projects

After graduation

- Open entry level and senior positions
- Locations across the globe and remote work possible

Talk to us! ☺



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