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
• 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
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?

Data → Information → Knowledge → Decisions (actionable knowledge)

- Context
- Meaning
- Insight
Some metaphacts customers

For details on other customers please visit: metaphacts.com/company/customers
<table>
<thead>
<tr>
<th>Smart Manufacturing Planning &amp; Execution</th>
<th>Materials Science Knowledge Graph</th>
<th>Turbine Spare Parts Management</th>
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<tbody>
<tr>
<td><strong>SIEMENS</strong></td>
<td><strong>BOSCH</strong></td>
<td><strong>SIEMENS</strong></td>
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<tr>
<td>✓ AI-based knowledge graph application for automated, skill-based allocation of machines to production requests</td>
<td>✓ Smart business application for material research &amp; development</td>
<td>✓ Smart and targeted maintenance of spare parts of large gas turbines</td>
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<tr>
<td>✓ Cost &amp; time savings by supporting planners &amp; line operators in validation of manufacturing plans</td>
<td>✓ One-stop knowledge hub for materials and chemical component information</td>
<td>✓ Preventive maintenance resulting in reduced turbine downtimes</td>
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<tr>
<td>✓ Enables realization of low-volume orders</td>
<td>✓ Meaningful &amp; actionable insights surfaced through a user-friendly interface</td>
<td>✓ Increased business user and customer satisfaction</td>
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Other customers in this sector

- **BKW**
- **SCHAEFFLER**
Configuration Management Demo

Application developed by

Developed together with
## References from Pharma & Life Sciences

### 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 »**
Market Access Demo

Developed together with
Data Lineage & Digital Twin Demo

Developed together with CAPCO
Principles for unlocking the value of data

**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

Adapted from: Mark D. Wilkinson et al., Comment: The FAIR Guiding Principles for scientific data management and stewardship (2016)
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<th>Platform based on open standards</th>
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<tr>
<td><img src="RDF.png" alt="RDF" /></td>
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<td>Graph Data Model</td>
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<td><img src="W3C.png" alt="W3C" /></td>
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<td>Linked Data Platform</td>
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Connecting the ontologies, vocabularies & instance data

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

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

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

**Semantic Model**
- One entry point for humans and machines to all data
- Describe and integrate all data

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

**Derived Data**
- Enable reusability across use cases & projects

**Graph Data**
- Knowledge Publishing, Discovery & Consumption
- Knowledge-driven Applications
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

**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

Run anywhere
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

Single Sign On LDAP, OAuth, SAML

Browser

Relational Database
OBDA/ETL
- R2RML mappings or query patterns

Graph Database
SPARQL 1.1
- Multiple graph databases
- External and internal data

Hybrid Services
REST APIs
- Machine Learning Algorithms
- Data Feeds for augmentation, e.g. live sensor data

Linked Data Platform
Ontology Repository
Query Catalog
Knowledge Graph Application Development

Ephedra (SPARQL 1.1 federation)
Data Access Infrastructure

Search
Visualization
Authoring

End User

Expert User

Developer

Applications

browser

Platform Services

Web Component-based UI

Graph databases
Relational databases
Compute services
REST APIs
Example Ontology from the Life Sciences Domain

Building the knowledge graph
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
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

Ontology for Representing Digital Twins of Technical Machinery – Equipment, Material & Processes
Interactive skill matching of production operations against the skills of a production line.
Visualization of manufacturing knowledge in metaphactory for user interaction and transparency over the knowledge graph.
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

“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
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
Excerpt of the Knowledge Graph showing a request item and connected resources.
Turbine Spare Part Management at Siemens Energy

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

### Display contents of SEF Package

#### Criteria
- Anchor ID
- Functional Component
- SEF Package

#### Results

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<th>Item Chain</th>
<th>Material</th>
<th>FC</th>
<th>Z11</th>
<th>REK</th>
<th>Pkg</th>
<th>Qty</th>
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Download CSV
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

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

“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 Zołnowski
Section Lead- Post Documentation, Siemens Energy
• 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

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

Tutorials to get you started included

Immediate access after registration

14-day trial period

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

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