



metaphacts

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

- 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



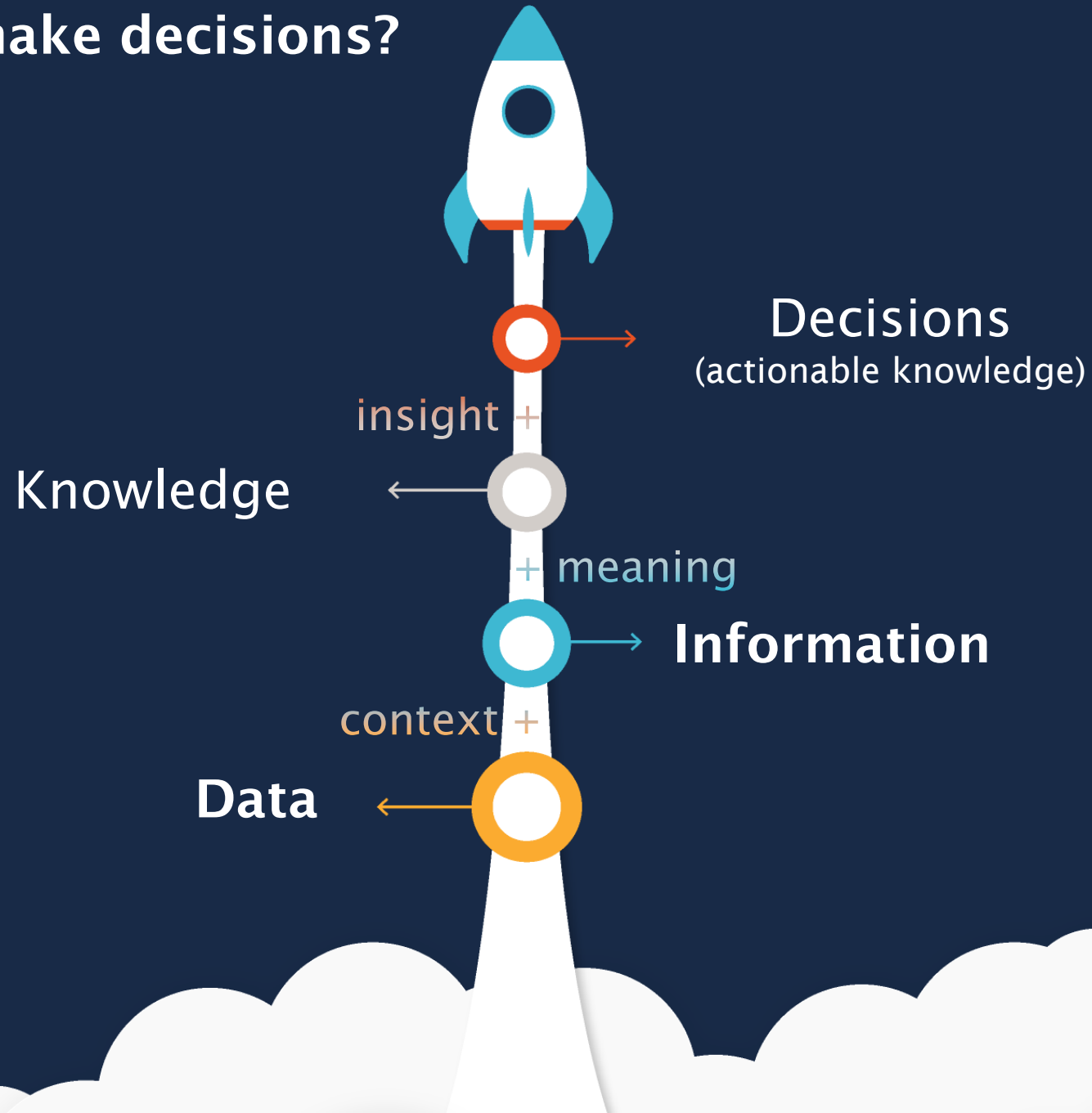
metaphacts

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?



Some metaphacts customers



SIEMENS
ENERGY



 **BOSCH**



 **Boehringer
Ingelheim**



 NLB | National Library
Singapore



SIEMENS



 **BKW**



SCHAEFFLER



 Swiss
Art
Research
Infrastructure




SANOFI



FOODIE

FARM-ORIENTED OPEN DATA IN EUROPE



sapia



 Agriculture and
Agri-Food Canada



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

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



- ✓ 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



- ✓ 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 »](#)

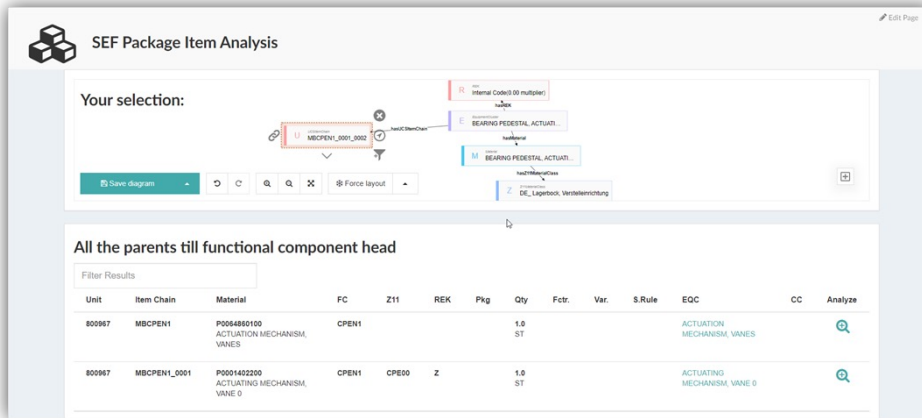
Other customers in this sector



SCHAEFFLER

Engineering & Manufacturing Demo

Turbine Spare Parts Management



SEF Package Item Analysis

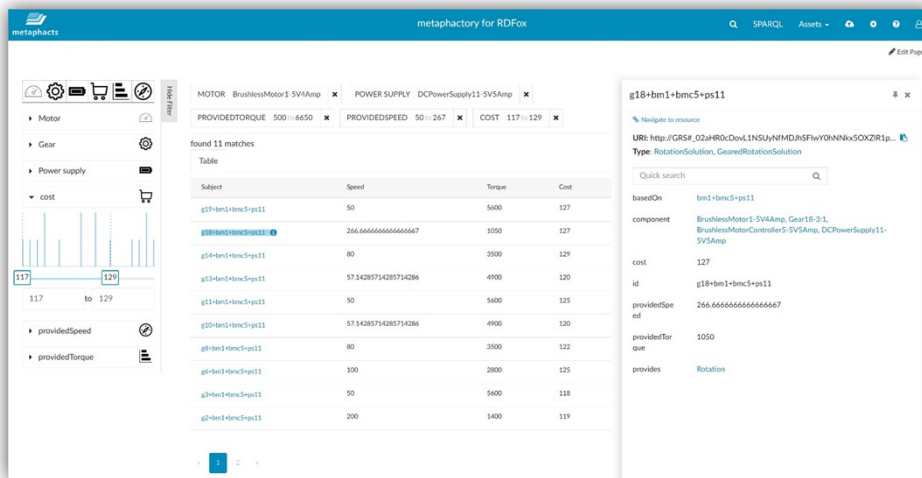
Your selection:

All the parents till functional component head

Unit	Item Chain	Material	FC	Z11	REK	Pkg	Qty	Fctr.	Var.	S.Rule	EOC	CC	Analyze
80067	MBCPEN1	P0064880100 ACTUATING MECHANISM, VANE	CPEN1				1.0 ST				ACTUATING MECHANISM, VANE		
80067	MBCPEN_0001	P0001402200 ACTUATING MECHANISM, VANE 0	CPEN1	CPE00	Z		1.0 ST				ACTUATING MECHANISM, VANE 0		

Application developed by
**SIEMENS
ENERGY**

Configuration Management Demo



metaphactory for RDX

MOTOR: BrushlessMotor1-5V5Amp x POWER SUPPLY: DCPowerSupply11-5V5Amp x

PROVIDEDTORQUE 500 : 6650 x PROVIDEDSPEED 50 : 267 x COST 117 : 129 x

found 11 matches

Subject	Speed	Torque	Cost
g18+bm1+bm5+ps11	50	5600	127
g18+bm1+bm5+ps11	266.6666666666667	1050	127
g14+bm1+bm5+ps11	80	3500	129
g13+bm1+bm5+ps11	57.34285714285714286	4900	120
g11+bm1+bm5+ps11	50	5600	125
g10+bm1+bm5+ps11	57.34285714285714286	4900	120
g8+bm1+bm5+ps11	80	3500	112
g6+bm1+bm5+ps11	100	2800	125
g3+bm1+bm5+ps11	90	5600	118
g2+bm1+bm5+ps11	200	1400	119

g18+bm1+bm5+ps11

baseOn: bm1+bm5+ps11

component: BrushlessMotor1-5V5Amp, Gear18-2-1, BrushlessMotorController5-5V5Amp, DCPowerSupply11-5V5Amp

cost: 127

id: g18+bm1+bm5+ps11

providedSpeed: 266.6666666666667

providedTorque: 1050

provides: Rotation

Developed together with



Omics Data Management



- ✓ 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 »](#)

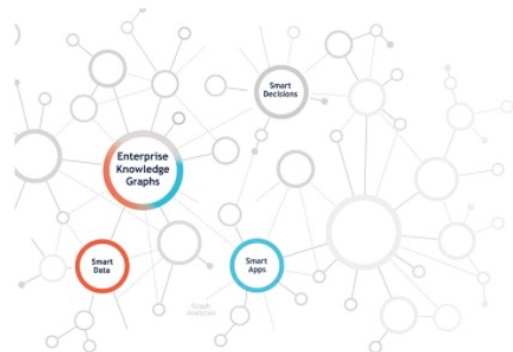
Enterprise Data Fabric

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

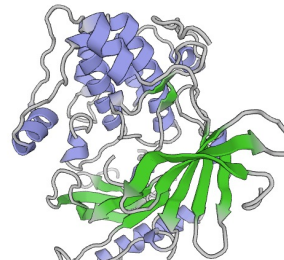
[Watch now »](#)

Omics Data Management Demo



AKT1_HUMAN
RAC-alpha serine/threonine-protein kinase

Overview ChEMBL Ensembl Reactome GWAS Citations (UniProt) Protein Viewer Drugs



Enter search term here



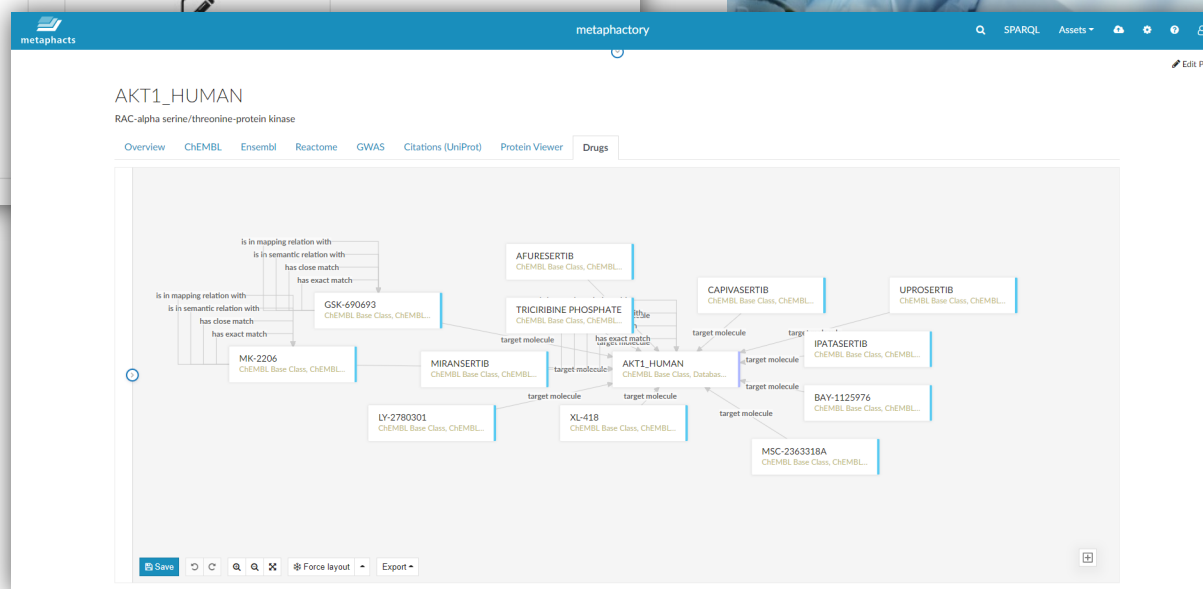
Protein
192655



Gene
24536



Disease
39863



metaphactory

AKT1_HUMAN
RAC-alpha serine/threonine-protein kinase

Overview ChEMBL Ensembl Reactome GWAS Citations (UniProt) Protein Viewer Drugs

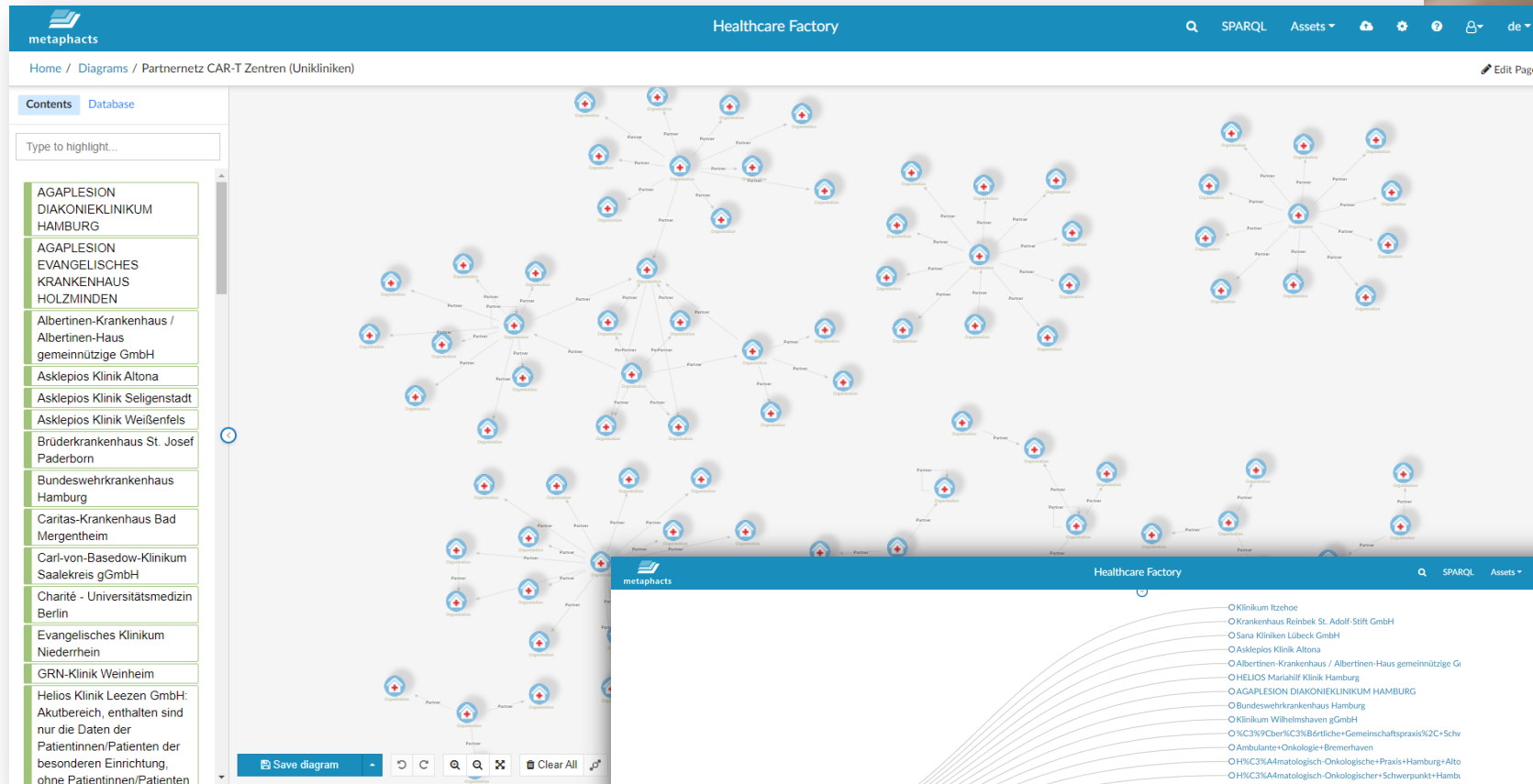
Knowledge graph showing relationships between AKT1_HUMAN and various drugs (e.g., AFURESERTIB, TRICIRIBINE PHOSPHATE, CAPIVASERTIB, UPROSERTIB, IPATASERTIB, BAY-1125976, MSC-2363318A, LY-2780301, XL-418, MIRANSERTIB, MK-2206, GSK-690693) and their classes (CHEMBL Base Class, CHEMBL...).

Buttons: Save, Force layout, Export

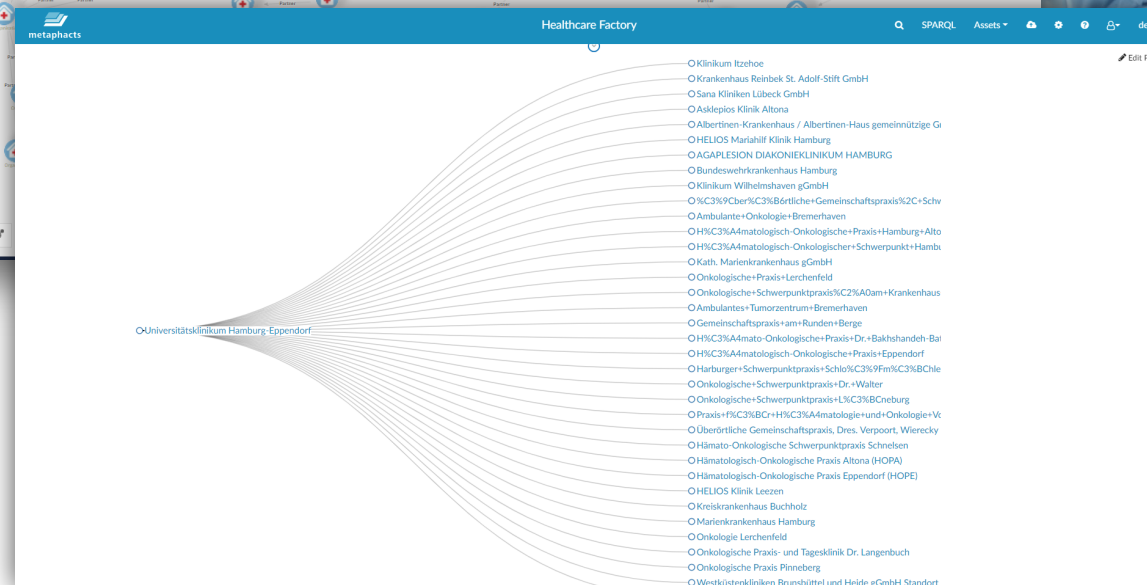
Developed together with



Market Access Demo



The screenshot shows the 'Healthcare Factory' web application. The top navigation bar includes 'metaphacts', 'Healthcare Factory', and search options for 'SPARQL', 'Assets', and user settings. The breadcrumb trail reads 'Home / Diagrams / Partnernetz CAR-T Zentren (Unikliniken)'. On the left, a 'Contents' sidebar lists various hospital names, with 'AGAPLESION DIAKONIEKLINIKUM HAMBURG' selected. The main area displays a complex network diagram where nodes represent hospitals and lines represent partnerships. A 'Save diagram' button and search tools are visible at the bottom of the diagram area.



This screenshot shows a detailed view of a node from the network diagram. The node is labeled 'Universitätsklinikum Hamburg - Eppendorf'. A list of associated hospital names is displayed on the right side of the interface, including:

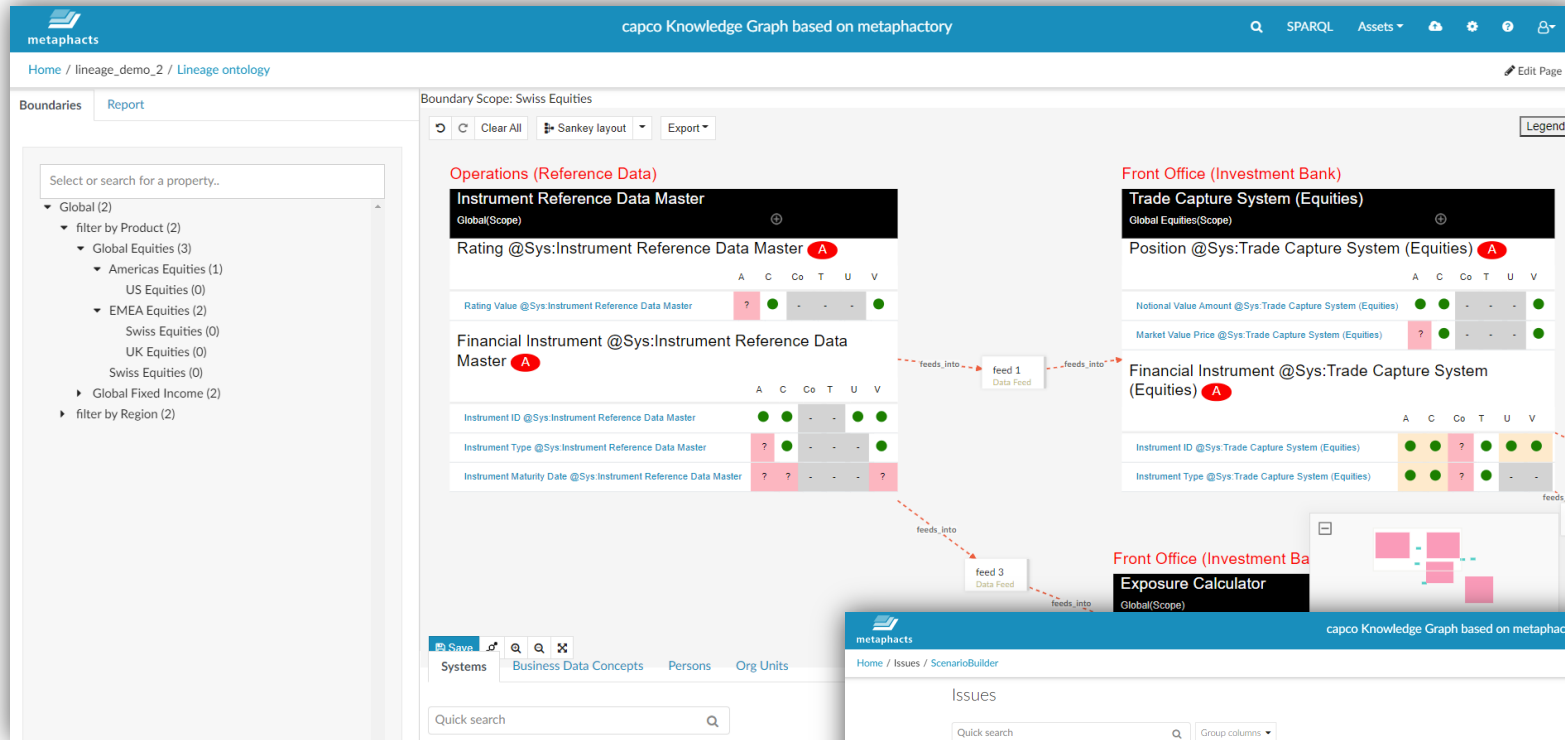
- Klinikum Itzehoe
- Krankenhaus Reinbek St. Adolf-Stift GmbH
- Sana Kliniken Lübeck GmbH
- Asklepios Klinik Altona
- Albertinen-Krankenhaus / Albertinen-Haus gemeinnützige Gr.
- HELIOS Mariahilf Klinik Hamburg
- AGAPLESION DIAKONIEKLINIKUM HAMBURG
- Bundeswehrkrankenhaus Hamburg
- Klinikum Wilhelmshaven gGmbH
- %C3%9Cber%C3%B6rtliche+Gemeinschaftspraxis%2C+Schw
- Ambulante+Onkologie+Bremerhaven
- H%3C3%Amatologisch-Onkologischer+Praxis+Hamburg+Alto
- H%3C3%Amatologisch-Onkologischer+Schwerpunkt+Hamb
- Kath. Marienkrankenhaus gGmbH
- Onkologische+Praxis+Lerchenfeld
- Onkologische+Schwerpunktpraxis%2%AQam+Krankenhaus
- Ambulantes+Tumorzentrum+Bremerhaven
- Gemeinschaftspraxis+am+Runden+Berge
- H%3C3%Amatologisch-Onkologischer+Praxis+Dr.+Balhohandeh-Bar
- H%3C3%Amatologisch-Onkologischer+Praxis+Eppendorf
- Harburger+Schwerpunktpraxis+Schlo%3C3%9Ffr%3C3%BChe
- Onkologische+Schwerpunktpraxis+Dr.+Walter
- Onkologische+Schwerpunktpraxis+L+%3C3%BCneburg
- Praxis+H%3C3%BC+H%3C3%Amatologie+und+Onkologie+Vt
- Überörtliche Gemeinschaftspraxis, Dres. Verpoort, Wierrecky
- Hämato-Onkologische Schwerpunktpraxis Schnelsen
- Hämatologisch-Onkologische Praxis Altona (HOPA)
- Hämatologisch-Onkologische Praxis Eppendorf (HOPE)
- HELIOS Klinik Leezen
- Kreiskrankenhaus Buchholz
- Marienkrankenhaus Hamburg
- Onkologie Lerchenfeld
- Onkologische Praxis- und Tagesklinik Dr. Langenbuch
- Onkologische Praxis Pinneberg
- Westküstenkliniken Brunsbüttel und Heide gGmbH Standort

Developed together with



**HEALTHCARE
FACTORY**

Data Lineage & Digital Twin Demo



capco Knowledge Graph based on metaphactory

Home / lineage_demo_2 / Lineage ontology

Boundary Scope: Swiss Equities

Operations (Reference Data)

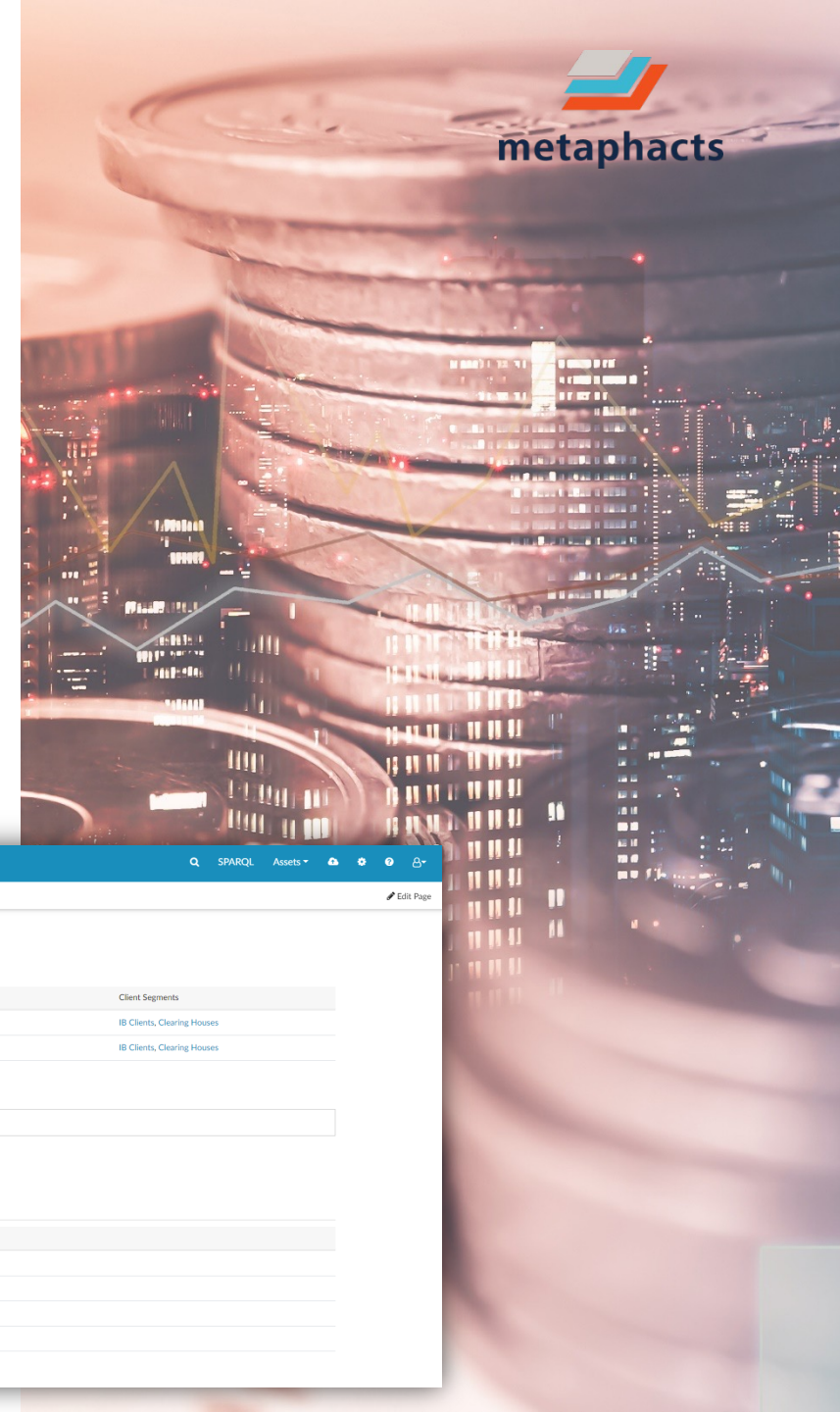
- Instrument Reference Data Master (Global(Scope))
- Rating @Sys:Instrument Reference Data Master (A)
- Financial Instrument @Sys:Instrument Reference Data Master (A)

Front Office (Investment Bank)

- Trade Capture System (Equities) (Global(Scope))
- Position @Sys:Trade Capture System (Equities) (A)
- Financial Instrument @Sys:Trade Capture System (Equities) (A)
- Exposure Calculator (Global(Scope))

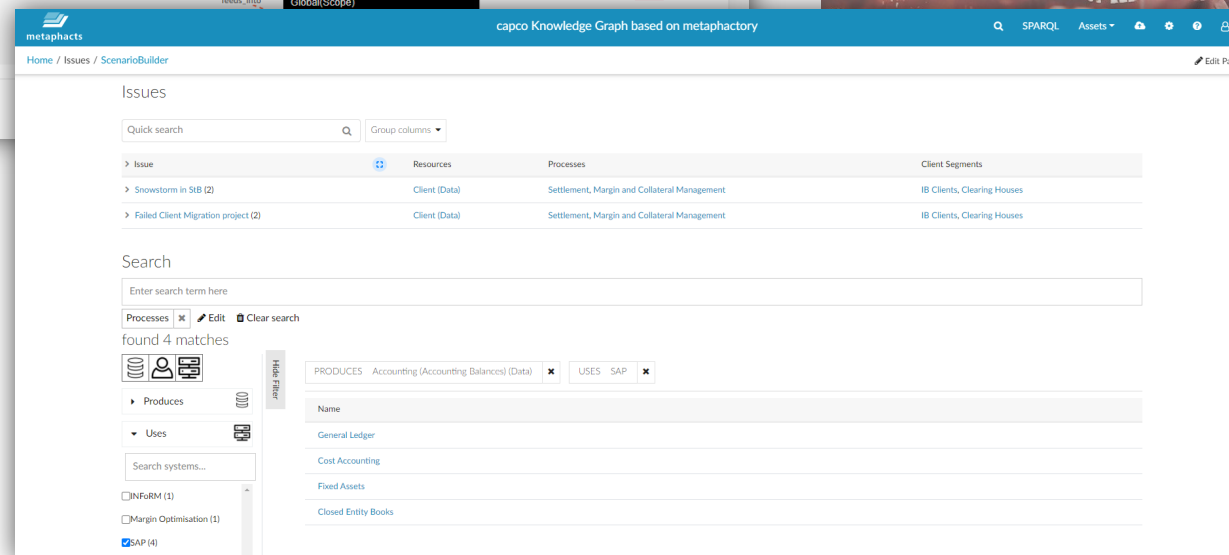
Legend

Quick search



Developed together with

CAPCO



capco Knowledge Graph based on metaphactory

Home / Issues / ScenarioBuilder

Issues

Issue	Resources	Processes	Client Segments
> Snowstorm in StB (2)	Client (Data)	Settlement, Margin and Collateral Management	IB Clients, Clearing Houses
> Failed Client Migration project (2)	Client (Data)	Settlement, Margin and Collateral Management	IB Clients, Clearing Houses

Search

Enter search term here

Processes x Edit Clear search

found 4 matches

PRODUCES Accounting (Accounting Balances) (Data) x USES SAP x

Name

- General Ledger
- Cost Accounting
- Fixed Assets
- Closed Entity Books

Search systems...

INFORM (1)

Margin Optimisation (1)

SAP (4)

F **indable**

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

A **ccessible**

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

I **nteroperable**

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

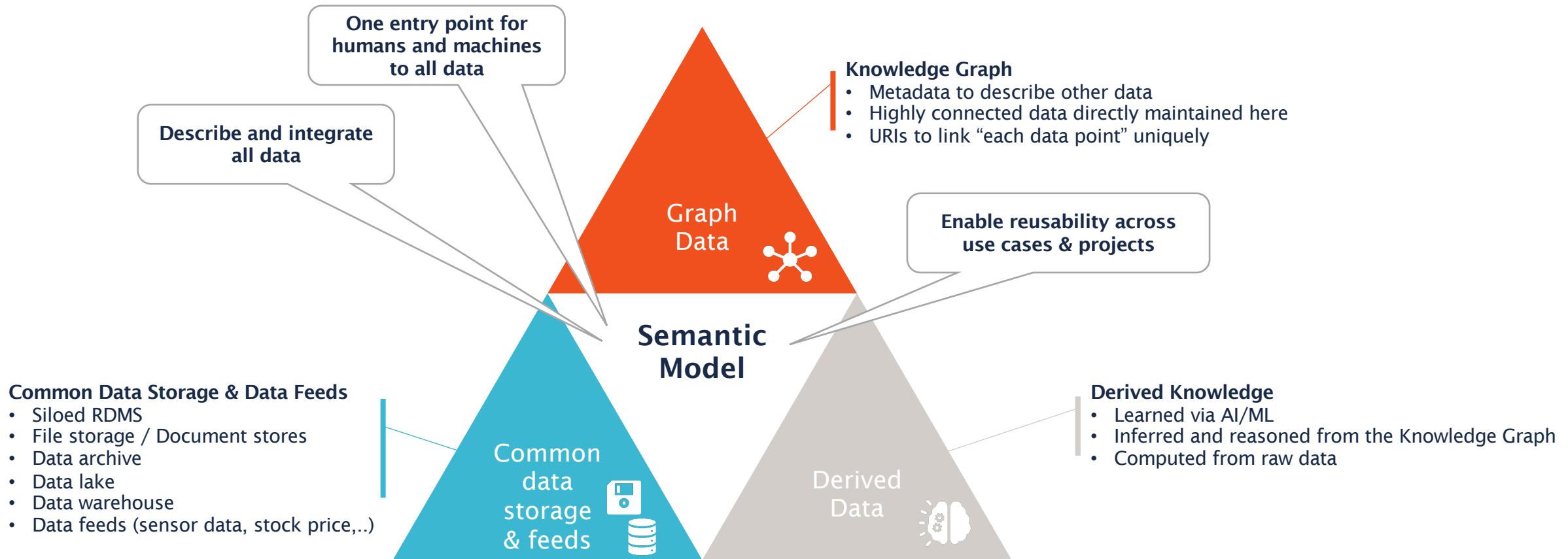
R **eusable**

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

Platform based on open standards

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

The semantic layer explained



Improve data literacy across the enterprise

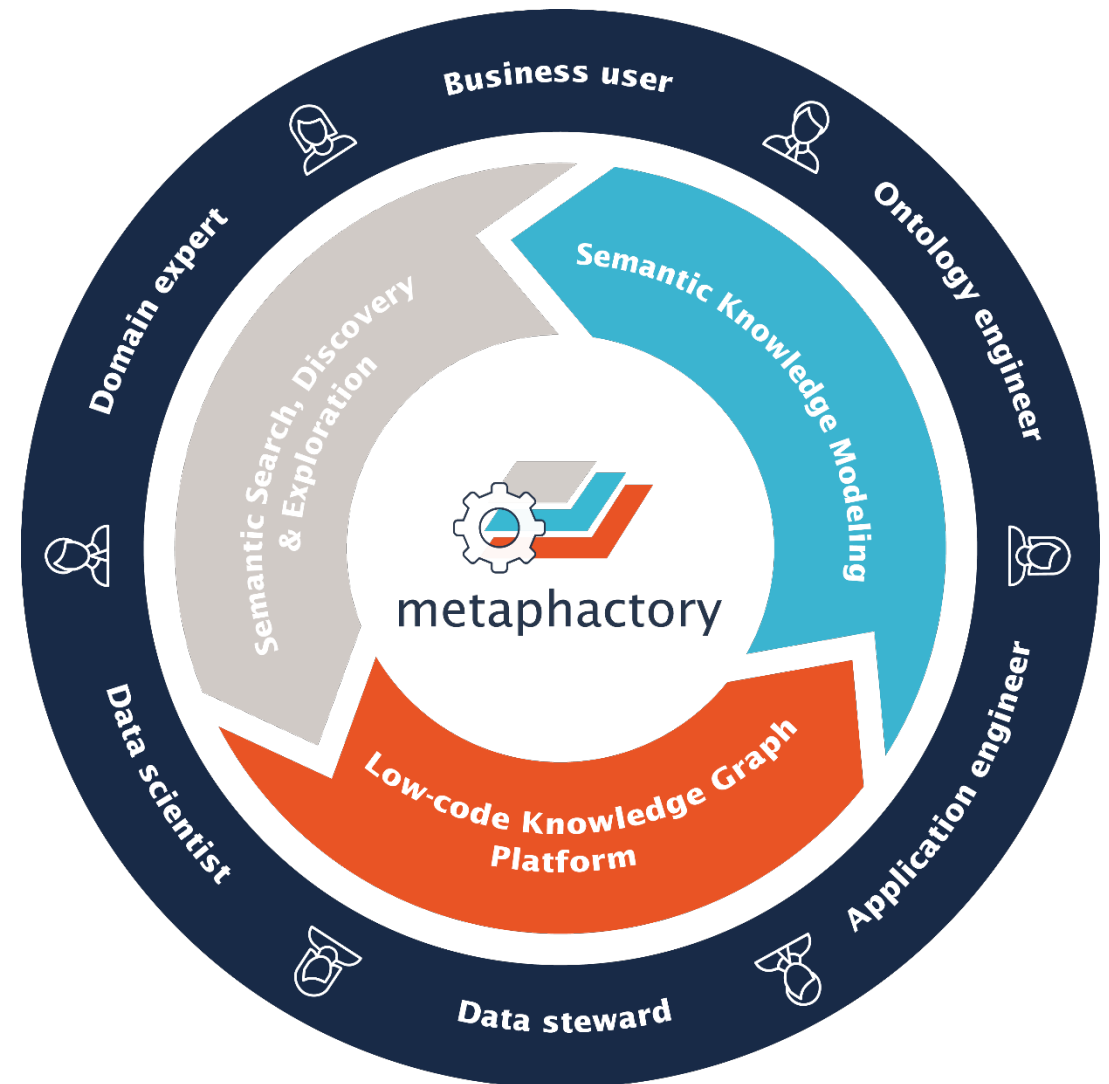
- › Out-of-the-box, intuitive interfaces for searching, browsing & exploring your Knowledge Graph

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



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



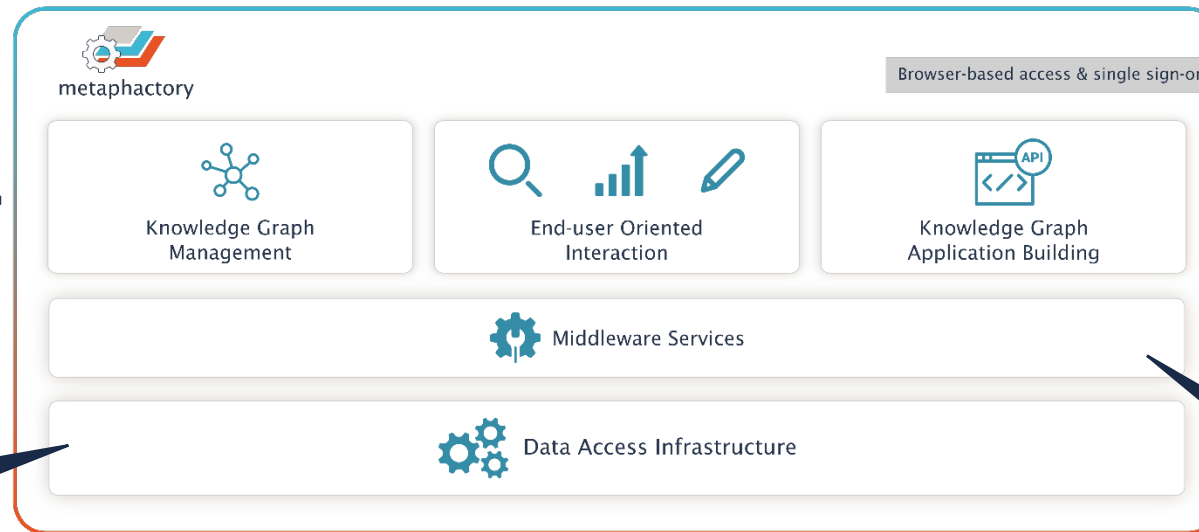
End User

DATA INTEGRATION & FEDERATION

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



Knowledge Graph Engineer



MIDDLEWARE SERVICES

Dynamic data-driven REST APIs based on queries
Role-based access control
Lookup & Reconciliation
Tableau – Web Data Connector Endpoint



✓ Run anywhere



Other Data Sources



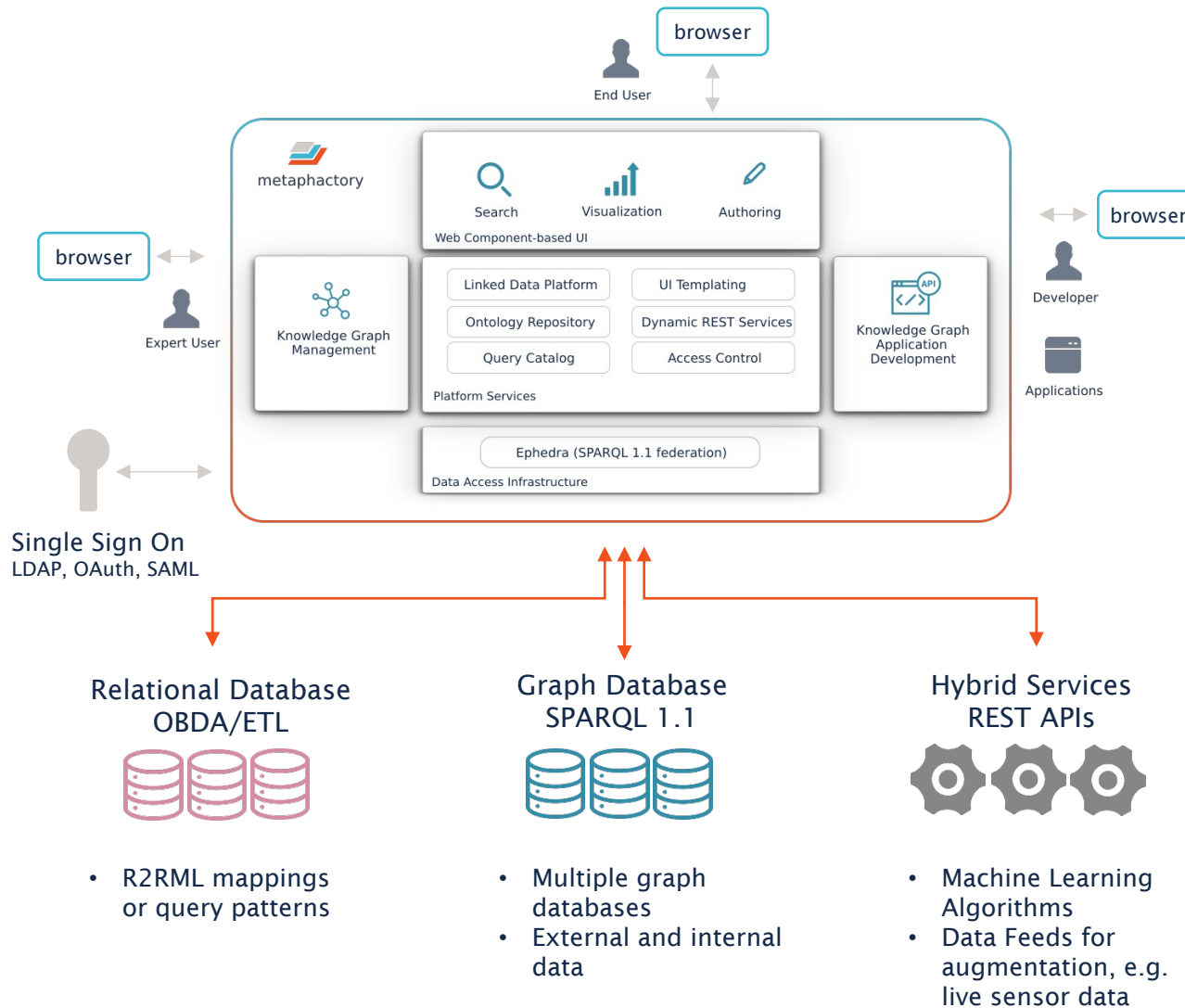
SPARQL 1.1 Graph Database



Data Processing Services



Enterprise Knowledge Graphs Span Multiple Data Spaces



Advantages of Enterprise Knowledge Graphs

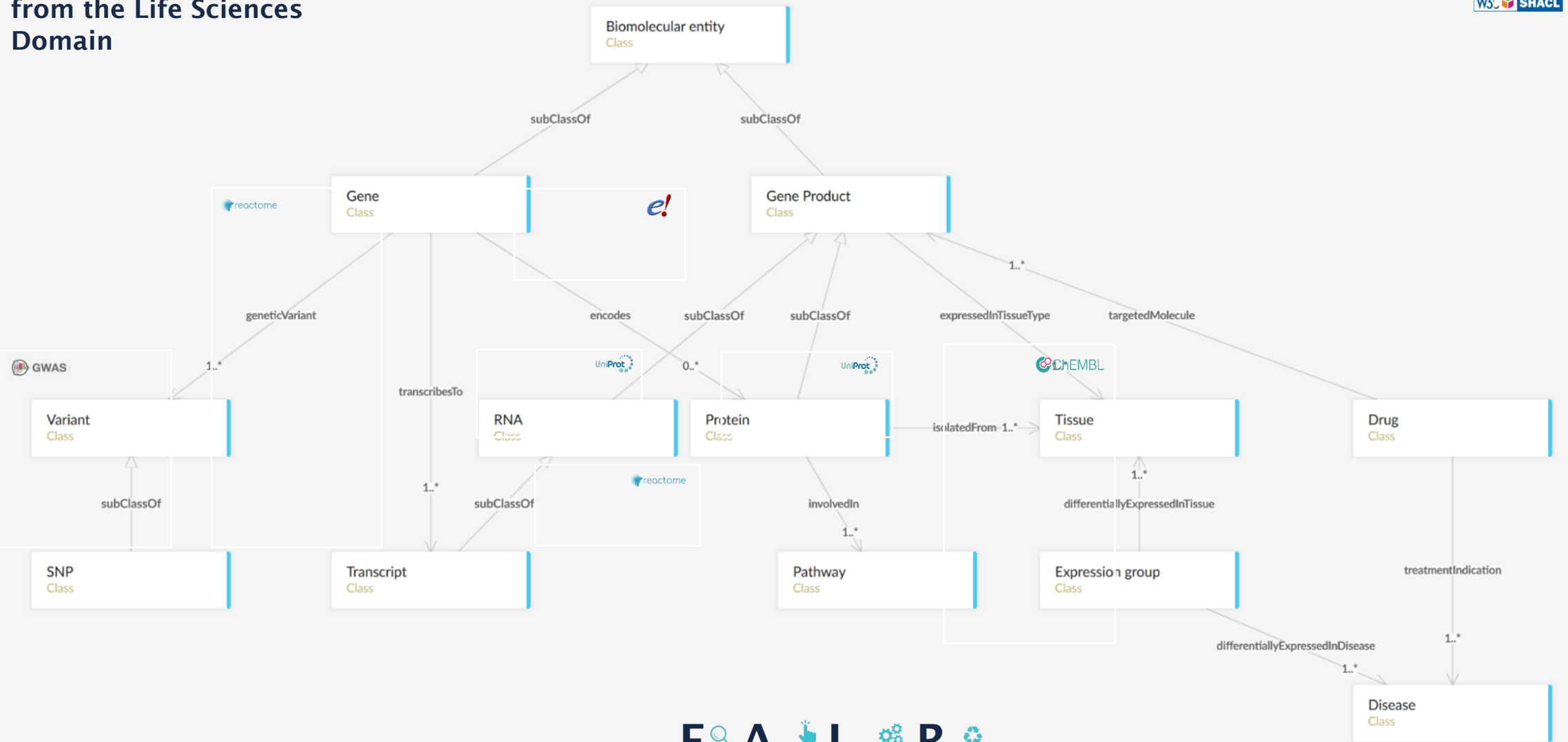
- Unlock isolated data silos
- Query across data sources
- 360° view on data

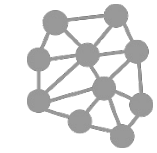
Ephedra – metaphactory’s federation engine

Virtual and materialized integration of multiple data sources

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

Example Ontology from the Life Sciences Domain





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)



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How Industry 4.0 Use Cases Benefit from Using Semantic Technologies

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 with metaphactory
Knowledge Graph Platform

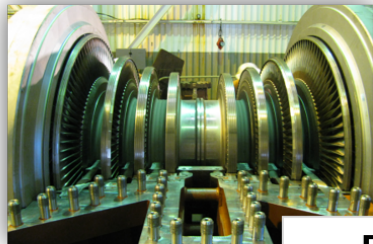
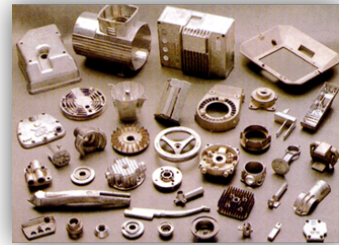
WWW.METAPHACTS.COM

SIEMENS
Ingenuity for life

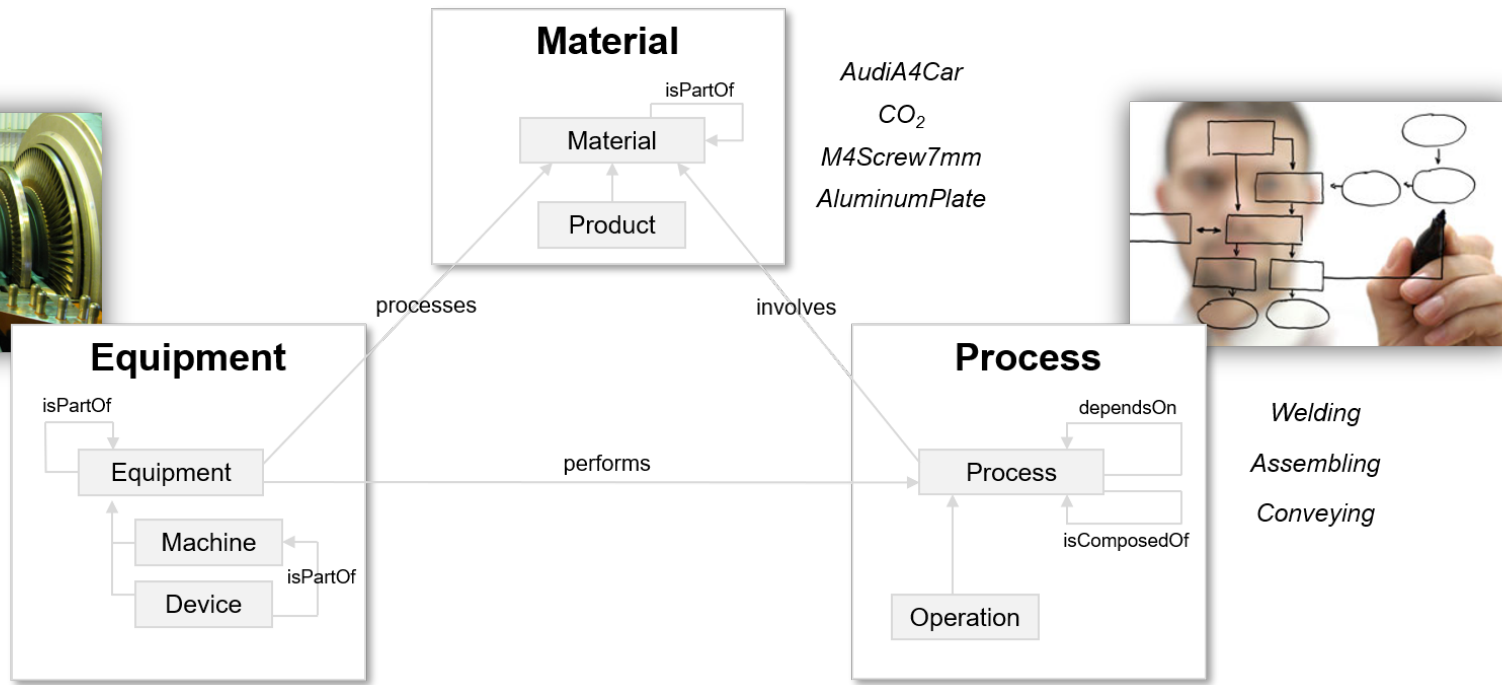


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Smart Manufacturing at Siemens Technology




KukaRobot
GasTurbine
ProductionCell
S7-PLC



Welding
Assembling
Conveying

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

Interactive skill matching



Quick Links ▾

PORTAL / OWL MODELS / SmA PRODUCTION LINE STAGE 2

Edit Page

Model

Search for something ▾

Structured Search

Taxonomy **Partonomy** Processes

- ▶ BOPP9 Production Line
- ▶ FT module
- ▶ CoSy Space Demonstrator
- ▶ SmA Production Line Stage 1
- ▶ SmA Production Line Stage 2
 - IndustrialRobotModule1
 - SmA AdditiveManufacturing Module 1
 - SmA Assembly Module 1
 - SmA Assembly Module 2
 - SmA Assembly Module 3
 - ▶ SmA Backbone 1
 - SmA Empty Module 1
 - SmA Recycling Module 1
 - StorageModule1
- ▶ I-00076-ex

SmA Production Line Stage 2 Instance

Ontology Meta View
URI: http://siemens.com/knowledge_graph/cyber_physical_systems/sma/equipment#ProductionLineStage2

Description:
SmA Production Line Stage 2 ist the production line of the SmA project in the second stage of expansion.

Attributes

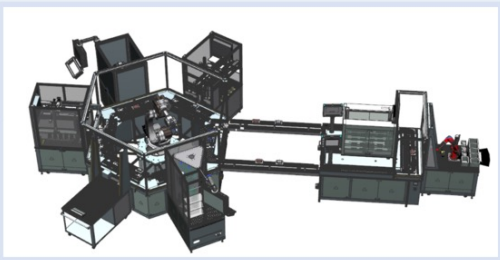
Ports

Skill Matching

Part of / has Part

Connected parts

operation	Machine	Offered Skill
I-017572-ex (Charging)	SmA Recycling Module 1 SmA Empty Module 1	Mount Baseplate Mount Baseplate
I-017573-ex (Inserting) 👁		
I-017575-ex (Inserting) 👁		
I-017578-ex (Dismantling)	SmA Empty Module 1 SmA Recycling Module 1	Recycle Product by Worker Recycle Product by Robot



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



SmA Production Line Stage 2 Instance

URI: http://siemens.com/knowledge_graph/cyber_physical_systems/sma/equipment#ProductionLineStage2

Description:
SmA Production Line Stage 2 is the production line of the SmA project in the second stage of expansion.

operation	Machine	Offered Skill
I-017572-ex (Charging)	SmA Recycling Module 1 SmA Empty Module 1	Mount Baseplate Mount Baseplate
I-017573-ex (Inserting)		
I-017575-ex (Inserting)		
I-017578-ex (Dismantling)	SmA Empty Module 1 SmA Recycling Module 1	Recycle Product by Worker Recycle Product by Robot

SmA Assembly Module 1 Instance

URI: http://siemens.com/knowledge_graph/cyber_physical_systems/sma/equipment#AssemblyModule1

Description:
SmA Assembly Module 1 is the assembly module in the production line in stage 1.

Types:
Direct Types: PortalRobotAssemblyModule
Inferred Types: Machinery, PhysicalObject, ProductionUnit, Resource, WorkUnit (ISA95), AssemblyModule, SmAModule

Production Skills:
Filter Results:
Skill: Performed by device:



“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.”

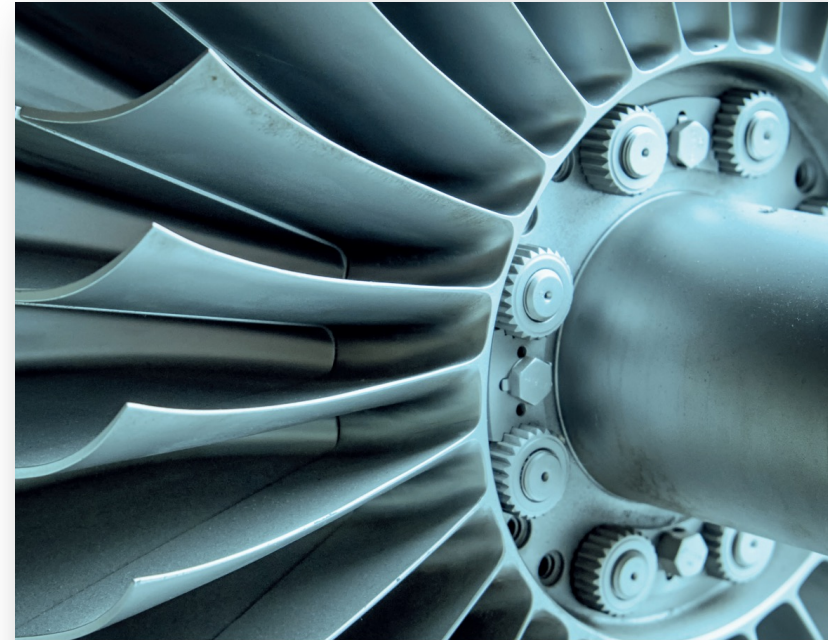
Steffen Lamparter
Head of Research Group on Semantics and Reasoning
Siemens Corporate Technology

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**

- 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



Siemens Energy significantly reduces manual effort for spare parts management of large gas turbines with metaphactory and Amazon Neptune

SIEMENS
ENERGY

WWW.METAPHACTS.COM

SIEMENS
Ingenuity for life



metaphacts

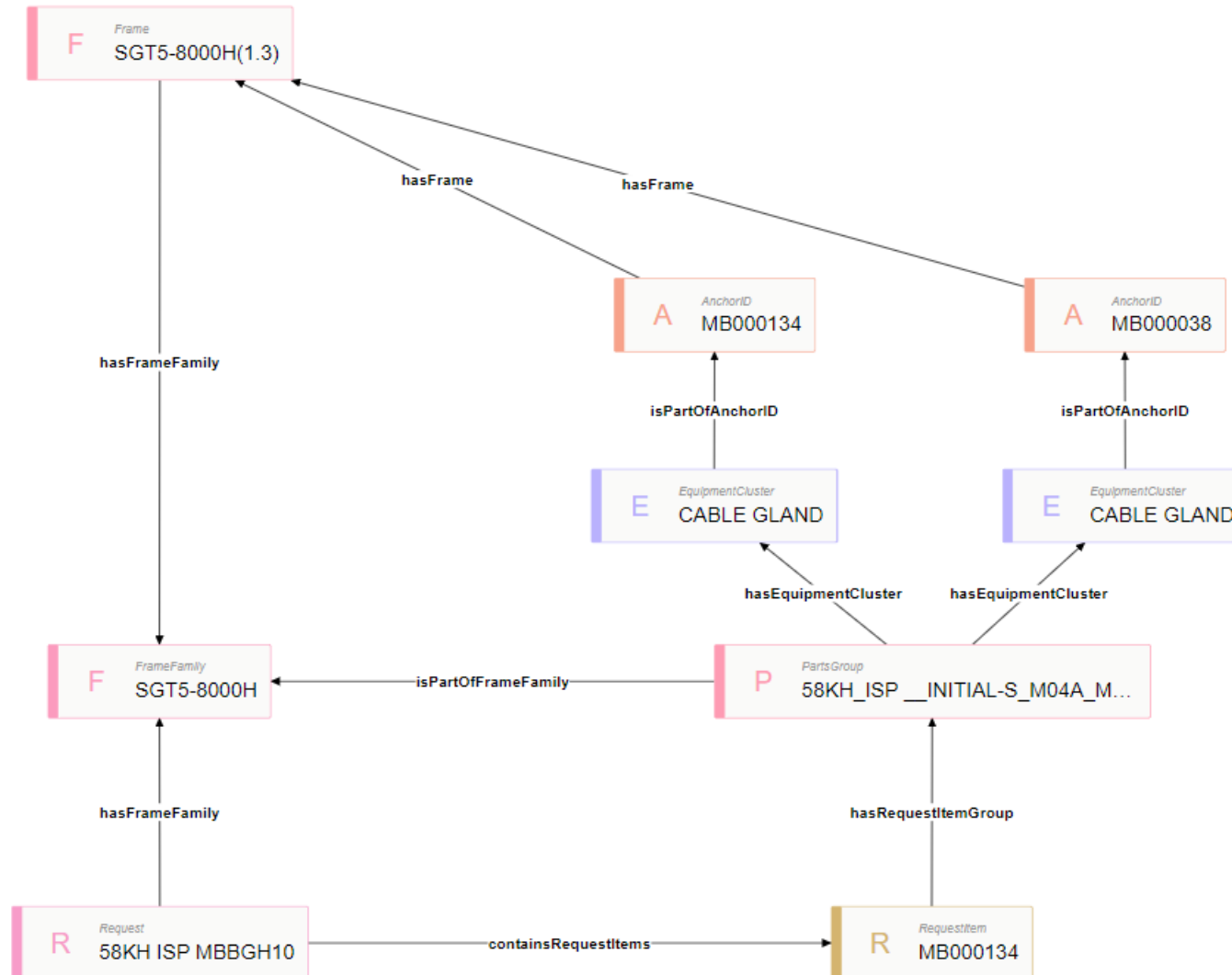
Turbine Spare Part Management at Siemens Energy



metaphacts


SIEMENS

Ingenuity for life



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

Turbine Spare Part Management at Siemens Energy



Display contents of SEF Package

Edit Page

Criteria

Anchor ID* ? x v [+ Add anchor id](#)

Functional Component ? x [+ Add functional component](#)

SEF Package ? x v [+ Add sef package](#)

REK ? x [+ Add rek](#)

Z11 Class ? x [+ Add z11 class](#)

[Search](#)

[Download CSV](#)

Results

Unit	Item Chain	Material	FC	Z11	REK	Pkg	Qty	Fctr.	S.Rule
800967	MBCPEN1_0001	P0001402200 ACTUATING MECHANISM, VANE 0	CPEN1	CPE00	Z	03	1.0 ST	3.0	
800967	MBCPEN1_0001_0004	P0001400400 LEVER, COMPLETE	CPEN1	CPE51	U	03	40.0 ST	1.0	TAB00099
800967	MBCPEN1_0001_0004_0001	PG0029949300 BOLT	CPEN1	32041	P	03	40.0 ST	0.999	
800967	MBCPEN1_0001_0007_0003	PB0000009495 SCREW SOCKET HEAD	CPEN1	20003	T	03	38.0 ST	0.999	

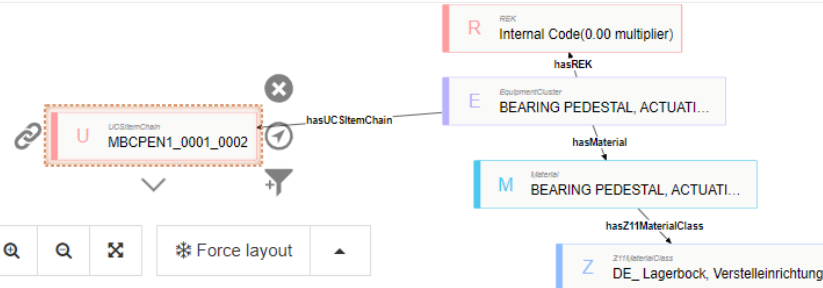
Intuitive end-user search interface across the fleet of large gas turbines



SEF Package Item Analysis



Edit Page

Your selection:



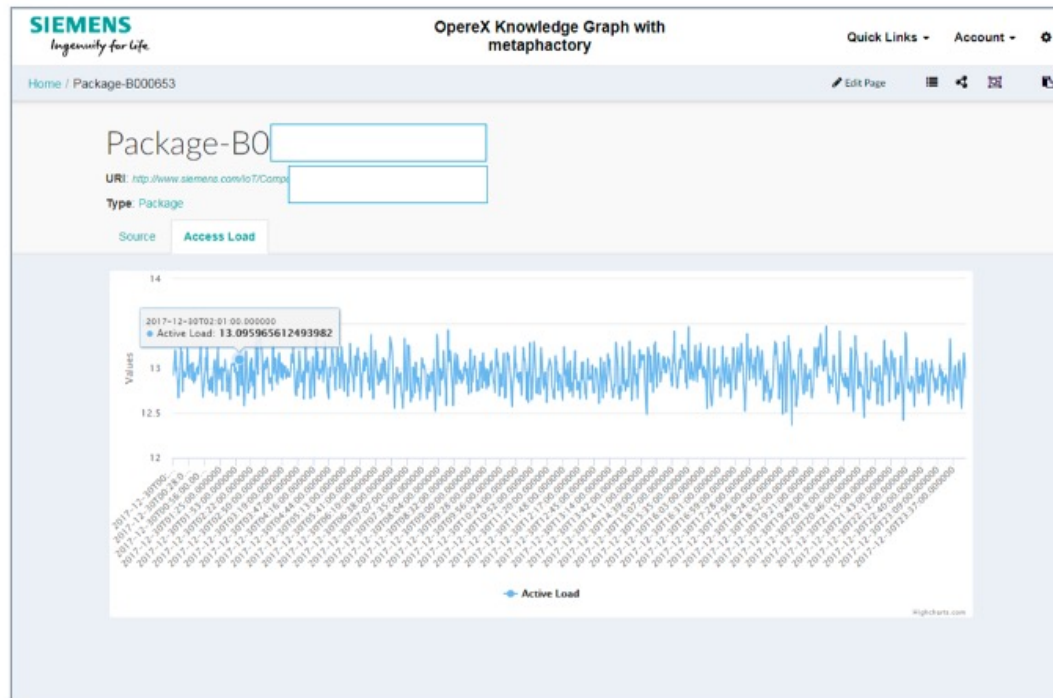
All the parents till functional component head

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

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



Ephedra Federation

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

Turbine Spare Part Management at Siemens Energy



metaphacts

SIEMENS

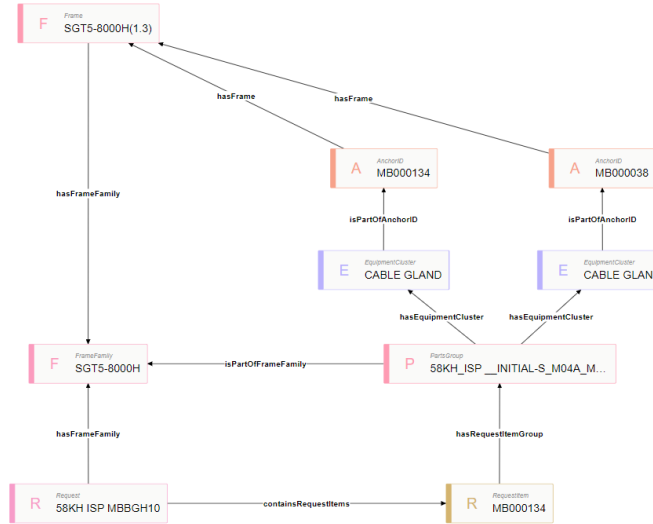
Ingenuity for Life



“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

SEF Package Item Analysis

Your selection:

All the parents till functional component head

Unit	Item Chain	Material	FC	Z11	REK	Pkg	Qty	Fctr.	Var.	S.Rule	EQC	CC	Analyze
800907	MBCPEN1	P0064800100 ACTUATING MECHANISM, VANE'S	CPEN1				1.0	ST			ACTUATING MECHANISM, VANE'S		
800907	MBCPEN1_0001	P0001402200 ACTUATING MECHANISM, VANE 0	CPEN1	CPE00	2		1.0	ST			ACTUATING MECHANISM, VANE 0		

- 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

- <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

While in academia

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

After graduation

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

Talk to us! 😊

<https://metaphacts.com/company/career>

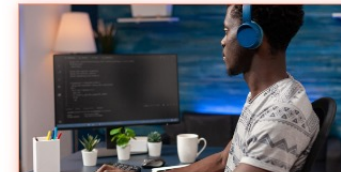
Job openings



Enterprise Sales Manager

JOB OPENING

What you'll be doing You will be part of the metaphacts sales team, where your responsibilities start with analysing customer requirements and mapp...



Senior Software Engineer

JOB OPENING

Your Role You will be part of our product development team and work together with our product manager, architects and fellow software engineers on fu...



Web Developer for Knowledge Graph Applications

JOB OPENING

Your role You know how to build beautiful Web applications, how to design interfaces that customers love, and you do this on top of our low-code appl...



Technical Consultant - Knowledge Graph Technologies

JOB OPENING

Your role You will be part of our professional services team, where your responsibilities start with understanding and documenting customer requireme...



Internship - Software Development

JOB OPENING

At metaphacts, we always have a range of challenging topics in the area of semantic technologies where we continue to look for student input. All topi...



Internship - User Experience & Interaction Design

JOB OPENING

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