

Industrial Knowledge Graph at Siemens

Powered by metaphactory and Amazon Neptune

CERN Openlab Technical Workshop, Geneva

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Motivation

- Challenges
- Why graphs?



What we do

- Our vision: Integrated intelligence
- A day of use cases



Technology

- Required functionalities
- Current infrastructure



Towards Graphs-as-a-Service

- Why go managed?
- First experiences with Neptune



Digitalization shapes our industry

Challenges in our industry

Isolated data silos

- By owner (Siemens divisions, customers, ...)
- By subject (operating data, maintenance data, error information, customer data, ...)
- By media type (time series, images, PDFs, ...)

Data inaccessibility

- Access paths are too complicated for domain experts leading to high costs for data access
- No integrated view of data
- No or limited search functionalities

Inefficient workflows

- Long delay from information needs to data access
- Data provisioning demands big capacities of IT experts
- Heterogeneous storage lead to complex data control

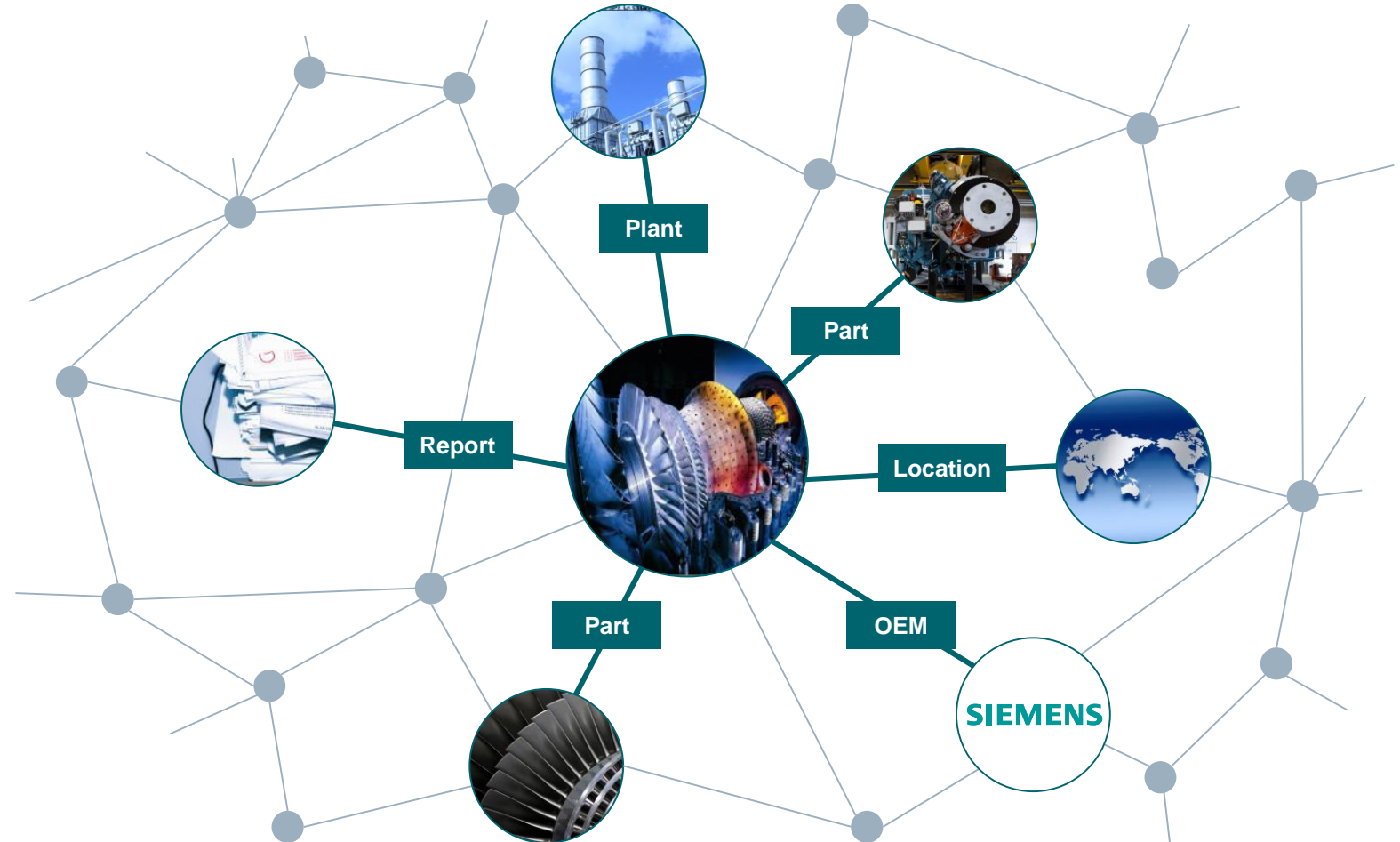
Low data quality

- Outdated
- Duplicated
- Incorrect or contradictory

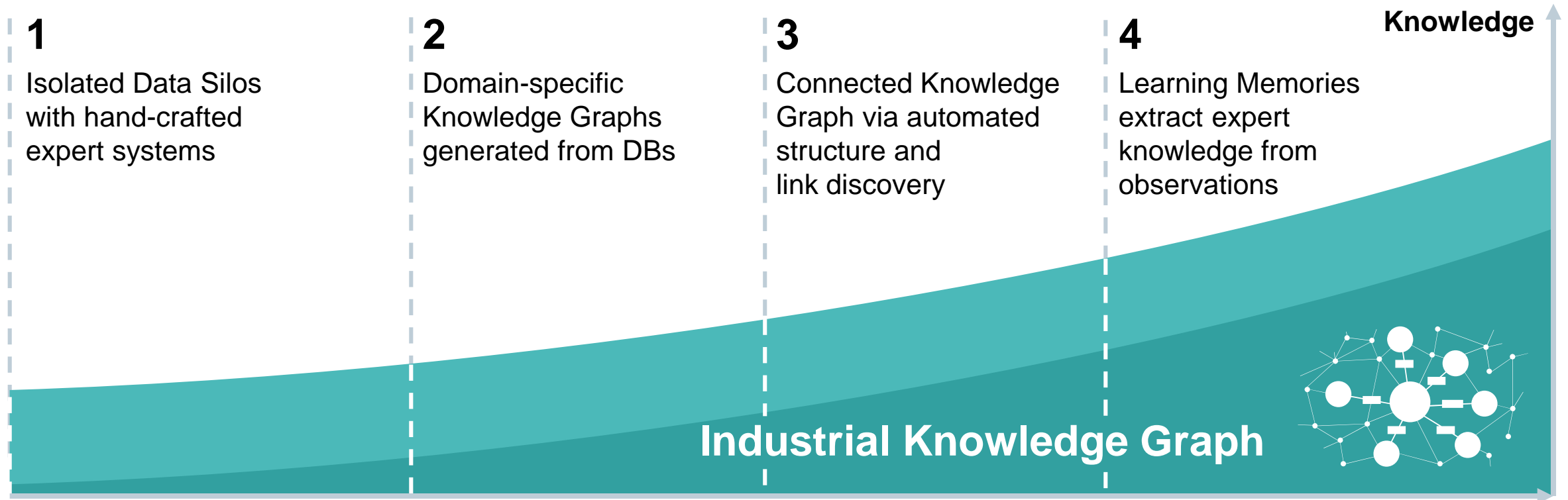
Why (Knowledge) Graphs?

Benefits of using knowledge graphs for data representation

- The world is entities and relations!
- Intelligible domain model instead of complex (physical) data model
- Schema-on-read instead of complex schema migration for extensions
- Easy integration of multiple data sources (schemas) and types (structured, unstructured, ...)
- Formal semantic representation enables inference and machine processing



Our answer – Industrial Knowledge Graphs for capturing Siemens Domain Knowledge

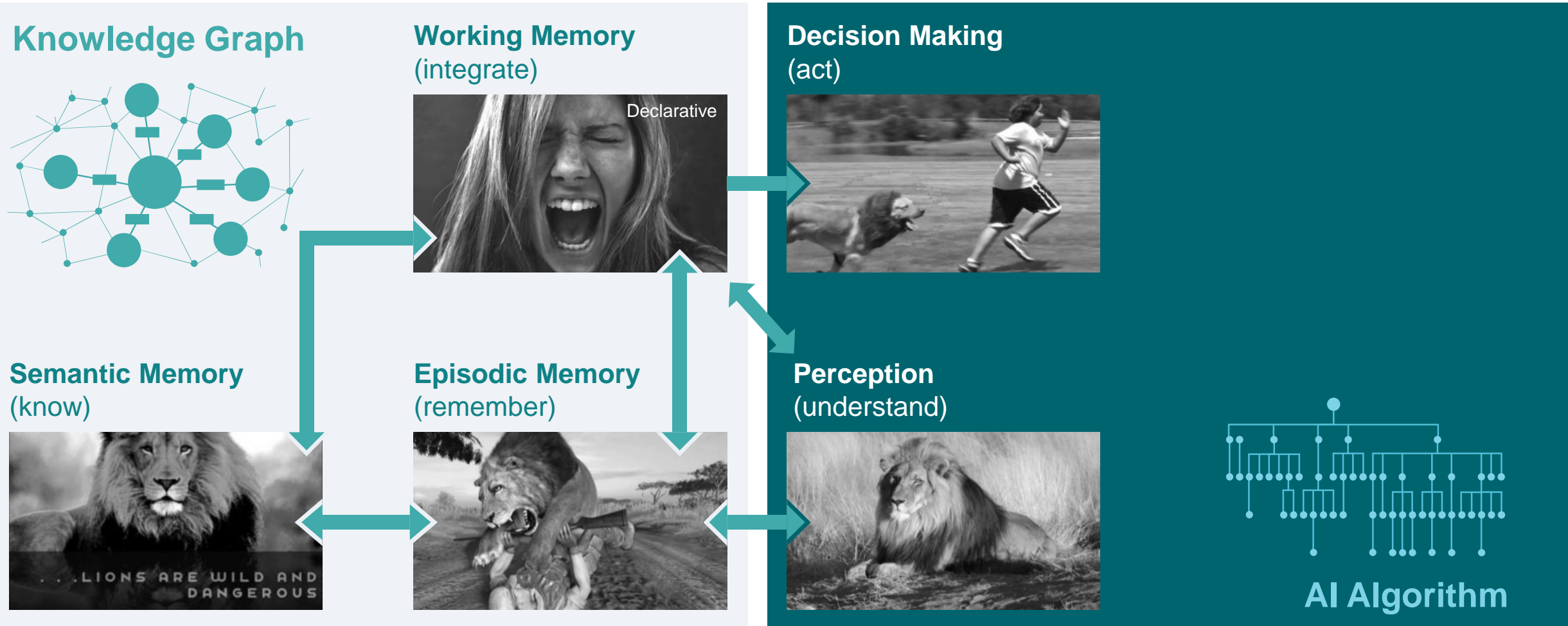


Degree of automated knowledge digitalization

From isolated data silos to learning memories

■ Collected data ■ Digitalized Knowledge (via reasoning and learning)

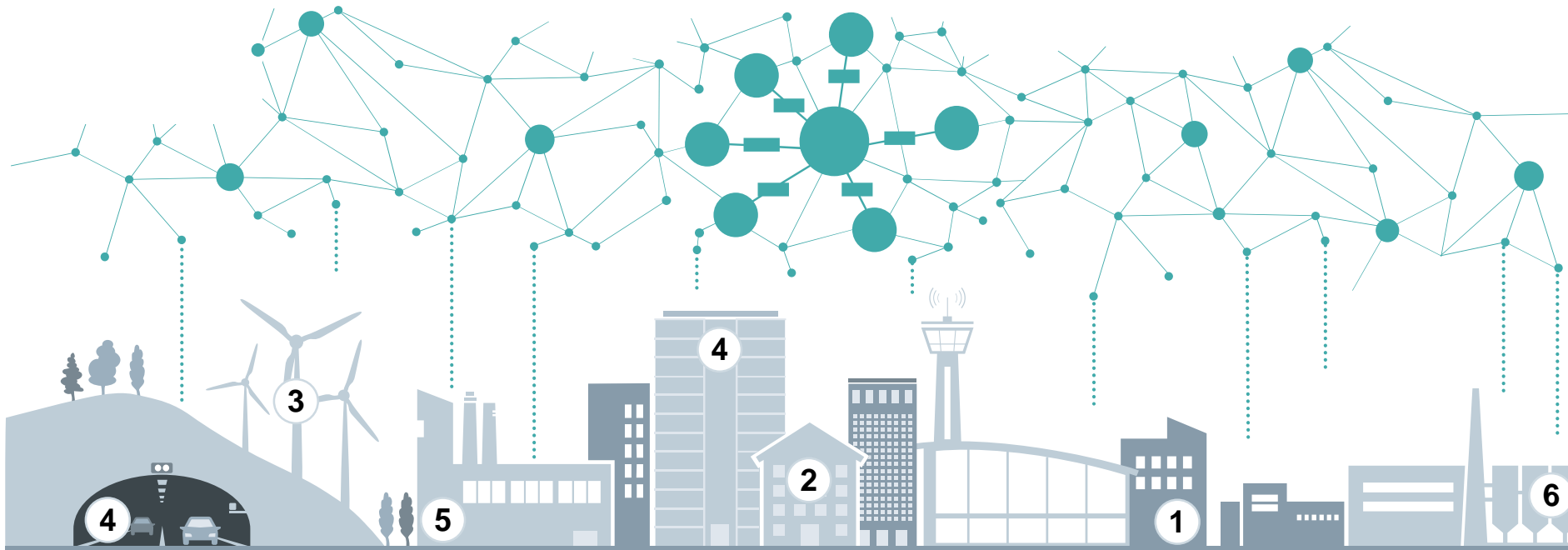
Vision – Learning Memories for Integrated Intelligence



One day in the life of an artificial assistant @ Siemens

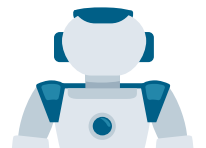


Industrial Knowledge Graph



- 
- 1 09:00 – Analyze**
Turbine data hub
 - 2 11:00 – Configure**
Configure turbine
 - 3 12:00 – Maintain**
Master Data Mgmt.
 - 4 13:00 – Mitigate**
Financial Risk Analysis
 - 5 15:00 – Connect**
Experts & Communities
 - 6 18:00 - Guide**
Rules & Regulations

AI Algorithms



Industrial Knowledge Graph @ Work – Flexible self-service data access for domain experts

09:00 ✓
11:00
12:00
13:00
15:00
18:00

What's the MTTF distribution across turbines with coating loss last FY?

I will compile the relevant data and visualize it in your favorite BI tool.

Data-as-a-service making anyone a data scientist

Challenge

- Required **data is distributed** across multiple databases
- Source systems have highly **complex schemas**
- Need to **include unstructured information** into analyses
- Reactivity and efficiency needs call for **end-user access to data**



Solution

- **NLP** to make information from documents accessible for analytics
- **Physical and virtual data integration** to provide unified view
- Access using a **domain ontology** and intelligent **query construction support**
- **Connectors** providing data to existing tools in legacy format



Value Generation

- **Unified Data Hub:** All information accessible from one system, independent of source and type
- **Empower domain experts:** Subject matter experts can use domain language to access data
- **Enabler for analytics:** Foundation for fleet-level analytics

Industrial Knowledge Graph @ Work – Generation of turbine configurations

09:00 ✓
11:00 ✓
12:00
13:00
15:00
18:00

How to configure the new turbine as to meet customer requirements?

I will evaluate all constraints and provide a list of possibilities.

PG0034684900 Instance

Ontology Meta View
URI: <http://www.siemens.com/ontology/meta-view?ppr/ind#PG0034684900>

Description:

Types Part of / has Part Connected part

Explicit semantic models define constraints

Challenge

- Product configuration information is **scattered** across spreadsheets, **inconsistent and redundant**
- **Missing transparency** on technology interactions
- Information only on **HOW to design**, but **not on WHY** to do so



Solution

- Use an Industrial Knowledge Graph to **store product configuration knowledge with rich semantics**
- For new order, **create constraint system on the fly** using knowledge graph information & **solve for feasible solutions**
- Use Industrial Knowledge Graph technology to **browse solutions**



Value Generation

- Introduce **knowledge management** into turbine configuration
- **Integrated design process** across all components and technologies
- Semantics allow **explain the WHY** behind a design decision
- **Speed-up** due to automation

Industrial Knowledge Graph @ Work – Building a single source of truth for product relation data

09:00	✓
11:00	✓
12:00	✓
13:00	
15:00	
18:00	

How can I make sure that users see consistent data across all apps?

I have integrated all product information and compiled a data integrity dashboard.

Challenge

- **Consolidate product relation data** scattered across multiple systems
- Use intelligible rules to **derive and quality-check product relations**
- **Provide high-quality data on intra-product relations** (successor, etc) for customer-facing applications



Solution

- **Link relevant product information** in the Industrial Knowledge Graph
- **Data integrity dashboard** with expert-defined rules (**SPARQL**) to identify data quality issues
- Use cases **access required information subsets using specific APIs**



Value Generation

- **Increase revenue** by cross- and up-selling (driven by richer information)
- **Facilitate knowledge management** by product experts with increased transparency and data integration
- **Guaranteed consistency** of information provided across tools
- **Reduced efforts** for product data management

Industrial Knowledge Graph @ Work – Understanding and mitigating risks in financing

09:00	✓
11:00	✓
12:00	✓
13:00	✓
15:00	
18:00	

Which investments we have are directly or indirectly affected by this storm?

I have browsed all investments and company relations and put into a report.

360° view of investments to identify risks Country

Challenge

- Siemens bank has a **wide range of investments** across industries
- Complex **networks of company relations** (own, partners, competitors)
- **Limited transparency on risks** due to external events, fraud, partner and competitor activities, etc



Solution

- **Combine internal and purchased information** on companies and projects in Knowledge Graph
- Highly **flexible query interface** to support arbitrary queries (structured and natural language search)
- Interfaces to **support analytics** on top of integrated data



Value Generation

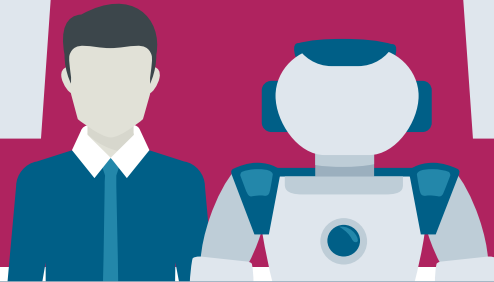
- **Highly agile analysis of risks** caused e.g. by unforeseen events
- **Improved transparency** over partners and competitors
- Identification of **potentially fraudulent behavior patterns**

Industrial Knowledge Graph @ Work – Cross-hierarchy community building and expert search

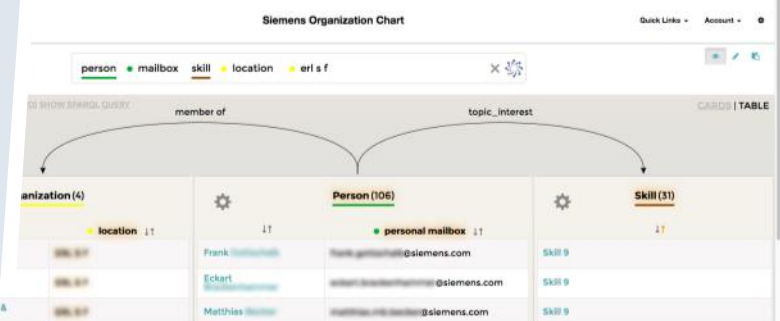


09:00	✓
11:00	✓
12:00	✓
13:00	✓
15:00	✓
18:00	

Do we have experts near my office who can help me with ontology design?



Stephan G. should be able to help. You might ask Thomas H. to make contact.



Flexible collaboration across organization boundaries

Challenge

- **Foster community building** across organizational boundaries
- **Finding experts within Siemens**, utilizing personal networks



Solution

- Industrial Knowledge Graph **integrates information on people, projects, and organizations**
- **Tapping into corporate data silos** to provide an integrated view
- Utilize public sources for **skill hierarchies** to improve search
- Possibility to **integrate relevant external sources** (career platforms)



Value Generation

- **Transparency over informal communities** as well as formal organizational hierarchies
- **Finding experts** made easy
- Utilize **FOAF-graph** to facilitate **support-seeking**

Industrial Knowledge Graph @ Work – Prescriptive advice from complex rule frameworks

09:00 ✓
11:00 ✓
12:00 ✓
13:00 ✓
15:00 ✓
18:00 ✓

I need this order done. Whom need I contact to get it approved?

Based on locally applicable rules, you first need to talk to John Doe from ECC.

Rules & Regulations 4.0
Semantic Search

TCFIC - Extractions Product Safety

Displaying results 1-3 of 3 results

- SC183: Principles of Product Safety
- SC232: Product & Solution Security

Help employees follow regulations easily and quickly

Challenge

- Large organizations have **huge bodies of rules & regulations**
- **Numerous facets of rule scope** (country, site, organization, ...) complicate finding applicable rules
- Rules tell **WHAT to do, not HOW**
- Communication is done via **PDF-based circular documents**



Solution

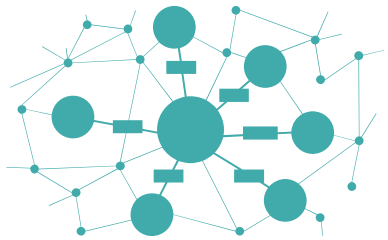
- Utilize **NLP technology** to extract subject, roles, scope, and activity information from circulars
- Industrial Knowledge graph to **integrate with organizational knowledge**, giving **contextualized descriptive guidance** (e.g. whom to call)



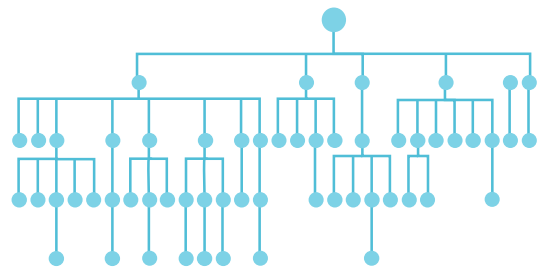
Value Generation

- **Reduce time** spent on understanding processes and following them
- **Reduce non-conformance cost** due to process violations
- **Increase employee satisfaction** by simplifying processes

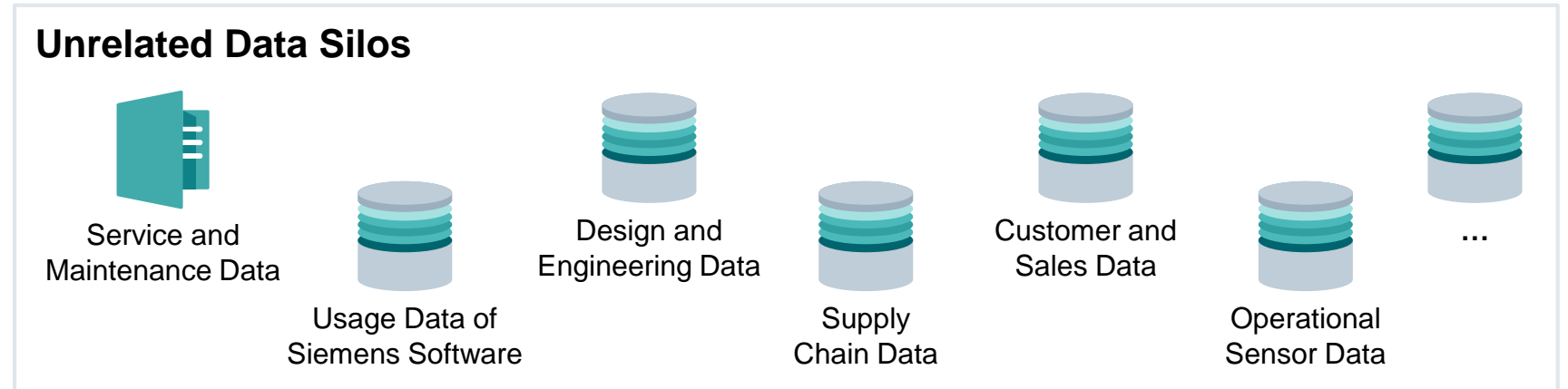
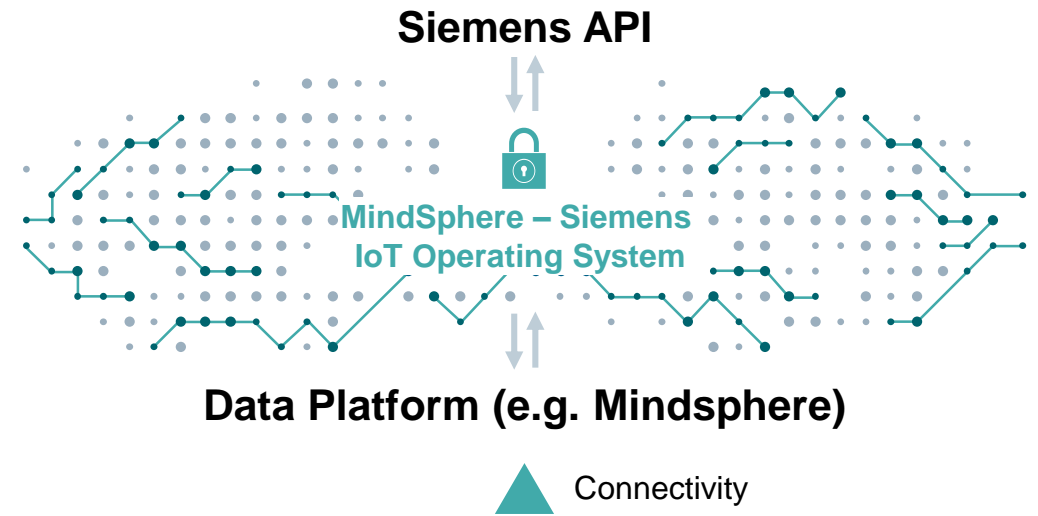
Knowledge as a Service – Consuming knowledge and analytics should be as easy as shopping



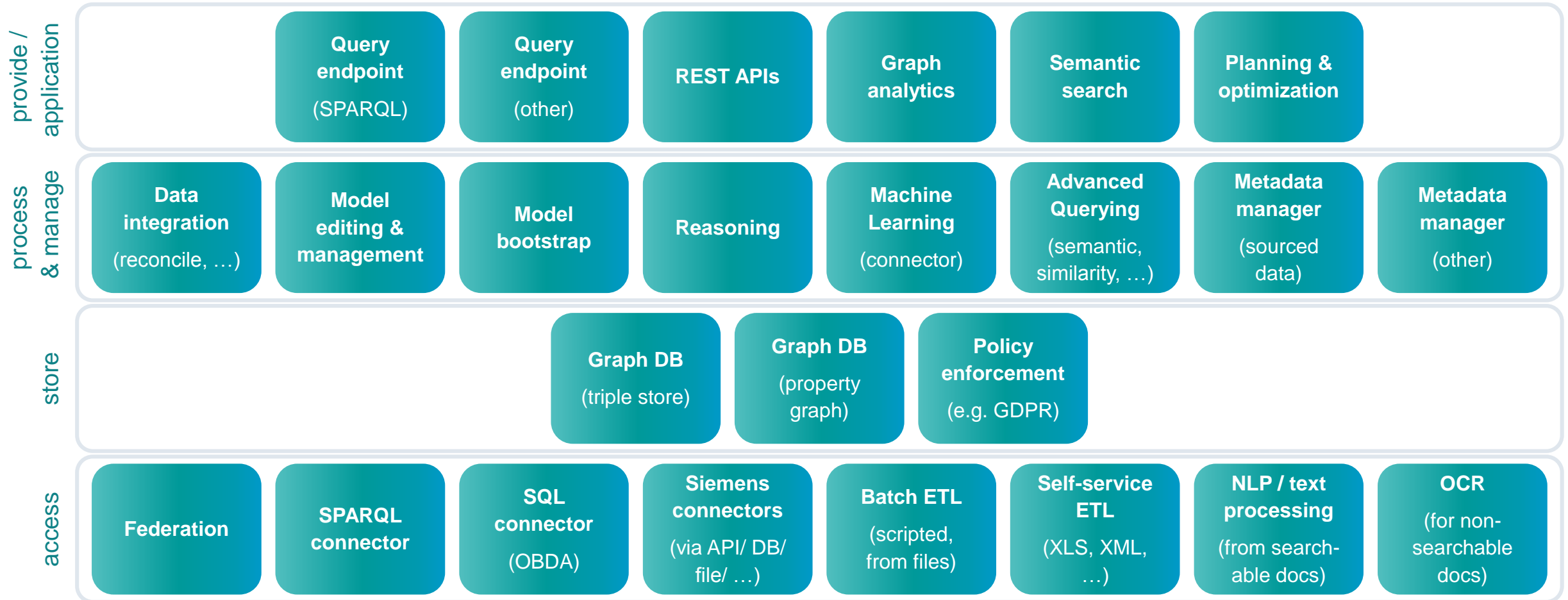
Knowledge Graph



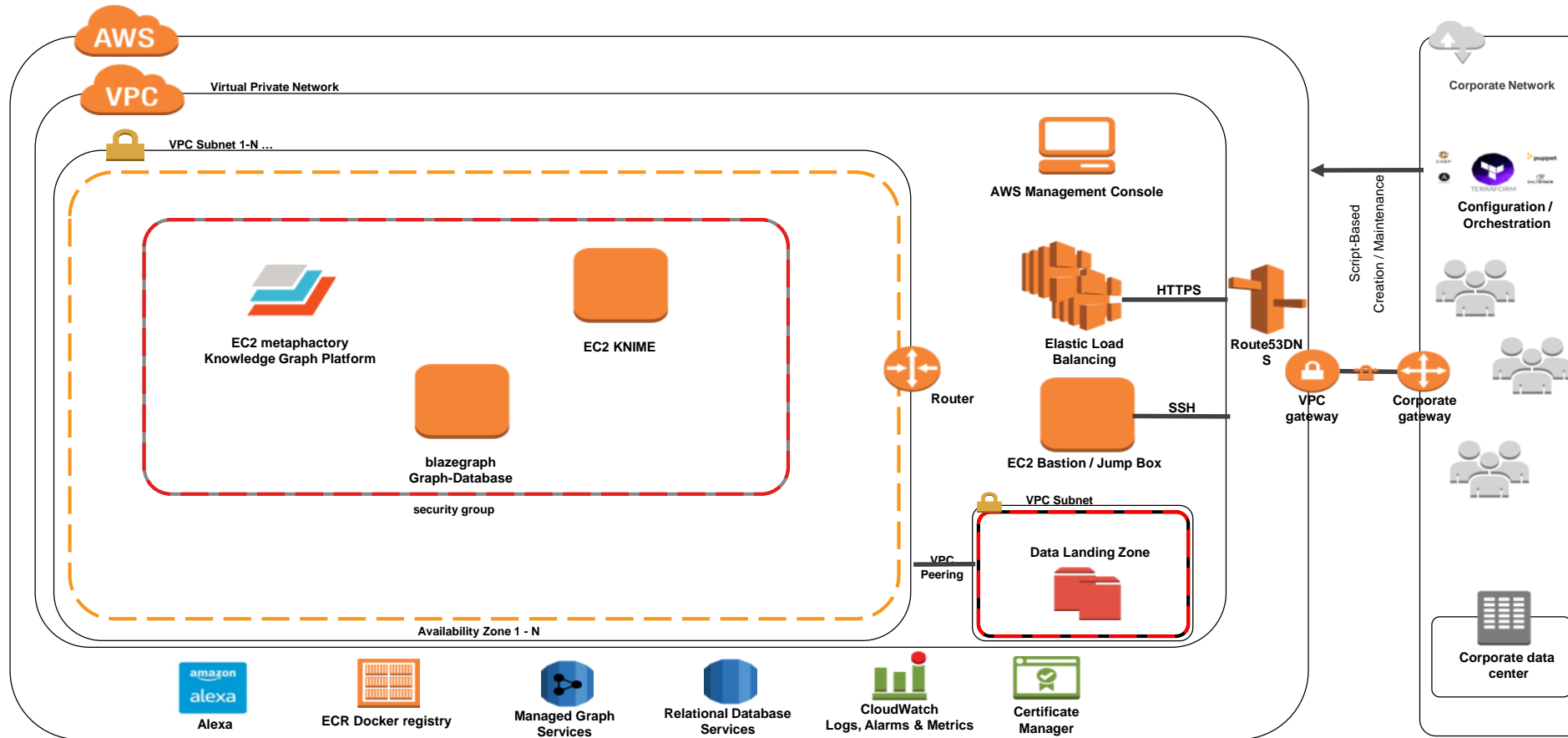
AI Algorithms



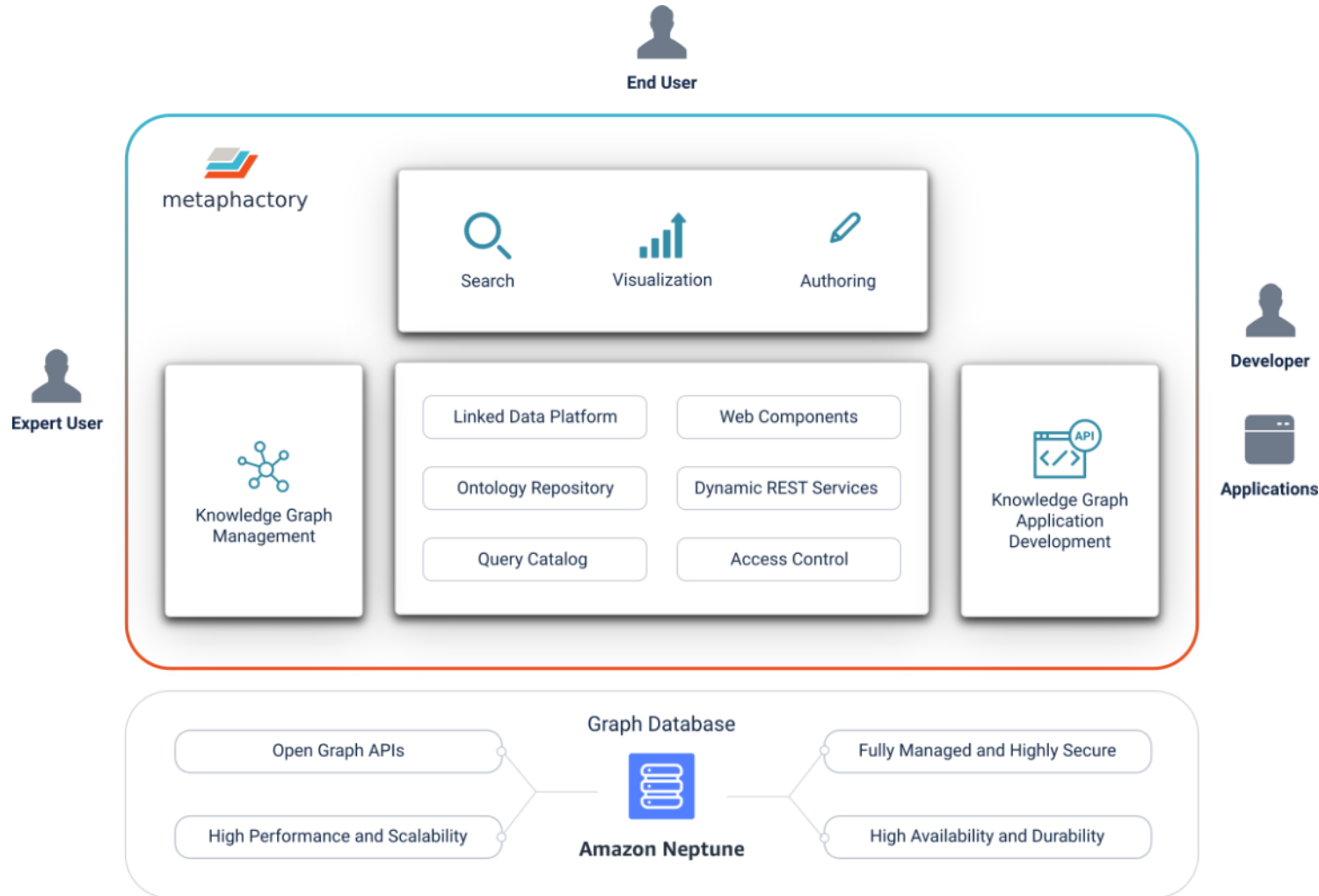
Functionalities for an Industrial Knowledge Graph Platform



Siemens AWS Use Case Architecture



metaphactory Knowledge Graph Platform



Knowledge Graph Management

- SPARQL endpoint UI
- Navigation, exploration, visualization
- Authoring, ontology and instance data management

Knowledge Graph Application Development

- Rapid prototyping of end-user oriented applications
- Web components for end-user oriented data interaction

Knowledge Graph Middleware

- “Queries as a Service”
- Interfaces to third party applications
- Integration with other AWS services

Reasons for Amazon Neptune



Amazon Neptune

Fully managed service

Scalability & Performance

High availability and durability

Security & Encryption

Standards compliance

RDF / SPARQL and property graphs

First Use Case on Neptune: Siemens Product Knowledge Network



SIEMENS
Ingenuity for Life

PKN @ metaphactory & Amazon Neptune

Quick Links - Account -


View Edit

Edit Page

**THERM. UEBERLASTRELAIS
11 - 16 A
3RU21264AB0**

OVERLOAD RELAY 11...16 A FOR MOTOR PROTECTION SZ 50, CLASS 10, F. MOUNTING ONTO CONTACTOR MAIN CIRCUIT: SCREW TERMINAL AUX. CIRCUIT: SCREW TERMINAL MANUAL-AUTOMATIC-RESET

Picture



Product group

Has product group	ADCD_CC
Has technical product group	3RU2

Material

Has material group	KGA
Has material type	FERT

Product Information

EGH Data quality indicator	G
EGH indicator	true
MALL data quality indicator	G

Product Type

Belongs to	SIRIUS ACT
Belongs to	Befehls- und Meldegeräte
subClassOf	Produkte (GCK)

Repair

Has spare part indicator	SN
Has repair indicator	S4

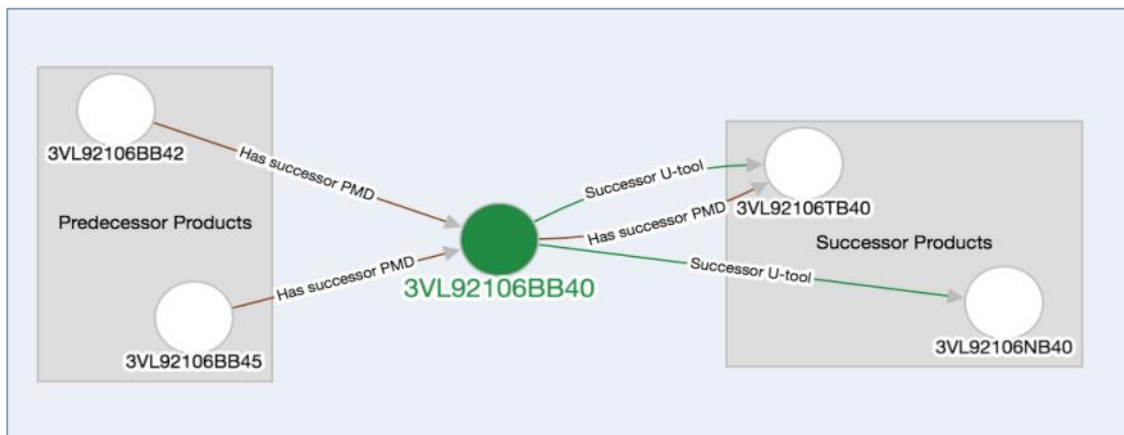
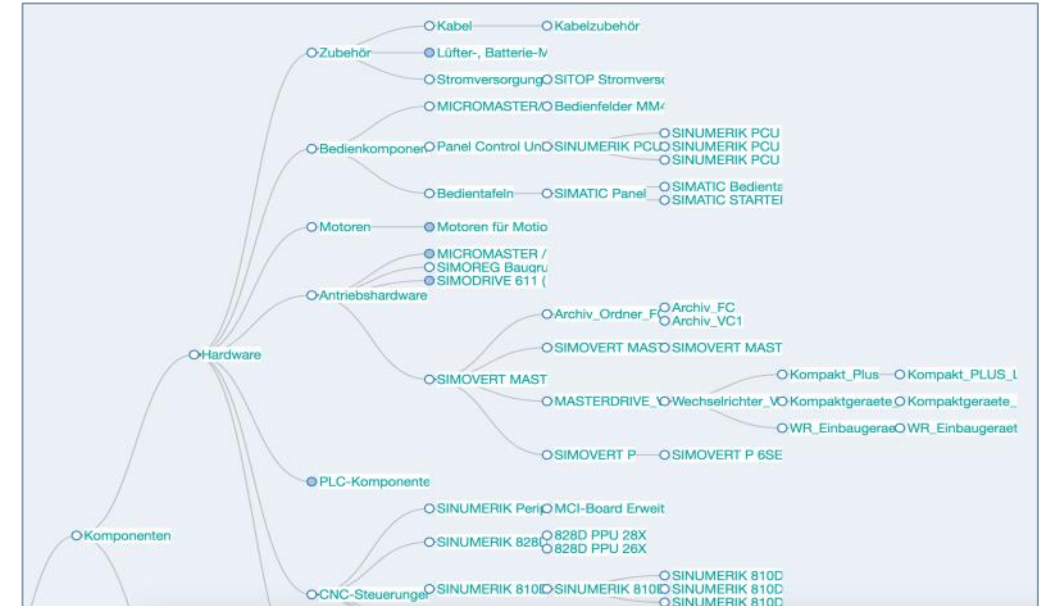
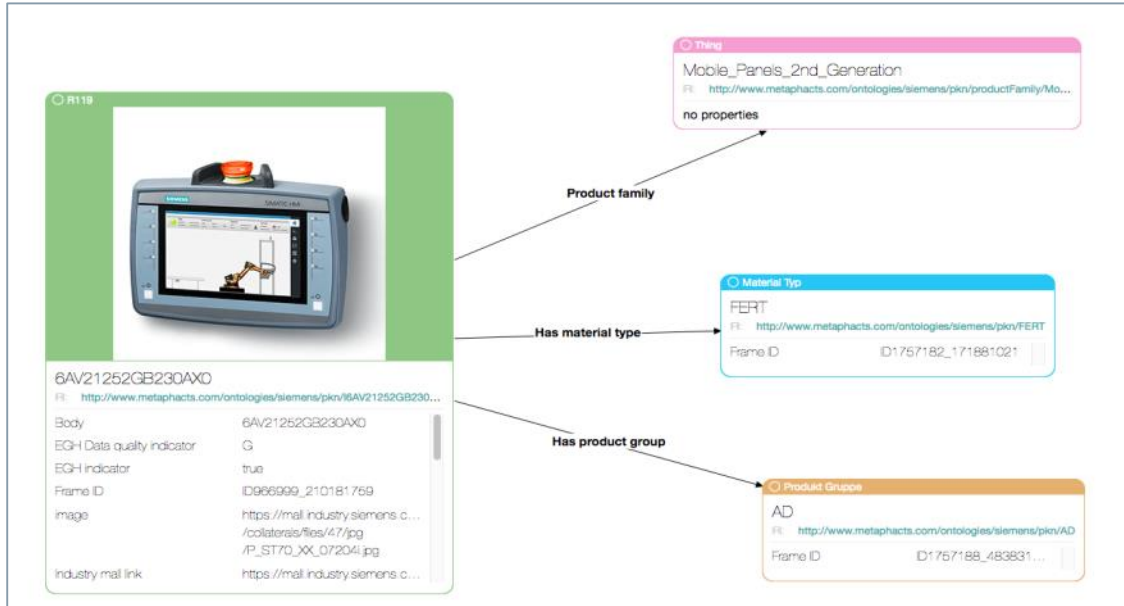
Product Relationship Management based on Master Data

- Integrated data from variety of sources
- Central hub for applications to access product data

POC with metaphactory and Neptune

- Graph-based data integration:
 - 1.2 M products

Graph Visualization and Exploration



Variety of graph structures:

- Product metadata and relationships
- Successor, predecessor network
- Taxonomic information

Editing instance data

The screenshot shows the 'Edit' page of the Neptune semantic platform. The header includes the Siemens logo, the tagline 'Ingenuity for life', the user 'PKN @ metaphactory & Amazon Neptune', and navigation links for 'Quick Links' and 'Account'. Below the header, there are 'View' and 'Edit' tabs, with 'Edit' being the active tab. The main content area is titled 'Edit' and contains three input fields: 'Label*' with the value '3RU21264AB0', 'Short Description*' with the value 'THERM. UEBERLASTRELAIS 11 - 16 A', and 'Type*' with the value 'R711'. At the bottom of the form are 'Save' and 'Reset' buttons. The footer of the page reads 'metaphactory semantic platform by Metaphacts'.

Semantic forms for authoring product data

- End-user oriented interface
- Auto-suggestions against the knowledge graph
- Constraint validation

Data Quality: Consistency Checks Across the Graph

SIEMENS
Ingenuity for Life

PKN @ metaphactory & Amazon Neptune

Quick Links ▾ Account ▾ ⚙

Edit Page

Data Quality Report

Total of 1714583 products are in this Product Knowledge Graph.

ERROR - Products with no overlapping Product-Successor information

There is a total of **992** products with inconsistent successor information.

- List of all products with inconsistent successor information

WARNING (1) - Products with overlapping, but not identical Product-Successor information

There is a total of **321** products with partially inconsistent successor information.

- List of all products with partially inconsistent successor information

Data quality checks

- Checks against integrated graph populated from many sources
- Rules and constraints defined as graph patterns
- Evaluated as SPARQL queries
- Visualized in interactive data quality dashboard

End-user Oriented Search

The screenshot displays the Siemens Electronic Parts search interface. At the top, the Siemens logo and 'Ingenuity for life' tagline are on the left, and 'Electronic Parts' is centered. To the right are 'Quick Links' and 'Account' menus. Below the header, a breadcrumb trail shows 'Home / Faceted Search'. A search filter is active: 'Find: Parts HAS PLATING MATERIAL Gold'. Below this, a faceted search bar shows 'Part' selected, followed by 'has plating material', 'Material', and 'Gold', with a 'remove' button. The main content area is a grid of 15 part thumbnails, each with a 3D model and a description. The descriptions include: '.058 DIA PIN PC AUSN/NI/PHBZ LF', '.058 PIN AUSN/NI/PHBZ LF', '.058 PCB PIN AU/SN NI PHBRZ LF', '.058 DIA PIN PC AUSN/NI/PHBZ', '.058 DIA PIN PC AU/PHBZ LF', '.058 DIA PIN PC AUSN/NI/PHBZ', '058 PCB PIN GPPHBZ', '.058 DIA PIN PC AUNI/PHBZ', '.058 PIN REC IS 24-20 GPPHBZ', '058 PIN REC 24-20 010GPBECU', and several others. On the left side, there is a 'HIDE FILTER' button and a list of filter categories: 'has Document', 'has Supplier', 'has contact plating material', 'has element material', 'has plating material', 'has underplating material', and 'is of Type'. Under 'is of Type', there is a search box and a list of checkboxes: 'PCB Terminal (27)', 'Component (27)', 'Part (27)', 'PartListEntity (27)', and 'Physical entity (27)'.

Semantic Search

- End-user interface supporting complex information needs
- Visual and interactive query construction
- Faceted result exploration

Queries as a Service: Dynamic REST APIs

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Ingenuity for Life

PKN @ metaphactory & Amazon Neptune

Quick Links Account

Home / System Settings / Query as a (REST) Service

Query as a (REST) Service

REST URL	Query	Enabled?	ACL permission	Response format	Repository	Publisher		
/rest/qaas/delete-instance	delete-instance	<input checked="" type="checkbox"/>	qaas:execute:*	(default)	(default)	admin	Edit	
/rest/qaas/new-asset-attribute	new-asset-attribute	<input checked="" type="checkbox"/>	qaas:execute:*	(default)	(default)	admin	Edit	
/rest/qaas/new-asset-instance	new-asset-instance	<input checked="" type="checkbox"/>	qaas:execute:*	(default)	(default)	admin	Edit	
/rest/qaas/new-asset-type	new-asset-type	<input checked="" type="checkbox"/>	qaas:execute:*	(default)	(default)	admin	Edit	
/rest/qaas/retrieve-instance	retrieve-instance	<input checked="" type="checkbox"/>	qaas:execute:*	text/turtle	(default)	admin	Edit	

Add service

Dynamic REST Services

- Declarative data access with SPARQL queries
- Automatically exposed as REST APIs
- Easy application development
- Fine-granular access control

Summary of First Experiences with Neptune



metaphacts



Amazon Neptune

Data scale

- 1.2 million products
- 120 million edges / triples
- Heterogeneous data

Query workload

- Real time queries against the graph for end-user frontend
- Analytical queries for data quality assessments

Standards-compliance

- Easy migration to Neptune via SPARQL 1.1 Protocol

Thanks for your attention! Questions?

SIEMENS
Ingenuity for life



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