# Industry Ontologies Foundry:
*Industrial applications of ontologies*

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# Some words about DK…

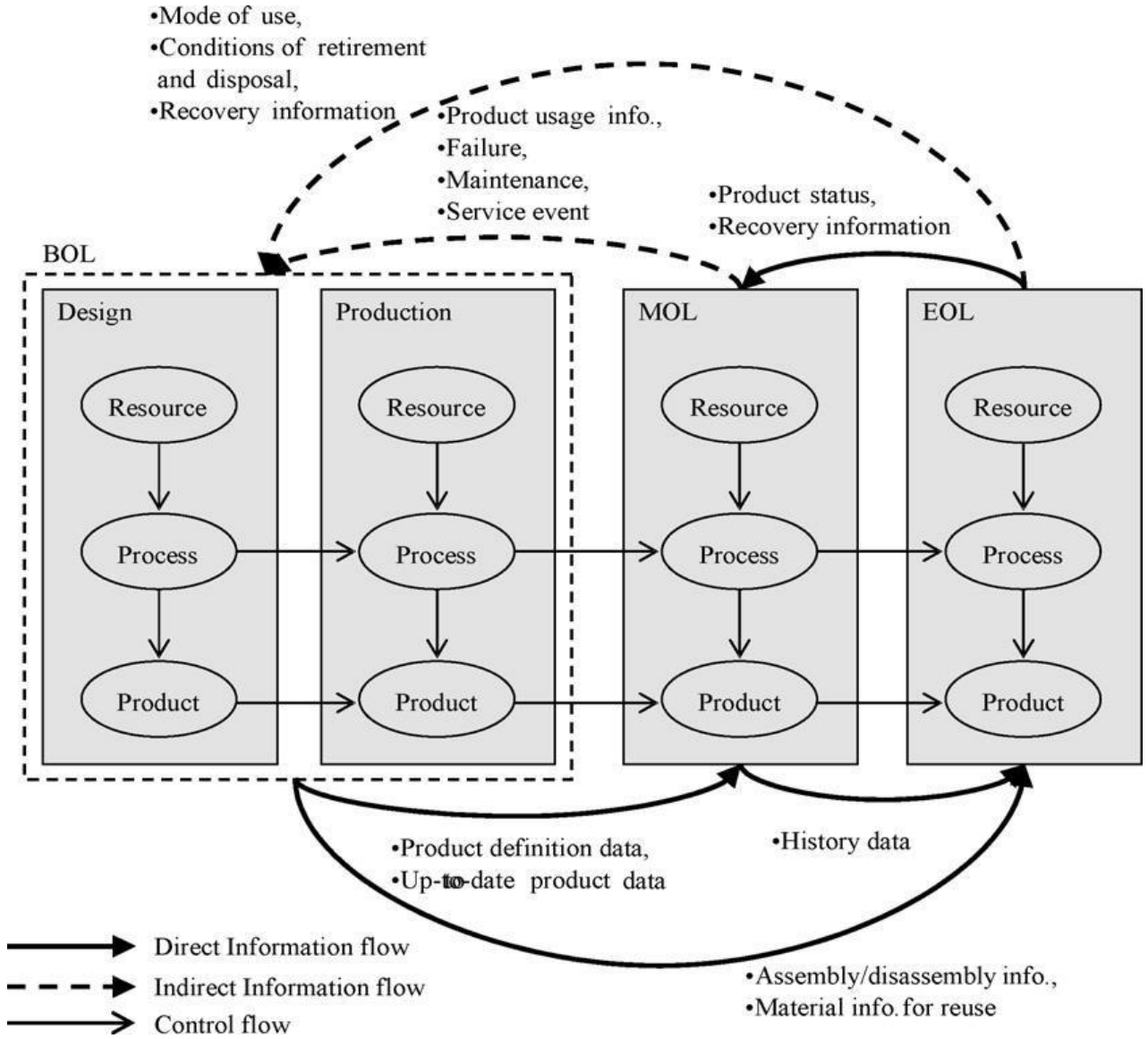
- ***STI-IGM***
  - ***Prof. ICT for Sustainable Manufacturing***


- EC – AG LEIT-NMBP
  - ***Individual Member***

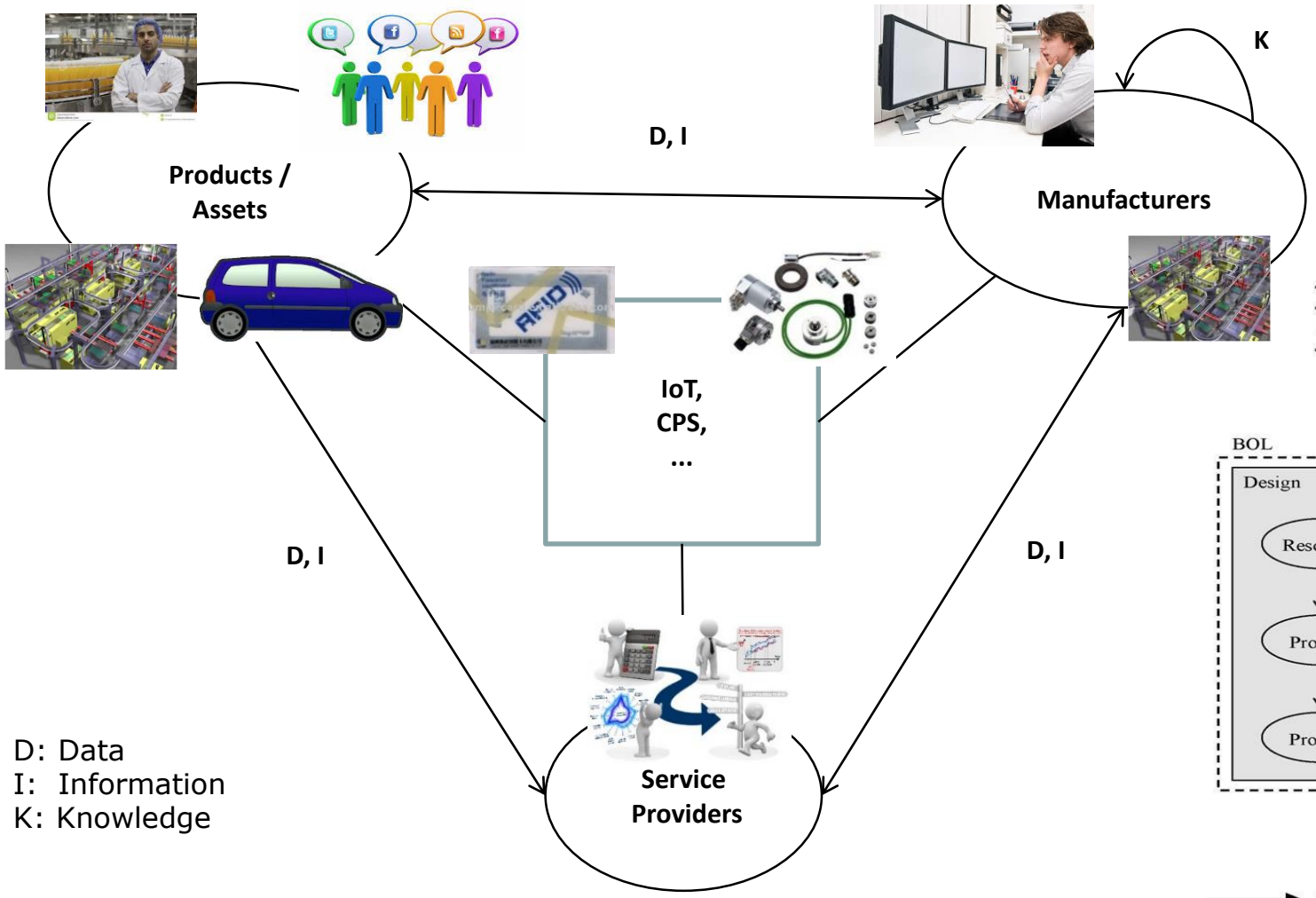
- IFIP WG5.7 – Advanced Production Management Systems
  - ***Chair***

- ***Member*** *(representing EPFL)*

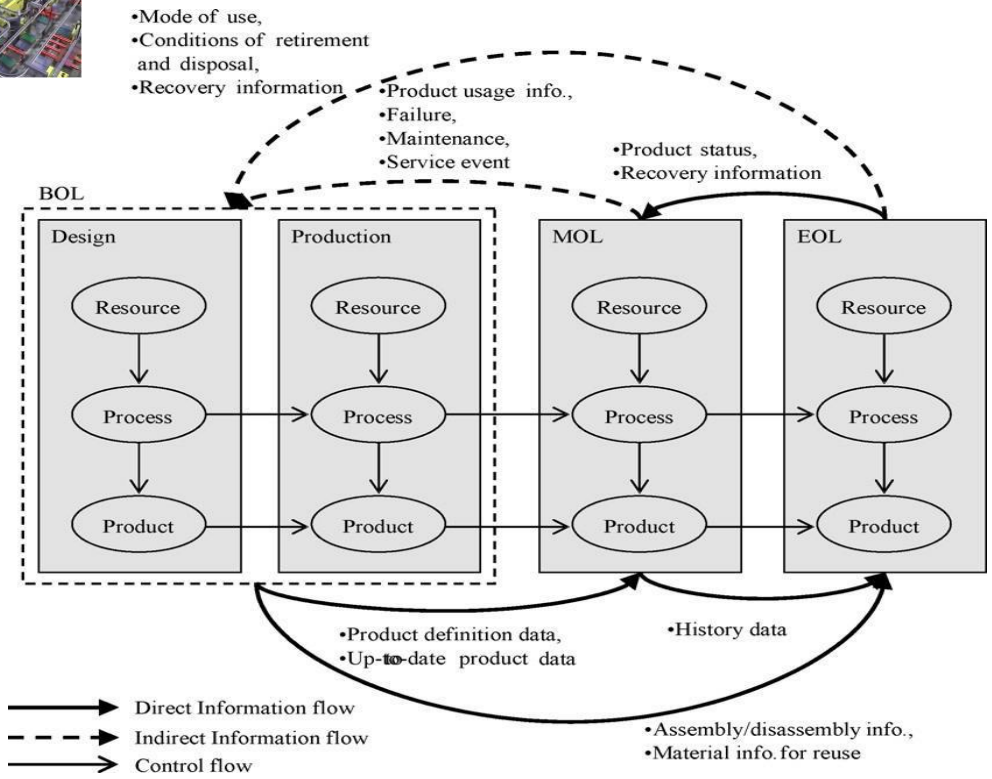
# Closing the information loops of product life cycles



# It’s about big lifecycle data transformations




***Lifecycle Data-Information-Knowledge Transformations***



**38.5**

**38.5 ºC**

Body temperature


Oven temperature

# Characteristics of Data

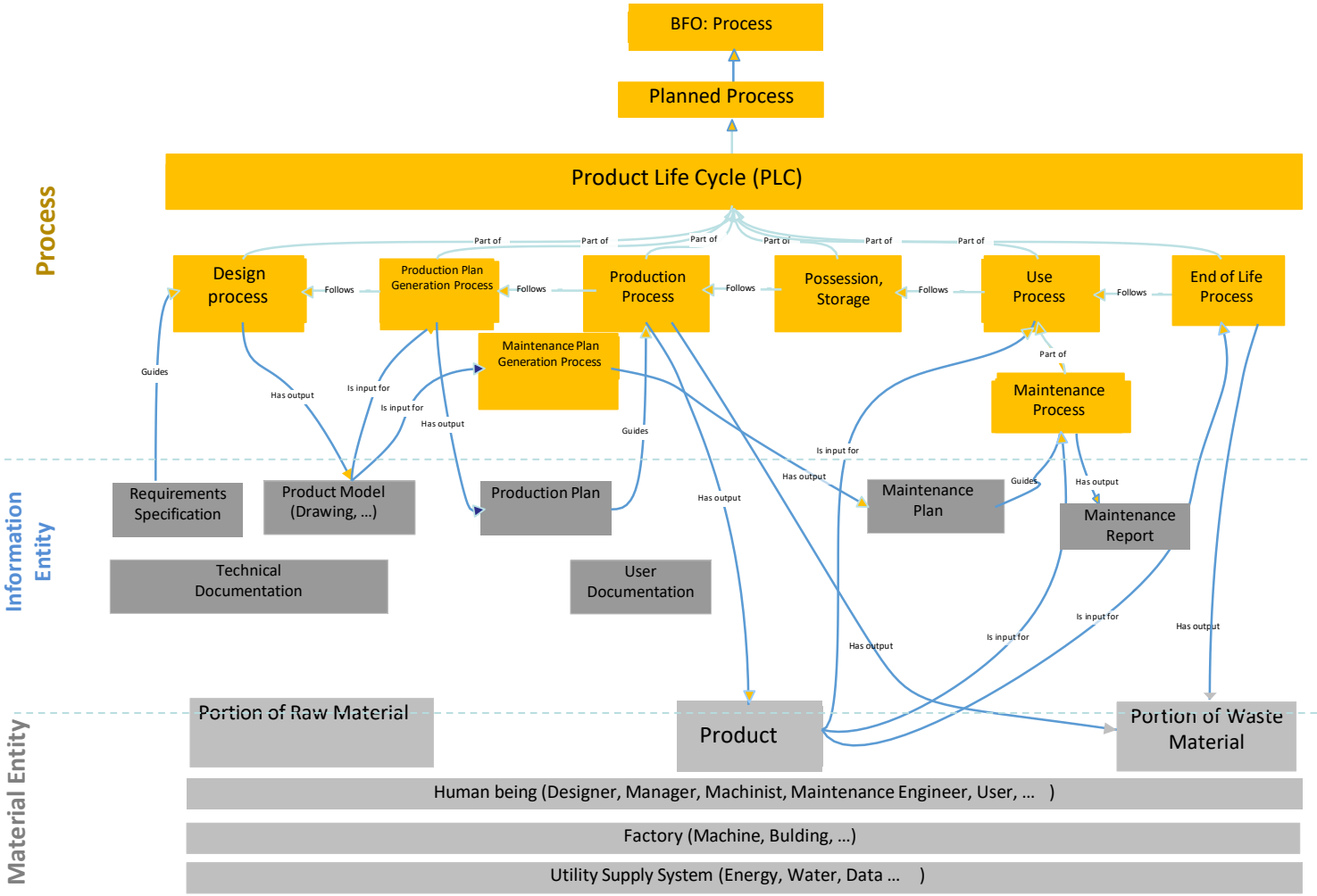
- Source of data
- Measurement (sensors, assessment, observation, records, …)
- Value
- Transformation / Interpretation
- Visualisation
- Meaning / Context

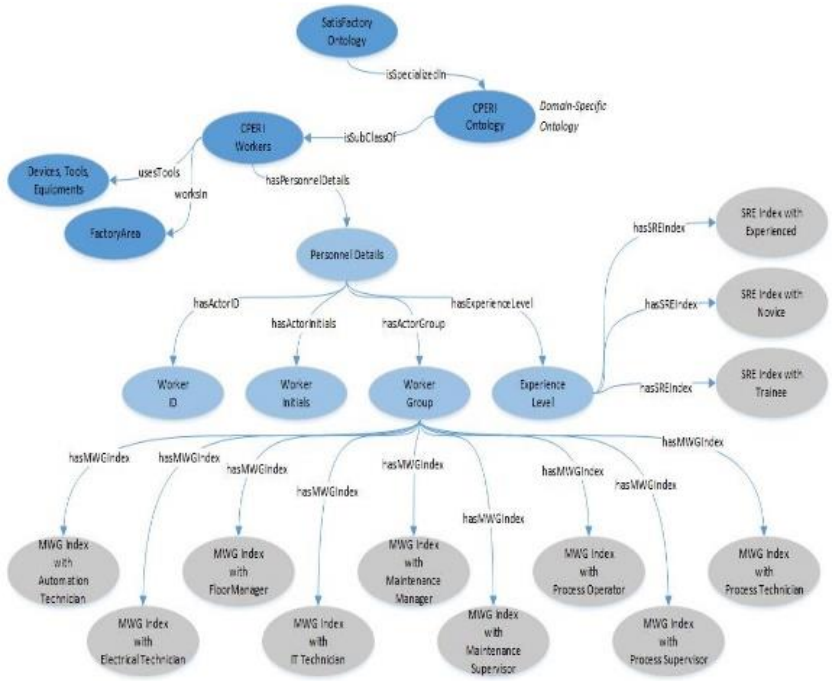
# Smart Manufacturing challenges

- **Domain modeling** for Big Industrial Data Analytics
- **Content analytics** enriched with semantic meaning
- **Recommend data and analytics** based on information / decision need
- **Improve the ability of analysts** to rapidly find and process relevant information in support of decision making
- The issue of **interoperability**:
  - *How do we get the domain modeling going on in **different communities** to coalesce?*

# Ontology Based Lifecycle Engineering

# Ontologies



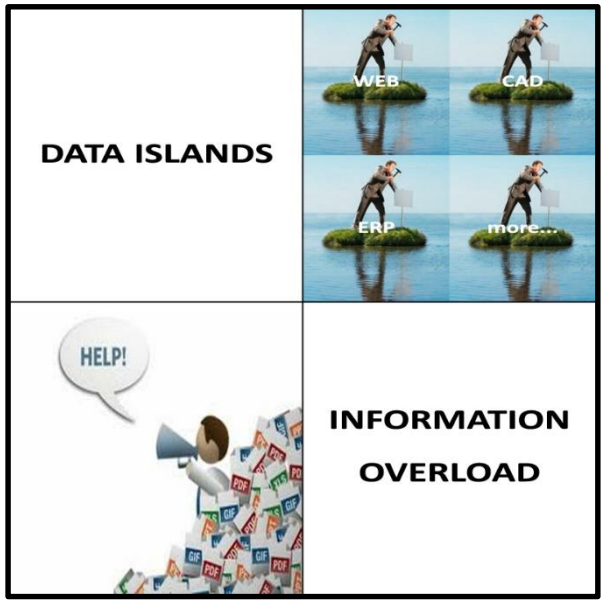




Bring together the Physical (**Real**)–Cyber (**Digital**)–Bio (**Human/Cognitive**) worlds

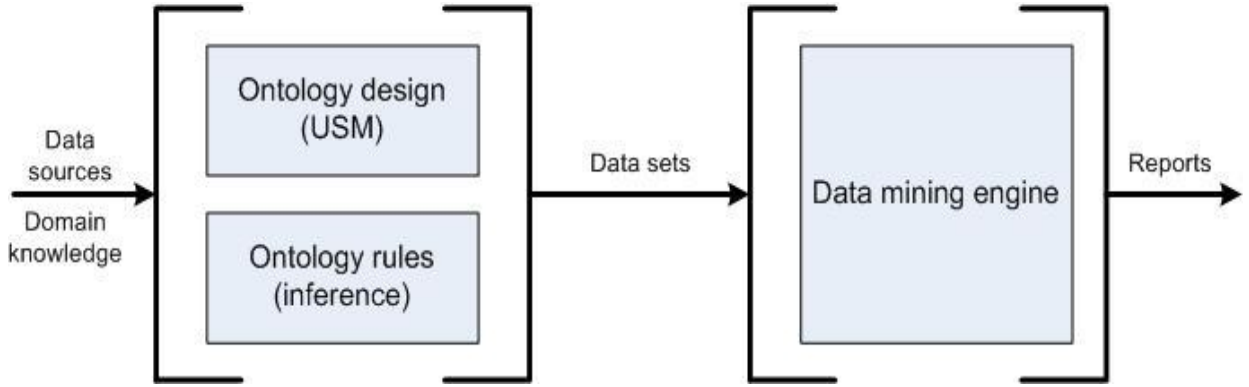
# Ontologies & Big Data

- **Scattered data in several sources, systems and services**

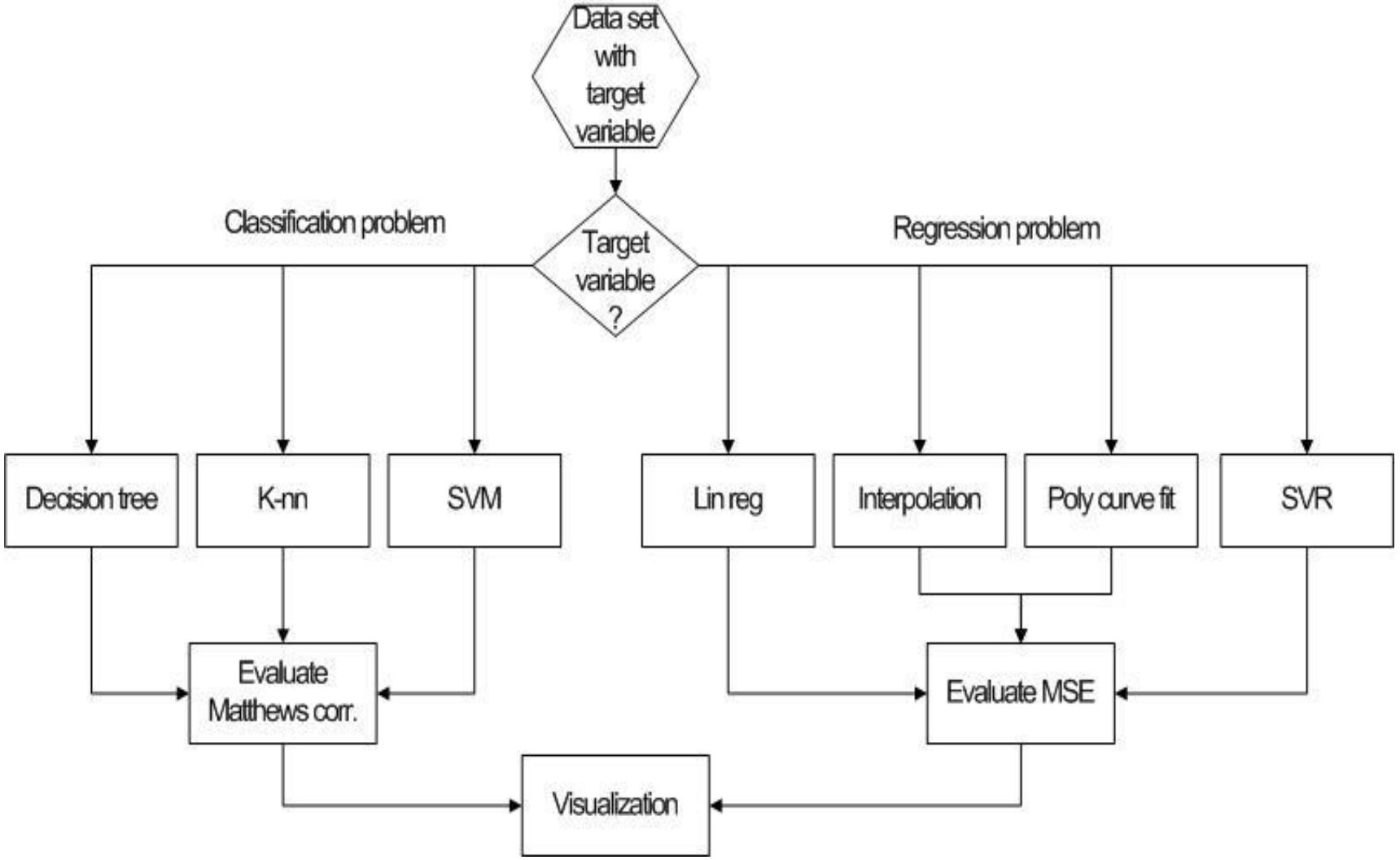
- **Different actors with multidisciplinary skills**




**Semantic modelling module** ✓ **Data Analytics module**

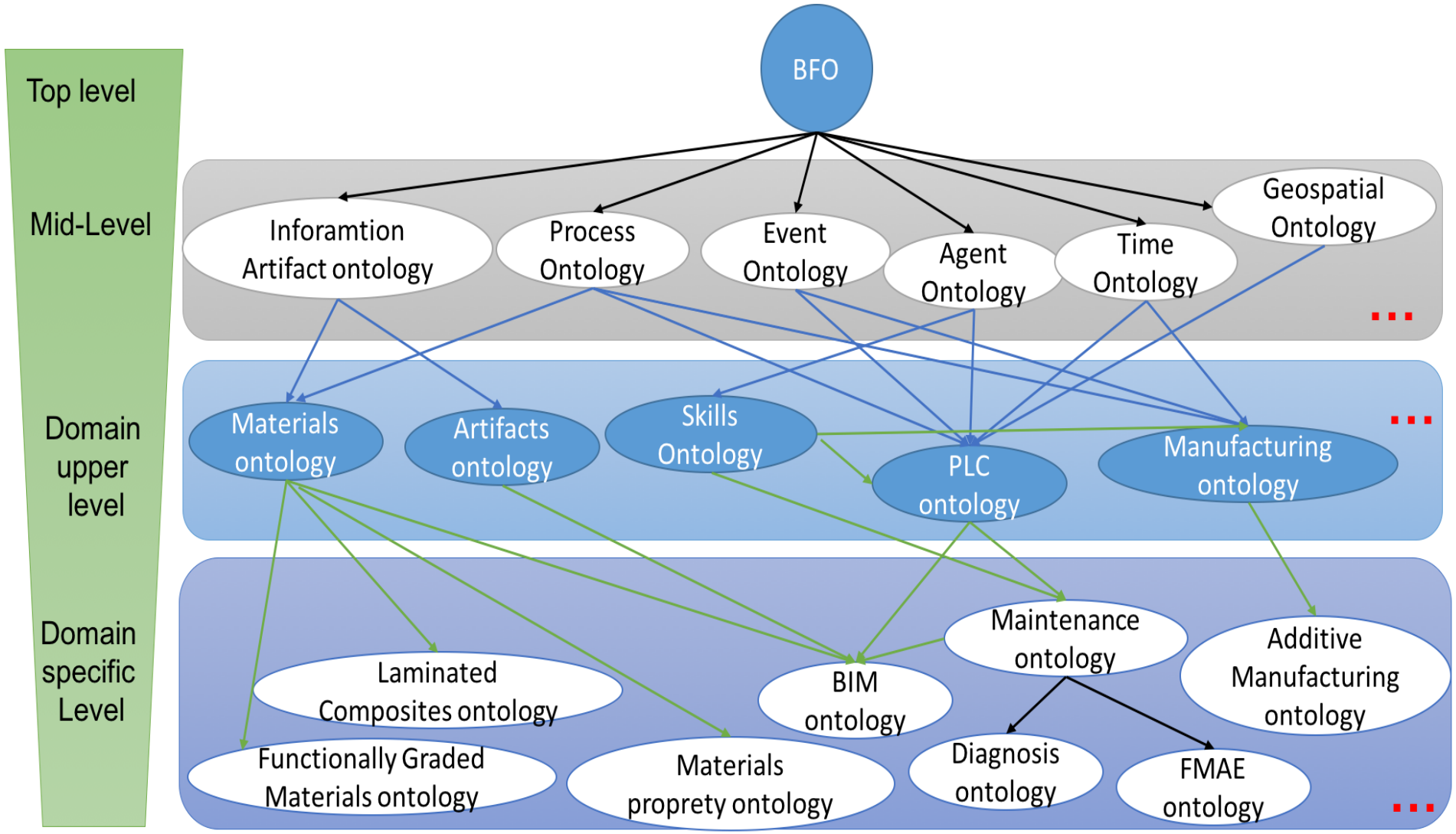


# What algorithm to apply ?

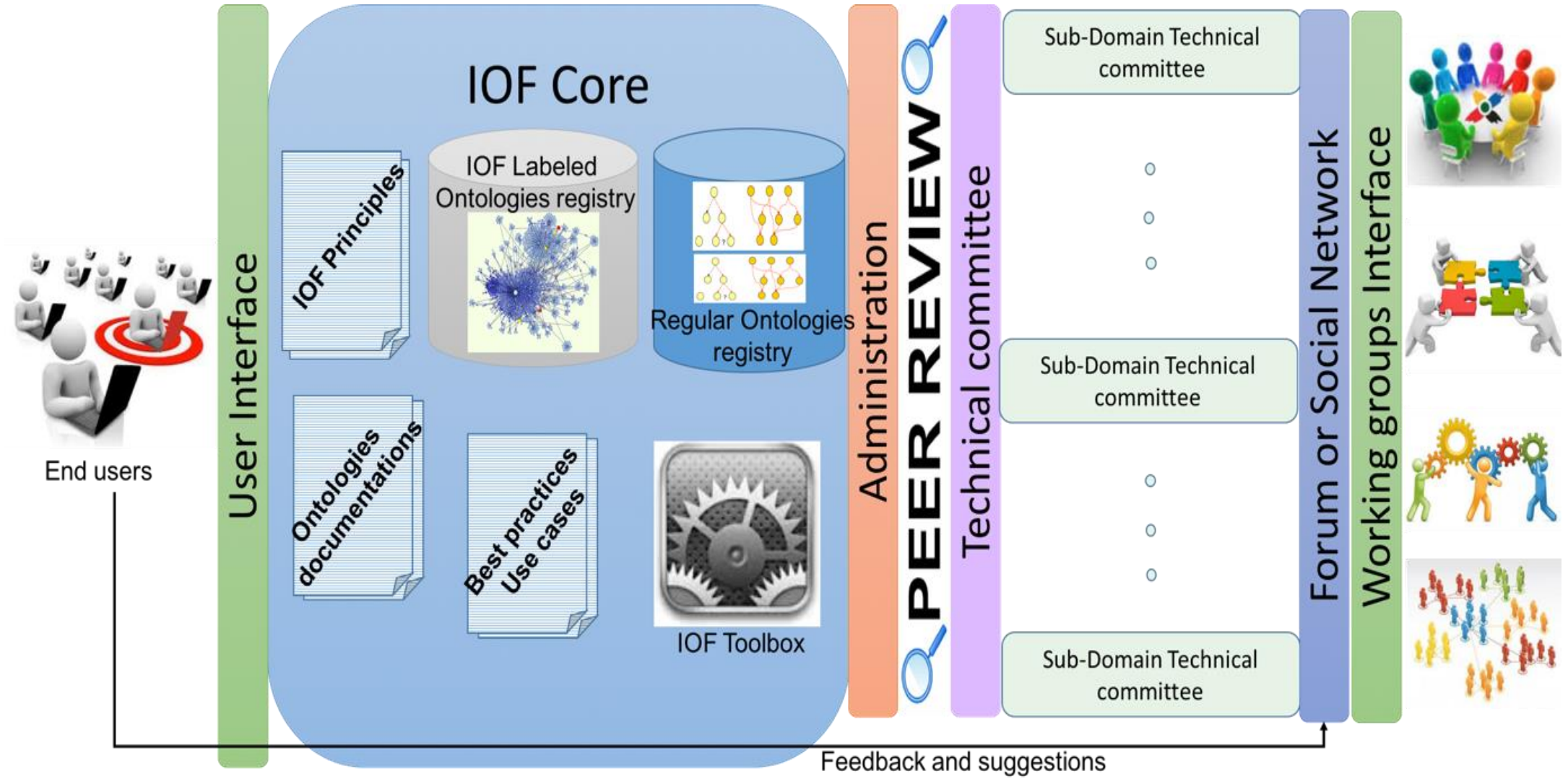



Taking the LEAP: The Methods and Tools of the Linked Engineering and Manufacturing Platform (LEAP)
https://www.elsevier.com/books/taking-the-leap/kiritsis/978-0-12-805263-1

# (Manufacturing) Industry Ontologies Foundry (IOF)



# IOF Archtecture




http://ieportal.ncor.buffalo.edu/ontologies

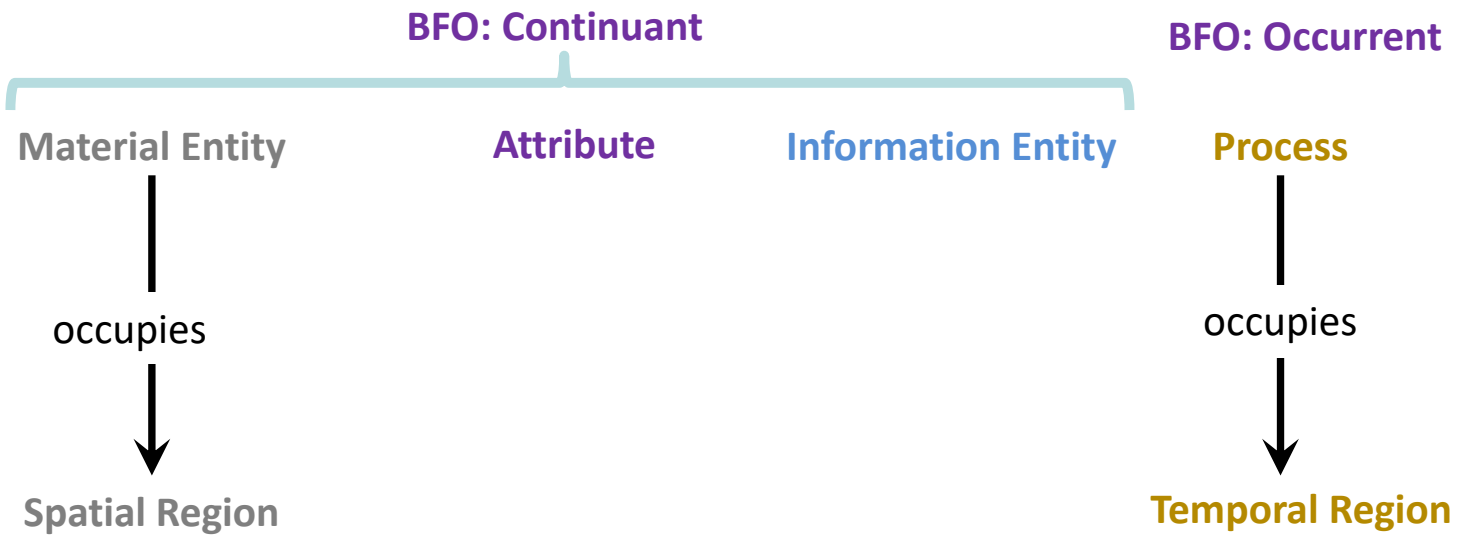
# Draft of a generic **PLC** (Product Life Cycle) Ontology

based on

# **BFO** (Basic Formal Ontology)

*With acknowledgments and thanks to **Barry Smith** (NCOR, Buffalo) for his ontological engineering approach*

# Following the BFO principles




- For some processes we have also process boundaries (beginning of process, end of process) at determinate Temporal Intervals.
- For some processes beginnings or endings may be indeterminate

# Material Entity instance examples

**Material Entity** **Information Entity** **Process**

Portion of
Material
Part/Component

Switch
Boiler
Furnace
Tank

Factory
Access road
Delivery vehicle

# Information Entity instance examples

| Material Entity | Information Entity | Process |
| --- | --- | --- |
| | Product Model (output of CAD system) | |
| | Requirement Specification | |
| | Process Plan<br>Production Plan<br>Part/Component List | |
| | Maintenance Plan<br>Maintenance Report<br>Maintenance History | |

# Process instance examples

Material Entity | Information Entity | **Process**

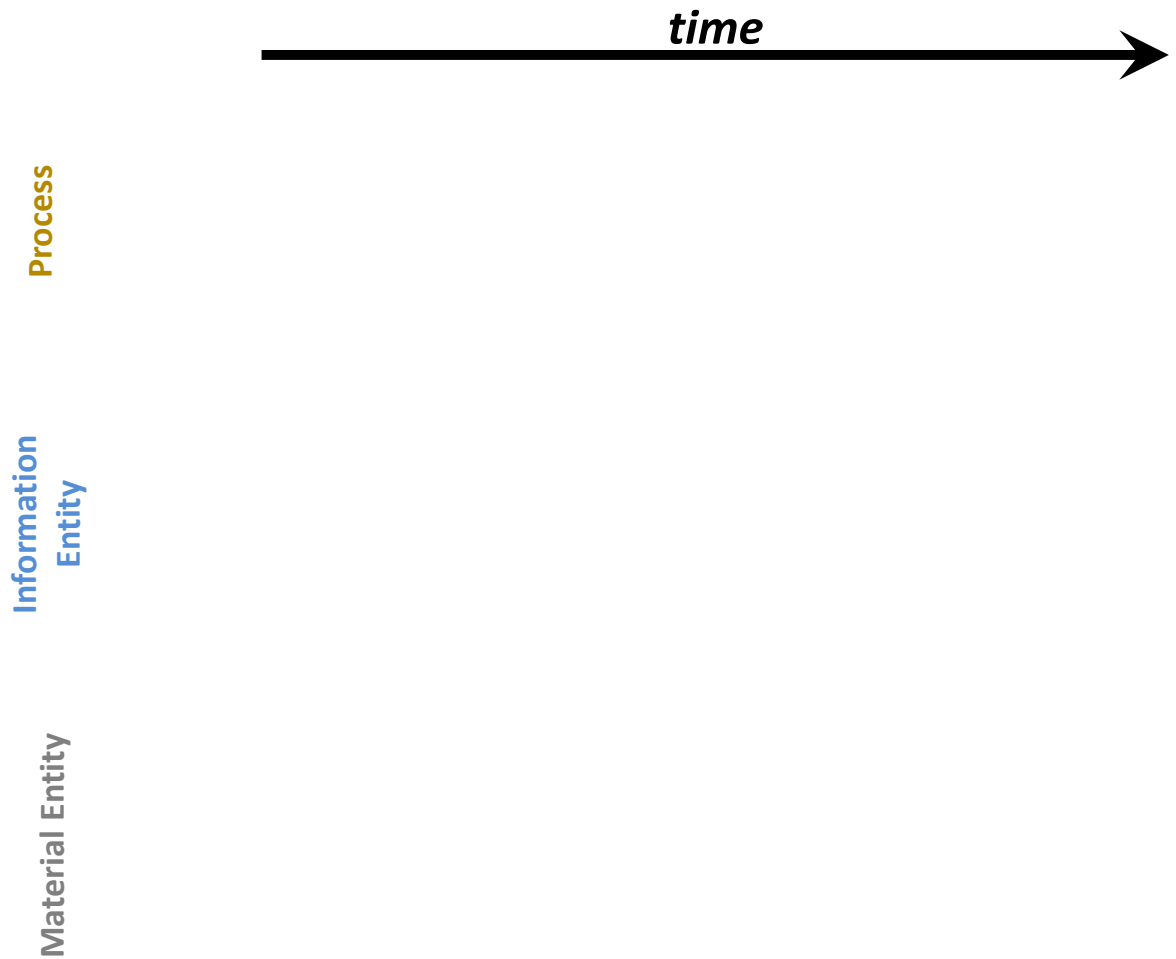
Design Process
Production Process

Production Plan Generation Process

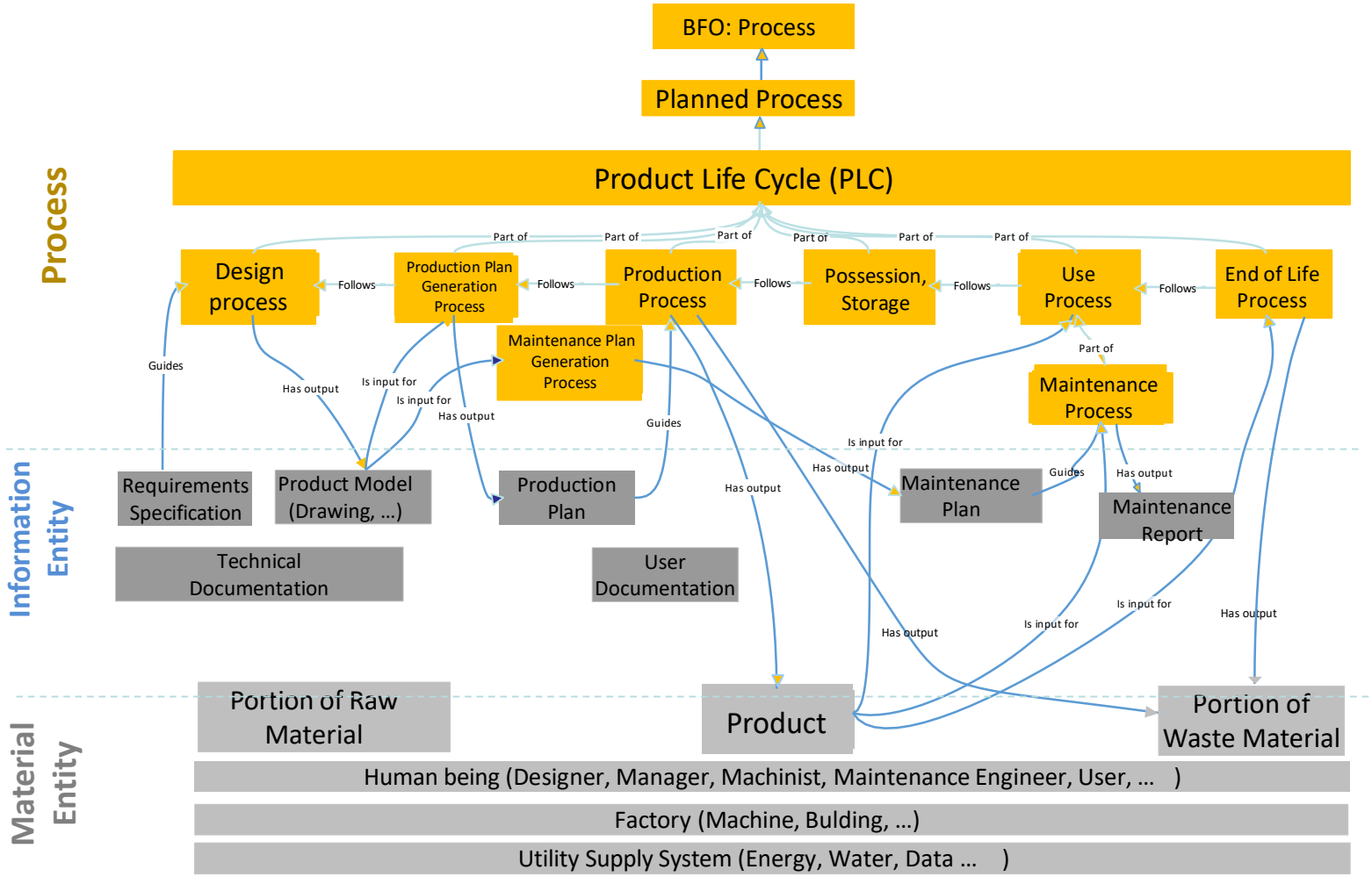
Product Use Process
Product Maintenance Process
Product Inspection Process

End Of Life Process

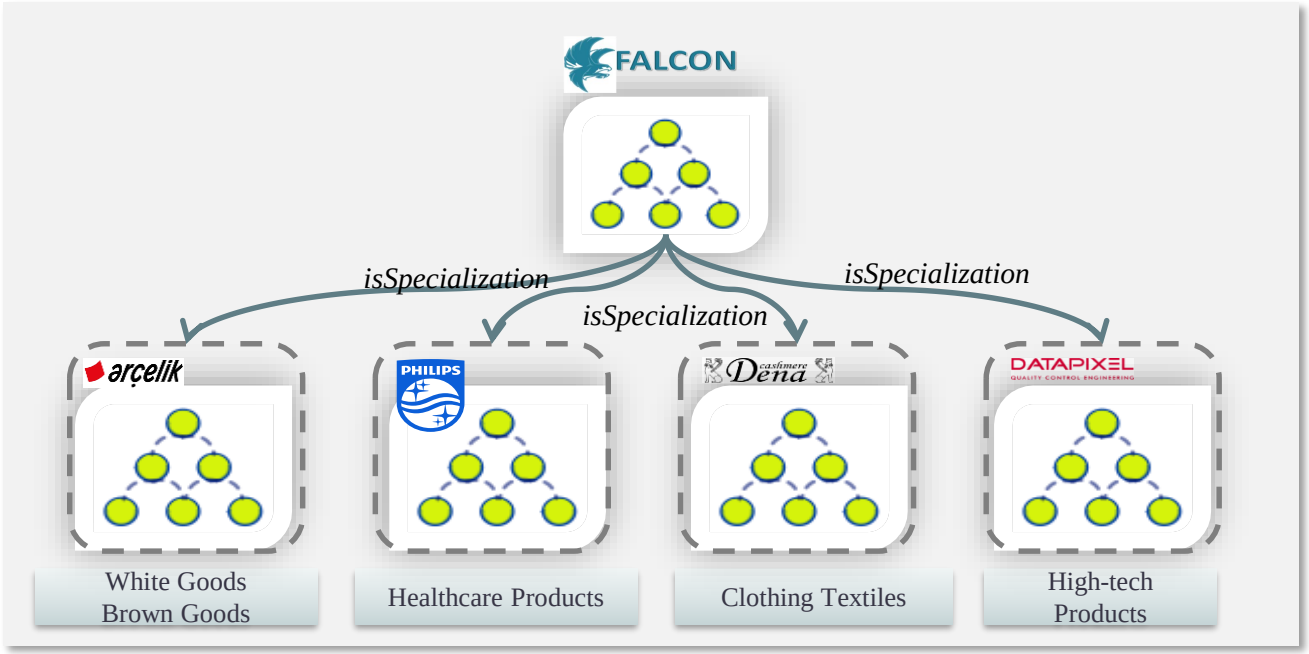
# Following the time



# PLC ontology: the complete schema



# FALCON Ontology




An FALCON upper ontology **is a generalization of the five business scenarios** of the FALCON project serving as **an upper template** for all FALCON business cases as well as future business cases in terms of **Product-Service System**.

***The FALCON ontology plays the roles***

- To define the structure and contact of the Triple Store
- To be used to define semantic search parameters for social media
- To be used to query PUI

# Process to create ontology

Identify taxonomies using USM for five business scenarios

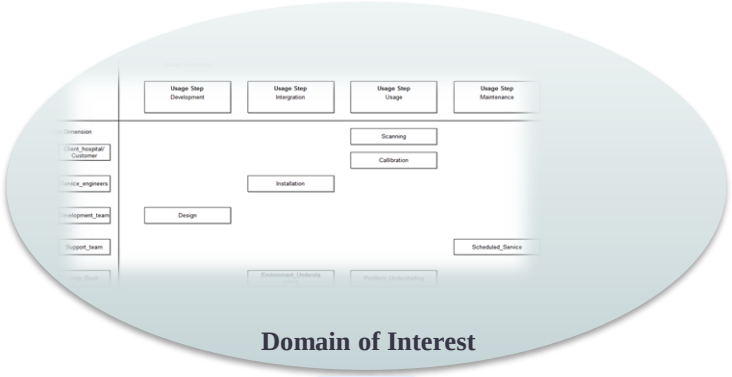
Generalization of five business scenarios

Refine taxonomies through comparison with reference ontologies

Create and update ontology

Discuss with end-users and experts

Test the ontology and refine



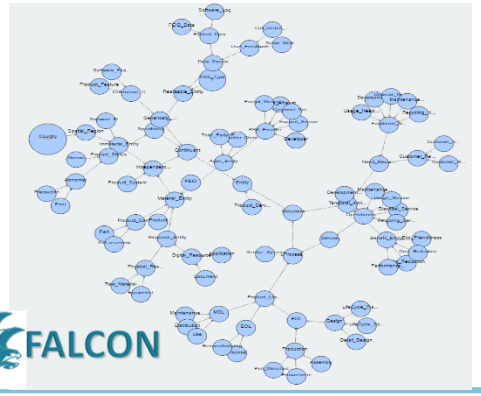
Domain of Interest

LinkedDesign

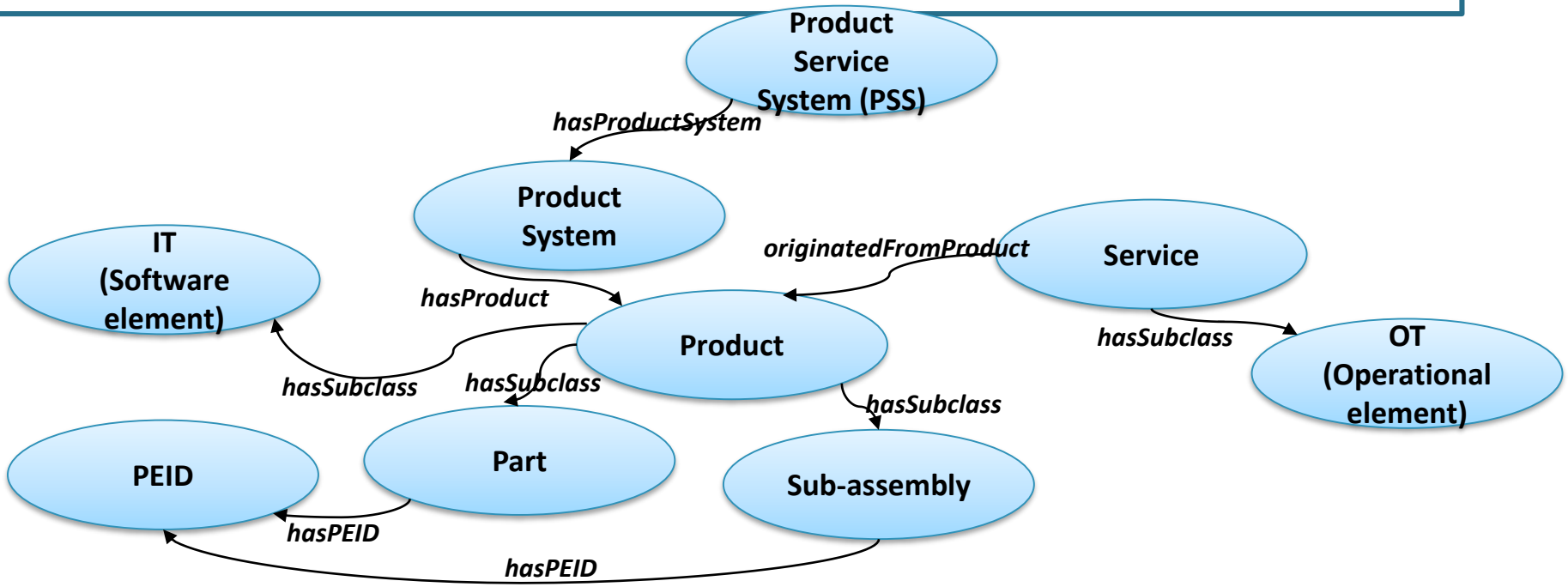
DiVERSITY

Reference ontologies

Adoption to Basic Formal Ontology

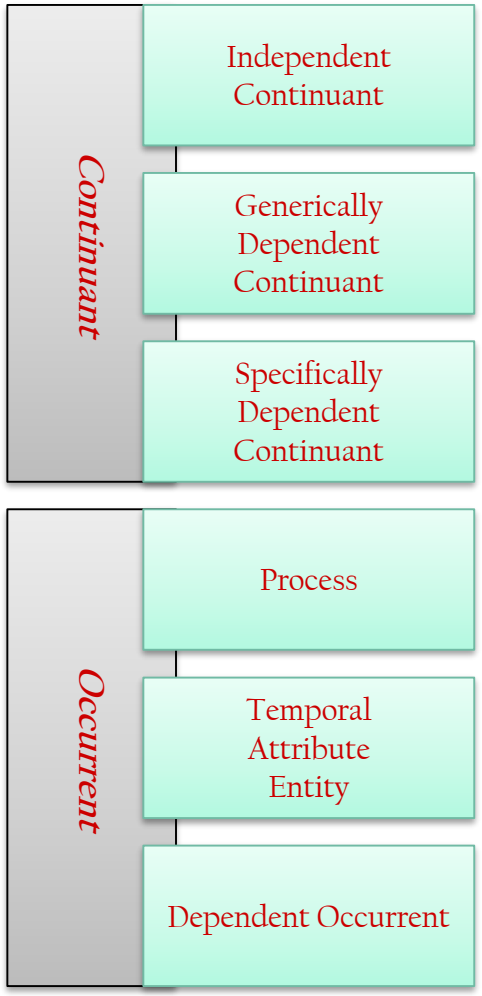


# FALCON Ontology- Product Service Entities




- ***Product Service System (PSS)*** : a marketable set of products and services capable of jointly fulfilling a user's need
- ***Product system*** : a set of material products needed to jointly fulfil a user's needs
- ***Product*** : a tangible commodity manufactured to be sold
- ***Service*** : an activity (work) done for others with an economic value and on a commercial basis

# FALCON Ontology-Alignment to BFO

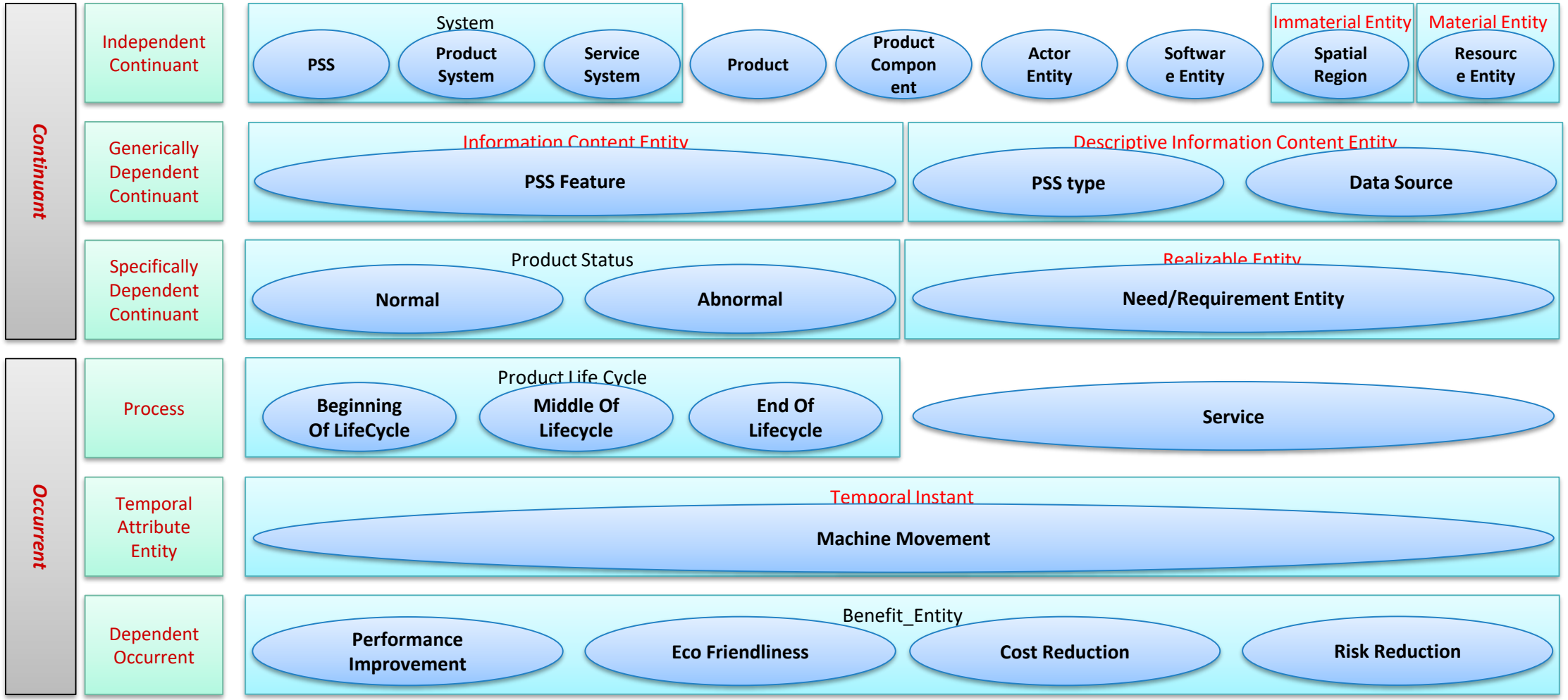



***Basic Formal Ontology***

- Formal ontology framework developed by Barry Smith and his associates (Smith at al., 2014).
- Entities in the FALCON semantic framework are arranged based on the Basic Formal Ontology (BFO) In BFO
- Two varieties
  - ✓ **Continuants** comprehending continuant entities such as three-dimensional enduring objects
  - ✓ **Occurrent** comprehending processes conceived as extended through (or as spanning) time

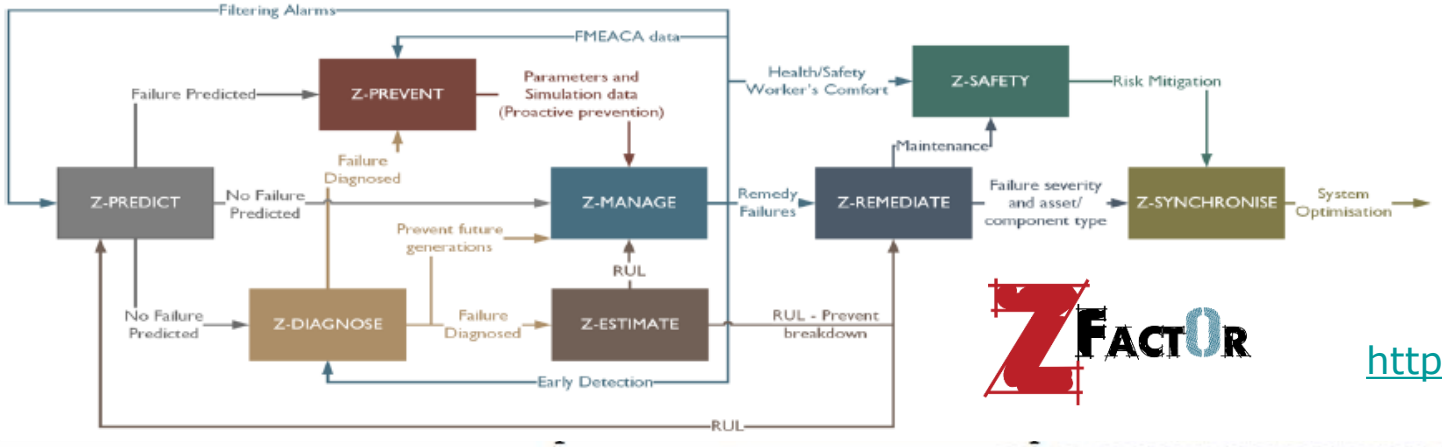
Red font : Entities from BFO
Black font : Entities originated from FALCON context

# FALCON Ontology-Alignment to BFO

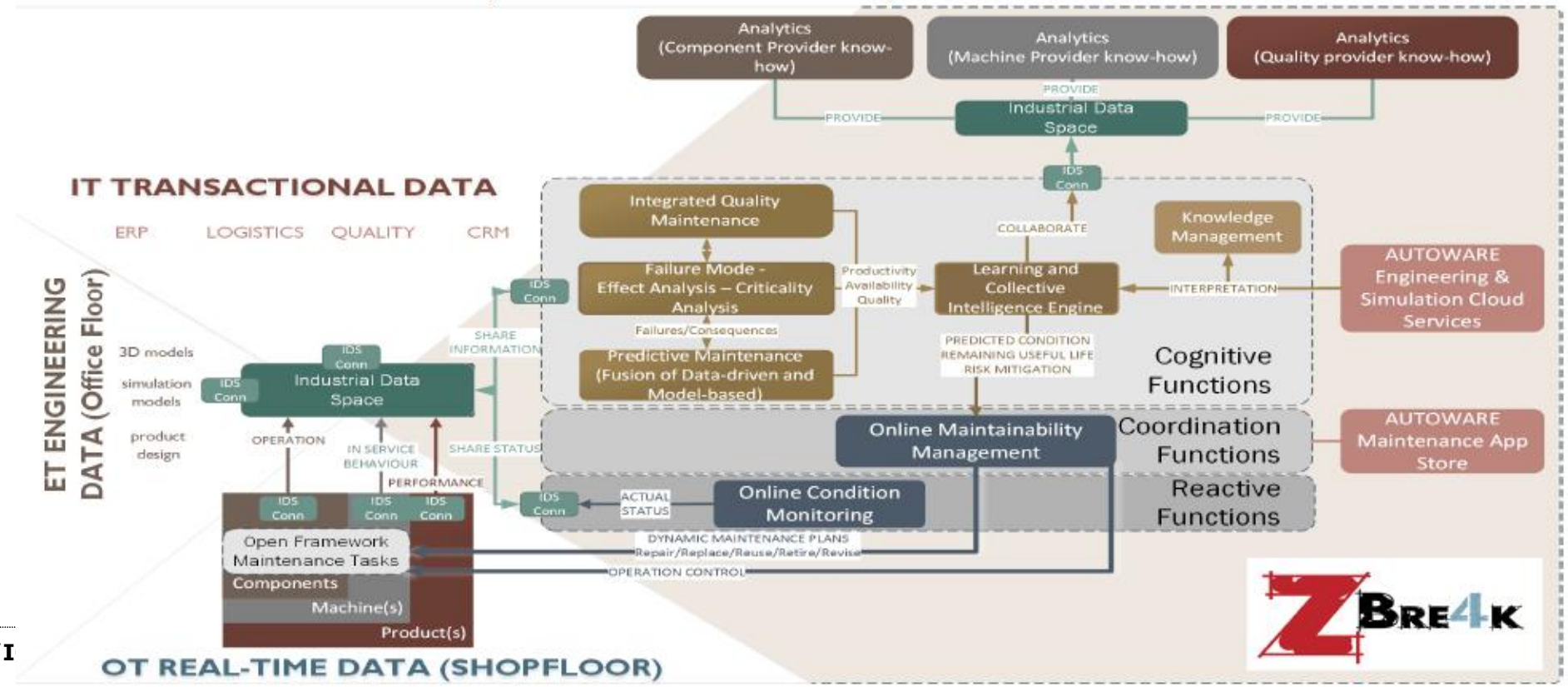


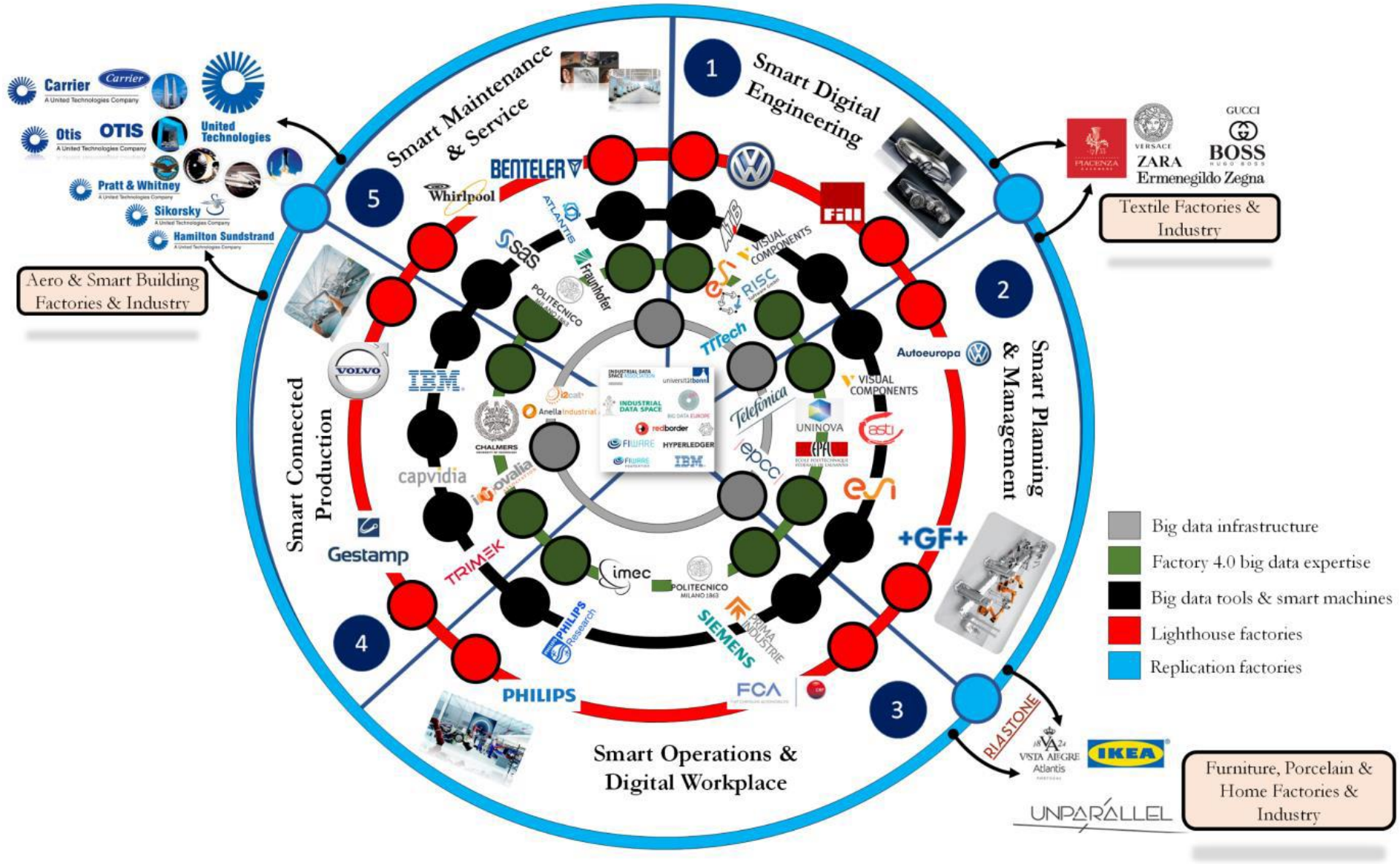

Red font : Entities from BFO
Black font : Entities originated from FALCON context

# Predictive Manufacturing




http://www.z-fact0r.eu/




1
Smart Digital Engineering
2
Smart Planning & Management
3
Smart Operations & Digital Workplace
4
Smart Connected Production
5
Smart Maintenance & Service
Carrier
Otis
OTIS
United Technologies
Pratt & Whitney
Sikorsky
Hamilton Sundstrand
Aero & Smart Building Factories & Industry
GUCCI
VERSACE
ZARA
BOSS
Ermenegildo Zegna
Textile Factories & Industry
Autoeuropa
Furniture, Porcelain & Home Factories & Industry
Big data infrastructure
Factory 4.0 big data expertise
Big data tools & smart machines
Lighthouse factories
Replication factories


Merci
Thank You