Towards FAIR Data Principles at Bosch

Dr. Irlan Grangel González

Corporate Research Project Leader

OntoCommons Workshop
Towards Materials and Manufacturing Commons - the enablers Digital Marketplaces, FAIR Principles and Ontologies

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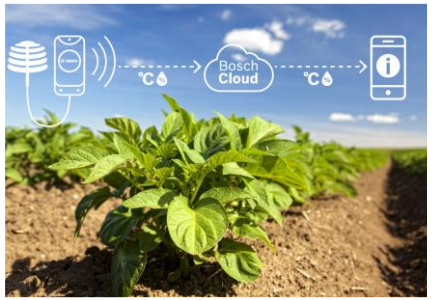
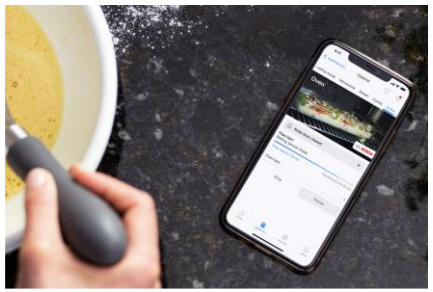
We want our products and solutions to spark enthusiasm, enhance the quality of people's lives, and help conserve natural resources.

In short, we aim to create technology

Invented for life





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Who we are
Our business sectors

Mobility Solutions

Industrial Technology

Energy and Building Technology

Consumer Goods

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Who we are
Our company in figures

In 2022

88.4

billion euros
sales revenue

3.7

billion euros EBIT
from operations

420,300

Bosch associates
worldwide at year-end
(approx.)

440

subsidiaries and
regional companies in
more than 60 countries

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02

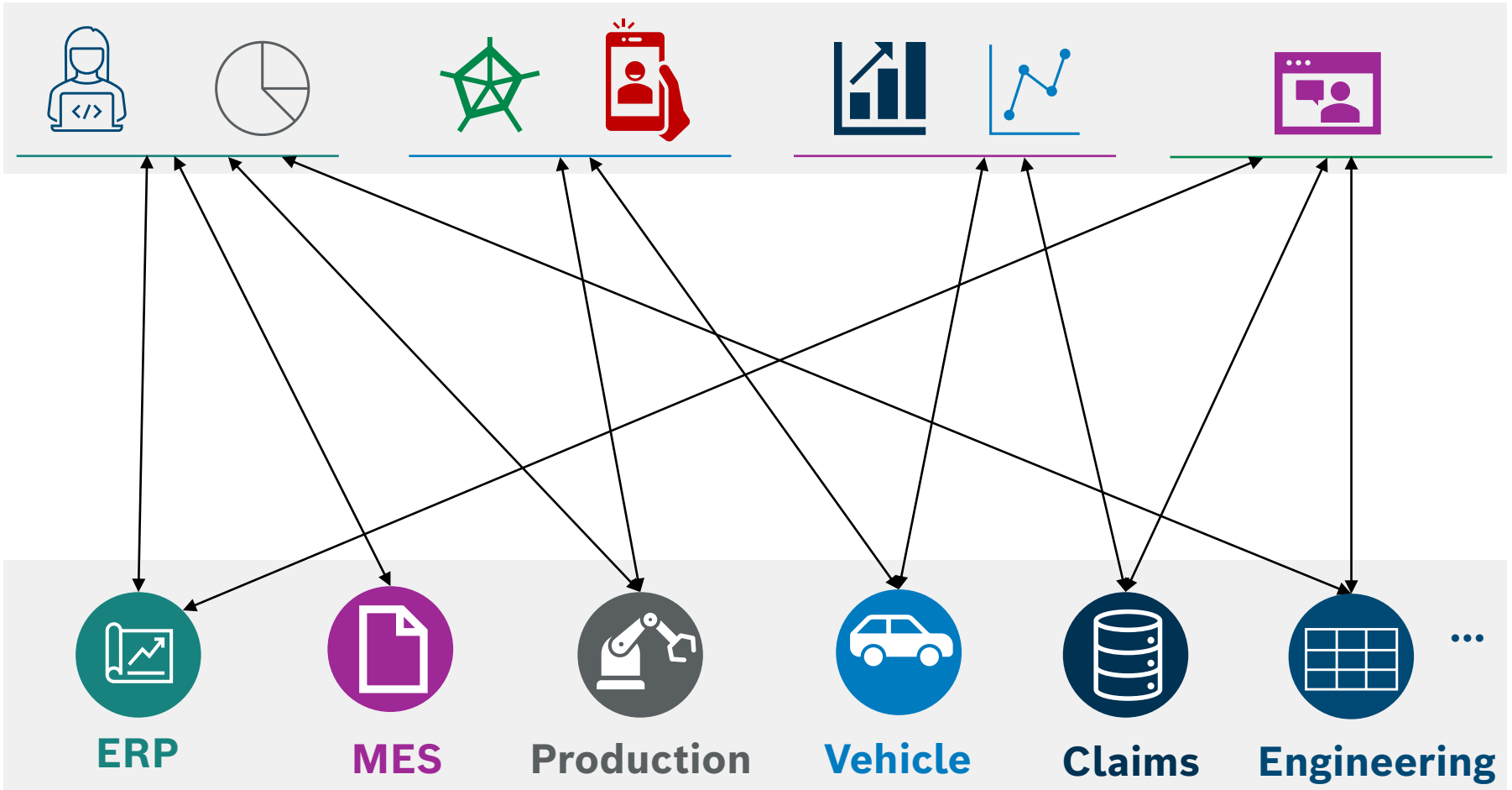
Where we want to go

Where we want to go
Industry 4.0

Bosch is a leading provider of innovative Industry 4.0 technologies which enhance teamwork between people and machines. Thanks to machines and processes that feature AI-driven connectivity, Bosch plants take automation to a new level.

Traditional approach for Data usage

Application centric approach



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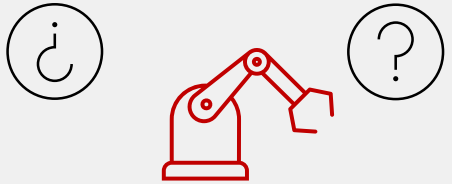
Traditional approach for Data usage
Challenges

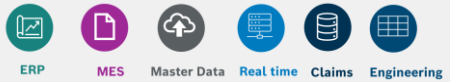
Non existing work towards **standardization, reusability and scalability**

Non reusable applications/data models



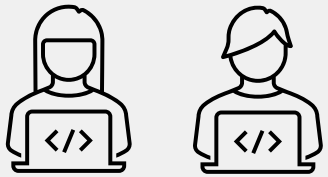
Do not make ***Semantic explicit*** leading to different interpretations and usage of data

Semantic Interoperability Conflicts



Data Silos – Yet another excel sheet, table or local data dump

Very poor data quality



Data Engineers, Scientists, have to do the ***same work*** over and over again

Time and money wasted

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Data Centric with Semantics (Meaning) at its Core

Data enables the business

Semantics enable the data

"Semantic work on data will be the future."

Dr. Stefan Hartung

Chairman of the board of management

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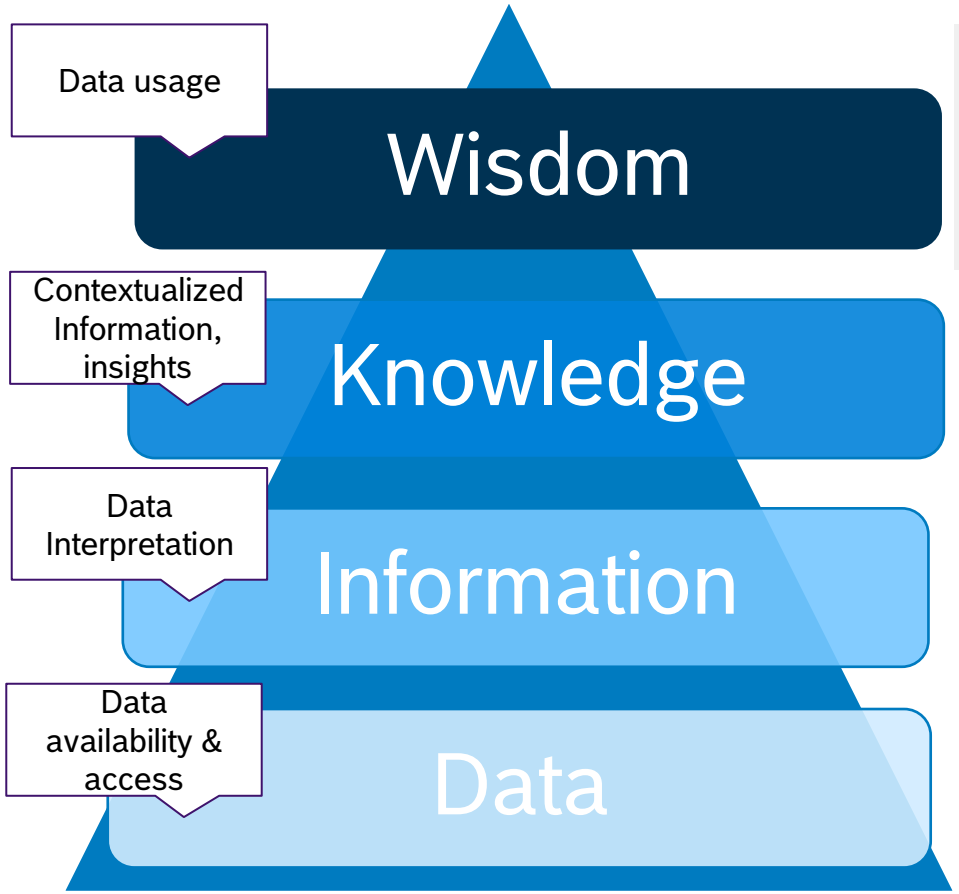
Where we want to go

Generate wisdom based on domain-specific knowledge



understanding, integration, applied, actionable, accumulated, principles, patterns	We have optimized process X in plant P to reduce errors of product Y
Know-how, concept, synthetized, compared, discussed	Process X in plant P is core for manufacturing product Y
organized, structured, categorized, calculated	Process X in plant P for product Y has produced more than 50 errors
individual facts, figures, signals, measurements	“dispensing process”, “plantP1”,”pump1”, error_code: “wrong dispensing”

Example: Process optimization

We can generate wisdom based on our domain-specific knowledge

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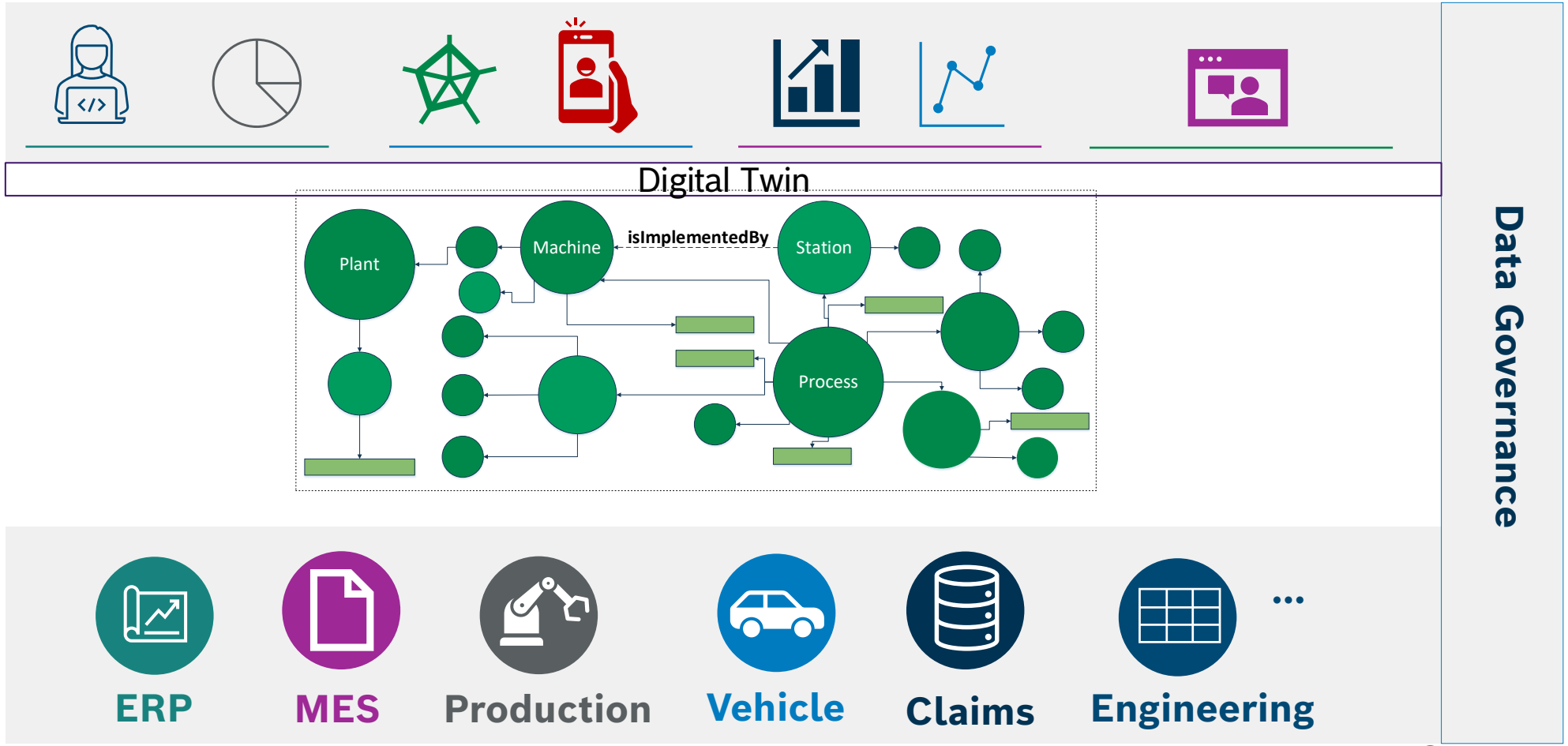
Semantic data integration and harmonization using Knowledge Graphs (KGs)



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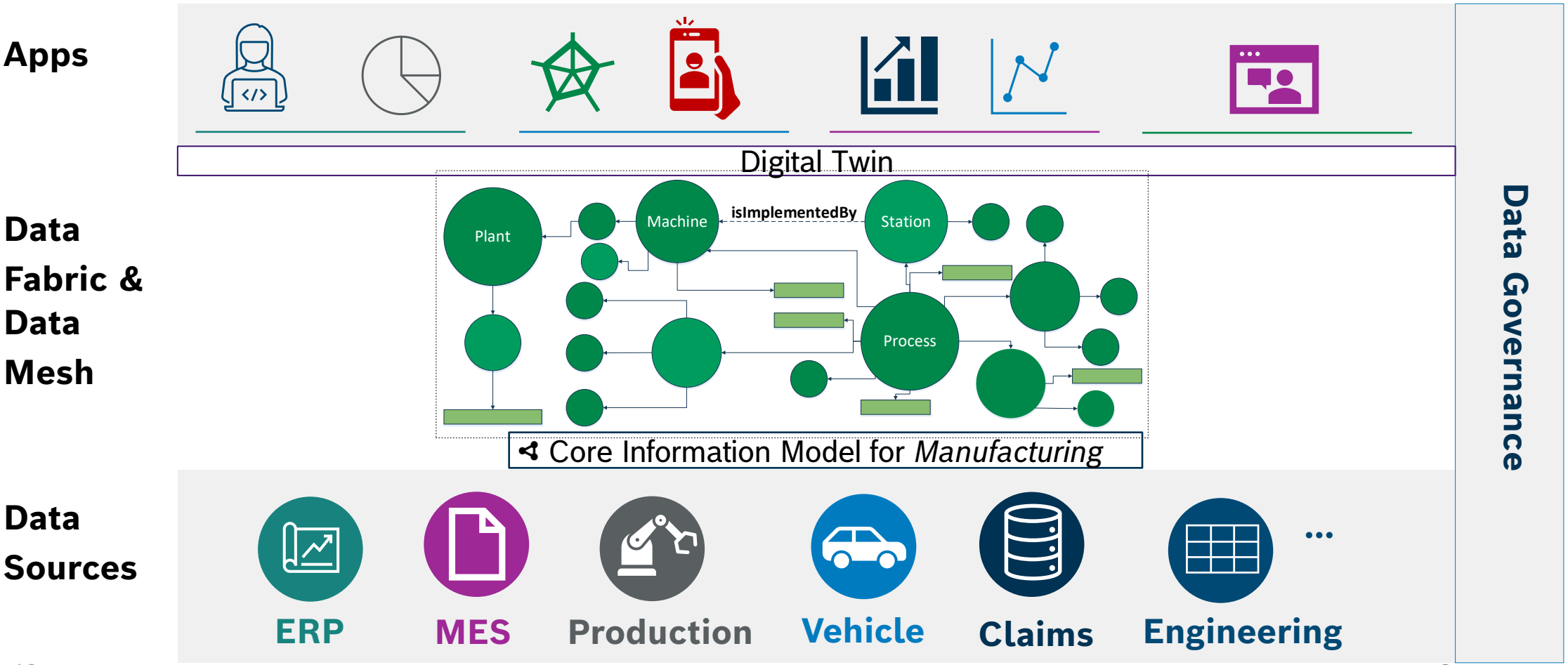
Knowledge Graph-based Approach

Semantic data integration and harmonization using KGs



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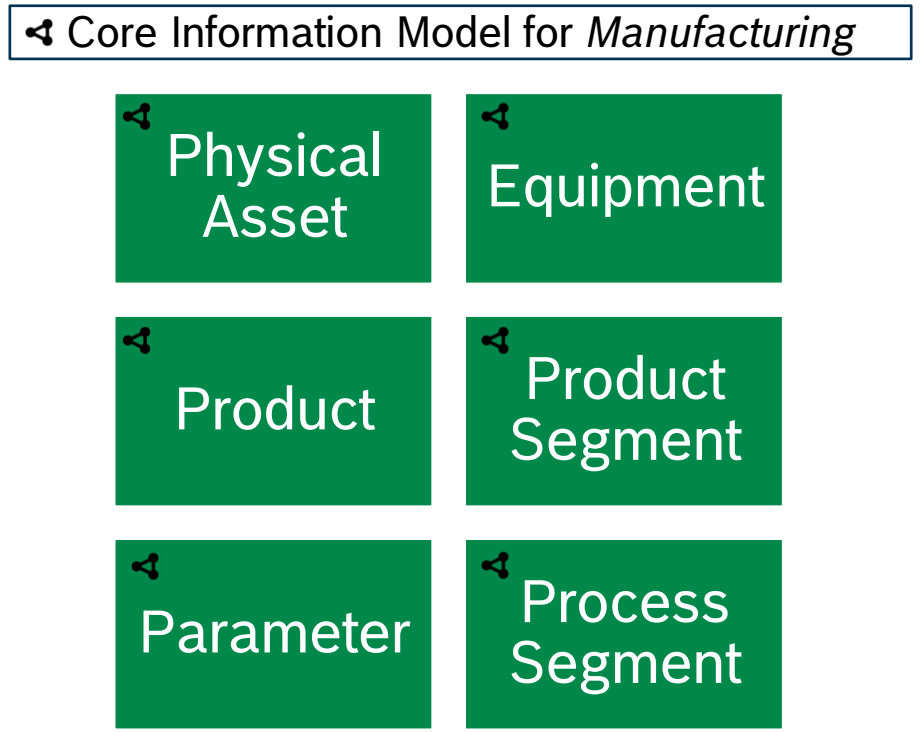
Industry 4.0 Core Information Model for *Manufacturing*

Ontologies

- A set of interconnected ontologies for dealing with core concepts in the Manufacturing domain
- Based on ***IEC 62264*** standard
- White paper and ontologies published in the context of Eclipse Foundation
- Used by Bosch in several use cases as well as by other manufacturing companies



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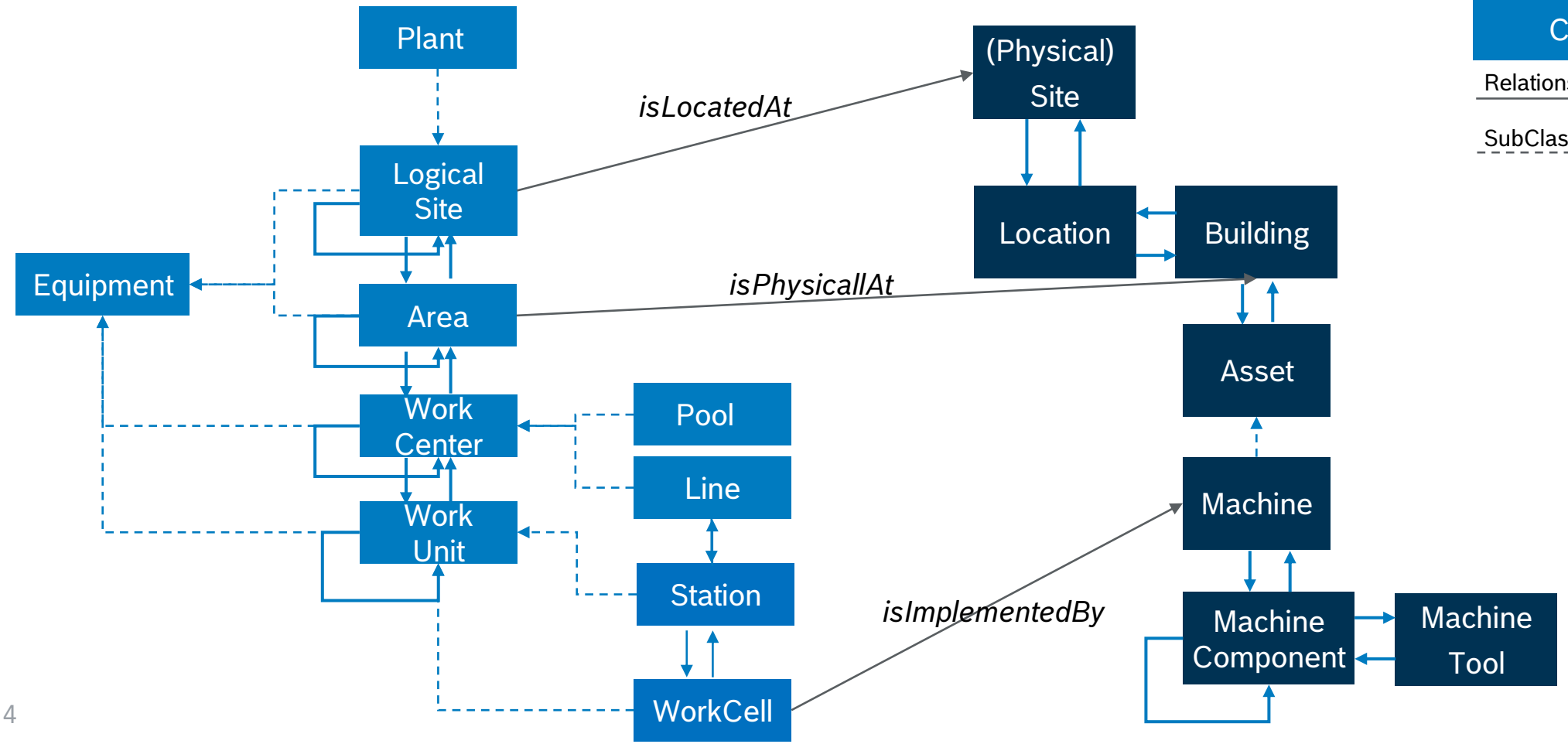
Industry 4.0 Core Information Model for *Manufacturing*

Equipment (logical) Ontology

Physical Asset Ontology



Legend

Class

Class

Relationship

SubClass

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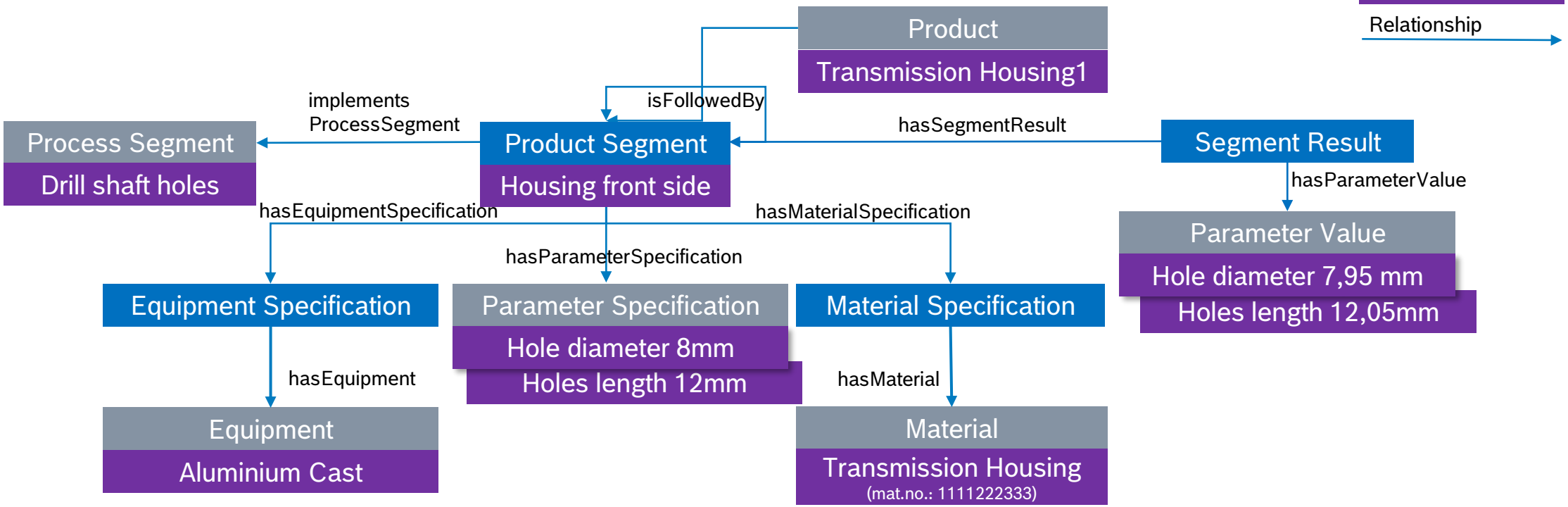
Industry 4.0 Core Information Model for *Manufacturing*

Product Segment Ontology



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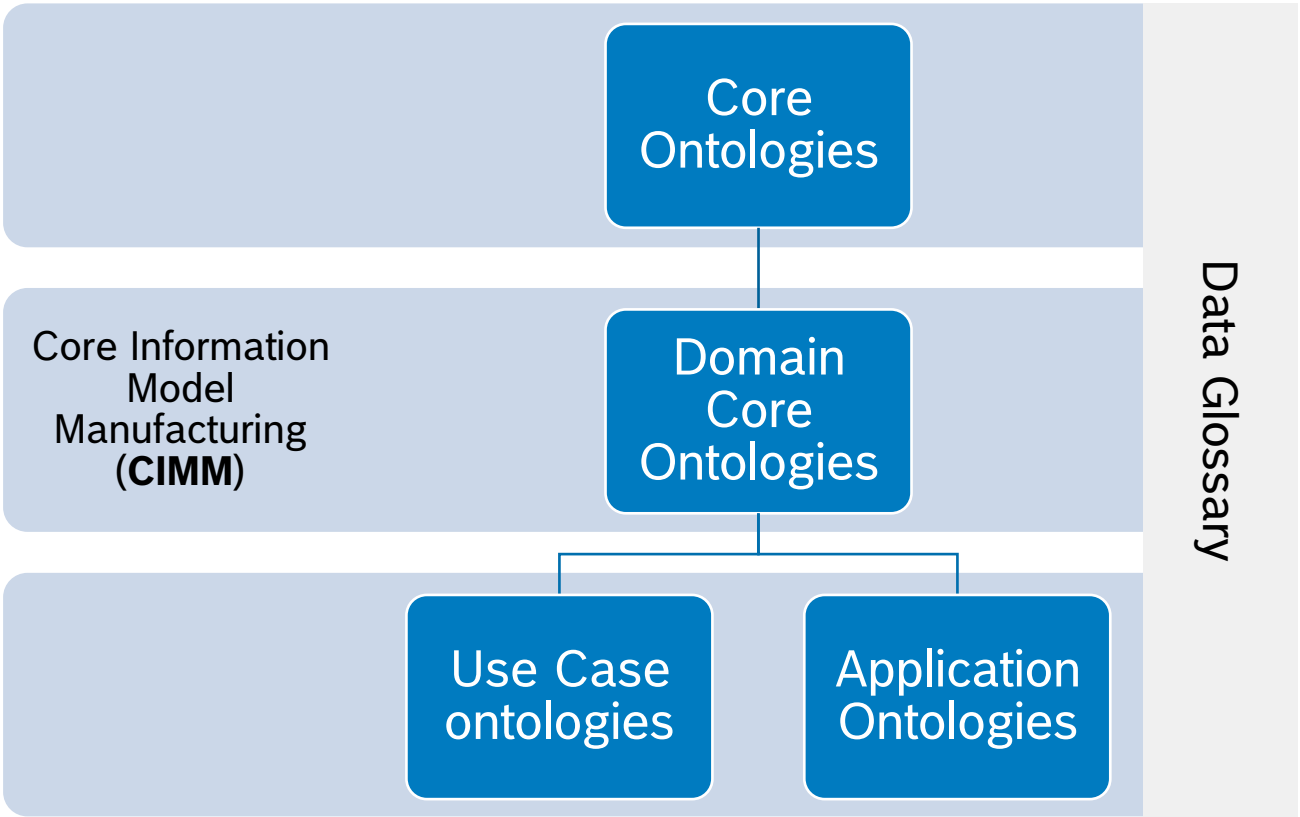
Different levels of ontologies

Core and domain ontologies, data catalog

- Core Ontologies are defined to represent central and cross-domain concepts inside the organization
- Domain ontologies are focused on specific domains, e.g., manufacturing with the **CIMM**
- Use case and application ontologies typical extend Domain ones and further especify concepts on demand
- All levels are inter-connected and make use of the Data Glossary



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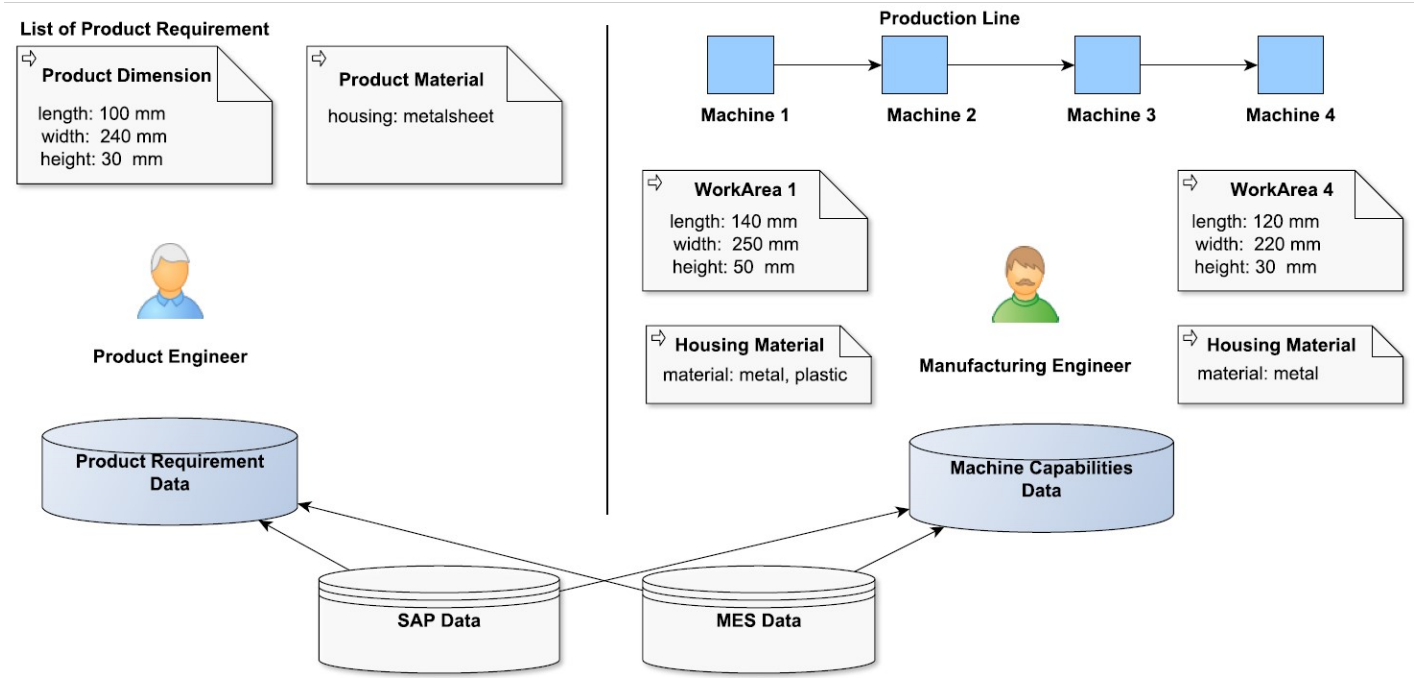
Use Case: Manufacturability Analysis

- Typical scenario for finding lines capable to manufacture a certain product
- Product and the Manufacturer Engineer collect data for answering the question whether a certain product can be manufactured in a production line
- Semantic interoperability conflicts in the data have to be manually harmonized, e.g., the dimensions of the machine



Can a certain product be manufactured in a production line?

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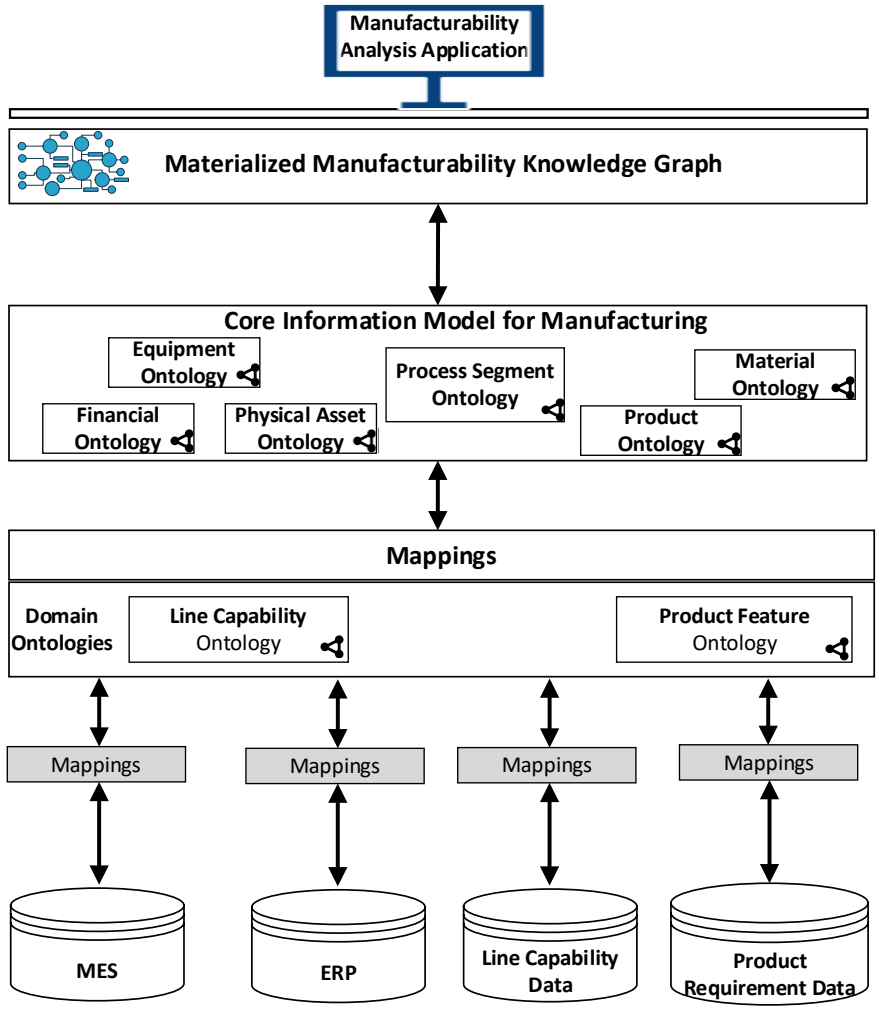
Use Case: Manufacturability Analysis

1. Data silos comprising semantic interoperability conflicts
2. Domain ontologies to capture the knowledge and resolve conflicts
3. Mappings to connect data silos with the domain ontologies
4. Describing general entities to be used in the I4.0 domain with the **CIMM**
5. KG enables the execution of queries to answer questions for the Manufacturability Analysis



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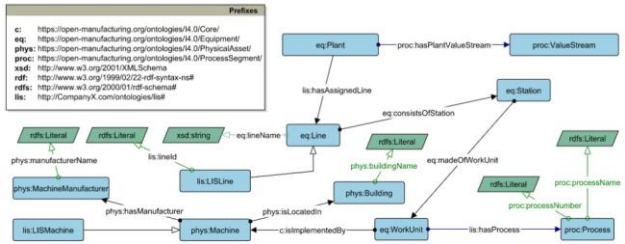
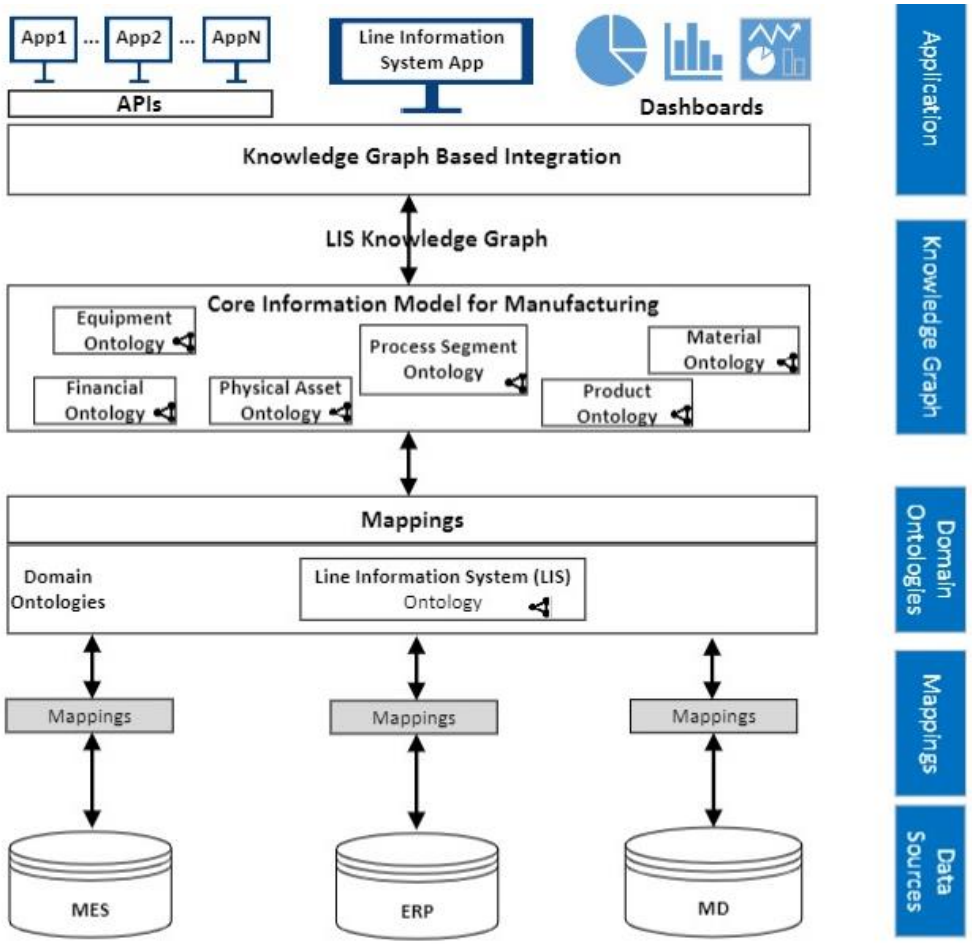
Use Case: Line Information System

Which production lines comprise machines from Manufacturer X?

Which production lines are currently installed in our plants?



LIS Ontology



A KG-based ecosystem capable of ***semantically harmonizing and integrating manufacturing data***

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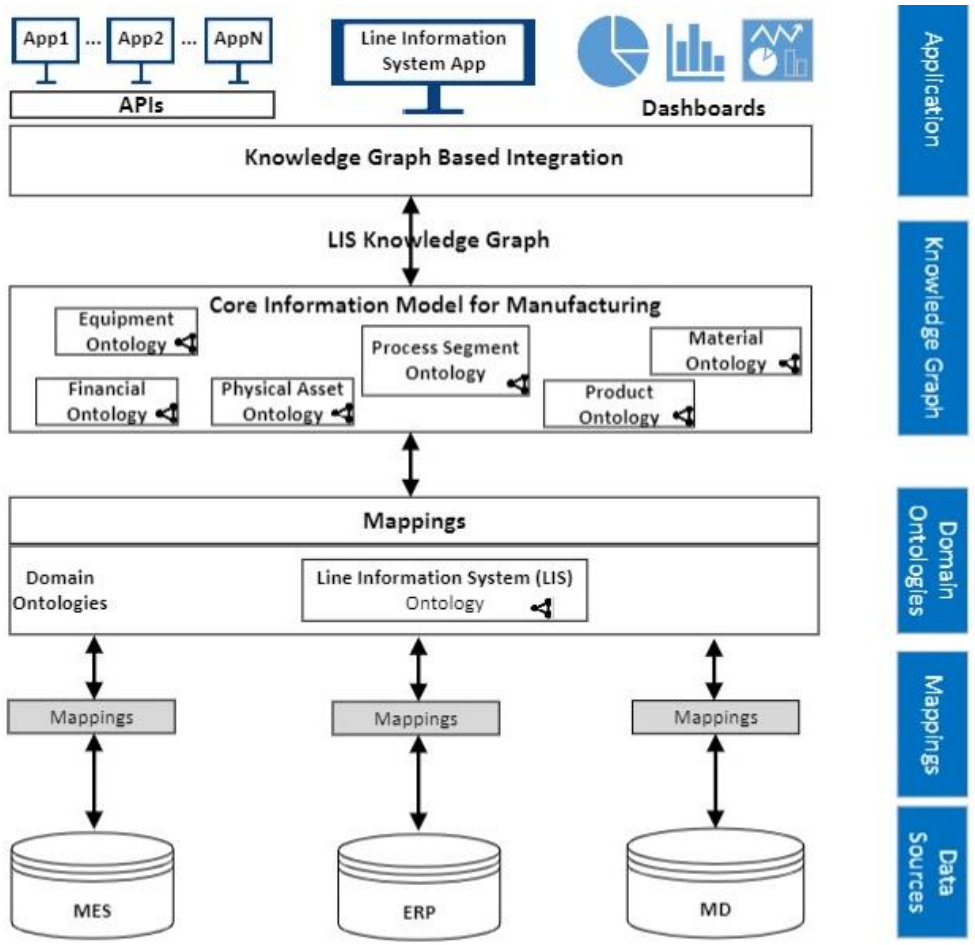
Use Case: Line Information System

Currently in use in more than 11 plants integrating data of more than

- **1.100** production lines,
- **16.000** physical machines,
- **13.000** manufacturing processes

After the first MVP, with the data semantically harmonized and integrated, more than five applications requested data to the system



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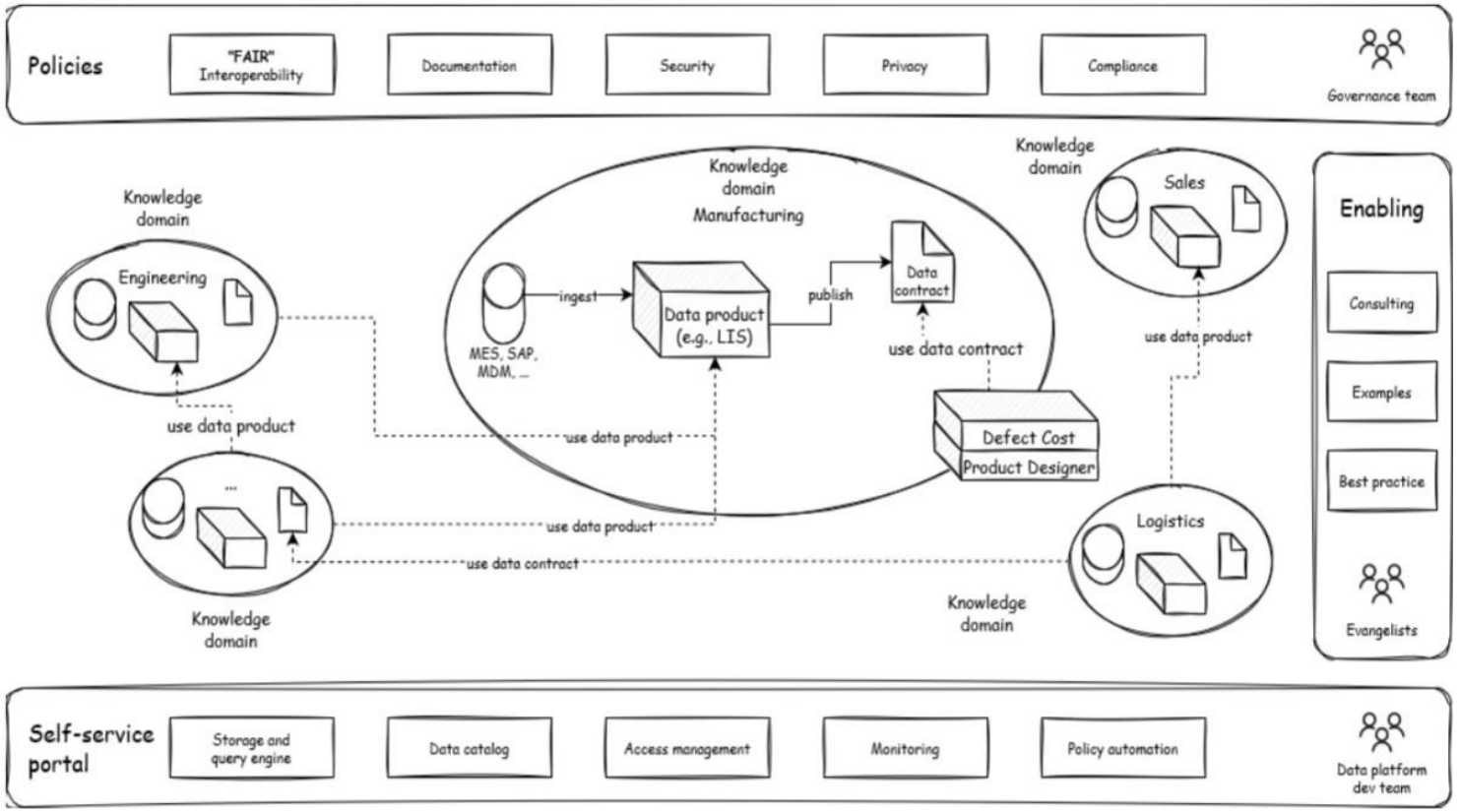
Use Case: Line Information System

Data Mesh architecture having **FAIR** principles right on top priority

Data products should all meet **FAIR** principles



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Discussion

- **Integrated 360-degree view of data**

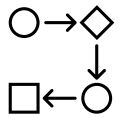
Enabled experts to access **semantically integrated data** to answer business questions that could not be answered with data spread in silos

- **Involvement of domain experts**

Making ***domain experts*** part of the process to understand, clean, share and enhance data was – and still is – core to the approach

* More than 400 domain experts trained in KG-related technologies

- **Data reusability**



Increasing need of applications to ***reuse data*** from KG-based solutions to avoid unnecessary data duplication

- **Impact on data quality**

For the first time it is possible to make the ***data quality*** of the integrated systems transparent.The findings are used to fix undetected failures in data

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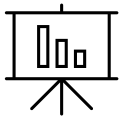
Where we want to go (And already started)

- **Full Data Fabric & Data Mesh**

Unification/full implementation of the Data Fabric & Data Mesh concept as part of the Data Strategy in the organization implementing **FAIR** principles

- **Performance and scalability**



To be have a sucessfull present and future we need to enhance performance and scalability of KGs

- **Search engines**

Google-like search engines on top of domain specific KGs

- **AI/ML on top of KGs**

AI/ML algorithms may be able to predict results, e.g., maintenance, most common errors in production, recommender systems

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Questions?

Dr. Irlan Grangel-González

Corporate Research Project Leader

Email: Irlan.grangelgonzalez@de.bosch.com

Linkedin: https://www.linkedin.com/in/dr-irlan-grangel-gonzalez/

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