



Leveraging Basic Formal Ontology (BFO)
by Allotrope Foundation Ontology (AFO)
to Achieve Data Interoperability

AF Product Team



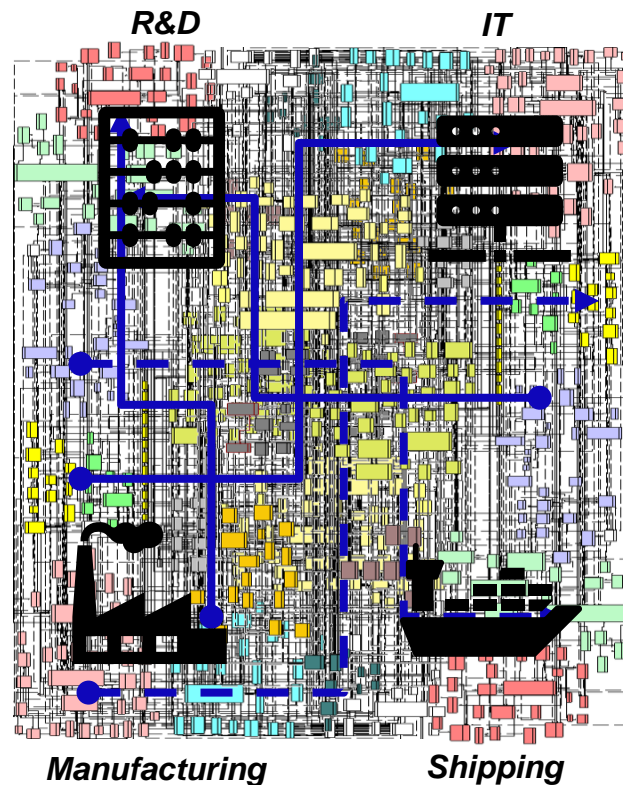
ADF file

BFO Primer*

Basic Formal Ontology

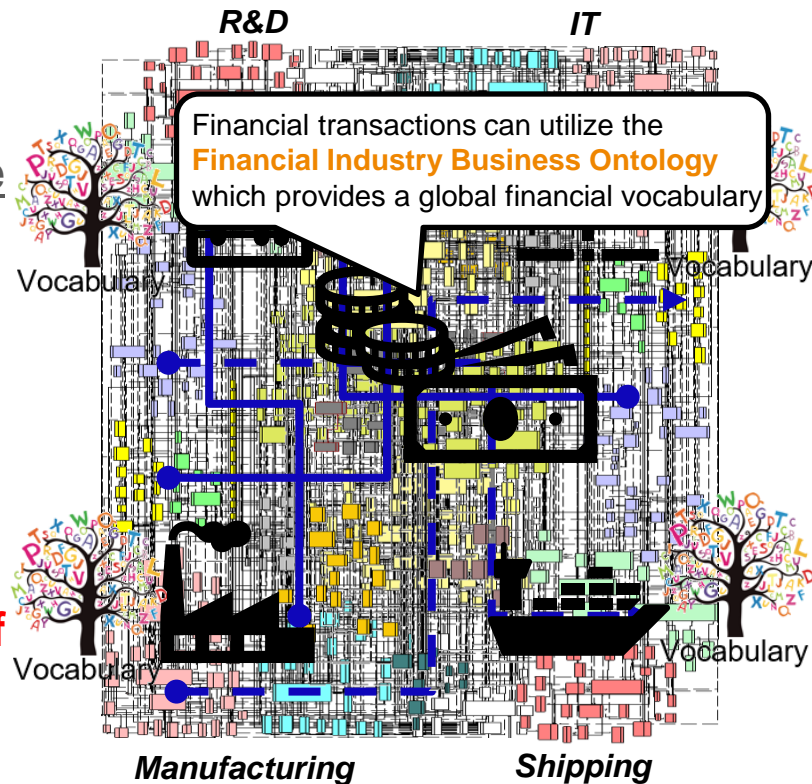
Why Ontology? The Problem and the Solution

- “Large organizations” are complicated...
- Most data is modeled in Relational Models and stored in tables in relational DB
- To extract meaningful information, you need to query data across tables, across domains and resolve which tables to join
- Can NOT query these tables without a deep knowledge of the tables and their relationships:
 - **No common and UNIVERSAL vocabulary/lexicon/terminology**
 - **Navigating between the different information systems can become complex and not scalable**



Why Ontology? The Problem and the Solution

- This is where ontology can come to the “rescue”. It provides a controlled way, meaning controlled vocabulary, to organize knowledge and navigate between domains
- So what is an ontology?
 - No exact definition
 - ≈ Computable lexicon
 - ≈ Dictionary that can be used by both computers and human being
 - ≈ Representation of categories in reality
- **Ontology = Representation of the type of entities in a given domain and the relations between them.**





Why Ontology? The Problem and the Solution

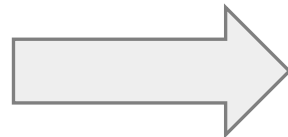
- **Interoperability:**
 - Ontologies promote interoperability across heterogeneous data systems
- **Stability:**
 - We create an ontology by exploiting the relative stability of our own natural language (English is stable, unlike a changing code/software that can be easily changed)
- **Extendibility:**
 - Ontologies are easily extendible (English is stable and extendable)



Phone in English is a phone



Phone



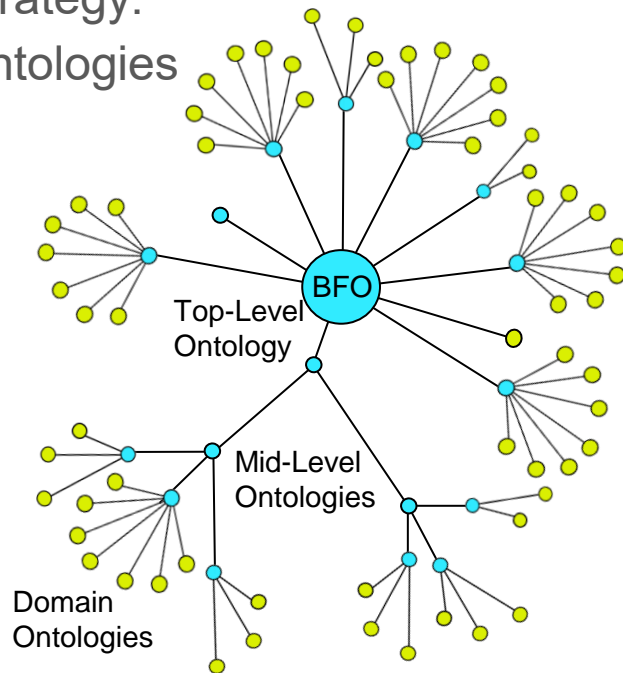
Smartphone

OBO Foundry Approach: Hub and Spokes

The OBO (Open Biological and Biomedical Ontology) Foundry is building its ontologies using the “Hub and Spokes” strategy: **BFO** is the “hub”, at the top and it is extended as the ontologies are getting built (the spokes, immediately from **BFO**)

- Why **BFO**?

- Very small
- Modular approach
- Evolves carefully
- Provides a **Domain neutral top-level ontology**
- Active user forum, large user base
- Well documented
- Trained personnel with portable expertise

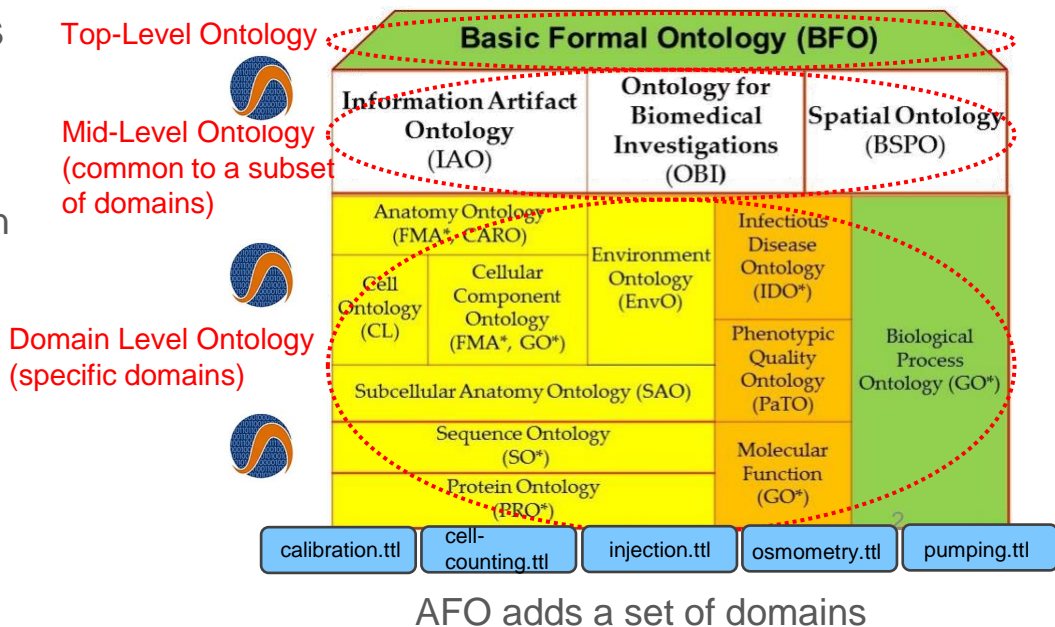




OBO Foundry Approach: Modularity

- Modularity is achieved vertically and horizontally
- It reduces the “mapping” needs
- At the domain level we get the division of authority and labor
 - SMEs are in charge on the domain ontology
 - SMEs are working within their domain
- Ownership by experts
- User discoverability
- Growing incrementality

OBO Foundry “hub and spokes” strategy for developing interoperable ontology modules



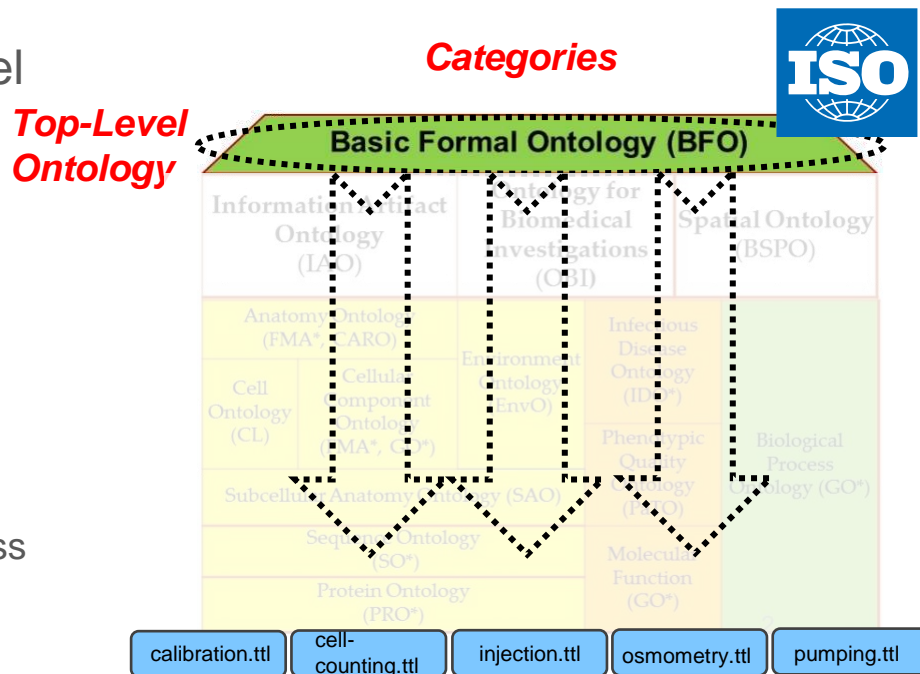


BFO: Top-Level Ontologies (TLO) ISO 21838-1

BFO evolved into an ISO/IEC standard 21838, Information technology, Top-Level Ontologies (TLO), July 2019.

It defines:

- Top Level Ontology
 - **Ontology** that is created to represent **categories** that are shared across a maximally broad range of **domains**
- Category
 - General **class** or **type** that is shared across many **domains** and is represented by a **domain-neutral term**





ADF file

AFO Alignment with BFO



BFO and AFO on BioPortal (Ontology Lookup Service)

the National Center for Biomedical Ontology

<https://bioportal.bioontology.org/ontologies/BFO>

<https://bioportal.bioontology.org/ontologies/AFO>

The screenshot shows the BioPortal interface for the Basic Formal Ontology (BFO). The title "Basic Formal Ontology" is circled in red. The page includes a navigation bar with links for Summary, Classes, Properties, Notes, Mappings, and Widgets. The "Details" section on the left provides information about the ontology, including its acronym (BFO), visibility (Public), and description. The "Submissions" table shows the history of releases and downloads.

Version	Released	Uploaded	Downloads
2.0 (latest)	08/29/2015	09/04/2015	OWL CSV RDF/XML DIF
1.1.1 (archived)	01/01/2009	07/24/2009	OWL

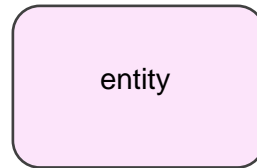
The screenshot shows the BioPortal interface for the Allotrope Merged Ontology Suite (AFO). The title "Allotrope Merged Ontology Suite" is circled in red. The page includes a navigation bar with links for Summary, Classes, Properties, Notes, Mappings, and Widgets. The "Details" section on the left provides information about the ontology, including its acronym (AFO), visibility (Public), and description. The "Submissions" table shows the history of releases and downloads. The "Views of AFO" section indicates that no views are available.

Version	Released	Uploaded	Downloads
REC/2020/06	08/06/2020	08/17/2020	OWL CSV RDF/XML
REC/2020/03	03/30/2019	05/21/2020	OWL DIF
REC/2019/05/10	05/11/2019	05/17/2019	OWL DIF
REC/2019/05/10	05/11/2019	05/15/2019	OWL DIF
REC/2019/05/10	05/11/2019	05/15/2019	OWL DIF



BFO: The Top

- BFO provides a hierarchy which can be used to categorize anything into several high-level categories
- **entity** is at the top of the hierarchy
- OWL (the WEB Ontology) places **thing** at the top of the hierarchy
- Practically, everything is an **entity**





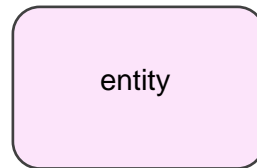
AFO: The Top

Allotrope Merged Ontology Suite
Last uploaded: August 17, 2020

Summary Classes Properties Notes

Jump to:

- Attachable (abstract)
 - Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
- Hierarchical Code List
- LicenseDocument
- Observation Group
- Organization
- Property
- RightsStatement



BFO: Top 2 Disjoint Categories

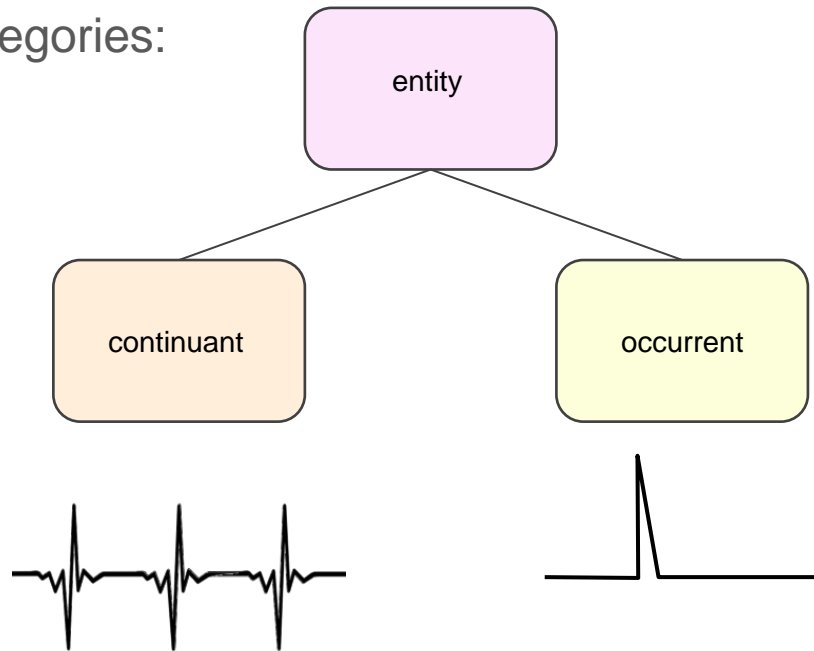
- **entities** are divided into two disjoint categories:
 - **continuant**
 - **occurrent**

- **continuant** entities (**exist through time**)

- Have continuous existence in time
- Can gain and loose parts
- Preserve their identity through change

- **occurrent** entities (**exist in time**)

- Have temporal parts
- Unfold themselves phase by phase
- Exist only in their phases/stages





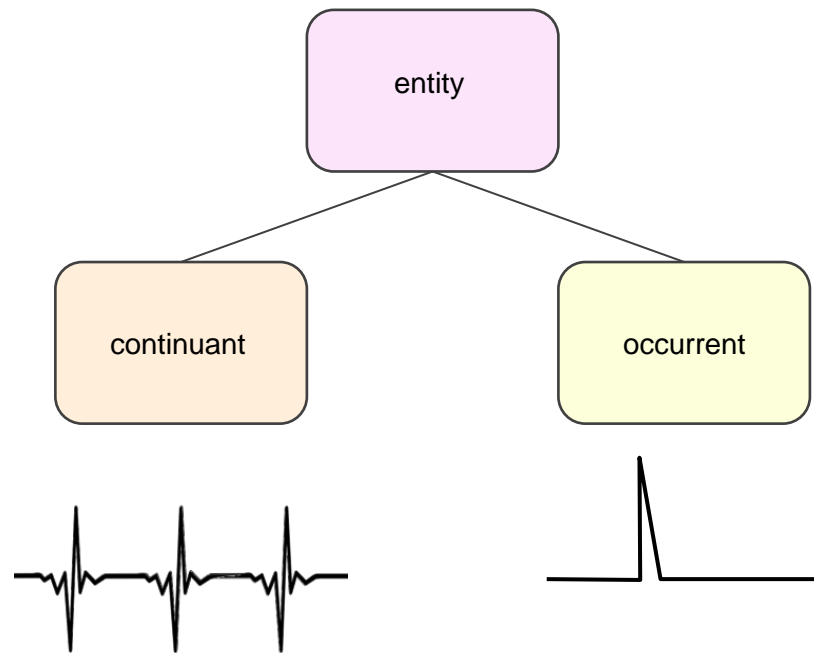
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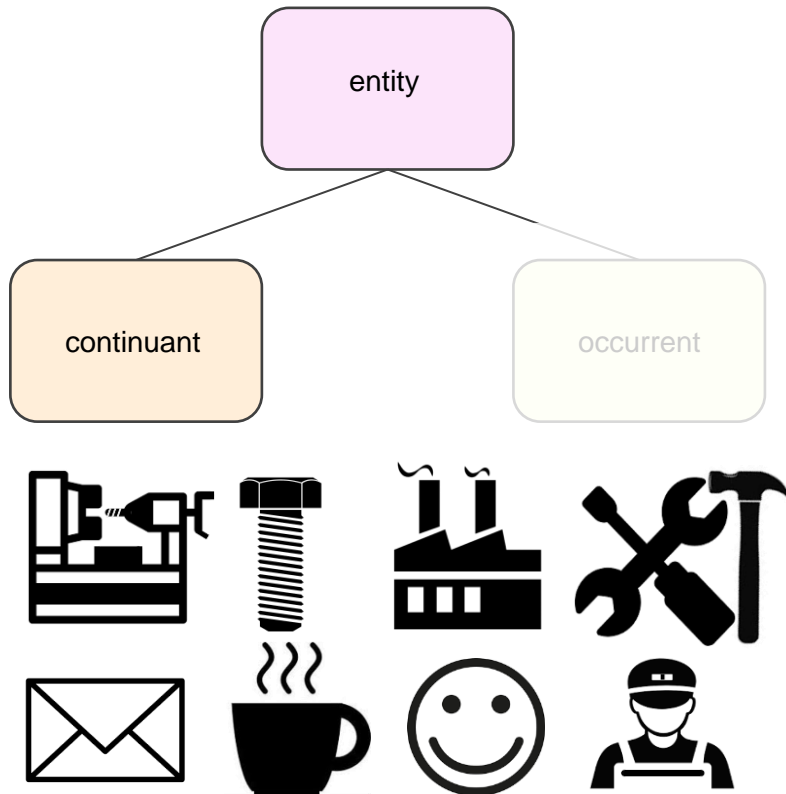
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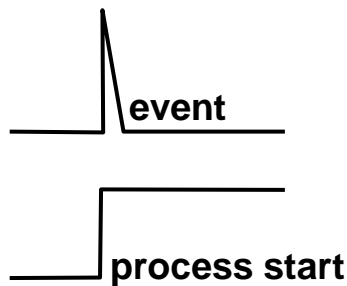
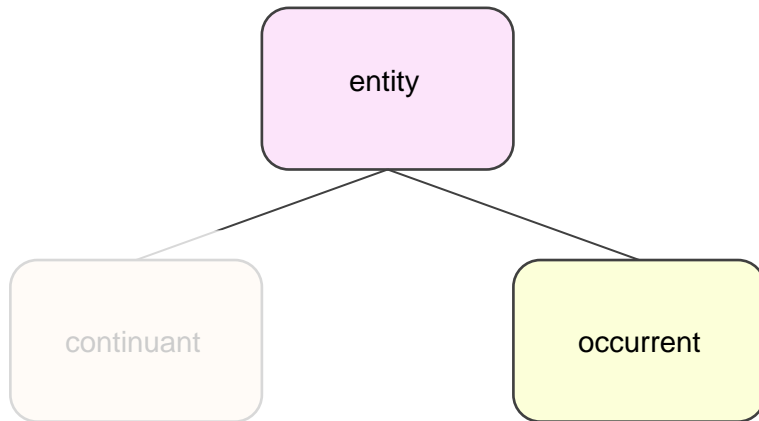
BFO: Top 2 Disjoint Categories

- A **continuant** is something that exists at an instant in time and it continues to exist through time
- Examples:
 - a machine, a bolt, a factory, a tool, a letter
 - the smell of a coffee
 - a smile
 - a handyman
- At any time when a **continuant** exists, so do its parts
- **continuant** preserve its identity through time



BFO: Top 2 Disjoint Categories

- ***occurrent*** is something that has temporal parts
- Examples:
 - an experiment
 - tools gathering
 - smiling
 - drinking coffee
 - fixing
 - sending a letter
- ***events*** that occur at an instant in time and ***processes*** that last through time are both ***occurrents***



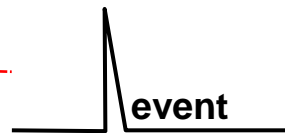
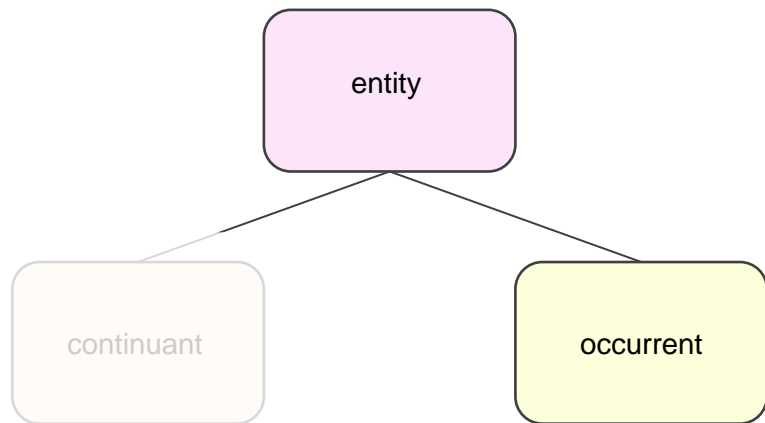
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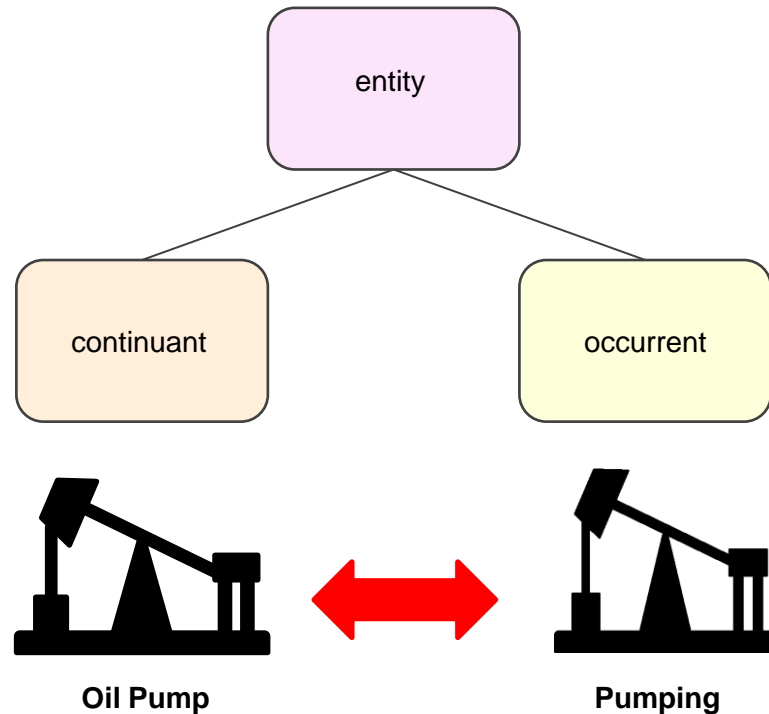
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 - repeated process
 - sequential process
 - state
 - process boundary
 - spatiotemporal region
 - temporal region



BFO: Top 2 Disjoint Categories

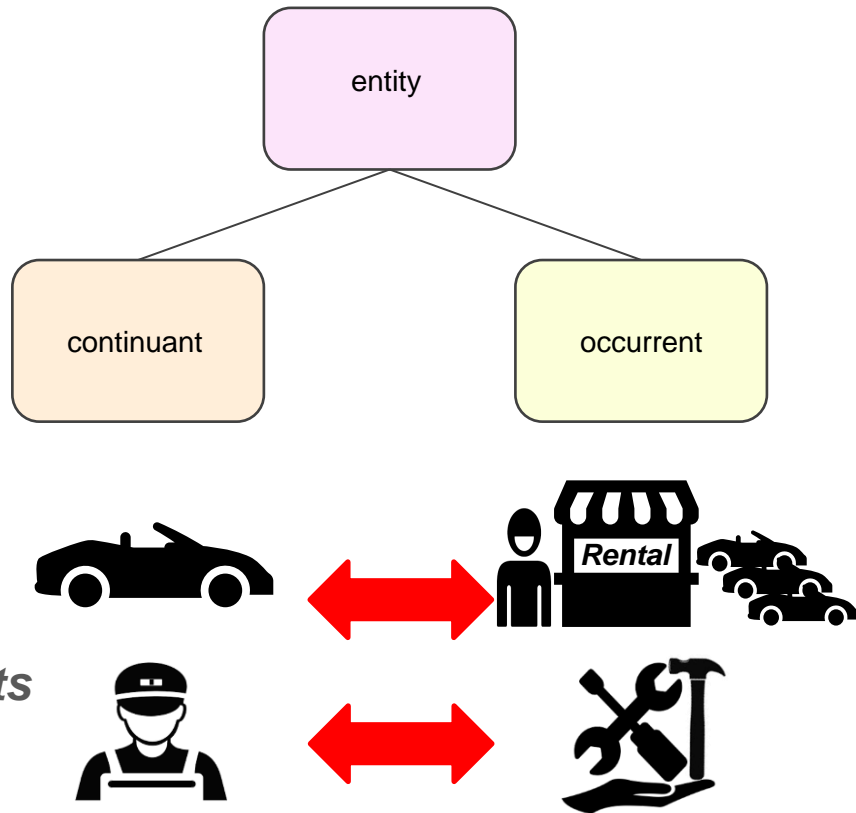
- In reality, **things** and **processes** exist in different ways and so we should keep the ontology
- Either **continuant** or **occurrent** but NOT both!



BFO: Top 2 Disjoint Categories

- They are two orthogonal, complementary perspectives in many areas:

- **continuants** vs. **occurents**
- **commodities** vs. **services** (car vs. car rental)
commodity is a **thing**, car rental is a **process**
- **stocks** vs. **flows** (in a warehouse)
- **products** vs. **processes**
- **anatomy** vs. **physiology**
- **musical instruments** vs. **performance**



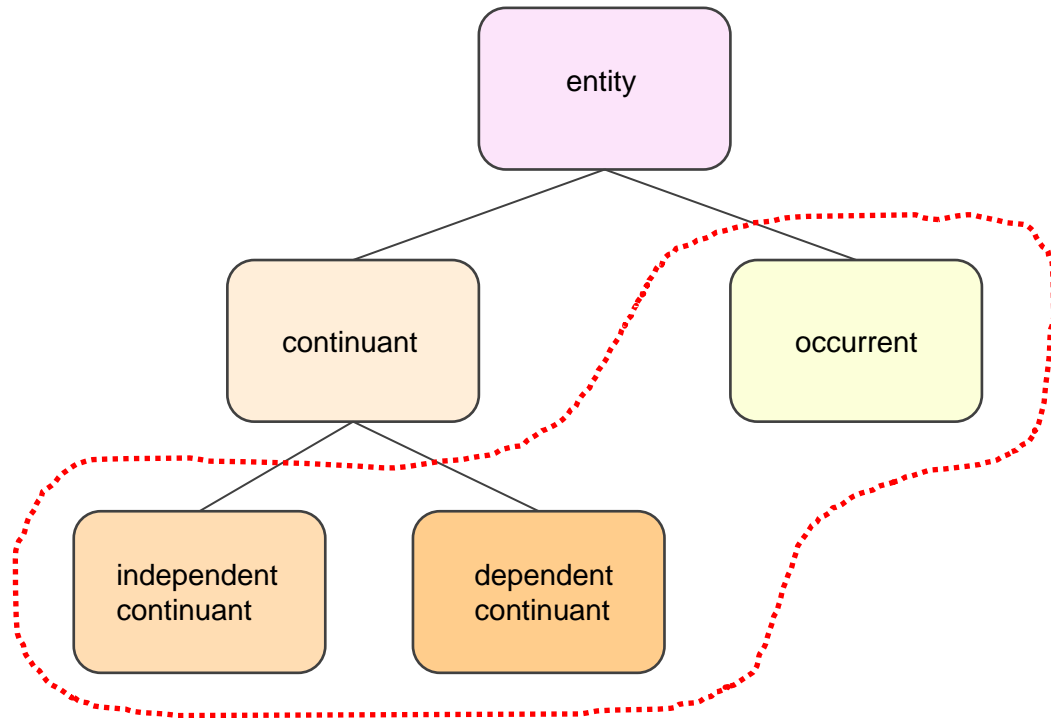
- **continuants** can participate in **occurents**
 - A handyman participates in tools gathering



BFO: Top 3 Most General Universals (Categories)

BFO top categories

- ***continuant***
 - *independent continuant*
or
 - *dependent continuant*
- ***occurrent***





BFO: Independent vs. Dependent Continuant

- Something that is a physical part of another entity is an ***independent continuant***

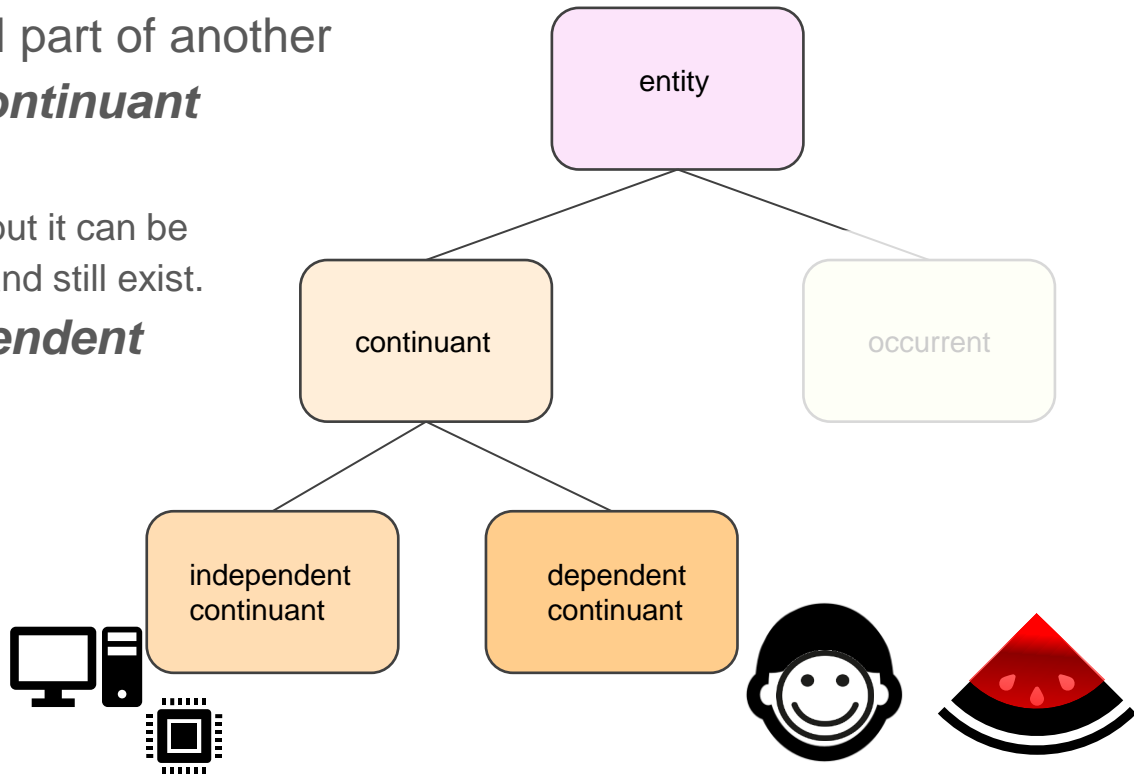
- Example:

- a CPU is part of a computer, but it can be detached from the computer and still exist.

- This is different from a ***dependent continuant***

- Examples:

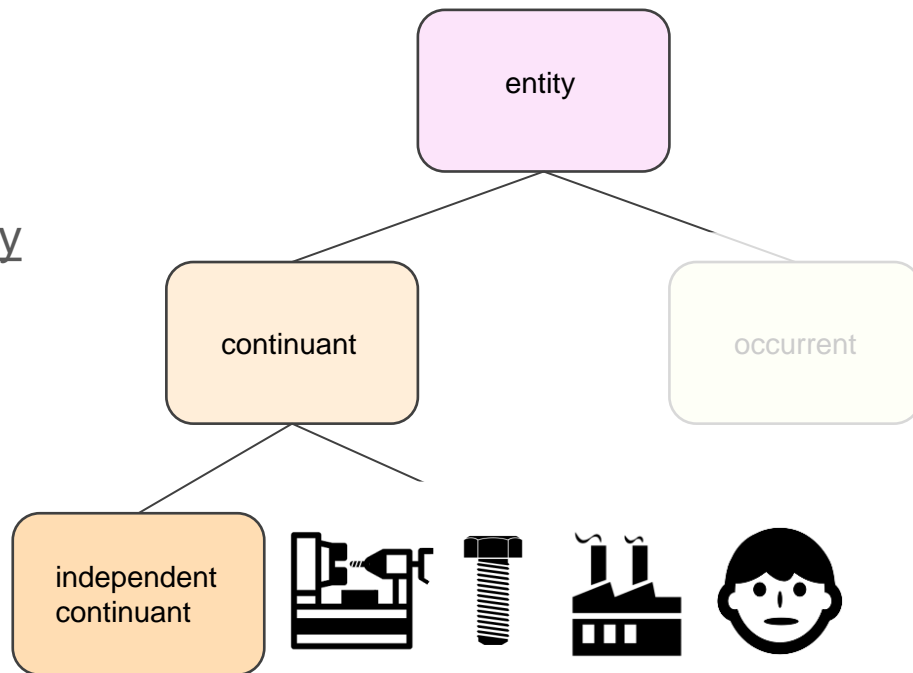
- a smile; you cannot detach a smile from a face
- the **red color** at the center of a ripe watermelon; you cannot have it without the watermelon





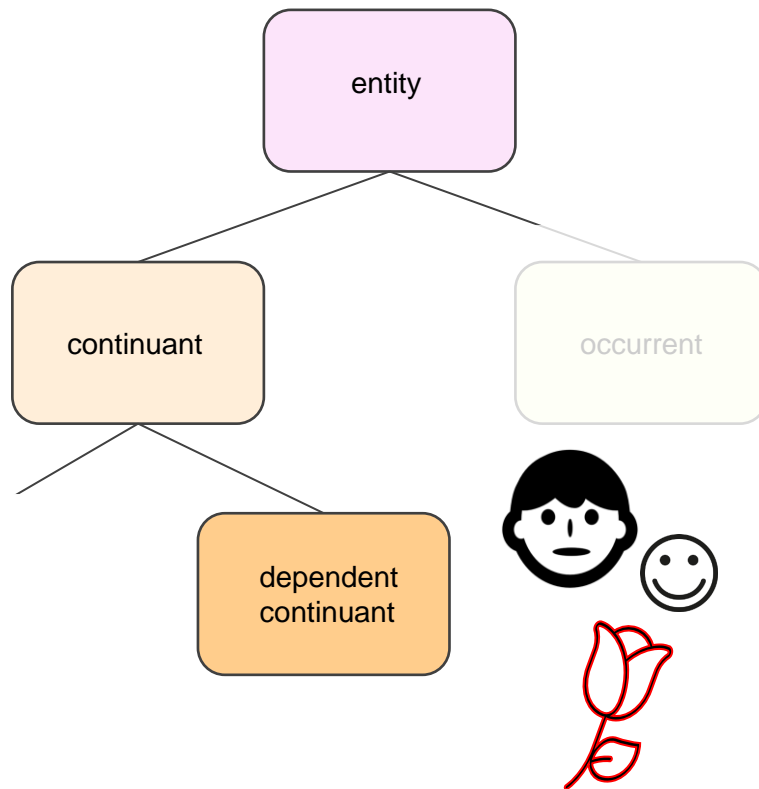
BFO: Independent vs. Dependent Continuant

- ***independent continuant*** is an entity that can exist by itself or it is a physical part of another entity
- Examples:
 - a machine
 - a bolt
 - a factory
 - a face



BFO: Independent vs. Dependent Continuant

- ***dependent continuant*** can only exist in relation to another object or objects. It means that ***dependent continuant*** exists only by virtue of another entity and it is not part of the entity
- Examples:
 - a smile
 - the color of a flower





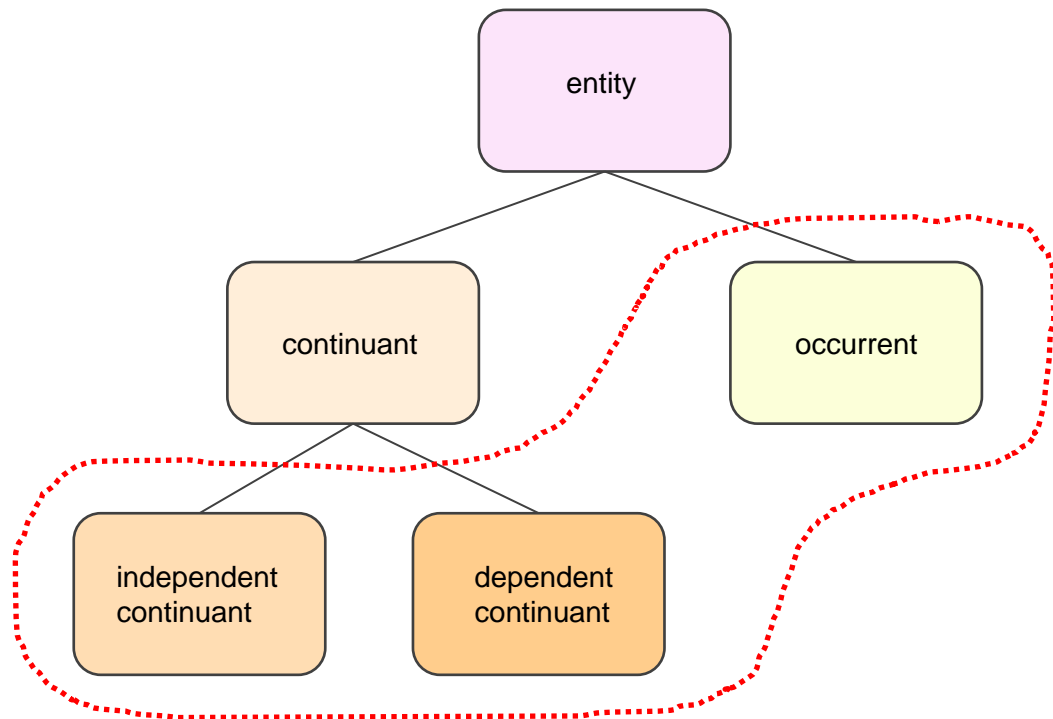
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 - continuant
 - general role
 - generically dependent continuant
 - independent continuant
 - specifically dependent continuant
 - occurent





AFO: Extension of the General Universals (Categories)

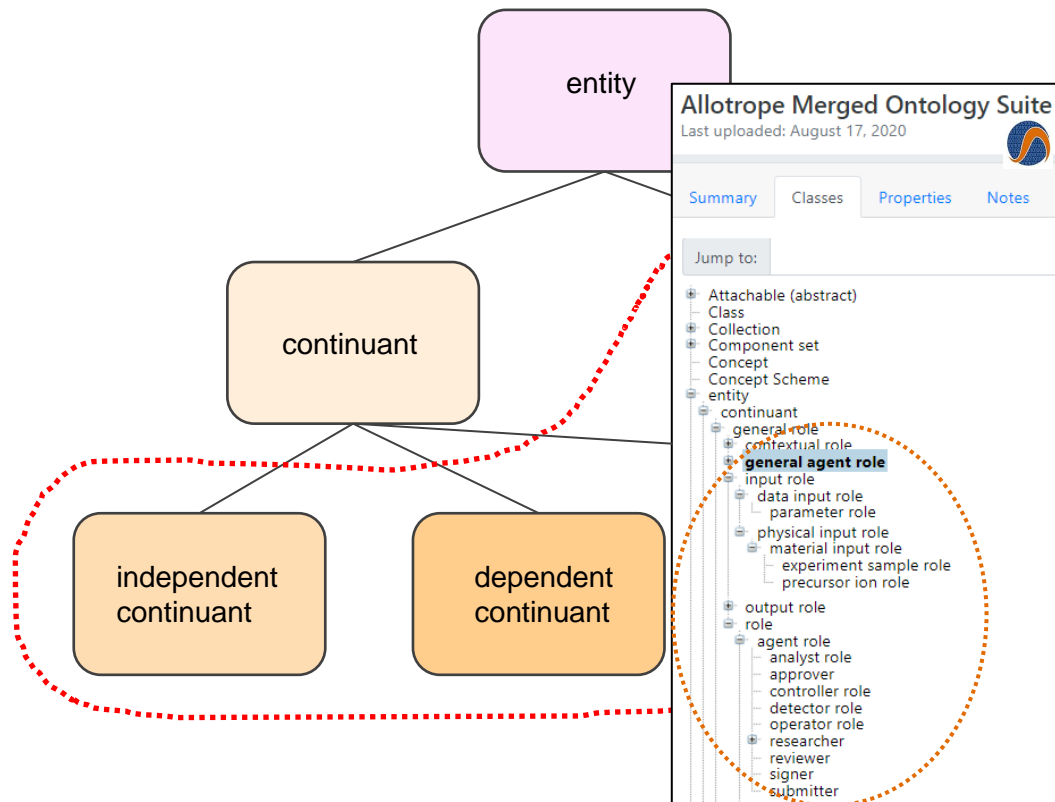
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AFO adds a category to express **general roles** in the context of data or people





AFO: Extension of the General Universals (Categories)

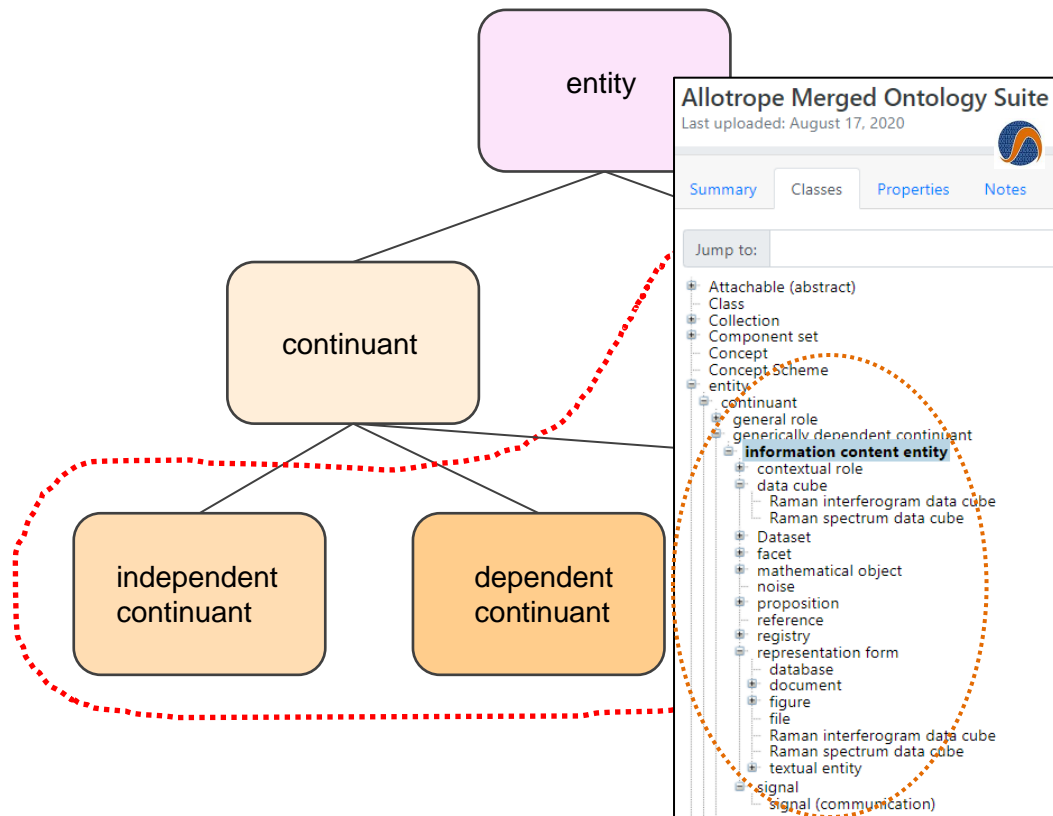
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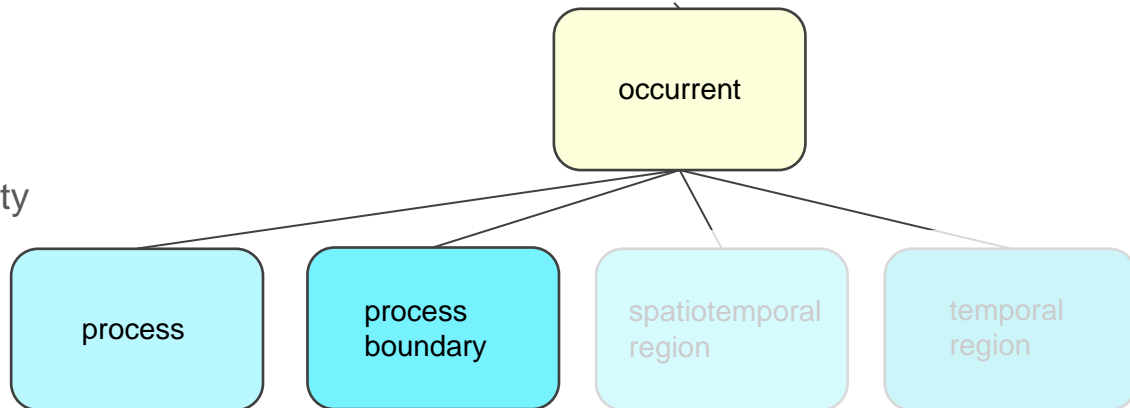
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 - independent continuant
 - specifically dependent continuant
 - occurrent

AFO adds a category to express **information content entity**



BFO: Occurrent

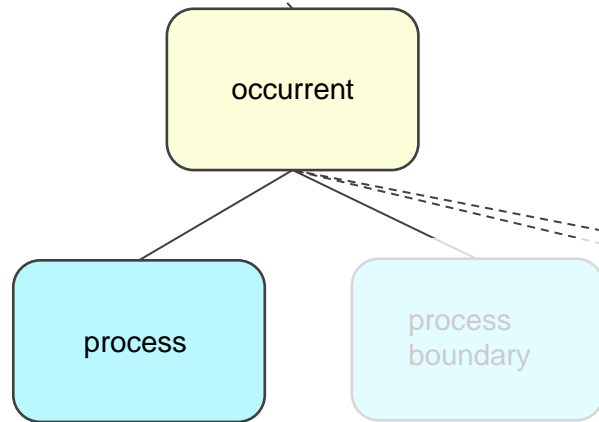
- An ***occurrent*** can be:
 - a ***process*** entity
 - a ***process boundary*** entity
 - a ***spatiotemporal region*** entityor a
 - ***temporal region*** entity





BFO: Process

- A ***process*** is something that happens over time, it has temporal parts, and it depends on a ***continuant***.
- Examples:
 - your life has several parts such as infancy, childhood, adolescence, and adulthood, senior age and involves a ***continuant***, which is “You”.
 - a trip, writing a letter, and a sample preparation in the lab are all ***processes***





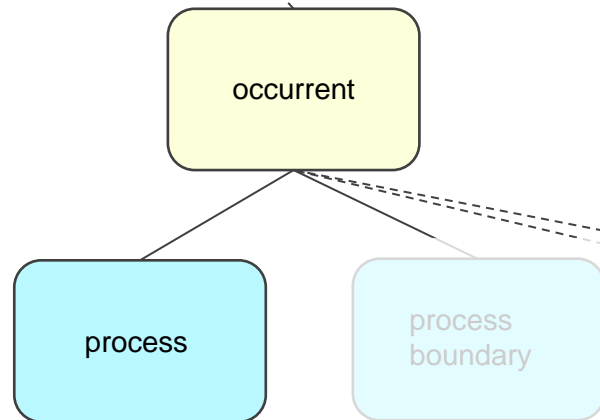
AFO: Process

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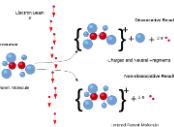
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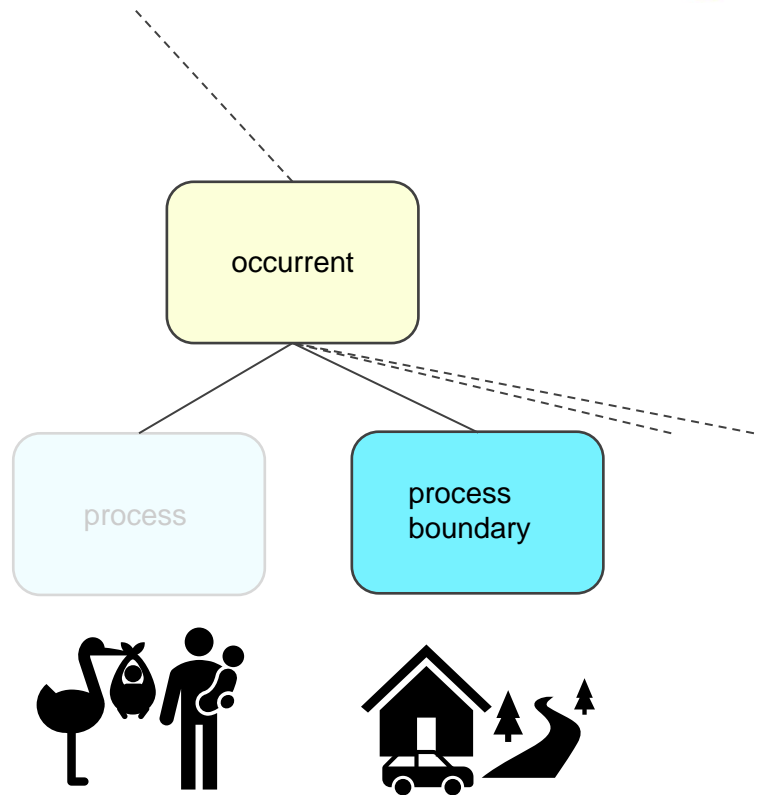
Details	Visualization	Notes (0)	Class Mappings (14)	
Preferred Name	electron ionization			
Synonyms	electron impact ionization			
	electron impact			
	EI			
Definitions	Electron ionization is a ionization that removes one or more electrons from an atom or molecule through interactions with electrons that are typically accelerated to energies between 10 and 150 eV. [IUPAC]			
ID	http://purl.allotrope.org/ontologies/process#AFP_0001701			
alternative label	electron impact ionization			
	electron impact			
definition	Electron ionization is a ionization that removes one or more electrons from an atom or molecule through interactions with electrons that are typically accelerated to energies between 10 and 150 eV. [IUPAC]			
	http://purl.allotrope.org/voc/afo/domain/REC/2020/06/mass-spectrometry			
isDefinedBy	http://purl.allotrope.org/voc/afo/domain/REC/2020/06/mass-spectrometry			
license	http://purl.allotrope.org/voc/iupac-license			
preferred label	electron ionization			
prefixIRI	afo-p:AFP_0001701			





BFO: Process Boundary

- A ***process boundary*** is the instant temporal boundary of a process,
- Examples:
 - first time eye opening of a newborn baby
 - leaving home to start a trip





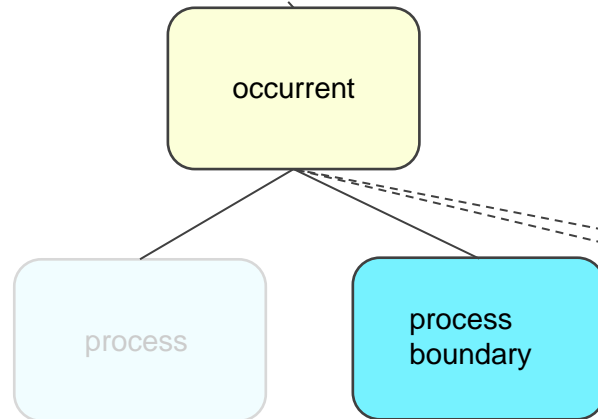
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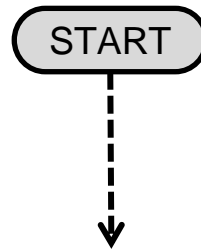
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 - process
 - process boundary**
 - achievement
 - arrival
 - departure
 - emission
 - reception
 - end
 - start



Details	Visualization	Notes (0)	Class Mappings (14)	
Preferred Name	start			
Definitions	The process boundary when the process starts. [Allotrope]			
ID	http://purl.allotrope.org/ontologies/process#AFP_0003328			
definition	The process boundary when the process starts. [Allotrope]			
isDefinedBy	http://purl.allotrope.org/voc/afo/REC/2020/06/aft			
preferred label	start			
prefixIRI	af-p:AFP_0003328			
subClassOf	process boundary			



BFO: Dependent Continuant

- A ***dependent continuant*** is either:

- a ***quality*** entity

or a

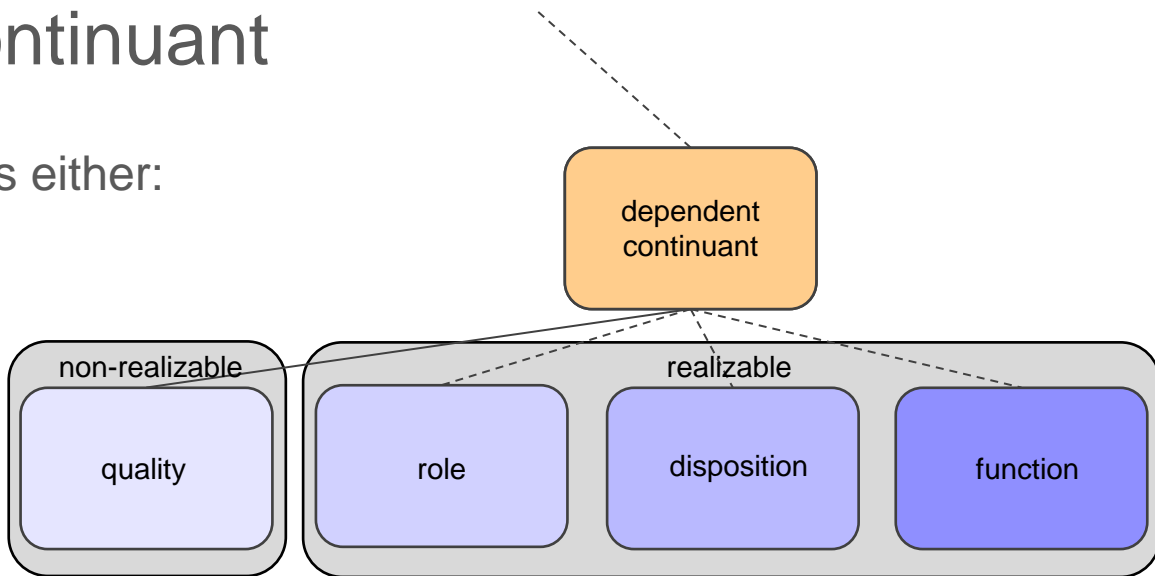
- ***realization of***

- a ***role***

- a ***disposition***

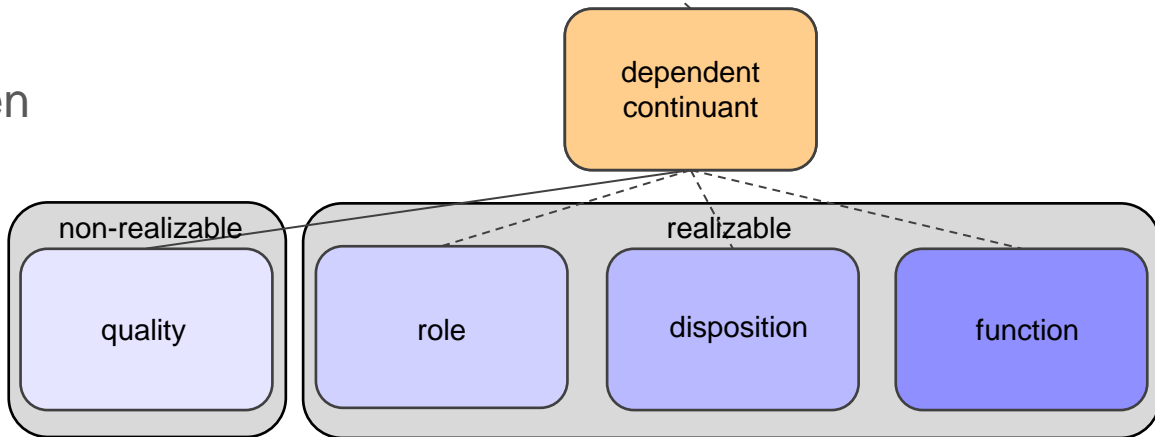
- a ***function***

- ***realizable dependent continuants*** are **not** ***quality***



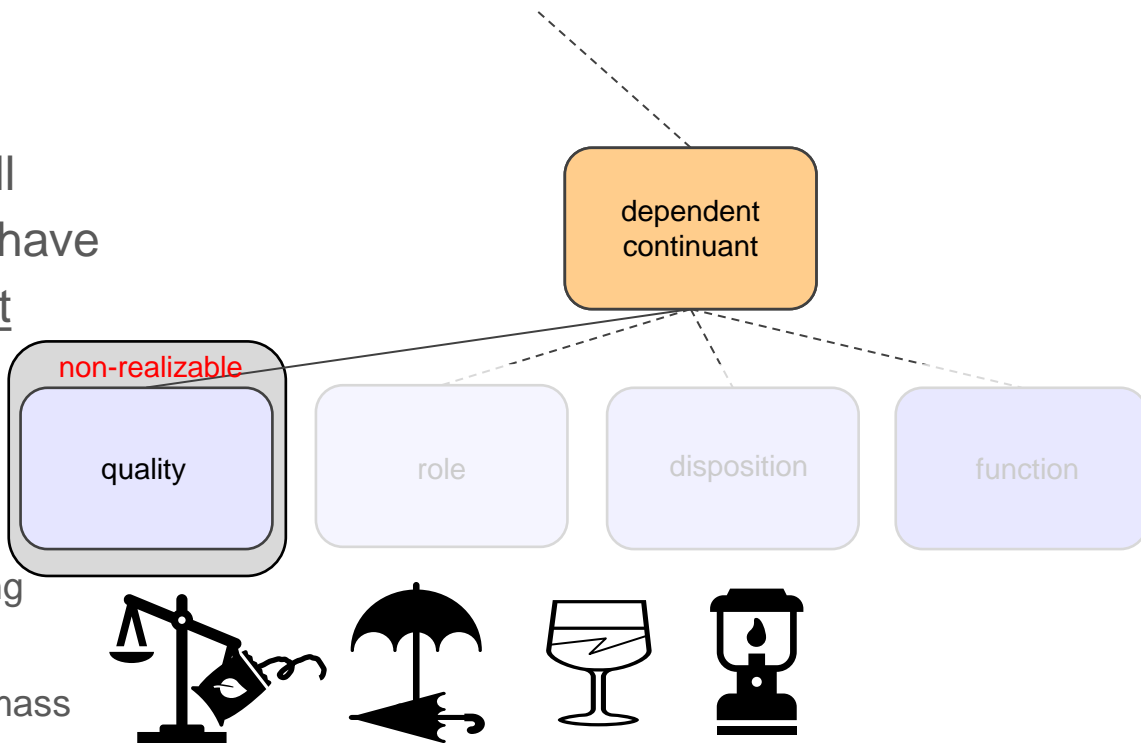
BFO: Realizable Dependent Continuant

- **realizable** = able to be achieved or made to happen
- with **realizable entity** the value does not need to exist and the existence can change over time
 - a screwdriver's function is realized by turning a screw
- **quality** is **not realizable**;
 - you just have temperature even it may change over time...



BFO: Quality

- **quality** is something that all objects of a particular type have for the entire time they exist
- Example:
 - the mass of a bag of tea
 - the shape of an umbrella
 - the fragility of a glass
 - the brightness of a gas lighting
- Although it may change
 - the bag of tea always has a mass and
 - the umbrella always has a shape...





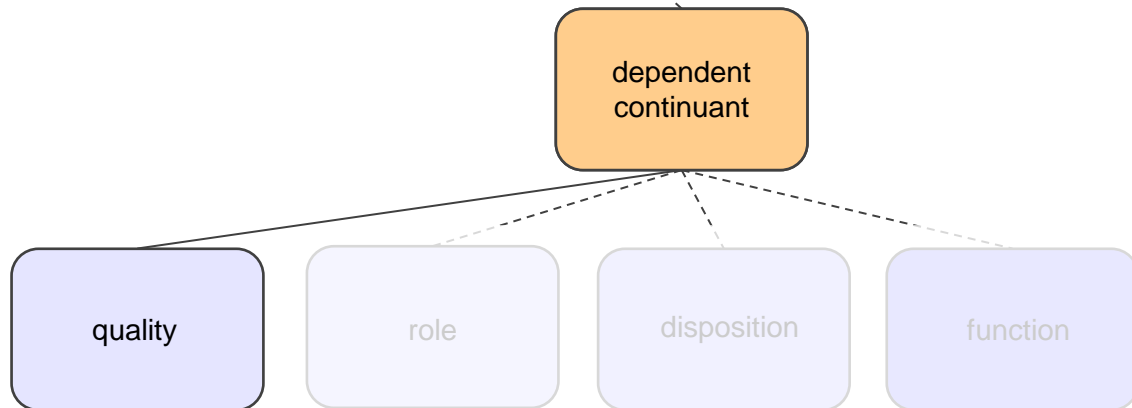
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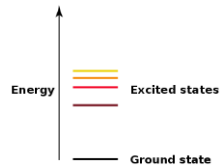
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 - quality**
 - acoustic quality
 - amount
 - chemical substance quality
 - conductivity
 - device configuration
 - electrical and magnetic quality
 - electromagnetic radiation quality
 - electron energy
 - energy (quality)
 - enthalpy (quality)
 - mechanical quality
 - molecular entity quality
 - morphology
 - number density
 - organismal quality
 - polarity (quality)
 - power (quality)
 - relational quality
 - resolution (quality)
 - thermal quality
 - wavelength (quality)
 - wavenumber (quality)



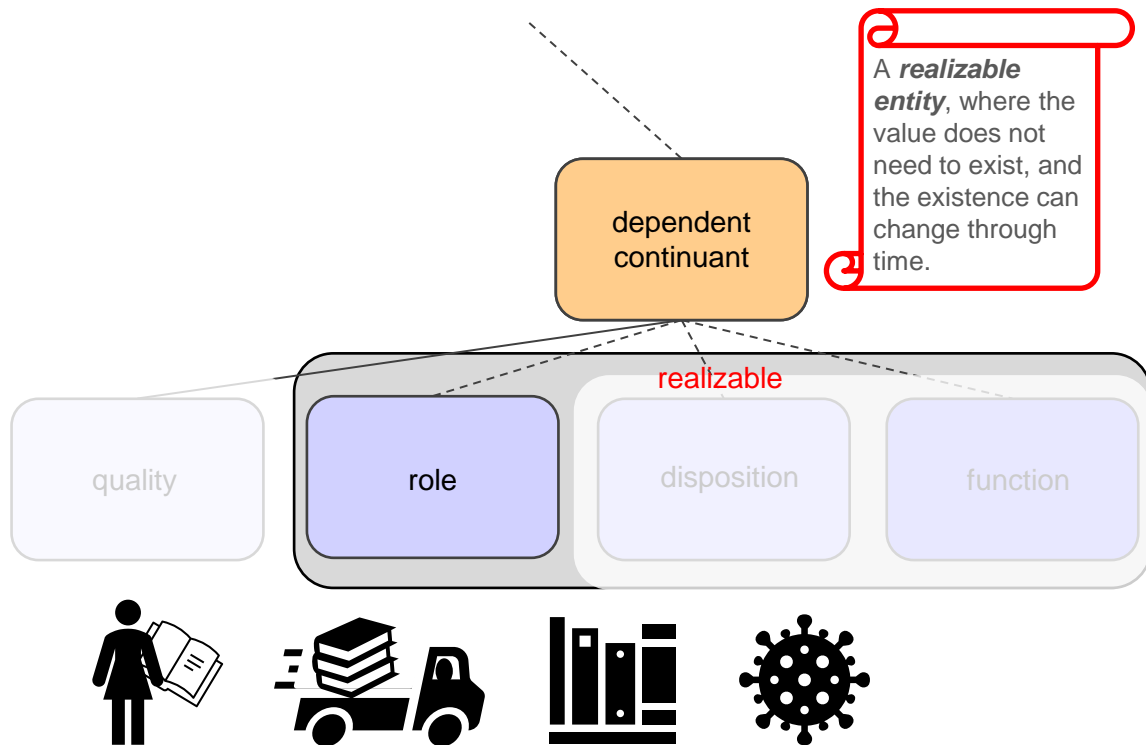
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Definitions	Electron energy is the translational energy that electrons acquire when accelerated in an electric field. [IUPAC]			
ID	http://purl.allotrope.org/ontologies/quality#AFQ_0000264			
definition	Electron energy is the translational energy that electrons acquire when accelerated in an electric field. [IUPAC]			
isDefinedBy	http://purl.allotrope.org/voc/afo/perspective/REC/2020/06/molecular-scale			
license	http://purl.allotrope.org/voc/iupac-license			
preferred label	electron energy			
prefixIRI	af-q:AFQ_0000264			
rights	http://purl.allotrope.org/voc/iupac-copyright			
RO_0000080	electron			





BFO: Role

- **role** specifies a goal that is not necessary to the object's design but can evolve.
- Examples:
 - role of being a Librarian
 - the role of delivering books
 - the role of a shelf to store books
 - the role of bacteria in causing an infection





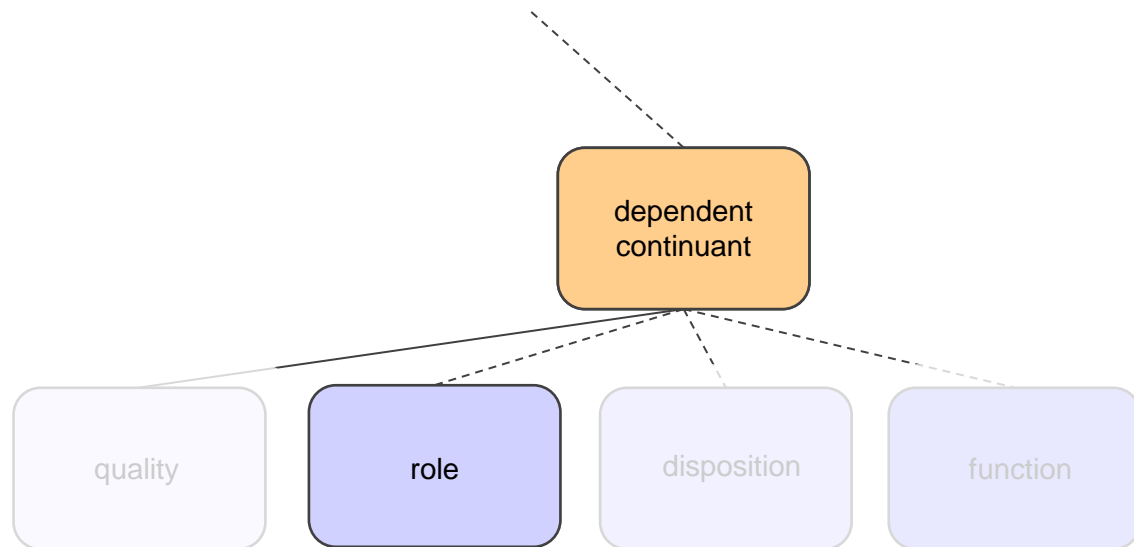
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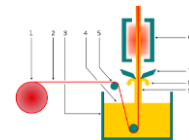
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 - quality
 - realizable entity
 - disposition
 - role
 - agent role
 - analysis role
 - approving role
 - calibration role
 - chromatographic phase
 - cleaning role
 - coating process role
 - coated material role
 - coating role
 - component role
 - controlling role
 - cooling role
 - debris role
 - detection role
 - dilution role
 - dissolution role
 - drying role
 - filtration role
 - head



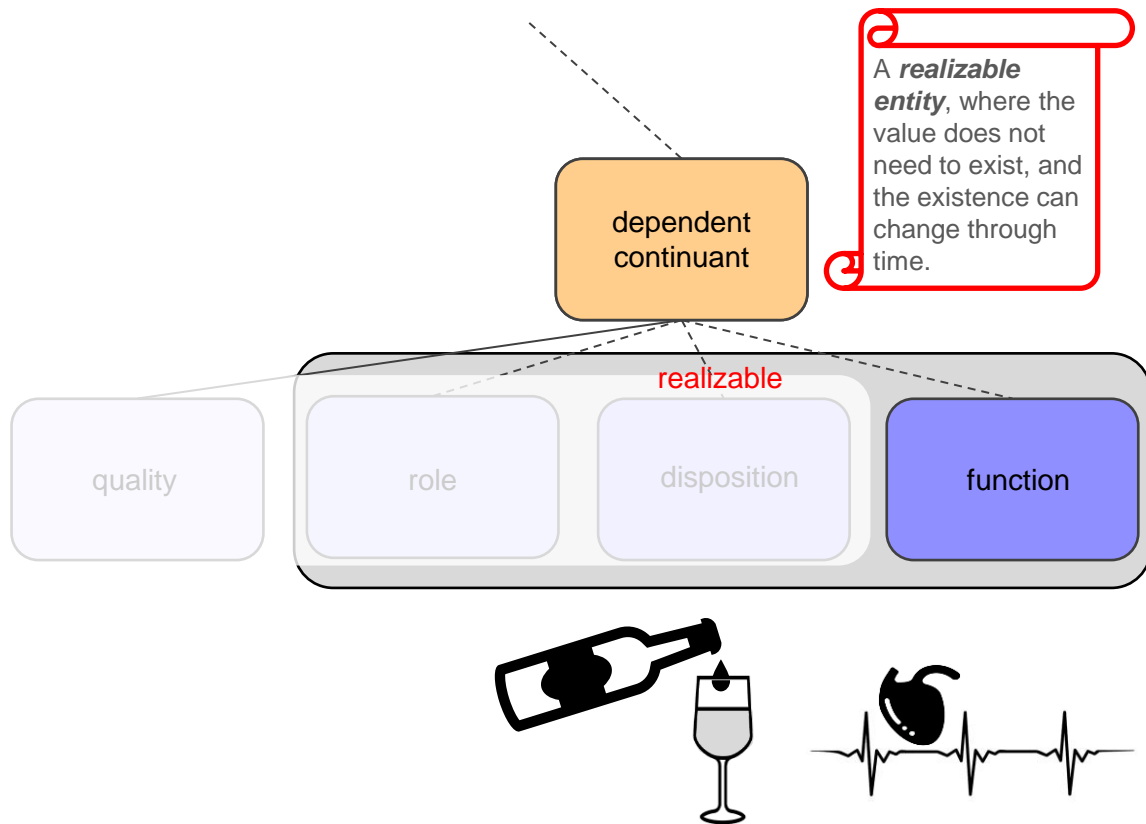
Details	Visualization	Notes (0)	Class Mappings (0)	
Preferred Name	coated material role			
Synonyms	substrate substrate role coated material			
Definitions	A coated material is a coating role of a material whose surface is being coated by another material which it covers. [Allotrope]			
ID	http://purl.allotrope.org/ontologies/role#AFRL_0000211			
alternative label	substrate substrate role coated material			
definition	A coated material is a coating role of a material whose surface is being coated by another material which it covers. [Allotrope]			
isDefinedBy	http://purl.allotrope.org/voc/af/REC/2020/06/aft			
preferred label	coated material role			
prefixIRI	af-rl:AFRL_0000211			
subClassOf	coating process role			





BFO: Function

- **function** is a disposition that is a purpose of an object, either through evolution or by design
- Examples:
 - the **function** of a glass may be to hold a drink
 - the **function** of the heart is to pump blood





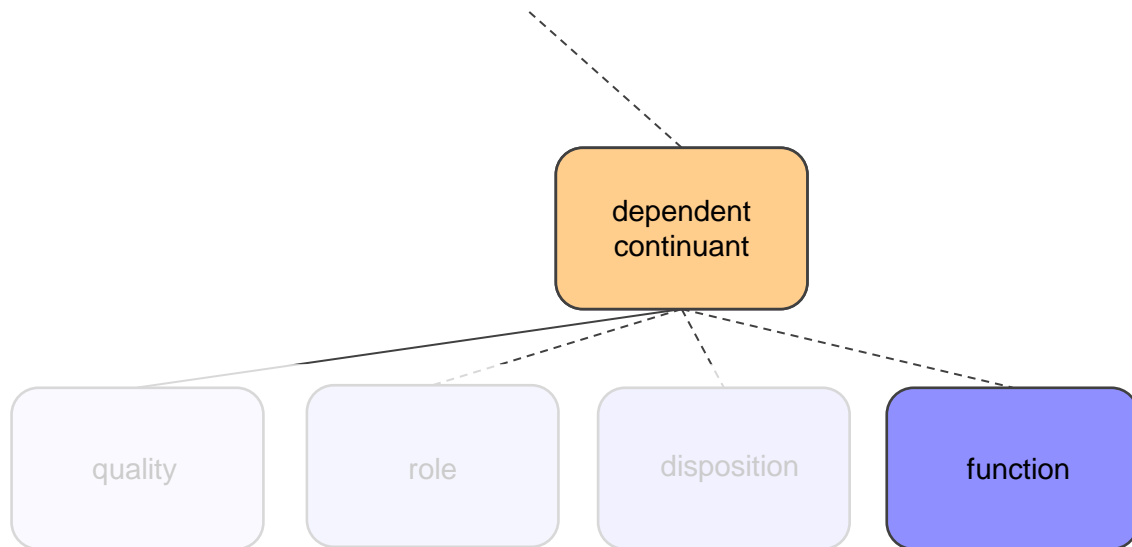
AFO: Function

Allotrope Merged Ontology Suite
Last uploaded: August 17, 2020

Summary Classes Properties Notes

Jump to:

- Attachable (abstract)
- Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
 - continuant
 - general role
 - generically dependent continuant
 - independent continuant
 - specifically dependent continuant**
 - quality
 - realizable entity
 - disposition
 - chemical disposition
 - function
 - material function
 - to branch
 - to combine
 - to consume
 - to control
 - to convert
 - to transform data
 - to calculate
 - to convert a signal
 - to count**
 - to count cells**
 - to divide
 - to localize
 - to plan
 - to produce
 - to provision
 - to signal
 - to support



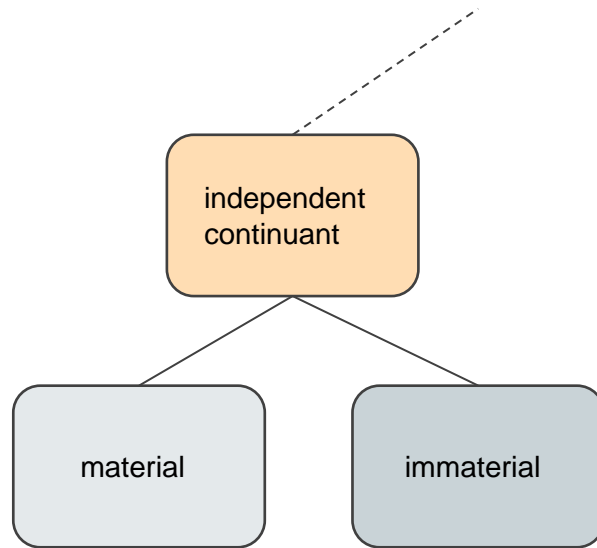
| Details | Visualization | Notes (0) | Class Mappings (0) | |
|-----------------|---|-------------|----------------------|--|
| Preferred Name | to count cells | | | |
| Definitions | To count cells is the function to count cells. [Allotrope] | | | |
| ID | http://purl.allotrope.org/ontologies/function#AFN_0000198 | | | |
| AFX_0002798 | true | | | |
| definition | To count cells is the function to count cells. [Allotrope] | | | |
| isDefinedBy | http://purl.allotrope.org/voc/afo/domain/REC/2020/06/cell-counting | | | |
| preferred label | to count cells | | | |
| prefixIRI | afo-fn:AFN_0000198 | | | |
| subClassOf | to count | | | |





BFO: Independent Continuant

- An independent continuant is either:
 - material entityor an
 - immaterial entity





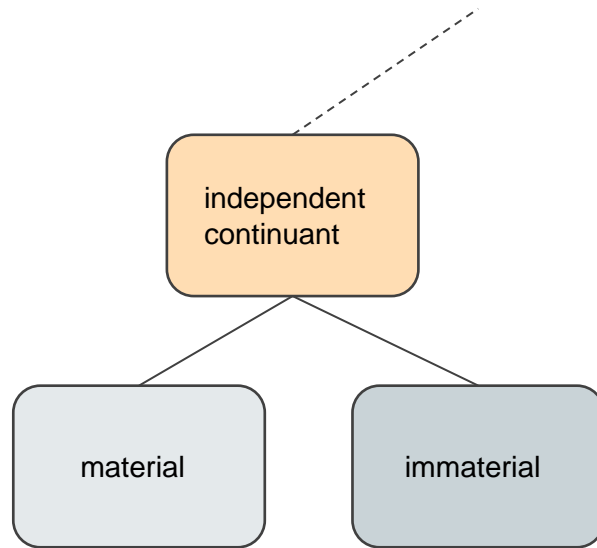
AFO: Independent Continuant

Allotrope Merged Ontology Suite
Last updated: August 17, 2020

Summary | Classes | Properties | Notes

Jump to:

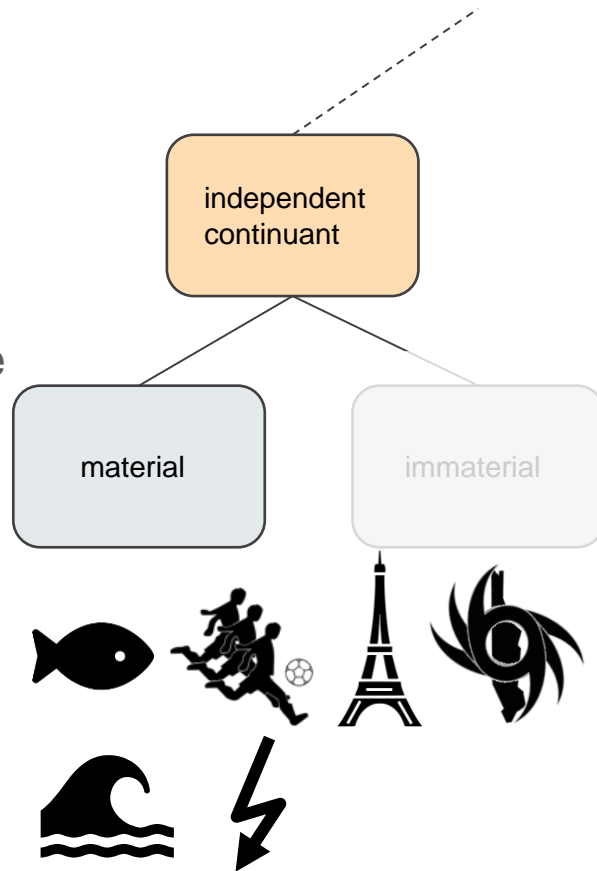
- Attachable (abstract)
 - data cube
 - Dataset
 - Item
 - Observation
 - Slice
- Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
 - continuant
 - general role
 - generically dependent continuant
 - independent continuant**
 - immaterial entity
 - material entity
 - specifically dependent continuant
 - occurrent





BFO: Material

- **material** entity has some matter as a part
- 'matter' is intended to encompass both mass and **energy**
- **material** entity can move or localized in space
- Examples:
 - a fish
 - a soccer team
 - Eifel tower
 - hurricane Sandy over NYC
 - a sea wave
 - an energy wave





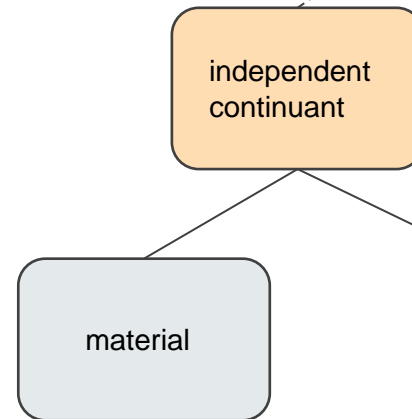
AFO: Material

Allotrope Merged Ontology Suite
Last updated: August 17, 2020

Summary Classes Properties Notes

Jump to:

- Attachable (abstract)
- Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
 - continuant
 - general role
 - generically dependent continuant
 - independent continuant
 - immaterial entity
 - material entity
 - energy
 - fiat object part
 - material
 - material information bearer
 - molecular entity
 - object
 - object aggregate
 - organizational entity
 - processed material
 - subatomic particle
 - system
 - artificial system
 - environmental system
 - gas chromatograph inlet
 - naked inlet
 - split inlet**
 - split/splitless inlet
 - splitless inlet
 - natural system



| Details | Visualization | Notes (0) | Class Mappings (0) | |
|-------------------|--|-------------|----------------------|--|
| Preferred Name | split inlet | | | |
| | split injector | | | |
| Synonyms | split | | | |
| | S | | | |
| Definitions | A split inlet is a gas chromatograph inlet followed by a splitter enabling the carrier gas to sweep a part of volatilized sample onto the GC column, with that remaining split/swept to waste. [Allotrope] | | | |
| ID | http://purl.allotrope.org/ontologies/equipment#AFE_0000811 | | | |
| | split injector | | | |
| alternative label | split | | | |
| | S | | | |
| definition | A split inlet is a gas chromatograph inlet followed by a splitter enabling the carrier gas to sweep a part of volatilized sample onto the GC column, with that remaining split/swept to waste. [Allotrope] | | | |
| isDefinedBy | http://purl.allotrope.org/voc/af/domain/REC/2020/06/gc | | | |
| preferred label | split inlet | | | |
| prefixIRI | af-e:AFE_0000811 | | | |
| subClassOf | gas chromatograph inlet | | | |



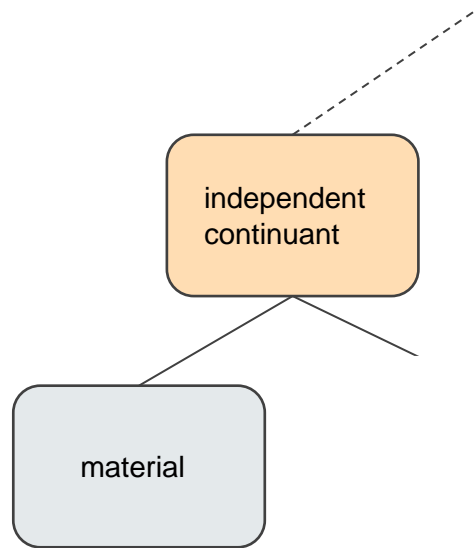
AFO: Material

Allotrope Merged Ontology Suite
Last uploaded: August 17, 2020

Summary | Classes | Properties | Notes

Jump to:

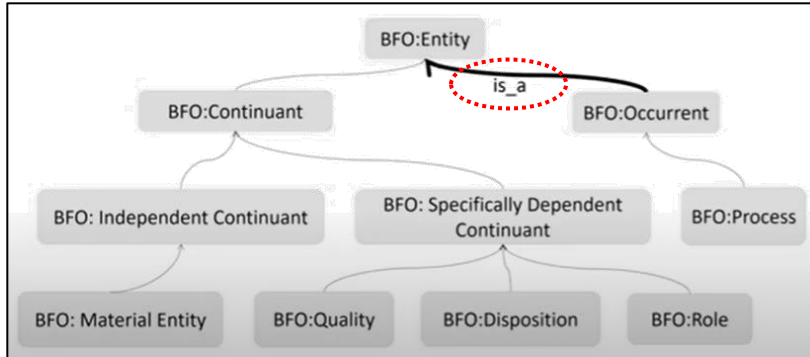
- Attachable (abstract) Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
 - continuant
 - general role
 - generically dependent continuant
 - independent continuant
 - material entity
 - material entity
 - energy
 - chemical energy
 - collision energy (material entity)
 - electrical energy**
 - electromagnetic energy
 - hydraulic energy
 - mechanic rotational energy
 - mechanic translational energy
 - pneumatic energy
 - thermal energy



| Details | Visualization | Notes (0) | Class Mappings (2) | |
|-----------------|---|-------------|----------------------|--|
| Preferred Name | electrical energy | | | |
| Definitions | Work resulting from the flow of electrons from a negative to a positive source. [NIST] | | | |
| ID | http://purl.allotrope.org/ontologies/material#AFM_0000884 | | | |
| AFX_0002818 | true | | | |
| definition | Work resulting from the flow of electrons from a negative to a positive source. [NIST] | | | |
| isDefinedBy | http://purl.allotrope.org/voc/afo/REC/2020/06/aft | | | |
| preferred label | electrical energy | | | |
| prefixIRI | af-m:AFM_0000884 | | | |
| subClassOf | energy | | | |

BFO: The Complete Hierarchy

- BFO is small
- Number of terms: 35
- 5 levels depth
- All relation are *is_a* relation, meaning sub type



Basic Formal Ontology

Last updated: September 4, 2015

[Summary](#) [Classes](#) [Properties](#) [Notes](#) [Mappings](#)

Jump to:

- entity
 - continuant
 - generically dependent continuant
 - independent continuant
 - immaterial entity
 - continuant fiat boundary
 - one-dimensional continuant fiat boundary
 - two-dimensional continuant fiat boundary
 - zero-dimensional continuant fiat boundary
 - site
 - spatial region
 - one-dimensional spatial region
 - three-dimensional spatial region
 - two-dimensional spatial region
 - zero-dimensional spatial region
 - material entity
 - fiat object part
 - object
 - object aggregate
 - specifically dependent continuant
 - quality
 - relational quality
 - realizable entity
 - disposition
 - function
 - role
- occurrent
 - process
 - history
 - process profile
 - process boundary
 - spatiotemporal region
 - temporal region
 - one-dimensional temporal region
 - zero-dimensional temporal region

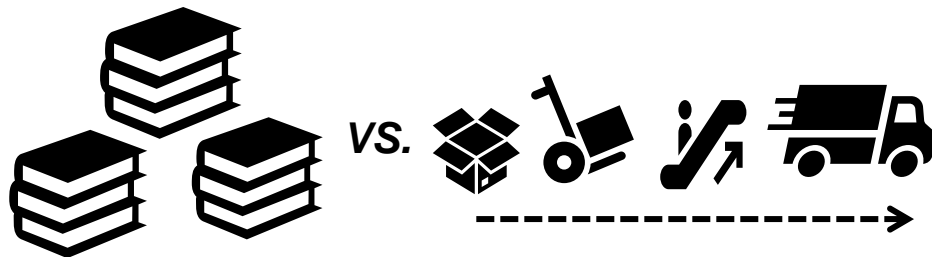


ADF file

Building Ontologies with BFO

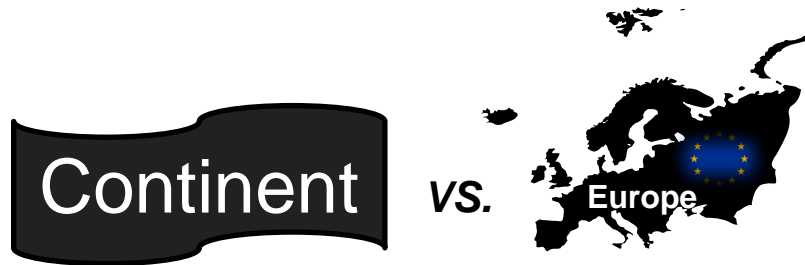
BFO: Based on Realism

- Ontologies are representation of reality
- That means that when you build an ontology you should look at the **things** in the world that the ontology suppose to be about! You should know what those **things** are like!
- We can view a fulfillment center as a
 - collection of goods (**stocks** perspective)
 - or as
 - distribution of goods (**flows** perspective)



BFO: Universals and Instances

- Ontologies are representation of ***universals*** in reality
- We are using general expressions to describe the kind of ***things*** that the ontology represents:
 - types
 - categories
 - species
 - etc.
- ***universals*** term has instances:
 - Continent is a type; Europe is an instance of type continent
 - Continent is an ontology term. Europe is not



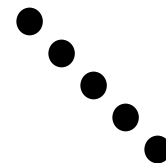
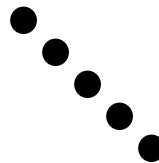
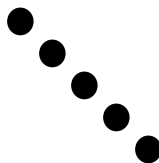
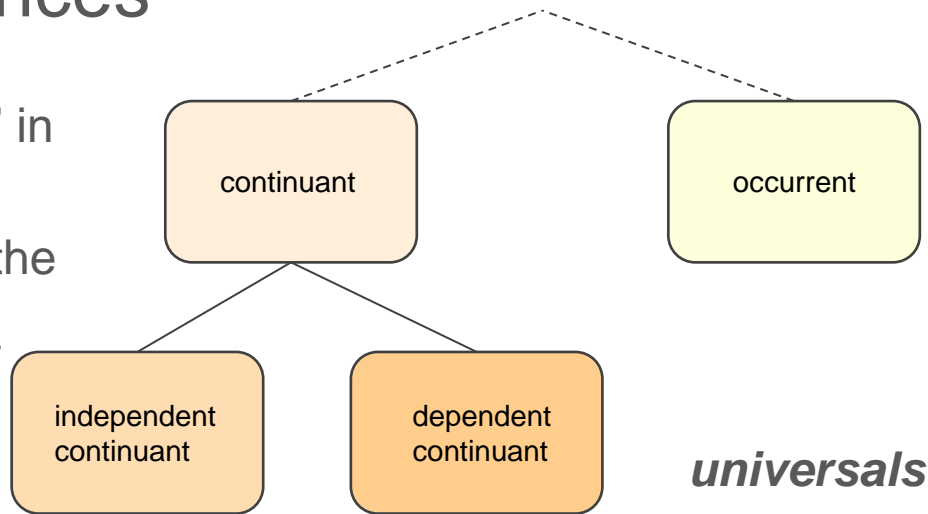


BFO: Universals and Instances

- Catalog is a list of the “kind of things” in the warehouse
- Inventory is a list of the instances of the “kind of thing” in a given point of time

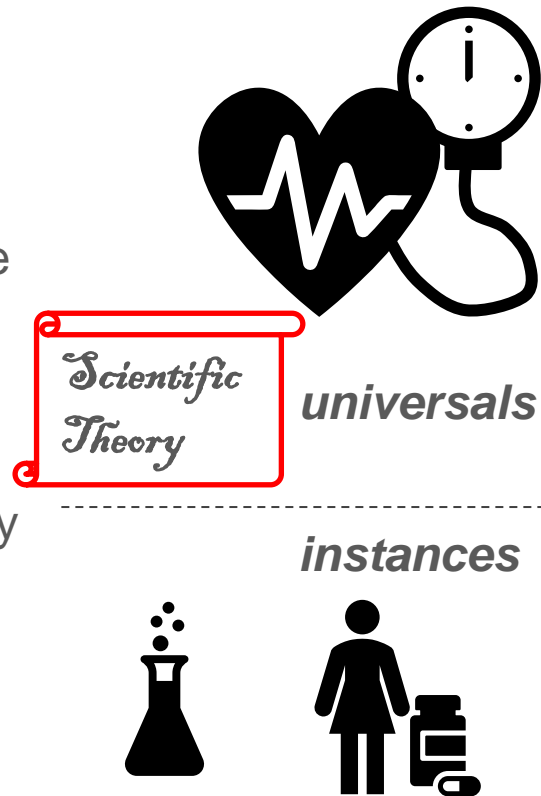
Catalog

Continent



BFO: Universals and Instances

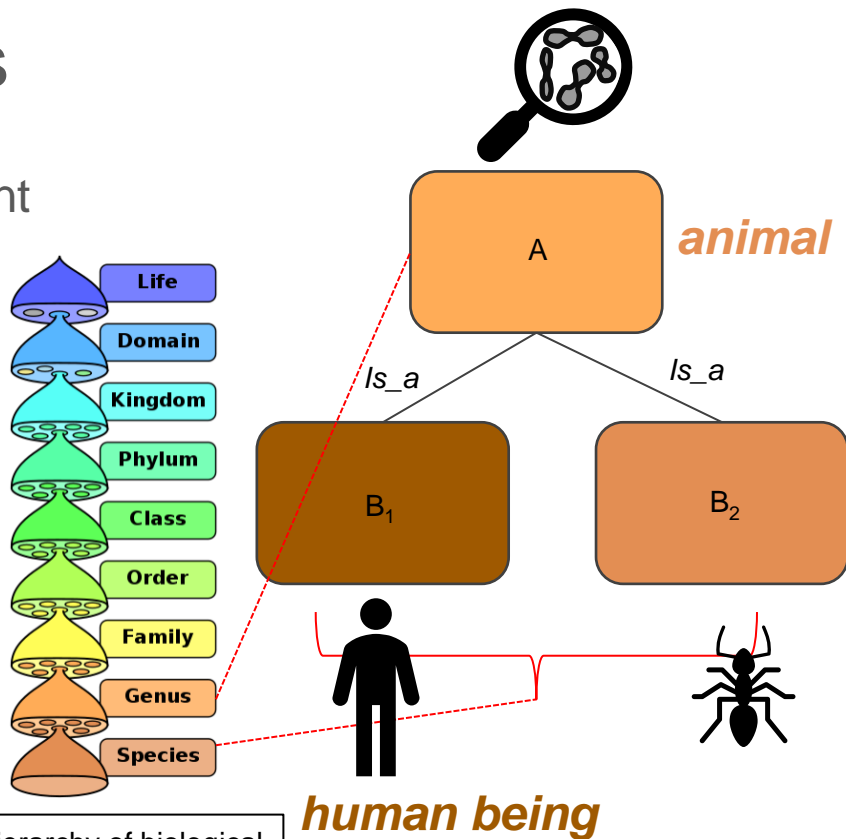
- Scientific ontologies consist of **general terms**
- **general terms** can be used to formulate scientific laws or design scientific experiments
- When we are performing a scientific experiment, we are interested in **instances**
- Scientific theories are about the **general, universals** (*kind, type...*)
- Scientific experiments are about the **particular** and they are performed to test the assertion of what is **general**
- To develop a new **medication** you need both:
 - The **kinds** of patients (this is **general**): **Hypertension**
 - Your **patients** (your instances)





BFO: Taxonomy Traffic Rules

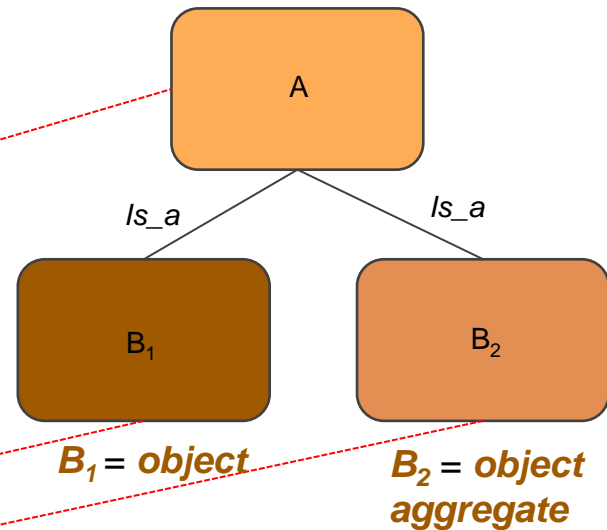
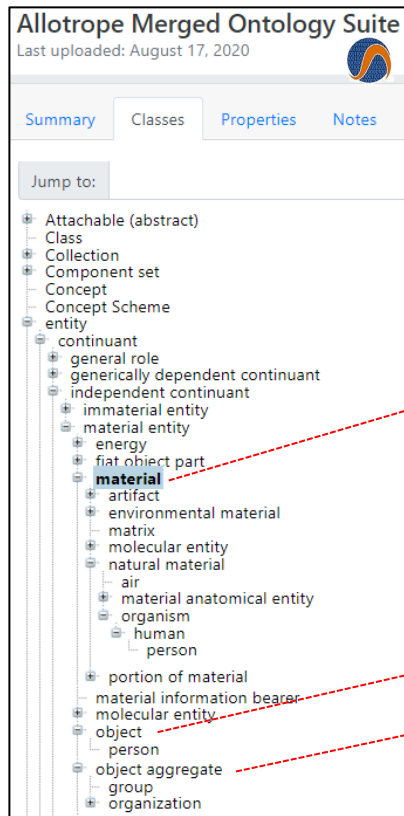
- Every term should have exactly one parent with *is_a* relation: **Single Inheritance**
- In term definition use two-part definition with the following expression:
 - **B** = def. **A** which **Cs**
 - **A** = genus (living and fossil organisms)
 - **B₁, B₂...** = species
 - **C** = specific difference
 - **a human being** = def. **an animal** which is **rational**
- If you have two parents, you are lost ☹️



The hierarchy of biological classification's eight major taxonomic ranks.



AFO: Taxonomy Traffic Rules



object = def. *material*
which is **single**

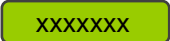

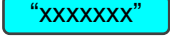


ADF file

AFO Composition



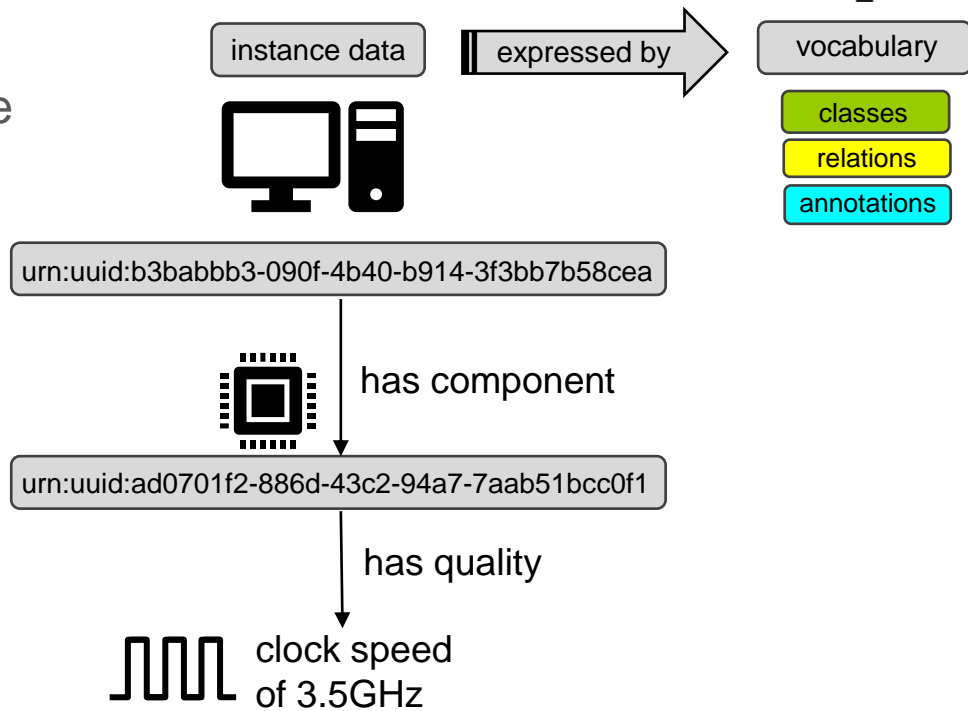
AFO: Data and Semantic

- We are using **vocabulary** to describe the **data**
- The **AFO vocabulary** contains:
 - classes 
 - relations 
 - annotations 
- Example:
 - Let's describe an **instance** of a **computer** with a **CPU** operating at a **clock speed** of **3.5Ghz**



AFO: Data and Semantic

- In a simple graph model, there are two nodes representing the **computer** and the **CPU**. Each node has a UUID and the connection between them
- In addition there is a **quality** related to the **CPU**
- As is, this graph has minimal information
- Using the **vocabulary** we can get semantic meaning about the nodes and the connections





AFO: Data and Semantic



Allotrope Merged Ontology Suite
Last uploaded: August 17, 2020

Summary Classes Properties Notes

Jump to:

- Attachable (abstract)
- Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
 - continuant
 - general role
 - generically dependent continuant
 - independent continuant
 - immaterial entity
 - material entity
 - energy
 - fiat object part
 - material
 - artifact
 - device
 - agitator
 - blood gas analyzer
 - collecting device
 - communication device
 - computer**
 - connecting device

central processing unit

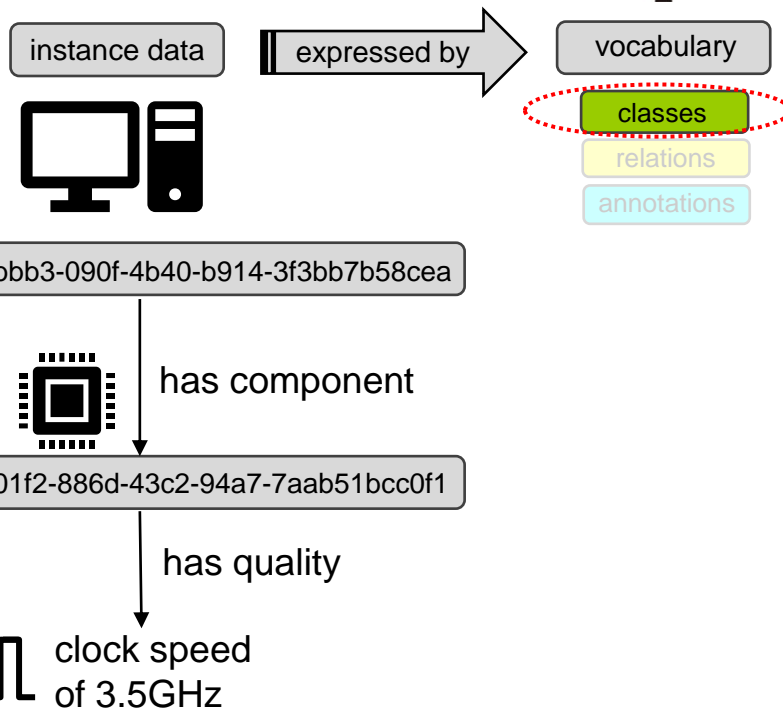
Allotrope Merged Ontology Suite
Last uploaded: August 17, 2020

Summary Classes Properties Notes

Jump to:

- Attachable (abstract)
- Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
 - continuant
 - general role
 - generically dependent continuant
 - independent continuant
 - specifically dependent continuant
 - quality**
 - acoustic quality
 - amount
 - chemical substance quality
 - conductivity
 - device configuration

frequency





AFO: Data and Semantic



```
### http://purl.allotrope.org/ontologies/property#AFX_0000972
af-x:AFX_0000972 rdf:type owl:ObjectProperty ;
    rdfs:subPropertyOf af-x:AFX_0002793 ;
    rdf:type owl:TransitiveProperty ;
    rdfs:domain ro:_0002577 ;
    rdfs:range bfo:_0000040 ;
    rdfs:isDefinedBy <http://purl.allotrope.org/voc/afo/REC/2020/09/ro:_0000086> ;
    skos:altLabel "has physical part" ;
    skos:definition "A physical object that forms a system that has as part a physical entity that is one of its components. [Allotrope]" ;
    skos:prefLabel "has component"
```

```
### http://purl.obolibrary.org/obo/RO_0000086
ro:_0000086 rdf:type owl:ObjectProperty ;
    rdfs:subPropertyOf ro:_0000053 ;
    rdfs:range bfo:_0000019 ;
    rdfs:isDefinedBy <http://purl.allotrope.org/voc/afo/REC/2020/09/relation> ;
    skos:definition "A relation between an independent continuant (the bearer) and a quality, in which the quality specifically depends on the bearer for its existence. [RO]" ;
    skos:editorialNote "A bearer can have many qualities, and its qualities can exist for different periods of time, but none of its qualities can exist when the bearer does not exist. [RO]" ;
    skos:example "this apple has quality this red color" ;
    skos:prefLabel "has quality"
```

instance data



expressed by

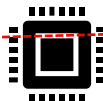
vocabulary

classes

relations

annotations

urn:uuid:b3babbb3-090f-4b40-b914-3f3bb7b58cea



has component

urn:uuid:ad0701f2-886d-43c2-94a7-7aab51bcc0f1

has quality



clock speed
of 3.5GHz



AFO: Data and Semantic



```
### http://purl.allotrope.org/ontologies/property#AFX_0000972
af-x:AFX_0000972 rdf:type owl:ObjectProperty ;
    rdfs:subPropertyOf af-x:AFX_0002793 ;
    rdf:type owl:TransitiveProperty ;
    rdfs:domain ro:_0002577 ;
    rdfs:range bfo:_0000040 ;
    rdfs:isDefinedBy <http://purl.allotrope.org/voc/afo/REC/2020/09/10/has-component> ;
    skos:altLabel "has physical part" ;
    skos:definition "A physical object that forms a system that has as part a physical entity that is one of its components. [Allotrope]" ;
    skos:prefLabel "has component" .
```

```
### http://purl.obolibrary.org/obo/RO_0000086
ro:_0000086 rdf:type owl:ObjectProperty ;
    rdfs:subPropertyOf ro:_0000053 ;
    rdfs:range bfo:_0000019 ;
    rdfs:isDefinedBy <http://purl.allotrope.org/voc/afo/REC/2020/09/relation> ;
    skos:definition "A relation between an independent continuant (the bearer) and a quality, in which the quality specifically depends on the bearer for its existence. [RO]" ;
    skos:editorialNote "A bearer can have many qualities, and its qualities can exist for different periods of time, but none of its qualities can exist when the bearer does not exist. [RO]" ;
    skos:example "this apple has quality this red color" ;
    skos:prefLabel "has quality" .
```

instance data



expressed by

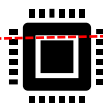
vocabulary

classes

relations

annotations

urn:uuid:b3babbb3-090f-4b40-b914-3f3bb7b58cea



has component

urn:uuid:ad0701f2-886d-43c2-94a7-7aab51bcc0f1

has quality



clock speed
of 3.5GHz

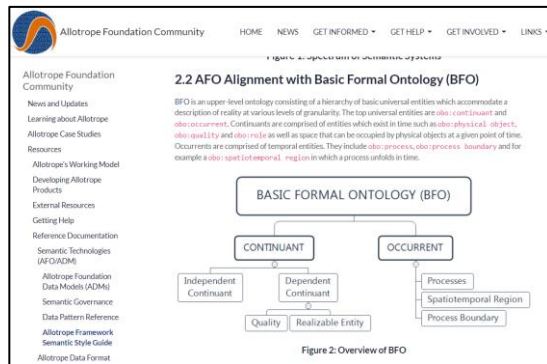
| | |
|-------------------|--|
| Preferred Name | computer |
| | desktop computer |
| Definitions | A computer is a general-purpose device that can be than one kind of problem. [Wikipedia] |
| id | http://purl.allotrope.org/ontologies/equipment#AFX_0002818 |
| AFX_0002818 | true |
| alternative label | desktop computer |
| definition | A computer is a general-purpose device that can be than one kind of problem. [Wikipedia] |
| isDefinedBy | http://purl.allotrope.org/voc/afo/REC/2020/06/aft |
| preferred label | computer |
| prefixIRI | af-e:AFE_0001695 |
| subClassOf | device |



AFO: Best Practice

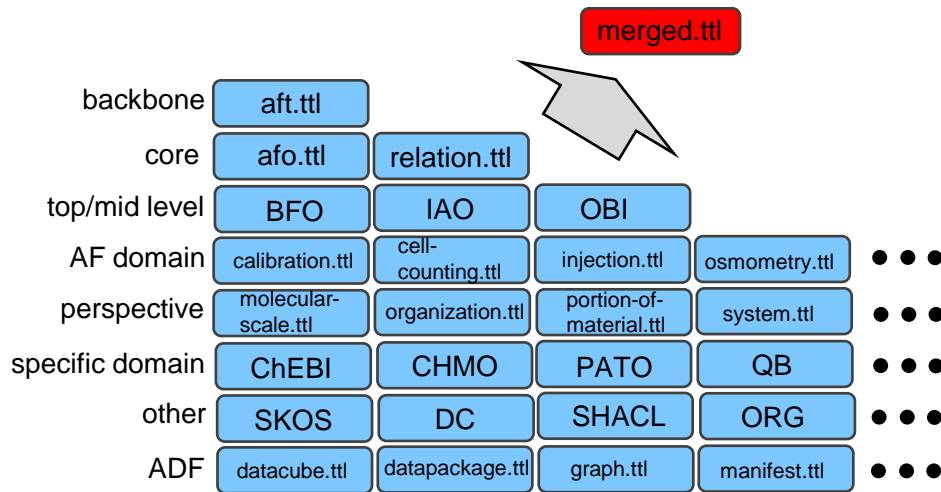
https://community.allotrope.org/resources/reference/semantic/style_guide/afo_style_guide/

- Defined by the Allotrope style guide
- AFO follows best practices for ontology design
 - Applying top level ontology
 - Ensures compatibility with other ontologies
 - Single inheritance principle
 - One parent class for each term
 - Prevents ambiguity
 - Easily modularized
 - Low computation when implementing logical reasoning
 - Consistency
 - Avoiding errors
 - Satisfiability
 - All classes can be instantiated
 - Modularization
 - reuse



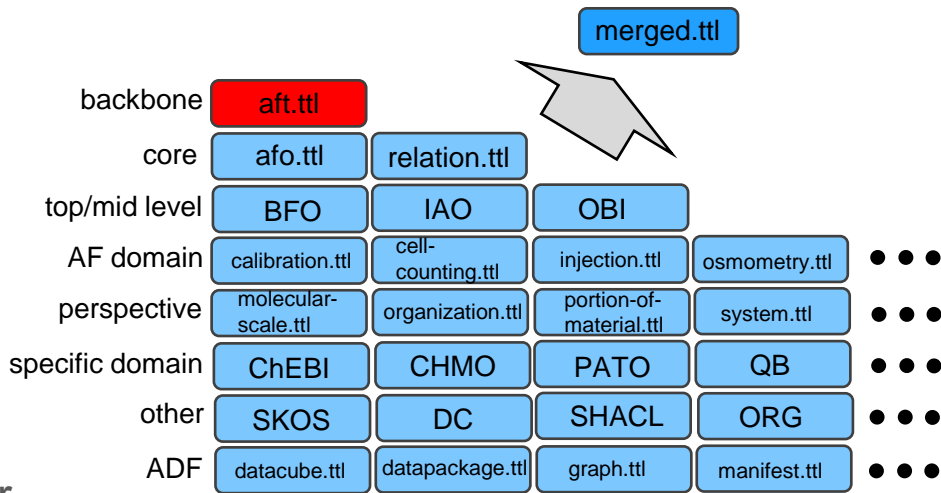
AFO: merged.ttl – A Suite of Ontologies

- AFO is a hierarchy of terms
- AFO can be serialized using text format such as TURTLE syntax (.ttl)
- merged.ttl is AFO suite of ontologies



AFO: aft.ttl – Allotrope Foundation Taxonomy (.ttl)

- AFT is the backbone of AFO
- AFT aligns with BFO
- AFT is a hierarchy of universals and Allotrope classes
- Hierarchy of *is_a*:
 - `rdfs:subClassOf`
- No relations
- Each term has a unique identifier
- Mandatory annotation:
 - `single skos:prefLabel`
 - `single skos:definition`
- terms must follow the Allotrope style guide



Taxonomy is a hierarchy of linked terms by subtype relations and denoting types:

- universals,
- classes,
- primitives



AFO: aft.ttl – Allotrope Foundation Taxonomy (.ttl)

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Last uploaded: August 17, 2020

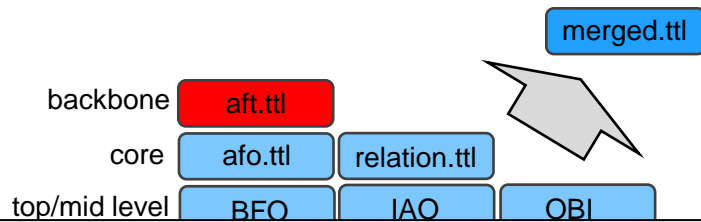
Summary Classes Properties Notes

Jump to:

- Attachable (abstract) Class
- Collection
- Component set
- Concept
- Concept Scheme
- entity
 - continuant
 - general role
 - generically dependent continuant
 - independent continuant
 - immaterial entity
 - material entity
 - energy
 - fiat object part
 - material
 - artifact
 - device
 - agitator
 - blood gas analyzer
 - collecting device
 - communication device
 - computer
 - connecting device
 - container
 - controller
 - conversion device
 - cooling device
 - dampener
 - data acquisition device
 - detector
 - diode
 - display**
 - distribution device
 - electrode
 - electromagnetic radiation source

BFO

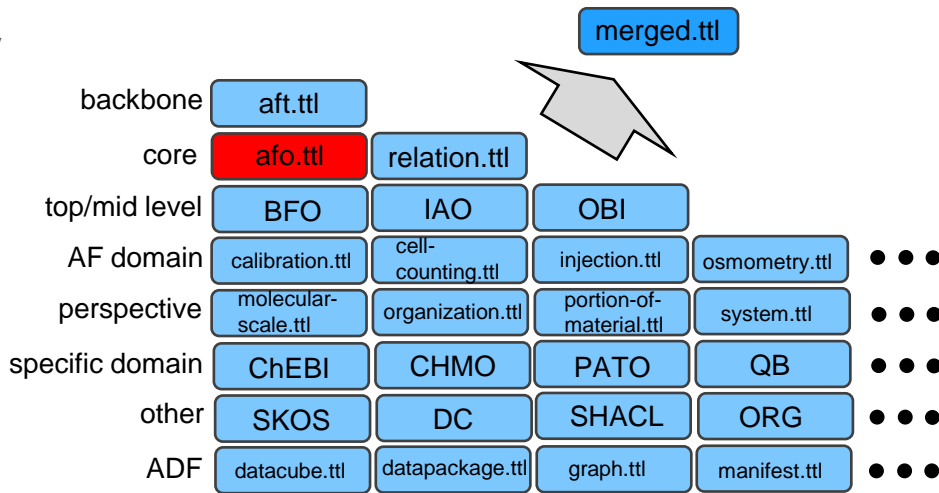
Hierarchy of
universals



| Details | Visualization | Notes (0) | Class Mappings (18) | |
|-------------------|---|-------------|-----------------------|--|
| Preferred Name | display | | | |
| Synonyms | display device | | | |
| Definitions | A display is a device or element of an instrument serving to represent information. [Allotrope] | | | |
| ID | http://purl.allotrope.org/ontologies/equipment#AFE_0000761 | | | |
| AFX_0002818 | true | | | |
| alternative label | display device | | | |
| definition | A display is a device or element of an instrument serving to represent information. [Allotrope] | | | |
| isDefinedBy | http://purl.allotrope.org/voc/afo/REC/2020/06/aft | | | |
| preferred label | display | | | |
| prefixIRI | af-e:AFE_0000761 | | | |
| RO_0000085 | to display | | | |
| subClassOf | device | | | |

AFO: afo.ttl - Allotrope Foundation Ontology (.ttl)

- afo.ttl contains the core ontology of Allotrope
- AFO
 - adds relations (other than *is_a*)
 - adds logical expression
 - contains defined classes
 - Imports aft.ttl

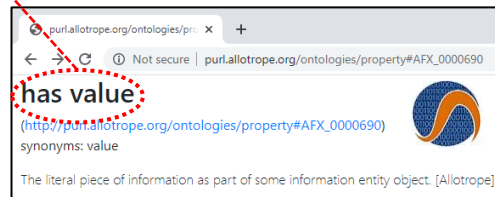
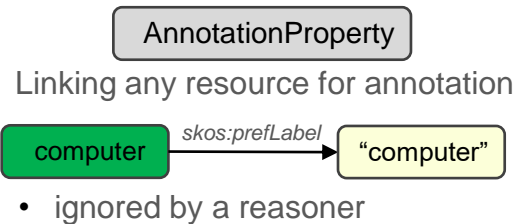
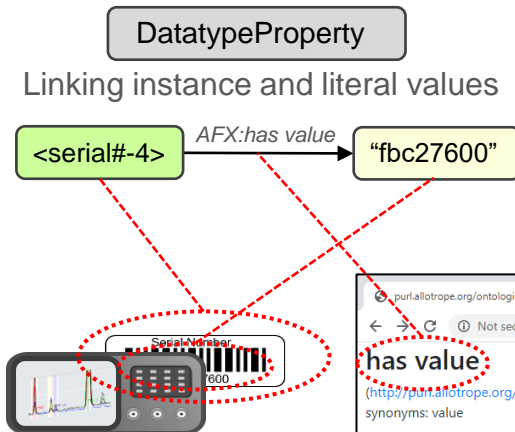
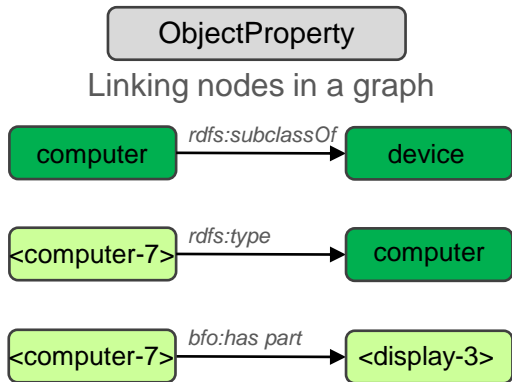


Ontology is a representational artifact, consisting of

- taxonomy as proper part, whose representations are intended to designate some combination of
 - universals,
 - defined classes (collection of individuals, grouped together)
- and certain relations between them

AFO: afo.ttl - Allotrope Foundation Ontology (.ttl)

- afo.ttl adds several different types of relations for linking Classes, Instances and Literals:
 - owl:ObjectProperty
 - owl:DatatypeProperty
 - owl:AnnotationPrperty

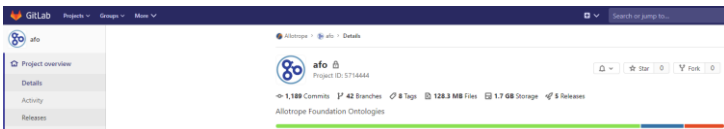




AF: AF Ontology Development Lifecycle

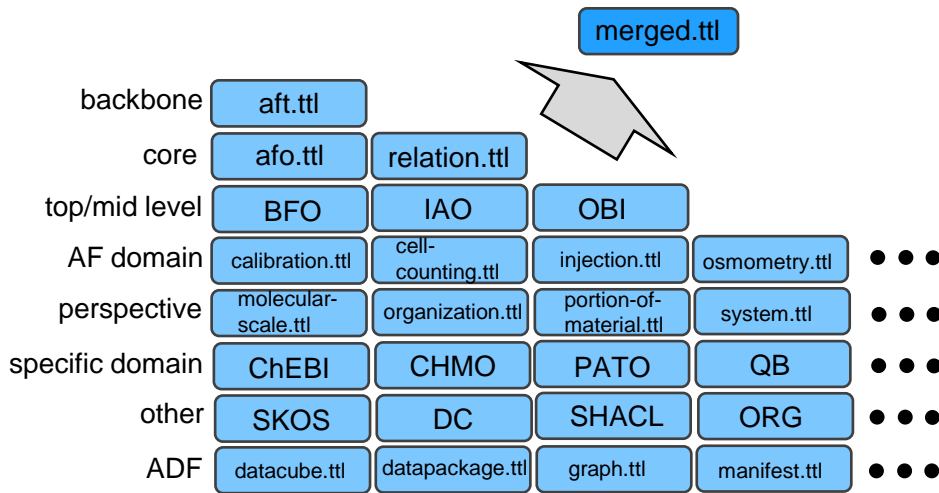
AFO source repository can be found at:

<https://gitlab.com/allotrope/afo>



AFO QA tools can be found at:

<https://gitlab.com/allotrope-open-source/allotrope-devops>



ADF file

Thanks for your attention!

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