Manufacturing

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Third Workshop on an Open Knowledge Network

Manufacturing Community of Practice

- Barry Smith, National Center for Ontological Research
- John Milinovich, Pinterest
- William Regli, DARPA
- Ram Sriram, NIST
- Ruchari Sudarsan, DOE

http://ncorwiki.buffalo.edu/index.php/manufacturing_community_of_practice

First use case: Manufacturing capabilities

of companies, equipment, sensors, persons, teams ...

- Use case: risk mitigation in supply-chain management -- screening to select suitable suppliers for example when accepted bidder drops out
- In progress: scraping information on the webpages of manufacturing companies and mapping identified terms to ontologies to enable reasoning (Farhad Ameri, Collaborative agreement between NIST and Texas State)
- Can we create wikipedia-like pages for each company from this activity?

Relevant:

- manufacturing readiness levels (MRL)
- workforce development (DFKI)
- of interest also to DOD
- generalizable to other domains (medicine, research …)

Second use case: Manufactured products

- what exists are primarily NLP-based attempts to identify emerging trends in customer needs or markets, for example from the study of Amazon reviews of products
- NIST Core Product Model
- Can we convert into an OKN?
- What would be benefits / synergies:
  - food
    - synergy between manufacturing and health – allergy, addiction, food safety…
    - synergy with smart cities/geosciences – obesity, food access, …
  - synergy with capabilities use case (what are the capabilities of products)?

Third use case: Patents

- to enable enhanced patent search resolving terminological inconsistencies
- this too will require ontology of capabilities

Fourth use case: manufacturing uses of robots, sensors, …

- Probably not enough data in the public domain to enable a useful OKN for robot use in manufacturing at this stage

Fifth use case: Promoting interoperability in smart manufacturing

- Smart manufacturing works for CAD.
- Large and small companies use customized software tools to support other aspects of model-based development
- These software tools are rarely interoperable, and so digital workflows break where communication is needed with vendors or suppliers, or even across distinct divisions within a single enterprise

Proposed ontological response: Industry Ontologies Foundry

Consequence: no real-world examples of industrial use

- The industrial IT world has been burned too often by bad experiences with ontologies
- Except for CAD, digital manufacturing still in its very early stages

Typical reasons for ontology failure

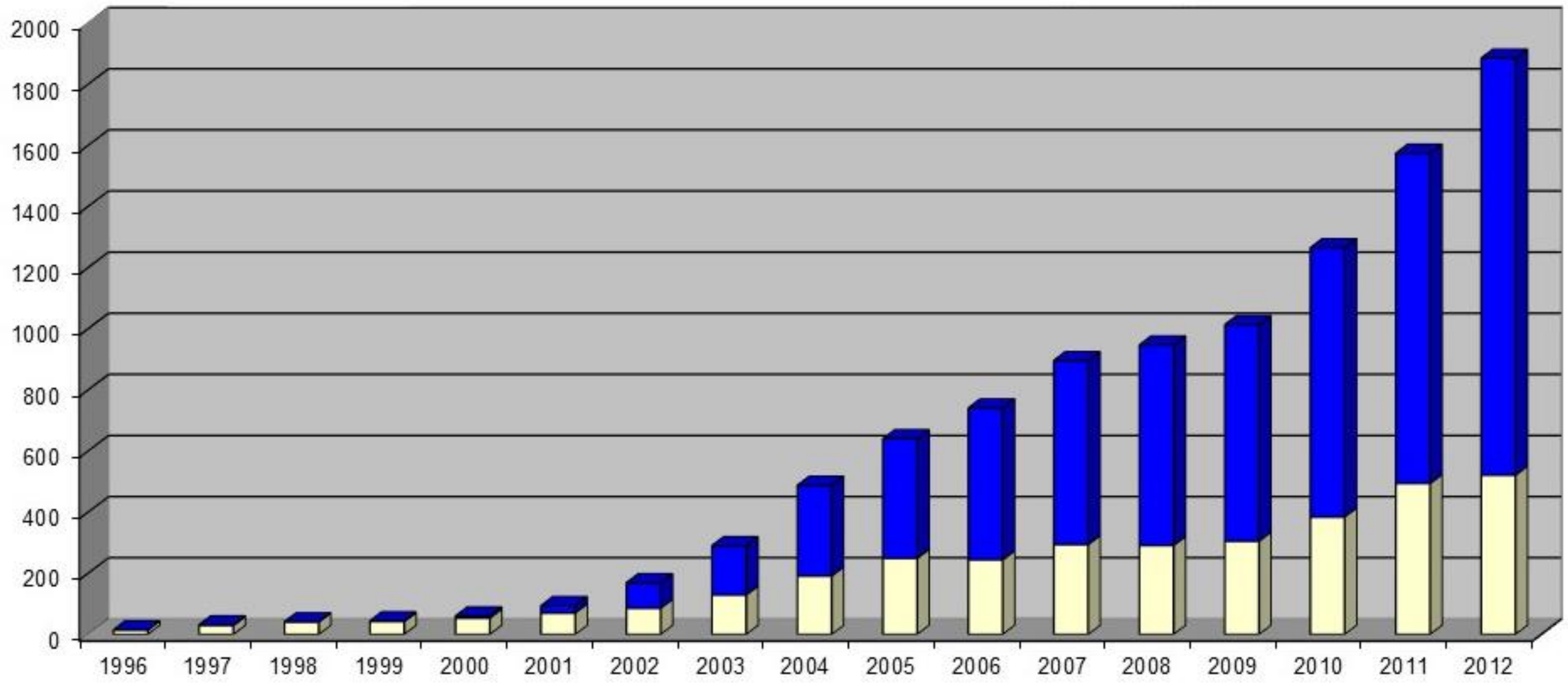
- Too many ontologies (everybody wants one; everybody thinks they are easy to build)
- So they are built in ad hoc ways – do *not* promote interoperability
- No common methodology
- No commonly accepted quality control standards
- Poor training
- Poor documentation

etc., etc.

These apply also to knowledge graphs

The Gene Ontology (GO, 1998–)

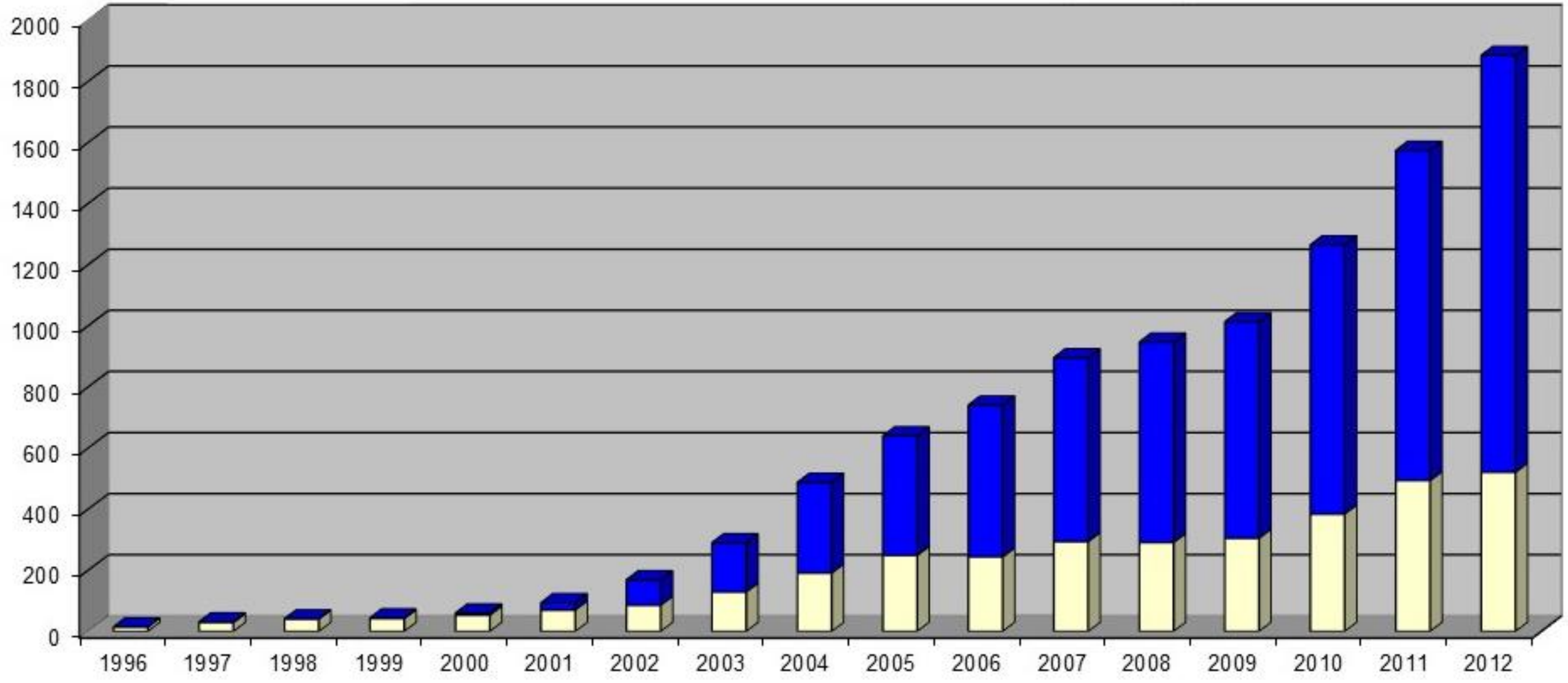
for consistent tagging of genomics data and literature, now used across all of life sciences



Uses of 'ontology' in PubMed abstracts

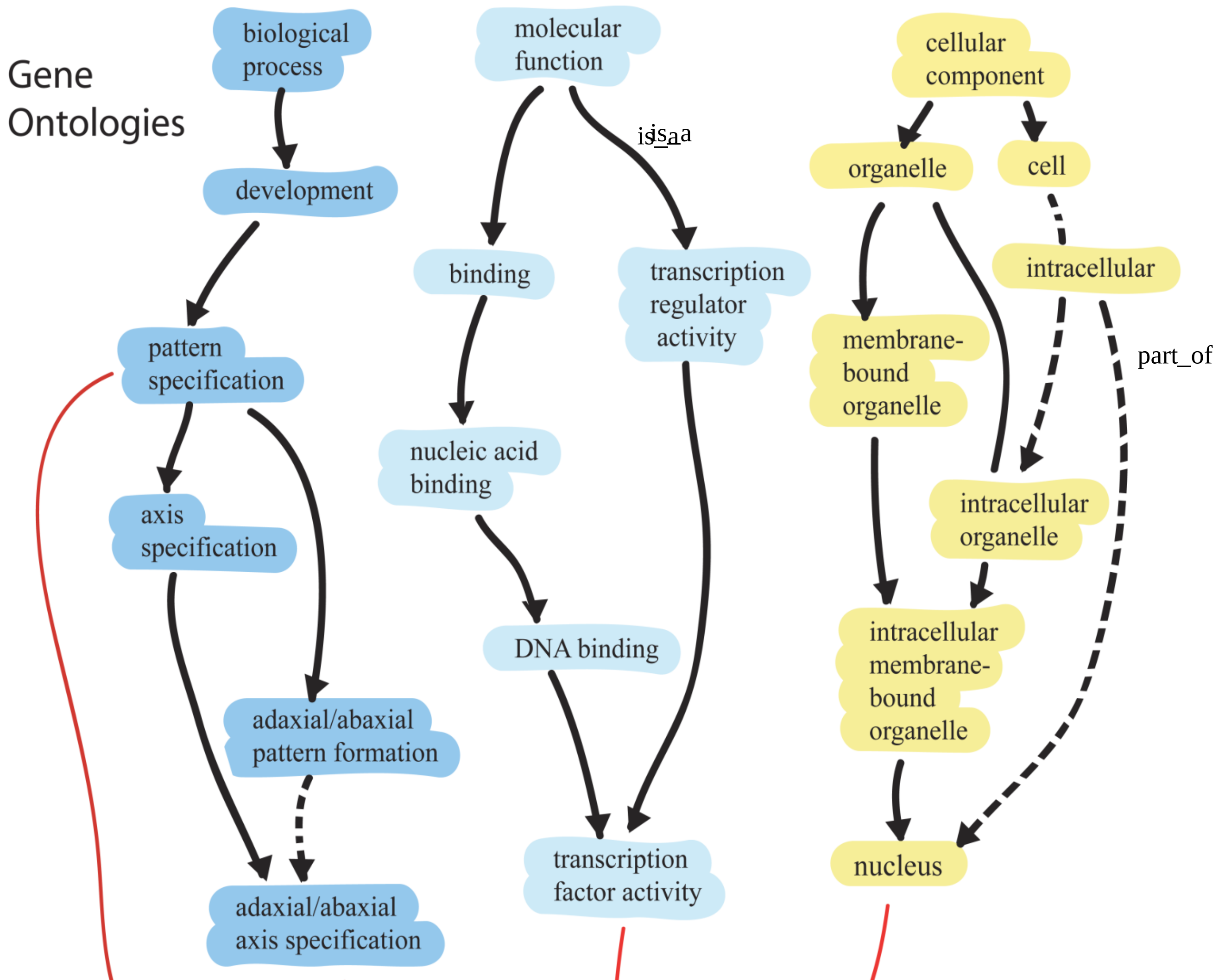
Why was the GO so successful?

only game in town, and so did indeed help to solve the problem of interoperability (of genomic data) across organism species; still has no competitors



GO's three sub-ontologies

biological process | molecular function | cellular component



2004–: GO extended with new ontology modules for:

cell types
proteins
sequences
metabolism
development
diseases
anatomy
…


nature biotechnology

Journal home > Archive > Research > Perspective > Full Text

Published online: 7 November 2007 | doi:10.1038/nbt1346

The OBO Foundry: coordinated evolution of ontologies to support biomedical data integration

Barry Smith[1], Michael Ashburner[2], Cornelius Rosse[3], Jonathan Bard[4], William Bug[5], Werner Ceusters[6], Louis J Goldberg[7],

Coordinated evolution of ontologies

<table>
<tr><th rowspan="2">RELATION TO TIME
GRANULARITY</th><th colspan="4">CONTINUANT</th><th>OCCURRENT</th></tr>
<tr><th colspan="2">INDEPENDENT</th><th colspan="2">DEPENDENT</th><th></th></tr>
<tr><td>ORGAN AND ORGANISM</td><td>Organism (NCBI Taxonomy)</td><td>Anatomical Entity (FMA, CARO)</td><td>Organ Function (FMP, CPRO)</td><td rowspan="2">Phenotypic Quality (PaTO)</td><td rowspan="2">Biological Process (GO)</td></tr>
<tr><td>CELL AND CELLULAR COMPONENT</td><td>Cell (CL)</td><td>Cellular Component (FMA, GO)</td><td>Cellular Function (GO)</td></tr>
<tr><td>MOLECULE</td><td colspan="2">Molecule (ChEBI, SO, RnaO, PrO)</td><td colspan="2">Molecular Function (GO)</td><td>Molecular Process (GO)</td></tr>
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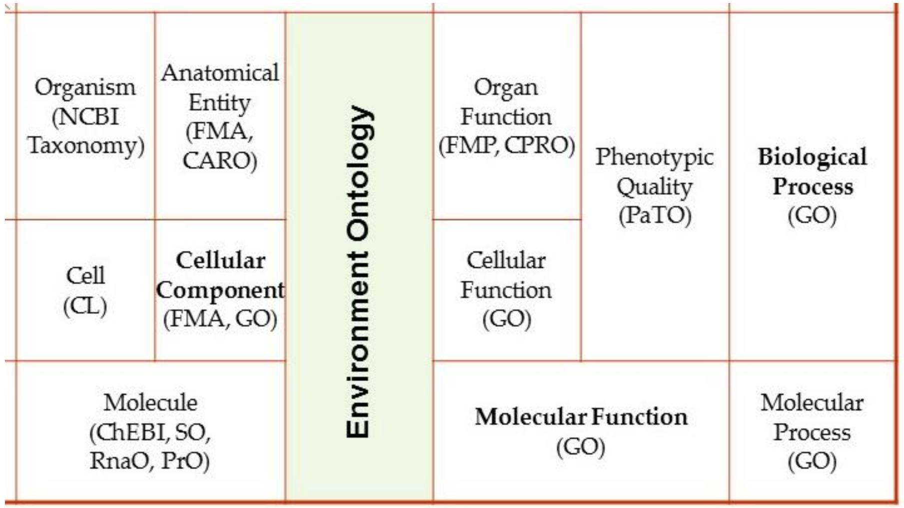
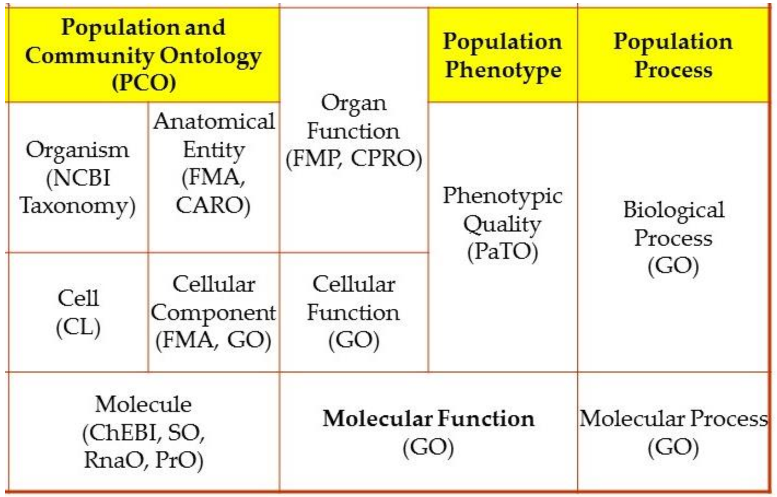
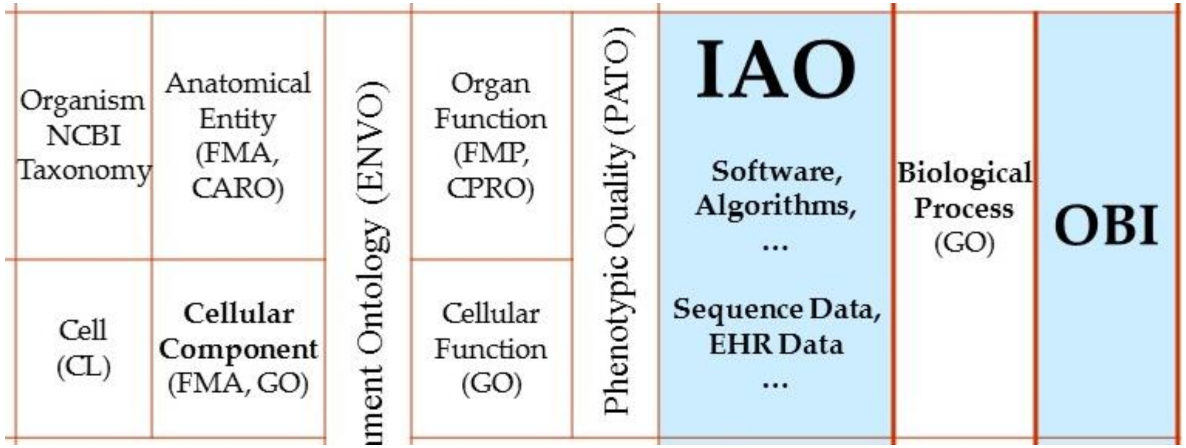
Open Biomedical Ontologies (OBO) Foundry (ca. 2004)

(Gene Ontology in yellow)

OBO Foundry growing to encompass further domains







Environments (ENVO)

Populations, Communities (PCO)

Information Artifacts (IAO)

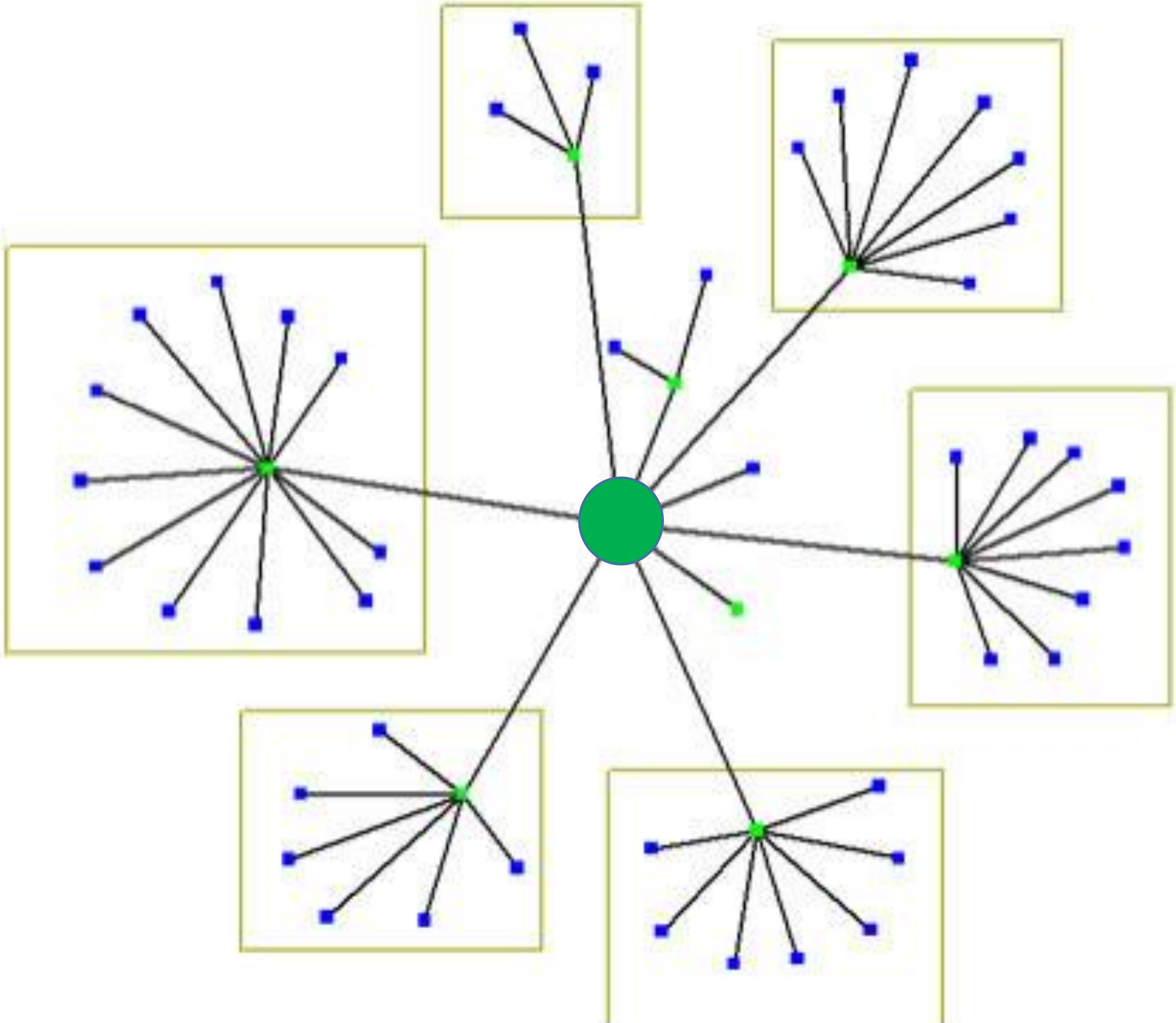
Experiments (OBI)

OBO Foundry Principles

1. commitment to collaboration
2. open
3. common formal language (OWL, CL)
4. maintenance in light of scientific advance
5. common architecture
6. locus of authority, trackers, help desk
7. provide all terms with definitions
8. one reference ontology for each domain

http://obofoundry.org

modular hub and spokes strategy



Examples of ontology suites with top-level ontology hubs

Ontology suite	Domain	URL
Open Biomedical Ontologies Foundry	life sciences	http://obofoundry.org
VIVO-Integrated Semantic Framework (VIVO-ISF)	scientific research (persons, works, relations of authorship)	https://bioportal.bioontology.org/ontologies/VIVO-ISF
Planteome Ontologies	plant science / genomics	http://www.plantontology.org/
Common Core Ontologies (CCO)	military and related domains	http://milportal.ncor.buffalo.edu/ontologies
Common IC Ontology	intelligence community	
Infectious Disease Ontologies (ISO)	Infectious diseases, vaccines	http://infectiousdiseaseontology.org/page/
UNEP SDGIO	UN Sustainable Development Interface Ontology	http://pre-uneplive.unep.org/portal

Industry Ontologies Foundry (IOF)

IOF testbeds

1. DMDII
2. MatOnto Materials Ontology
3. Product Life Cycle Ontology

DMDII

DIGITAL MANUFACTURING AND DESIGN INNOVATION INSTITUTE

DMDII-15-11 COMPLETING THE MODEL-BASED DEFINITION

February 7, 2017

Objective

Current industrial implementations of Model-Based Definition (MBD) primarily deal with product geometry, and limited metadata. The use of MBD in manufacturing has been limited compared to its use in design. Moreover, MBD is inherently dependent upon the software application that authors use to create the model. These software applications may or may not be accessible/affordable by small/medium enterprises. All three of these issues need to be addressed in order to support a seamless digital thread throughout the entire product life cycle.

http://dmdii.uilabs.org/projects/calls/completing-the-model-based-definition

DMDII initiative: Coordinated Holistic Alignment of Manufacturing Processes

create a flexible extensible suite of interoperable generic public-domain ontologies covering the domain of manufacturing engineering

test the utility of these ontologies in the day to day work flows of a local manufacturing enterprise on the basis of ability to digitally generate reports

http://www.cubrc.org/index.php/data-science-and-information-fusion/ontology

IOF testbeds

1. DMDII
2. MatOnto Materials Ontology
3. Product Life Cycle Ontology

MatOnto

background in Materials Genome Initiative

MatOnto ontology initiative under direction of Clare Paul (AFRL), author of large SemanticWiki for materials science

MatOnto: A suite of ontology modules based on BFO

Existing ontologies in process of being re-engineered to be intererable

for **Laminated Composites**: SLACKS (UMass)

for **Functionally Graded Materials**: FGMO (NCOR, Milan Polytechnic)

Existing ontology for **Polymers**: CHEBI from OBO Foundry

Potential for synergy with Capabilities use case?

IOF testbeds

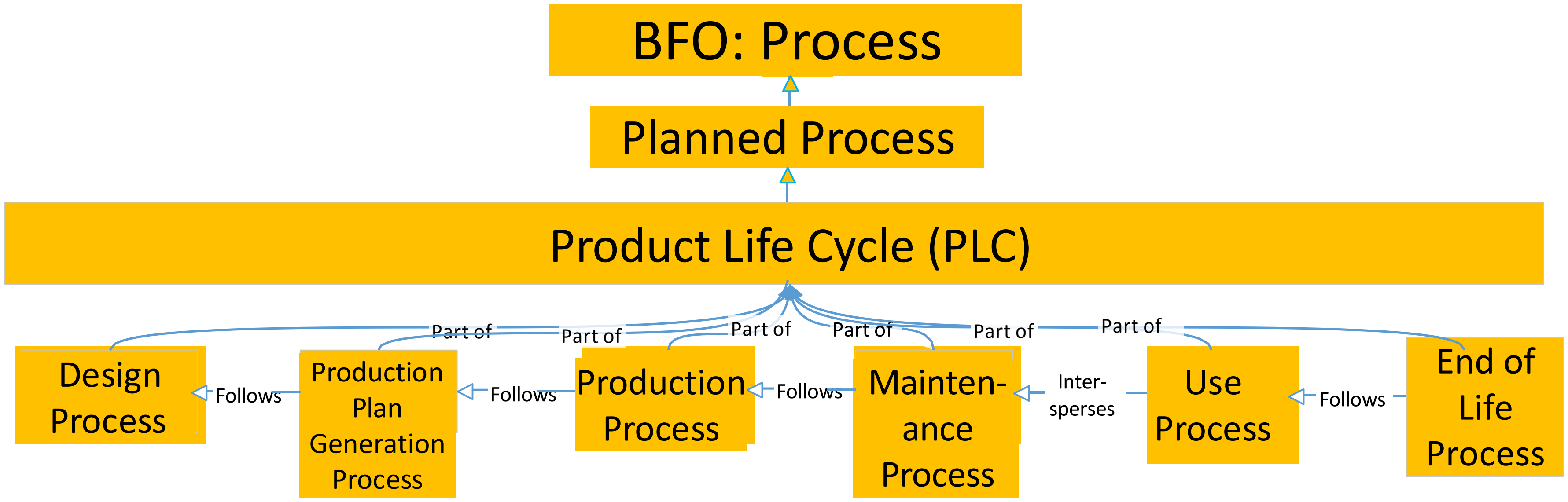
1. DMDII / CUBRC / CHAMP
2. MatOnto (Materials Ontology)
3. Product Life Cycle Ontology

time

Process

Information Entity

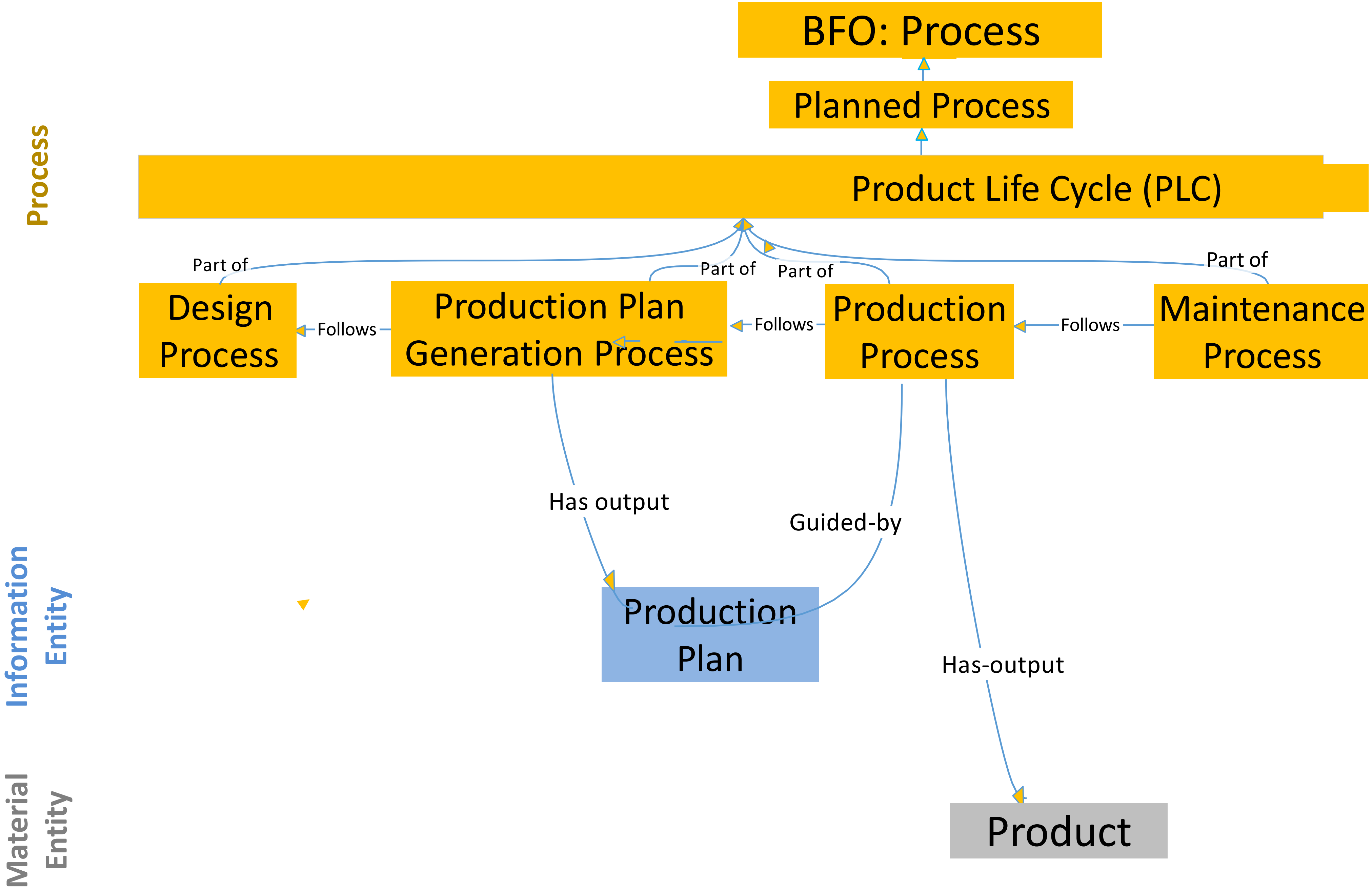
Material Entity

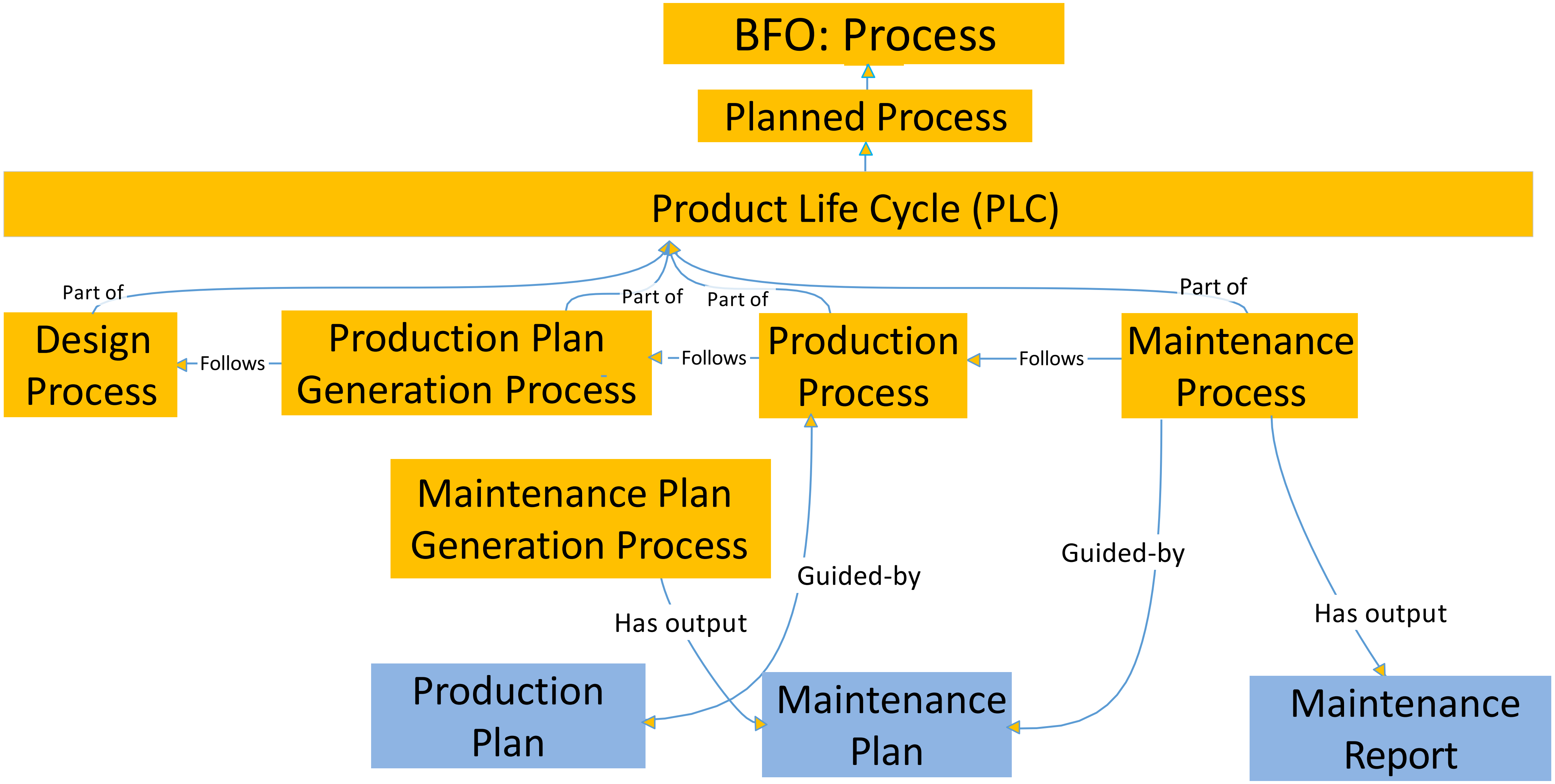


Process

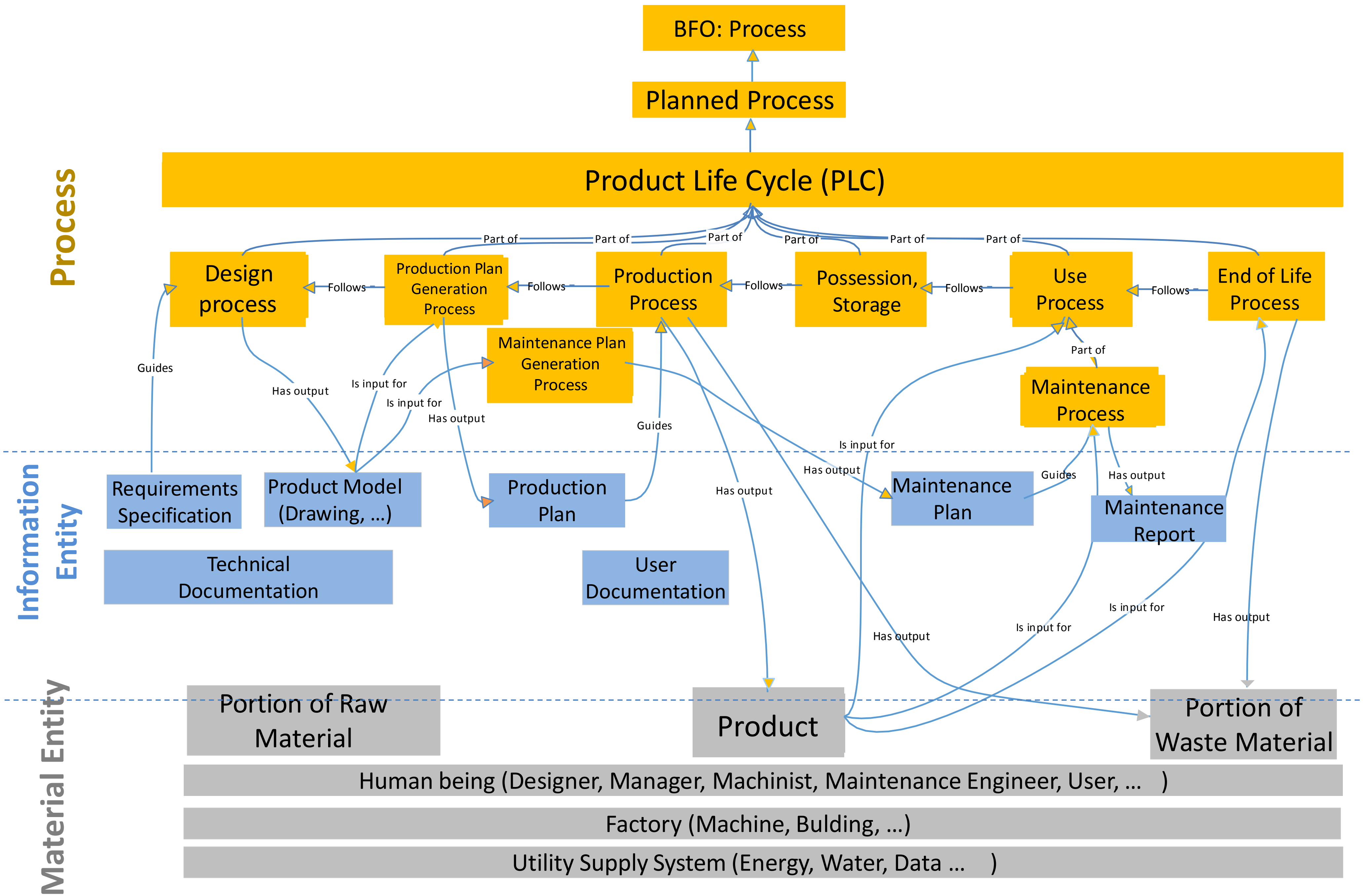
Information Entity

Material Entity


BFO: Process
Planned Process
Product Life Cycle (PLC)
Process
Part of
Part of
Part of
Part of
Design Process
Follows
Production Plan Generation Process
Follows
Production Process
Follows
Maintenance Process
Has output
Guided-by
Information Entity
Production Plan
Has-output
Material Entity
Product



In what sense is the maintenance process ‘Guided-by’ the maintenance plan? To deal with this we need to introduce the dimension of inspection and decision to maintain (similarly we need to add the dimension of market research and decision to produce, prior to the design and production plan generation processes)



BFO: Process
Planned Process
Product Life Cycle (PLC)
Process
Part of
Part of
Part of
Part of
Part of
Part of
Design process
Follows
Production Plan Generation Process
Follows
Production Process
Follows
Possession, Storage
Follows
Use Process
Follows
End of Life Process
Part of
Maintenance Process
Maintenance Plan Generation Process
Guides
Has output
Is input for
Is input for
Has output
Guides
Is input for
Has output
Has output
Guides
Has output
Information Entity
Requirements Specification
Product Model (Drawing, ...)
Production Plan
Maintenance Plan
Maintenance Report
Technical Documentation
User Documentation
Has output
Is input for
Is input for
Has output
Material Entity
Portion of Raw Material
Product
Portion of Waste Material
Human being (Designer, Manager, Machinist, Maintenance Engineer, User, ...)
Factory (Machine, Bulding, ...)
Utility Supply System (Energy, Water, Data ...)

Applications of PLC Ontology

- Provides common seed for multiple extensions by specific companies
- Supply chain management (digital architecture should enable rapid reconfiguring, …)
- Provides controlled vocabulary for talking about all aspects of PLC (can provide support for assuring government compliance of product pipelines or for negotiations in case of company merger)
- Provides support for PLC reconfiguration – one day this will happen digitally (self-driving factories)

What we might do with a knowledge graph

Ruchari Sudarsan: System level classification of manufacturing language can serve as basis for a science of system integration for manufacturing