Ontology Implementation with gUFO: A Hands-on Tutorial

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Team & Acknowledgements

- Giancarlo Guizzardi
- Ricardo de Almeida Falbo
- Claudenir M. Fonseca
- and all the contributors to UFO over the years

Building Better Ontology Implementations

We need all the help we can get!

- Reuse of definitions and rules in foundational layer
  - "a little semantics goes a long way", "some more semantics goes further"
- Conceptual patterns
  - cope with recurrent implementation challenges
  - improve implementation stability
- Automatic error detection
  - beyond what can be achieve in the ontologically-neutral OWL

Background

- “Foundational ontology”
- Captures our understanding of general (ubiquitous!) notions
- Objects, their aspects, their types, their parts, … events, situations, …

Unified Foundational Ontology

Approach

- Reference ontology x ontology implementation
  - Reference ontology is built as a conceptual model giving precedence to real-world adequacy
  - Ontology implementation (also called computational or lightweight ontology) sacrifices real-world adequacy to obtain computational properties
- UFO as a reference ontology
- gUFO as an ontology implementation of UFO in OWL
  - ‘g’ for gentle

Approach

gUFO

domain-independent

more specific

gUFO-based (domain) ontology

gUFO overview

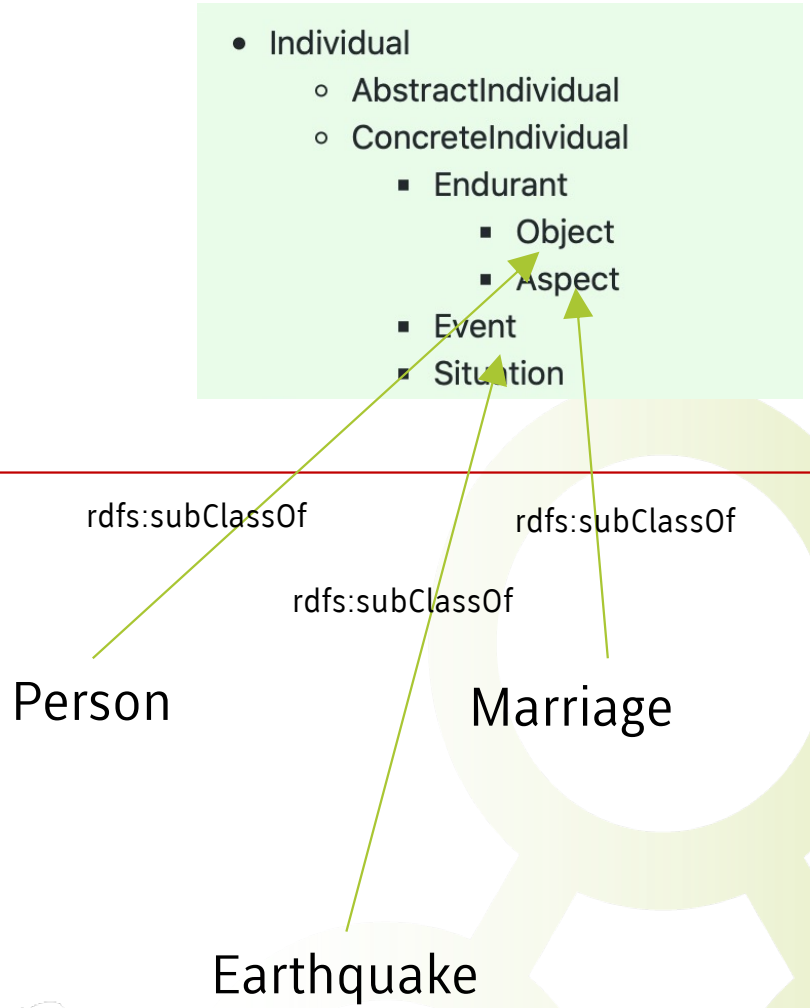
- gUFO reflects UFO taxonomies of individuals and types (universals)
- Minor terminological differences to avoid philosophical jargon

- Individual
  - AbstractIndividual
  - ConcreteIndividual
    - Endurant
      - Object
      - Aspect
    - Event
    - Situation
- Type
  - AbstractIndividualType
  - ConcreteIndividualType
    - EndurantType
      - Sortal
        - Kind
        - Phase
        - Role
        - SubKind
      - NonSortal
        - Category
        - PhaseMixin
        - RoleMixin
        - Mixin
    - EventType
    - SituationType
  - RelationshipType

gUFO taxonomy of individuals

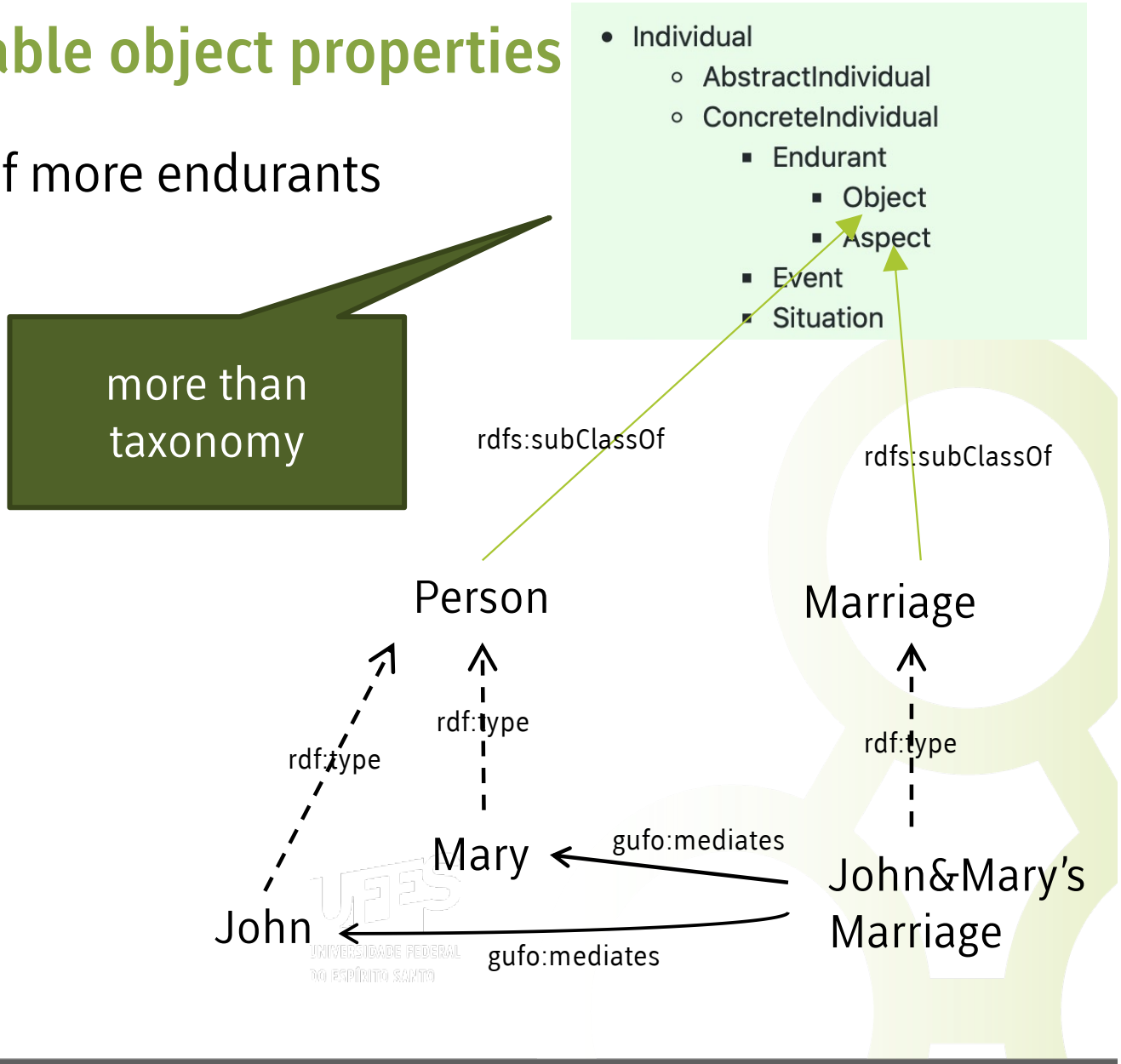
gUFO

gUFO-based (domain) ontology



More semantics... reusable object properties

- A relator mediates one of more endurants



Agenda

Part 0: Baseline – Constructs employed from RDFS/OWL

- Classes, sub-classes, object properties, data properties, sub-properties…

Part 1: Reuse of foundational layer – The basics

- Reusing the gUFO taxonomy of individuals and object properties
  - Endurants, events, objects, aspects, relators, …

Part 2: Patterns and advanced features

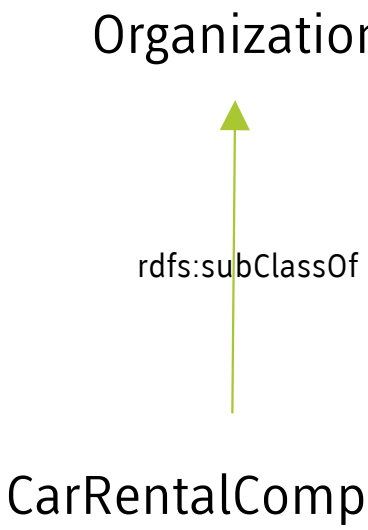
- 2.1 Representing qualities
- 2.2 Representing situations
- 2.3 Reusing the gUFO taxonomy of types
  - Kinds, subkinds, categories, phases, roles, …

0. Baseline

“A little semantics goes a long way” – Jim Hendler

Constructs Employed from RDF(S)/OWL

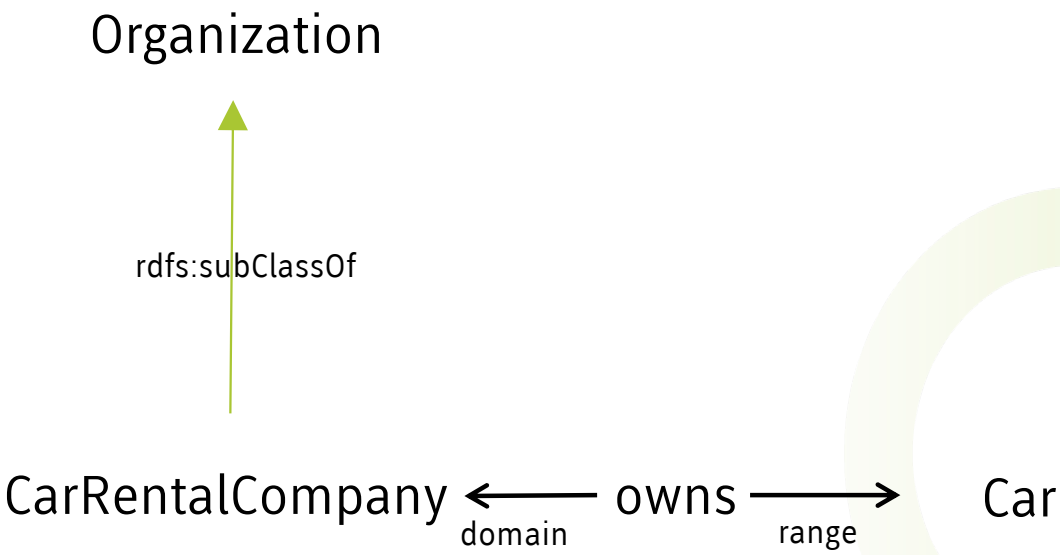
- owl:Class
- rdfs:subclassOf



Car

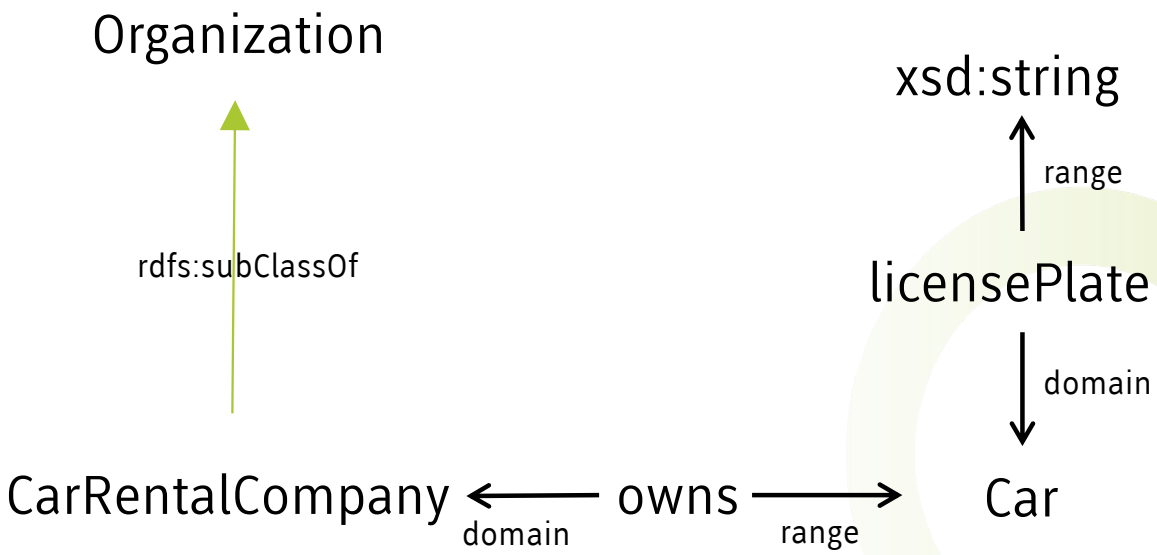
Constructs Employed from RDF(S)/OWL

- owl:Class
- rdfs:subclassOf
- owl:ObjectProperty
- rdfs:domain
- rdfs:range



Constructs Employed from RDF(S)/OWL

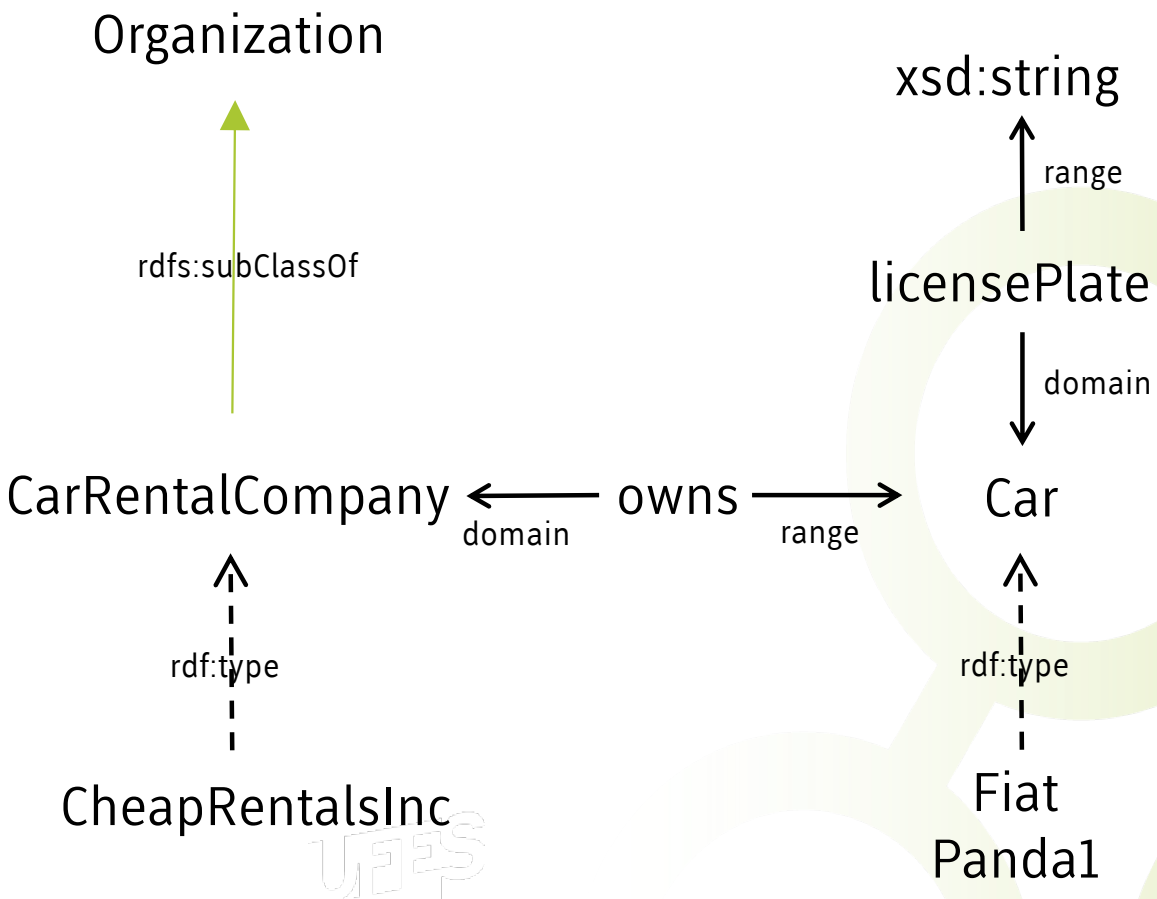
- owl:Class
- rdfs:subclassOf
- owl:ObjectProperty
- rdfs:domain
- rdfs:range
- owl:DatatypeProperty



Constructs Employed from RDF(S)/OWL

- owl:Class
- rdfs:subclassOf
- owl:ObjectProperty
- rdfs:domain
- rdfs:range
- owl:DatatypeProperty
- (rdfs:subPropertyOf)

- owl:NamedIndividual
- rdf:type



Constructs Employed from RDF(S)/OWL

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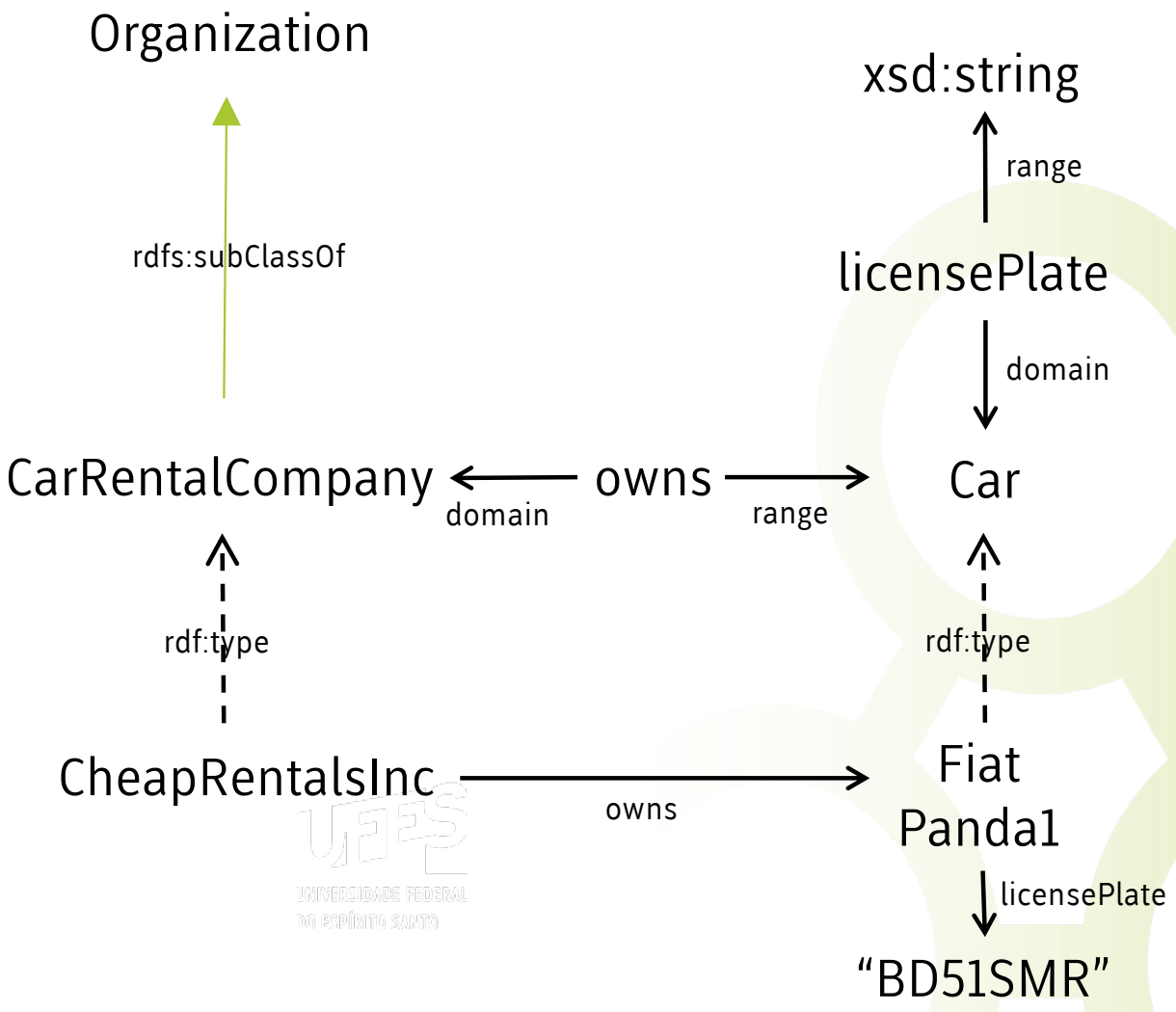
- rdfs:subclassOf
- owl:ObjectProperty
- rdfs:domain
- rdfs:range
- owl:DatatypeProperty
- (rdfs:subPropertyOf)

- owl:NamedIndividual
- rdf:type



Constructs Employed from RDF(S)/OWL

- Disjointess axioms
- (Disjoint) unions
- Cardinalities
- Property characteristics: functional, inverse functional, transitive...

1. Reuse of foundational layer

“A little semantics goes a long way” – Jim Hendler

“Some more semantics goes further...”

gUFO: A Lightweight Implementation of the Unified Foundational Ontology (UFO)

IRI

`http://purl.org/nemo/gufo#`

Creator(s)

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Falbo, Ricardo A.
Guizzardi, Giancarlo
Sales, Tiago P.

Version Information

1.0.0

License

https://creativecommons.org/licenses/by/4.0/legalcode

Ontology Source

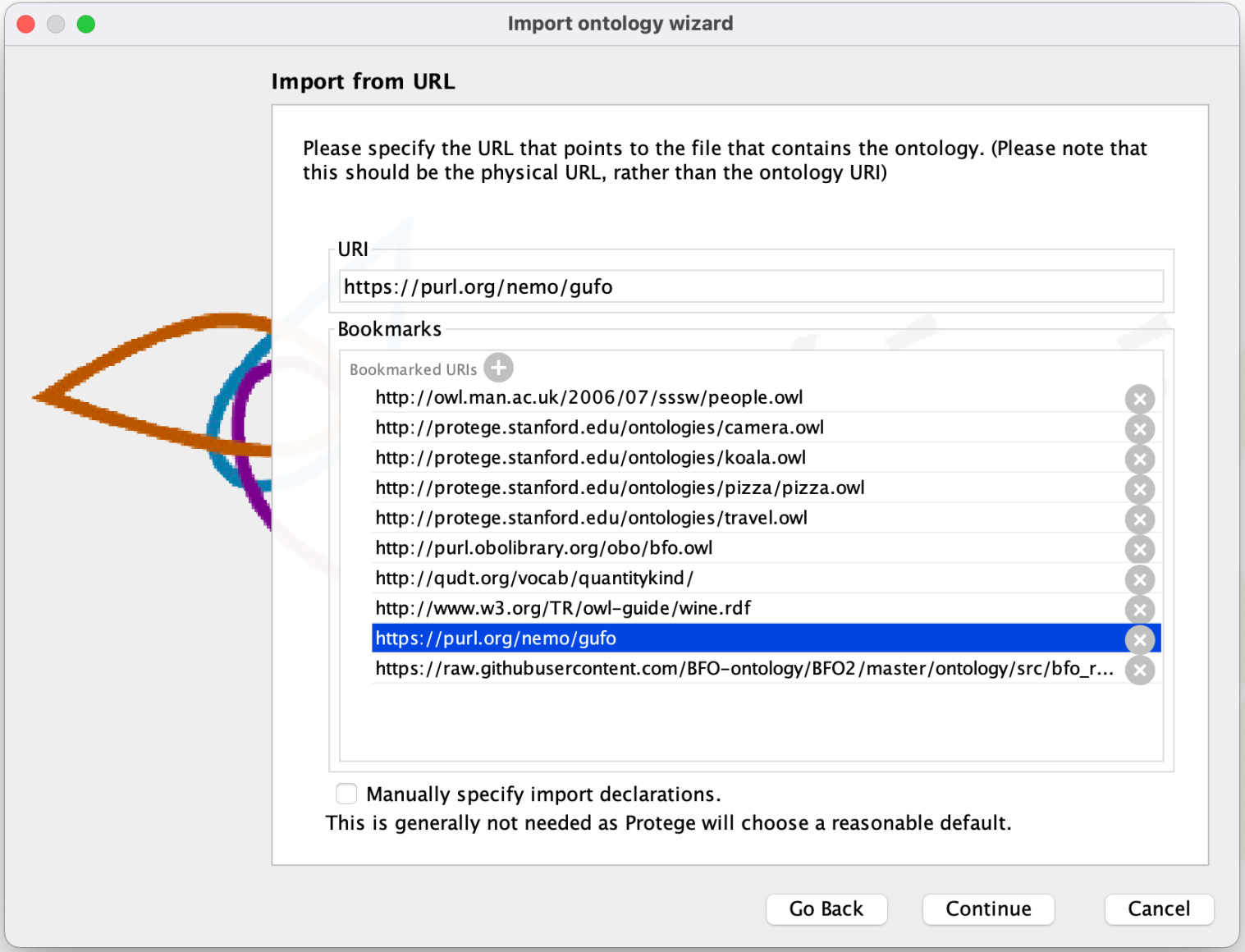
RDF (Turtle)

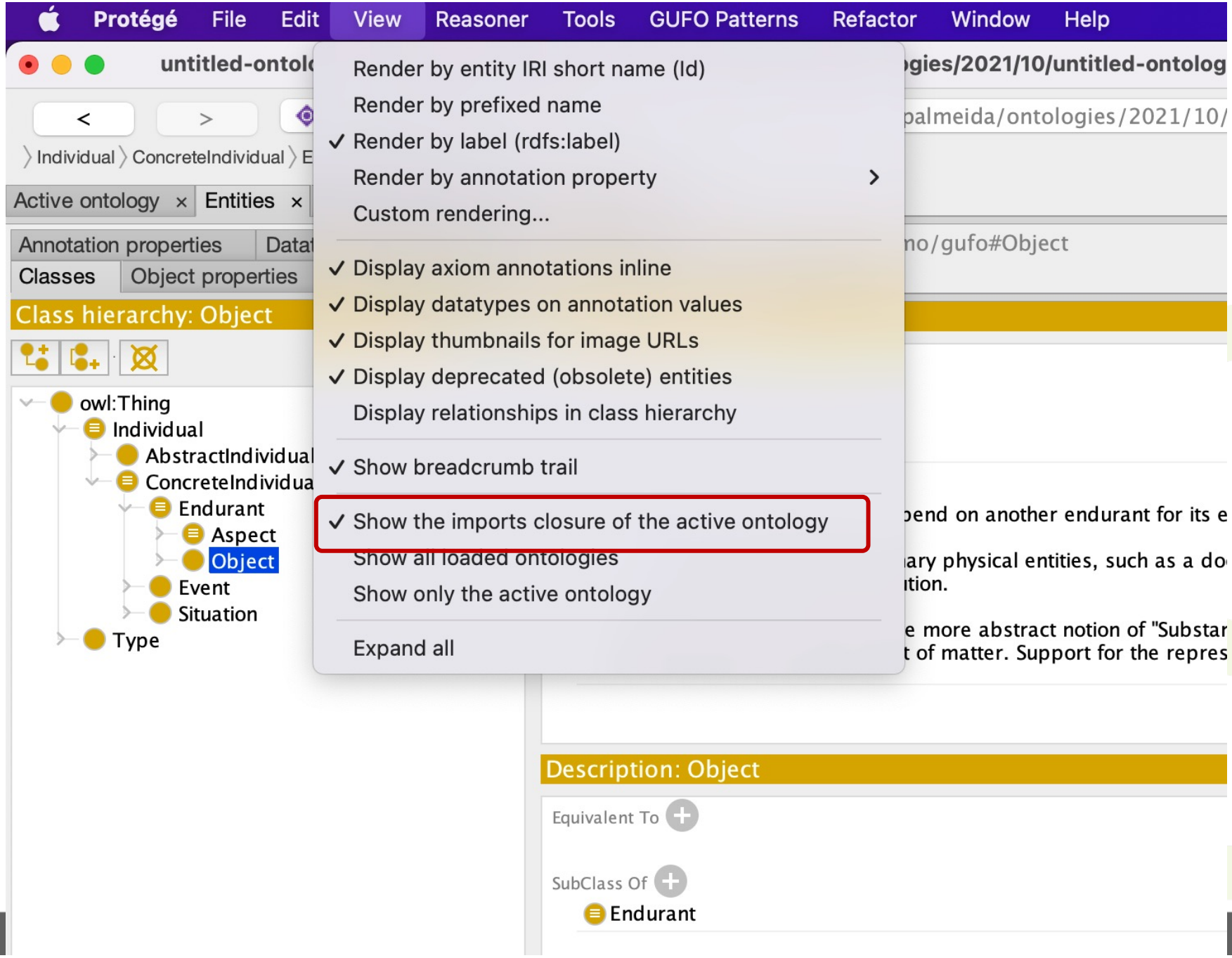
Description

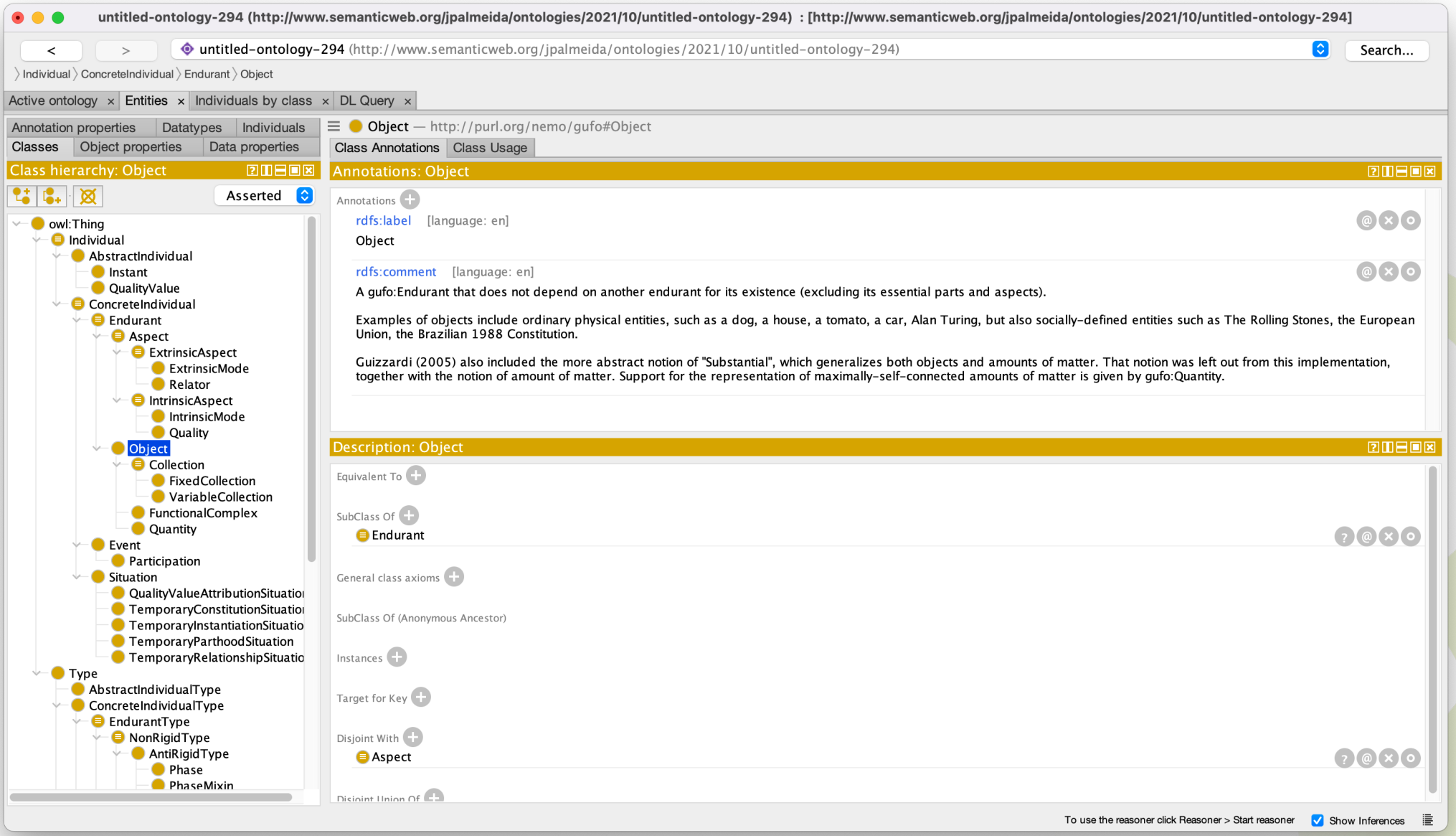
The objective of gUFO is to provide a lightweight implementation of the Unified Foundational Ontology (UFO) [1-5] suitable for Semantic Web OWL 2 DL applications.

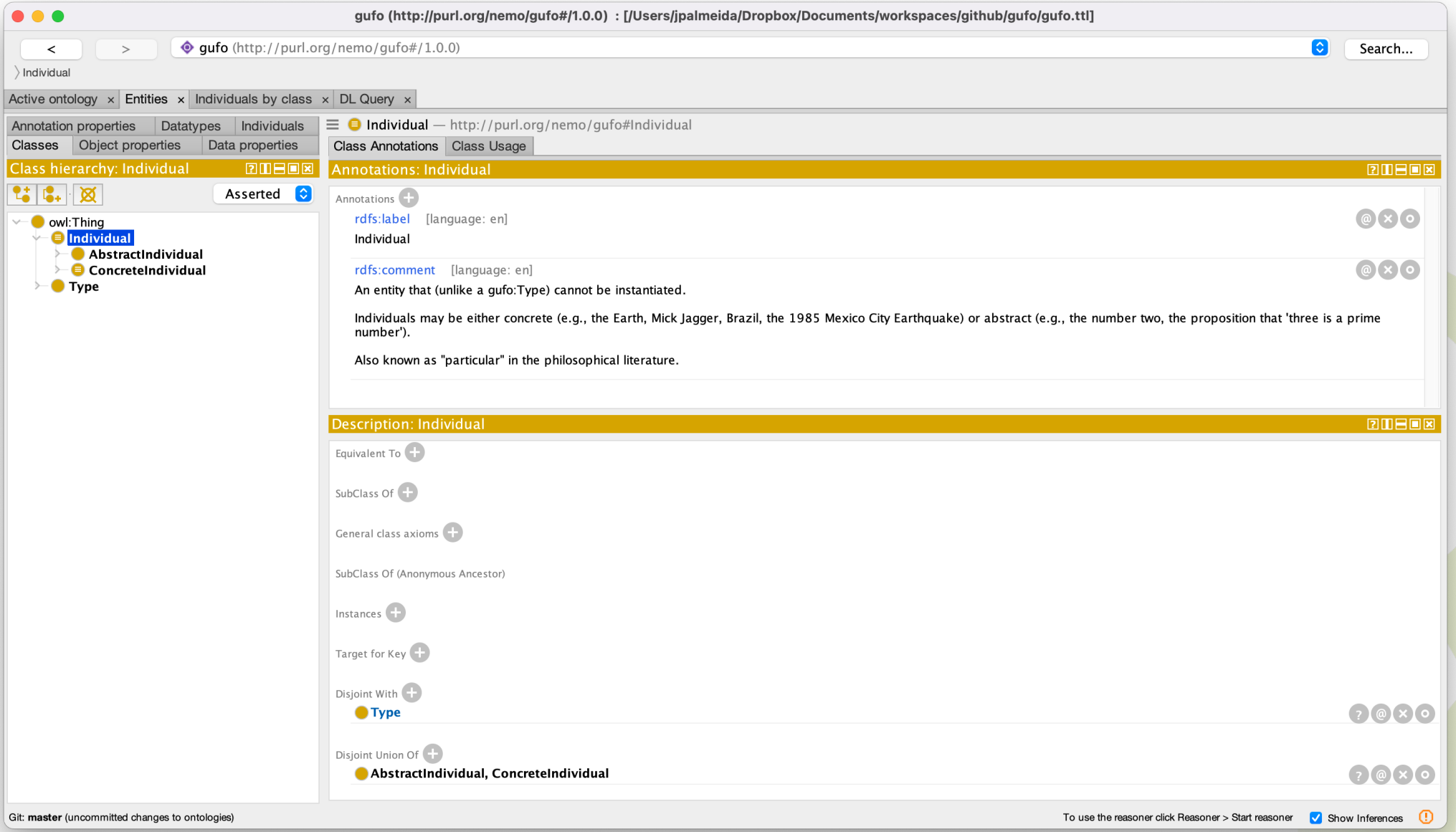
Intended users are those implementing UFO-based lightweight ontologies that reuse gUFO by specializing and instantiating its elements.

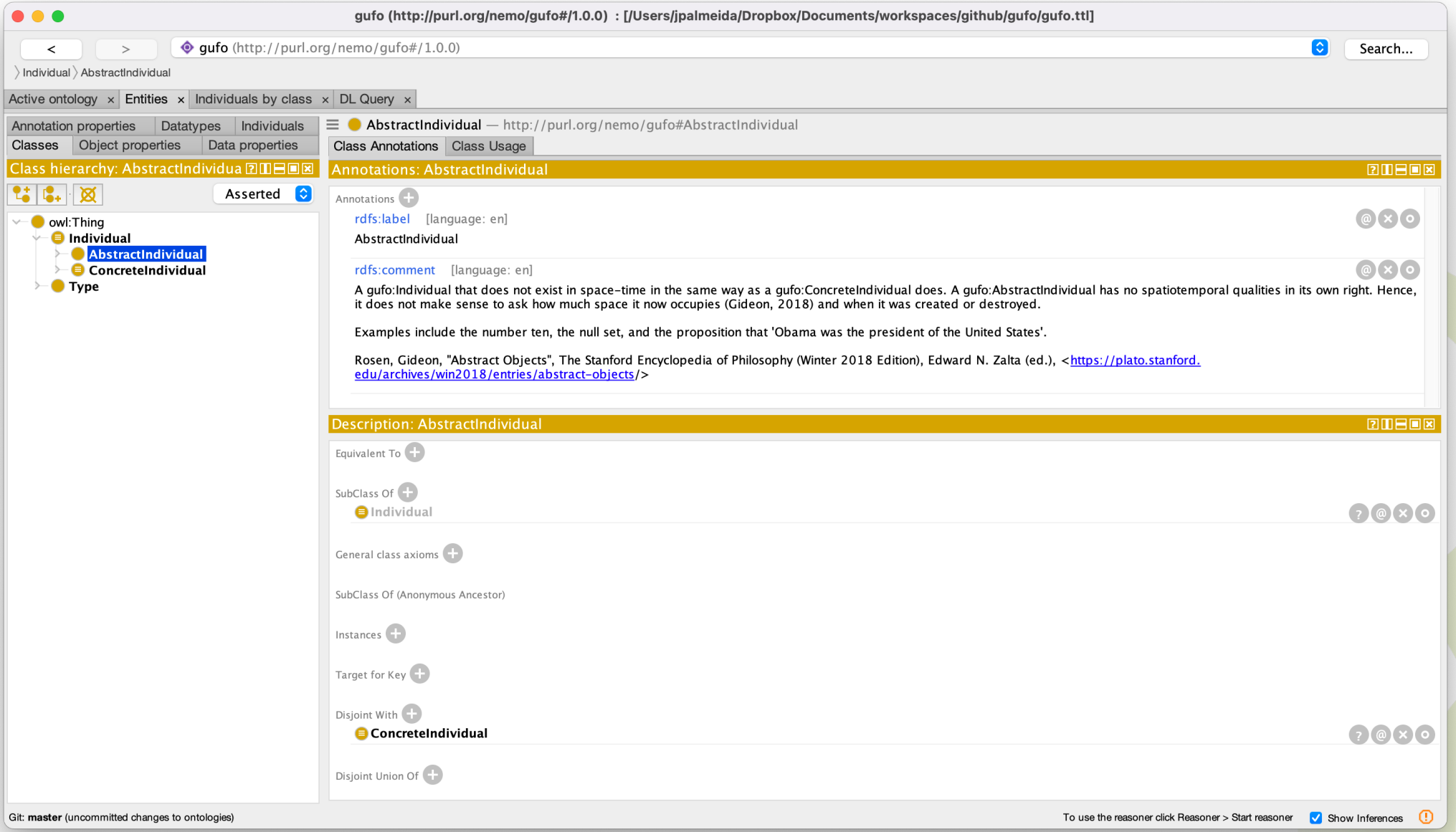
There are three implications of the use of the term lightweight. First of all, we have employed little expressive means in an effort to retain computational properties for the resulting OWL ontology. Second, we have selected a subset of UFO-A [1, 2] and UFO-B [3] to include here. In particular, there is minimalistic support for UFO-B (only that which is necessary to establish the participation of objects in events and to capture historical dependence between events). Third, a lightweight ontology, differently from a reference


Import ontology wizard
Import from URL
Please specify the URL that points to the file that contains the ontology. (Please note that this should be the physical URL, rather than the ontology URI)
URI
https://purl.org/nemo/gufo
Bookmarks
Bookmarked URIs
http://owl.man.ac.uk/2006/07/sssw/people.owl
http://protege.stanford.edu/ontologies/camera.owl
http://protege.stanford.edu/ontologies/koala.owl
http://protege.stanford.edu/ontologies/pizza/pizza.owl
http://protege.stanford.edu/ontologies/travel.owl
http://purl.obolibrary.org/obo/bfo.owl
http://qudt.org/vocab/quantitykind/
http://www.w3.org/TR/owl-guide/wine.rdf
https://purl.org/nemo/gufo
https://raw.githubusercontent.com/BFO-ontology/BFO2/master/ontology/src/bfo_r...
Manually specify import declarations.
This is generally not needed as Protege will choose a reasonable default.
Go Back
Continue
Cancel


Protégé
File
Edit
View
Reasoner
Tools
GUFO Patterns
Refactor
Window
Help
Render by entity IRI short name (Id)
Render by prefixed name
Render by label (rdfs:label)
Render by annotation property
Custom rendering...
Display axiom annotations inline
Display datatypes on annotation values
Display thumbnails for image URLs
Display deprecated (obsolete) entities
Display relationships in class hierarchy
Show breadcrumb trail
Show the imports closure of the active ontology
Show all loaded ontologies
Show only the active ontology
Expand all
Individual
ConcreteIndividual
Active ontology
Entities
Annotation properties
Classes
Object properties
Class hierarchy: Object
owl:Thing
Individual
AbstractIndividual
ConcreteIndividua
Endurant
Aspect
Object
Event
Situation
Type
Description: Object
Equivalent To
SubClass Of
Endurant


untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294) : [http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294]
untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294)
Search...
Individual 〉 ConcreteIndividual 〉 Endurant 〉 Object
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: Object
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Aspect
ExtrinsicAspect
ExtrinsicMode
Relator
IntrinsicAspect
IntrinsicMode
Quality
Object
Collection
FixedCollection
VariableCollection
FunctionalComplex
Quantity
Event
Participation
Situation
QualityValueAttributionSituatio
TemporaryConstitutionSituatio
TemporaryInstantiationSituatio
TemporaryParthoodSituation
TemporaryRelationshipSituatio
Type
AbstractIndividualType
ConcreteIndividualType
EndurantType
NonRigidType
AntiRigidType
Phase
PhaseMixin
Object — http://purl.org/nemo/gufo#Object
Class Annotations
Class Usage
Annotations: Object
Annotations
rdfs:label [language: en]
Object
rdfs:comment [language: en]
A gufo:Endurant that does not depend on another endurant for its existence (excluding its essential parts and aspects).
Examples of objects include ordinary physical entities, such as a dog, a house, a tomato, a car, Alan Turing, but also socially-defined entities such as The Rolling Stones, the European Union, the Brazilian 1988 Constitution.
Guizzardi (2005) also included the more abstract notion of "Substantial", which generalizes both objects and amounts of matter. That notion was left out from this implementation, together with the notion of amount of matter. Support for the representation of maximally-self-connected amounts of matter is given by gufo:Quantity.
Description: Object
Equivalent To
SubClass Of
Endurant
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
Aspect
Disjoint Union Of
To use the reasoner click Reasoner > Start reasoner
Show Inferences


gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: Individual
Asserted
owl:Thing
Individual
AbstractIndividual
ConcreteIndividual
Type
Individual — http://purl.org/nemo/gufo#Individual
Class Annotations
Class Usage
Annotations: Individual
Annotations
rdfs:label [language: en]
Individual
rdfs:comment [language: en]
An entity that (unlike a gufo:Type) cannot be instantiated.
Individuals may be either concrete (e.g., the Earth, Mick Jagger, Brazil, the 1985 Mexico City Earthquake) or abstract (e.g., the number two, the proposition that 'three is a prime number').
Also known as "particular" in the philosophical literature.
Description: Individual
Equivalent To
SubClass Of
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
Type
Disjoint Union Of
AbstractIndividual, ConcreteIndividual
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences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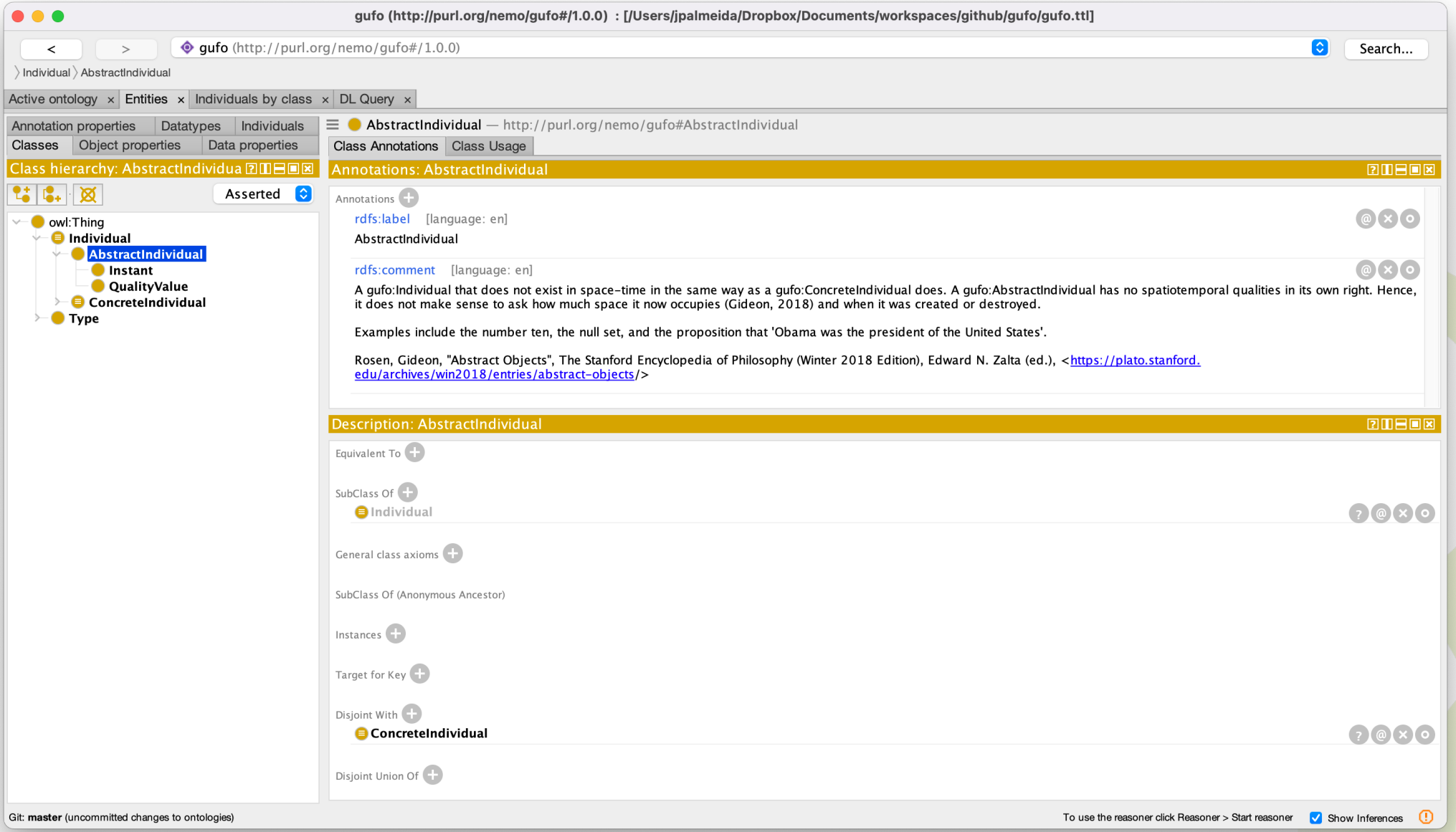
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual
AbstractIndividual
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: AbstractIndividua
Asserted
owl:Thing
Individual
AbstractIndividual
ConcreteIndividual
Type
AbstractIndividual — http://purl.org/nemo/gufo#AbstractIndividual
Class Annotations
Class Usage
Annotations: AbstractIndividual
Annotations
rdfs:label [language: en]
AbstractIndividual
rdfs:comment [language: en]
A gufo:Individual that does not exist in space-time in the same way as a gufo:ConcreteIndividual does. A gufo:AbstractIndividual has no spatiotemporal qualities in its own right. Hence, it does not make sense to ask how much space it now occupies (Gideon, 2018) and when it was created or destroyed.
Examples include the number ten, the null set, and the proposition that 'Obama was the president of the United States'.
Rosen, Gideon, "Abstract Objects", The Stanford Encyclopedia of Philosophy (Winter 2018 Edition), Edward N. Zalta (ed.), <https://plato.stanford.edu/archives/win2018/entries/abstract-objects/>
Description: AbstractIndividual
Equivalent To
SubClass Of
Individual
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
ConcreteIndividual
Disjoint Union Of
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences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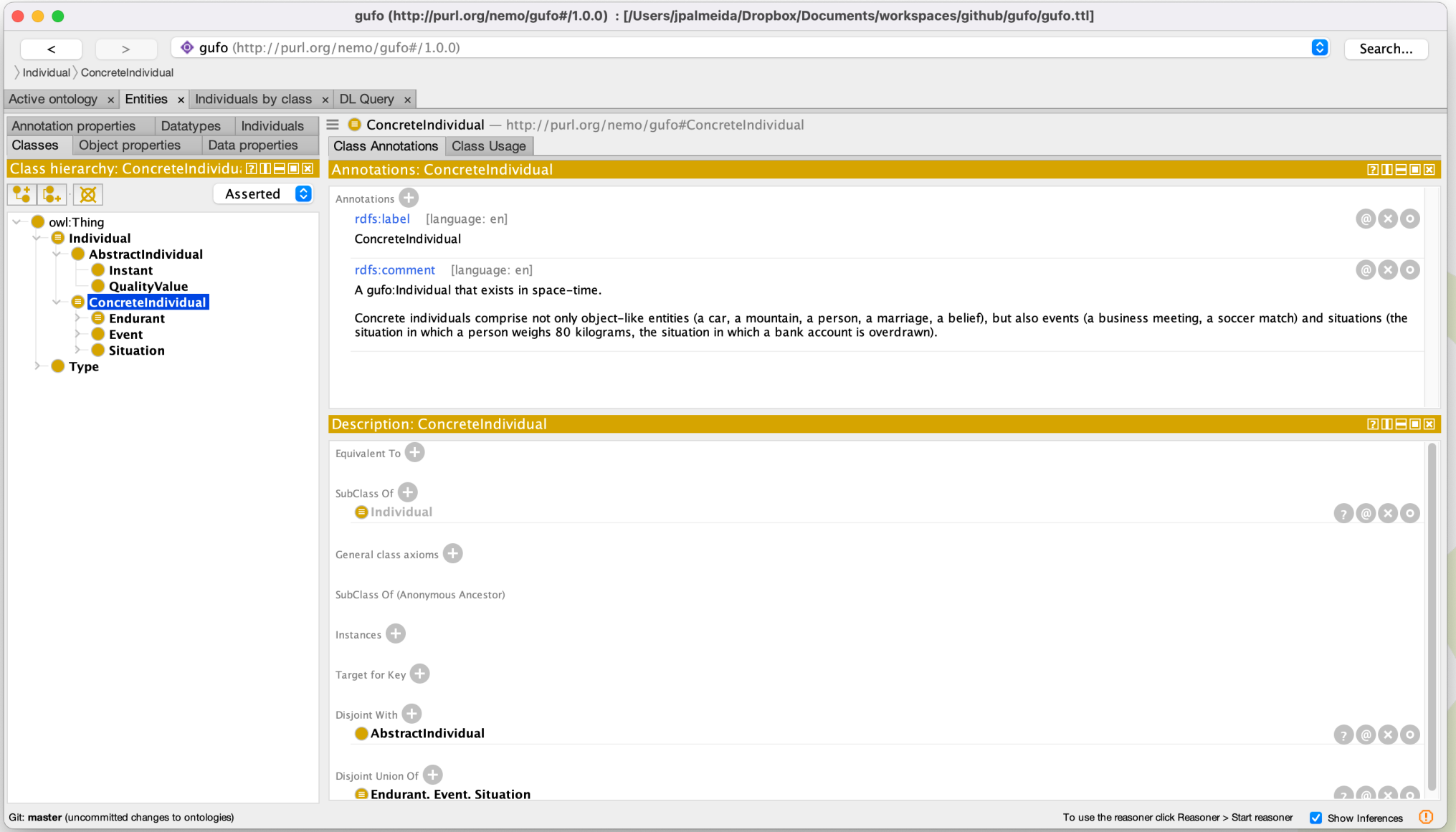
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual
AbstractIndividual
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: AbstractIndividua
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Type
AbstractIndividual — http://purl.org/nemo/gufo#AbstractIndividual
Class Annotations
Class Usage
Annotations: AbstractIndividual
Annotations
rdfs:label [language: en]
AbstractIndividual
rdfs:comment [language: en]
A gufo:Individual that does not exist in space-time in the same way as a gufo:ConcreteIndividual does. A gufo:AbstractIndividual has no spatiotemporal qualities in its own right. Hence, it does not make sense to ask how much space it now occupies (Gideon, 2018) and when it was created or destroyed.
Examples include the number ten, the null set, and the proposition that 'Obama was the president of the United States'.
Rosen, Gideon, "Abstract Objects", The Stanford Encyclopedia of Philosophy (Winter 2018 Edition), Edward N. Zalta (ed.), <https://plato.stanford.edu/archives/win2018/entries/abstract-objects/>
Description: AbstractIndividual
Equivalent To
SubClass Of
Individual
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
ConcreteIndividual
Disjoint Union Of
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences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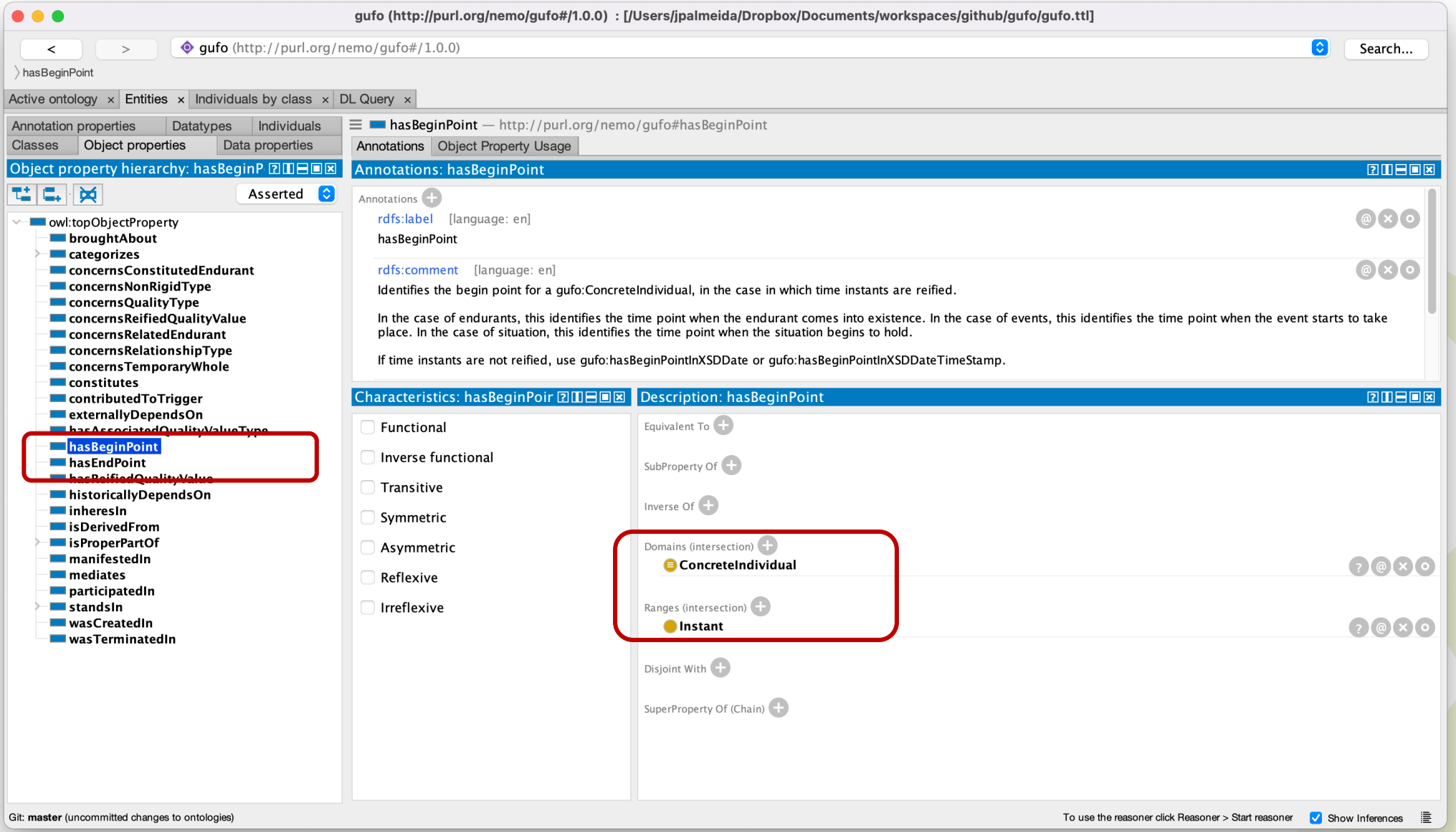
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual
ConcreteIndividual
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: ConcreteIndividu
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Event
Situation
Type
ConcreteIndividual — http://purl.org/nemo/gufo#ConcreteIndividual
Class Annotations
Class Usage
Annotations: ConcreteIndividual
Annotations
rdfs:label [language: en]
ConcreteIndividual
rdfs:comment [language: en]
A gufo:Individual that exists in space-time.
Concrete individuals comprise not only object-like entities (a car, a mountain, a person, a marriage, a belief), but also events (a business meeting, a soccer match) and situations (the situation in which a person weighs 80 kilograms, the situation in which a bank account is overdrawn).
Description: ConcreteIndividual
Equivalent To
SubClass Of
Individual
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
AbstractIndividual
Disjoint Union Of
Endurant, Event, Situation
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences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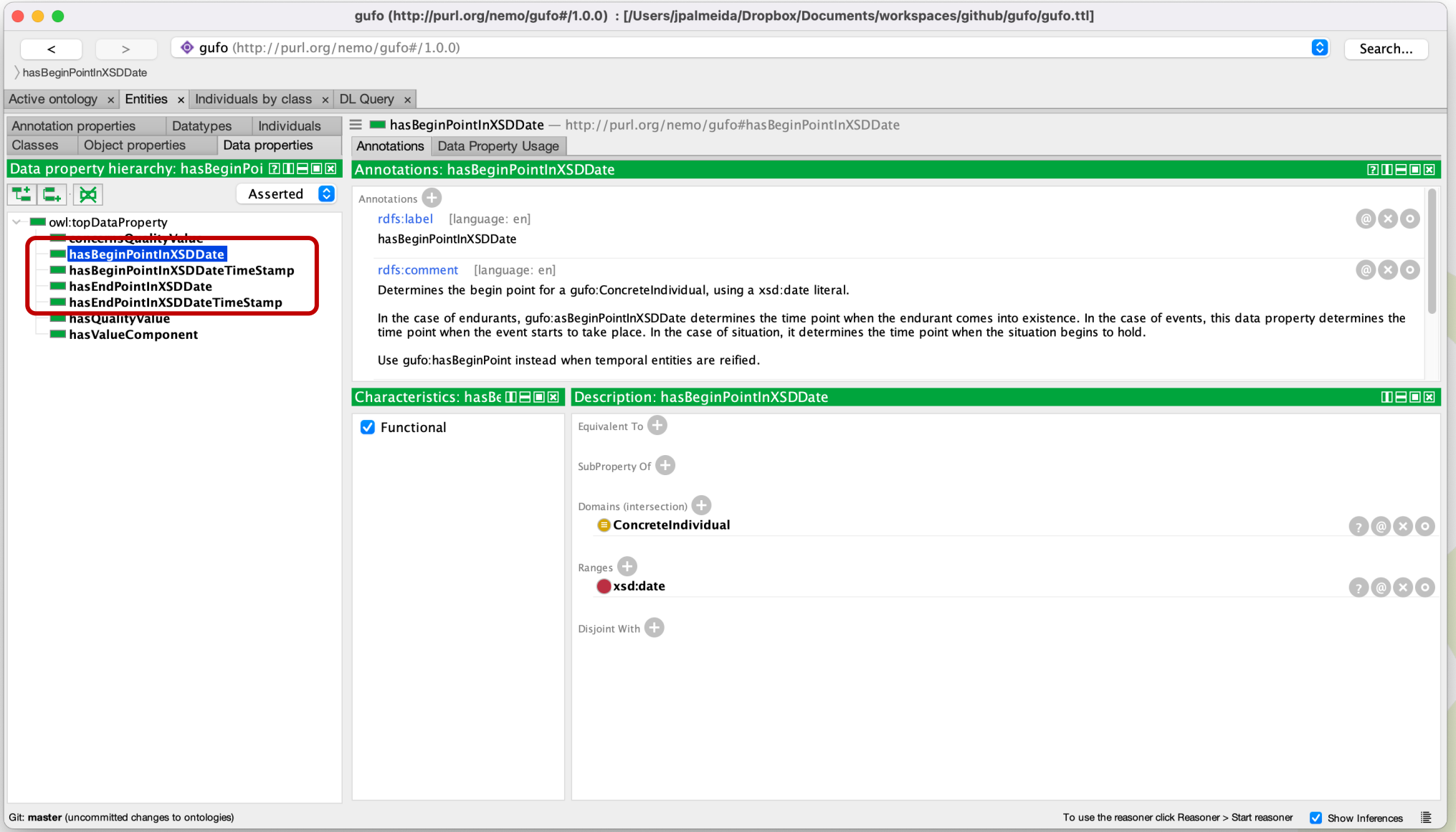
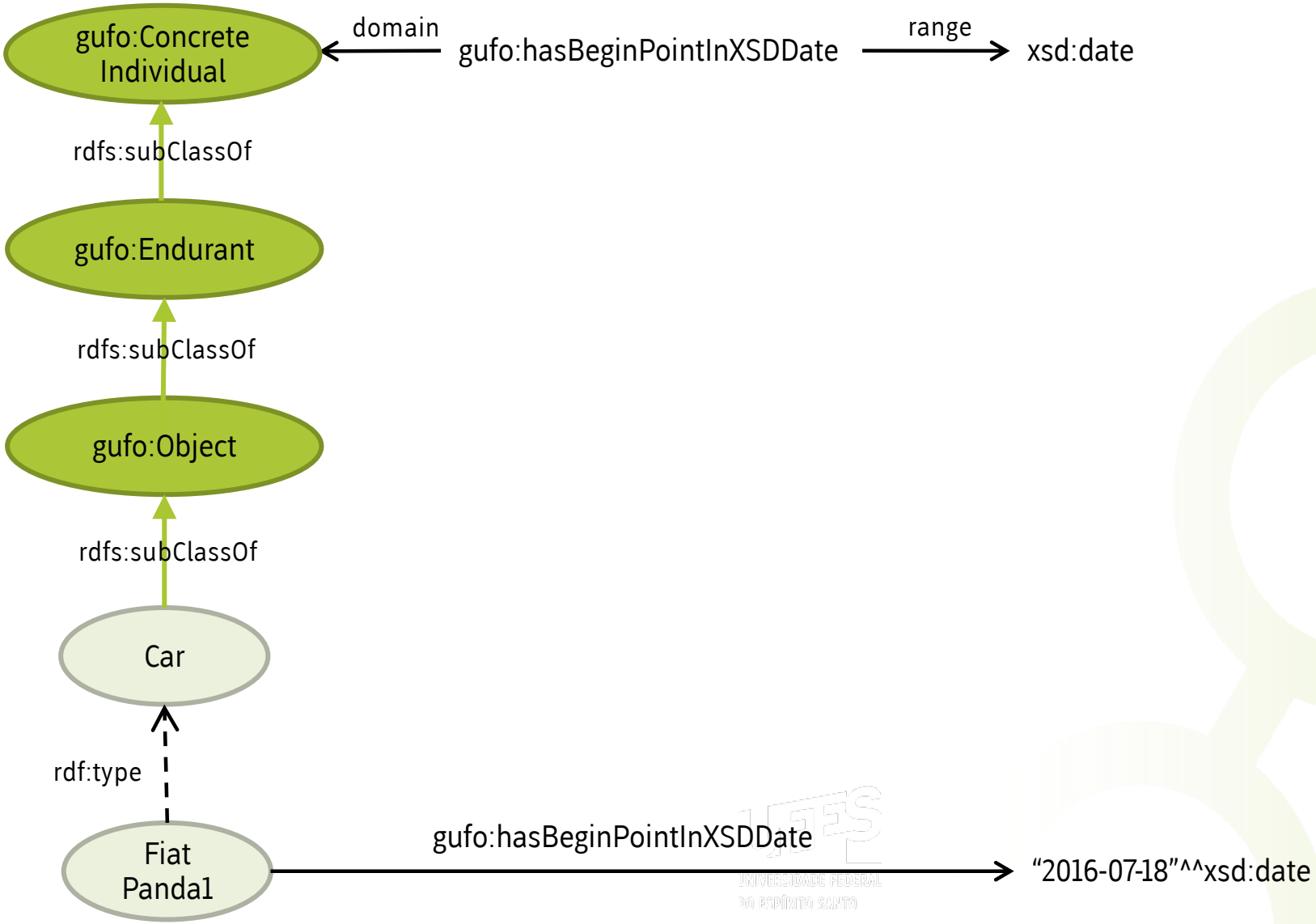
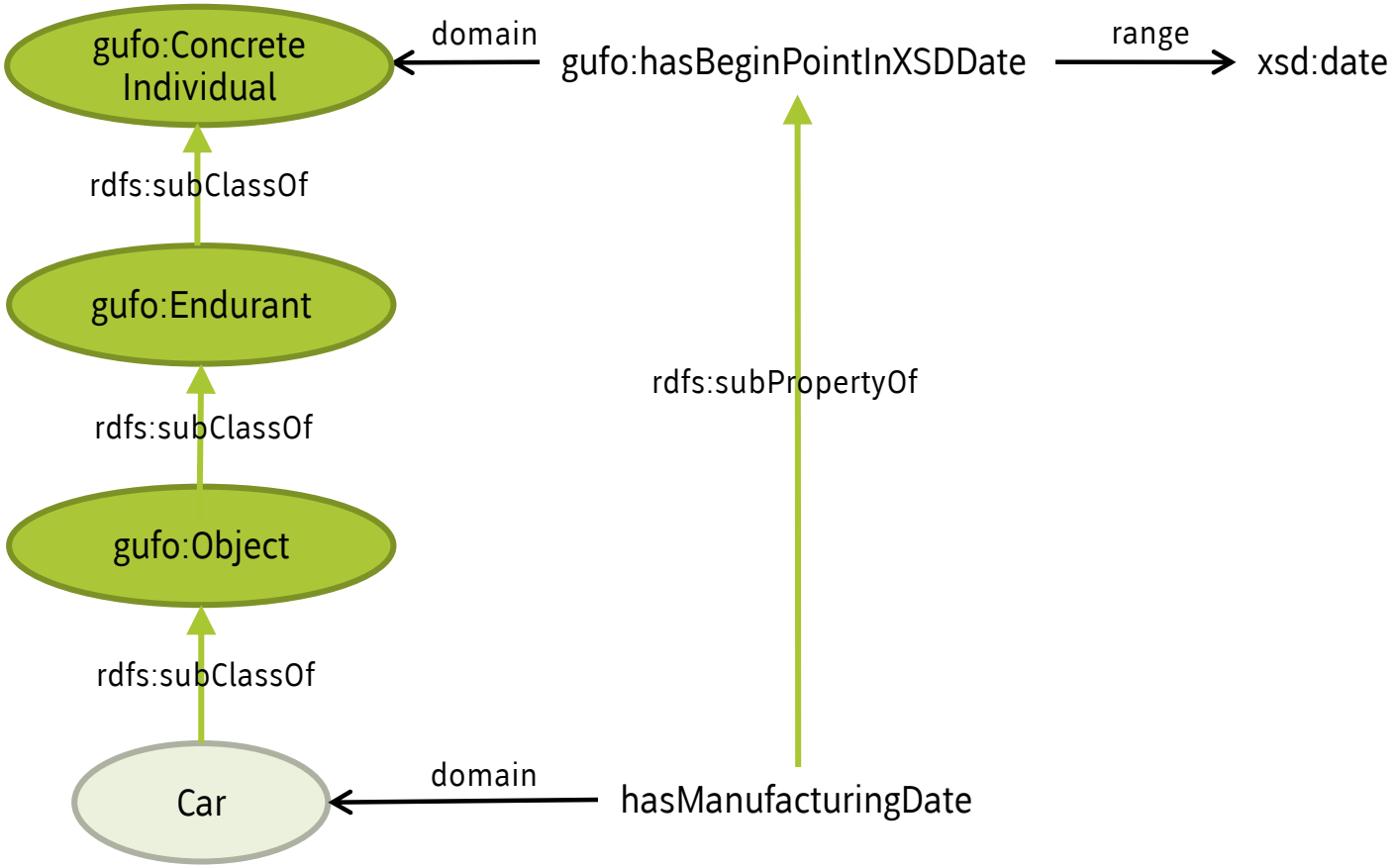
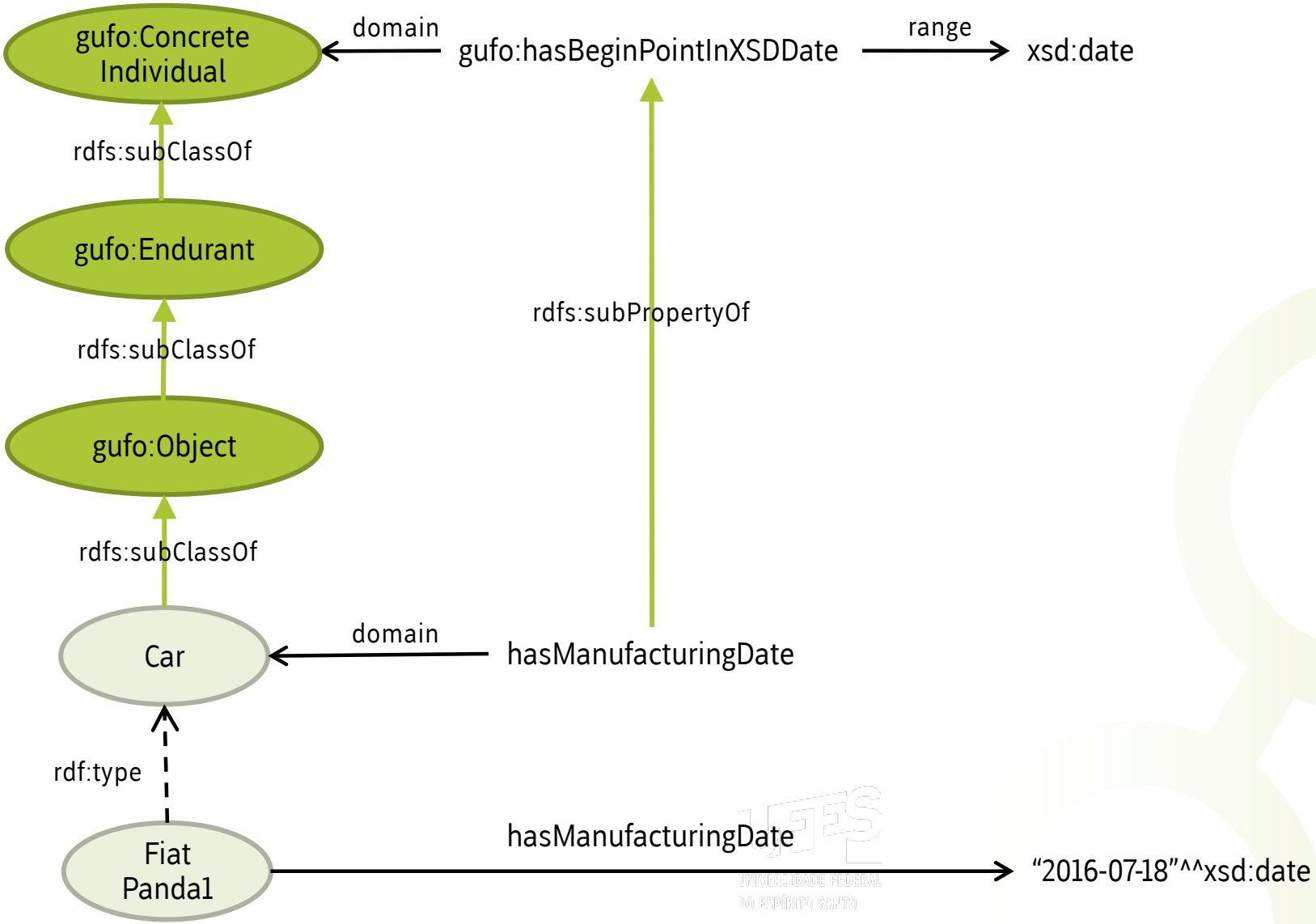
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
hasBeginPoint
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Object property hierarchy: hasBeginP
Asserted
owl:topObjectProperty
broughtAbout
categorizes
concernsConstitutedEndurant
concernsNonRigidType
concernsQualityType
concernsReifiedQualityValue
concernsRelatedEndurant
concernsRelationshipType
concernsTemporaryWhole
constitutes
contributedToTrigger
externallyDependsOn
hasBeginPoint
hasEndPoint
historicallyDependsOn
inheresIn
isDerivedFrom
isProperPartOf
manifestedIn
mediates
participatedIn
standsIn
wasCreatedIn
wasTerminatedIn
hasBeginPoint — http://purl.org/nemo/gufo#hasBeginPoint
Annotations
Object Property Usage
Annotations: hasBeginPoint
Annotations
rdfs:label [language: en]
hasBeginPoint
rdfs:comment [language: en]
Identifies the begin point for a gufo:ConcreteIndividual, in the case in which time instants are reified.
In the case of endurants, this identifies the time point when the endurant comes into existence. In the case of events, this identifies the time point when the event starts to take place. In the case of situation, this identifies the time point when the situation begins to hold.
If time instants are not reified, use gufo:hasBeginPointInXSDDate or gufo:hasBeginPointInXSDDateTimeStamp.
Characteristics: hasBeginPoir
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: hasBeginPoint
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
ConcreteIndividual
Ranges (intersection)
Instant
Disjoint With
SuperProperty Of (Chain)
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences

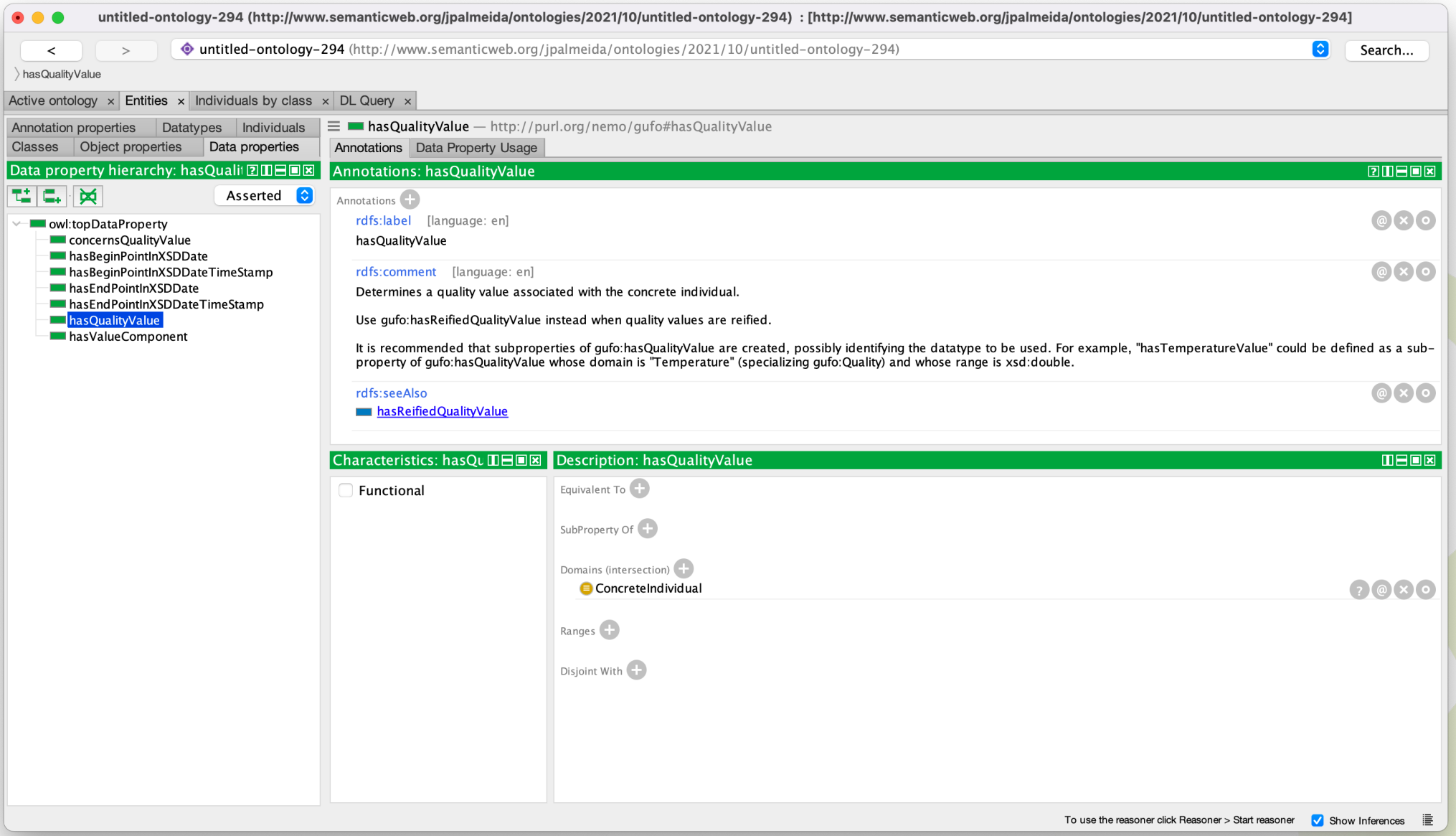

gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
hasBeginPointInXSDDate
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Data property hierarchy: hasBeginPoi
Asserted
owl:topDataProperty
hasBeginPointInXSDDate
hasBeginPointInXSDDateTimeStamp
hasEndPointInXSDDate
hasEndPointInXSDDateTimeStamp
hasQualityValue
hasValueComponent
hasBeginPointInXSDDate — http://purl.org/nemo/gufo#hasBeginPointInXSDDate
Annotations
Data Property Usage
Annotations: hasBeginPointInXSDDate
Annotations
rdfs:label [language: en]
hasBeginPointInXSDDate
rdfs:comment [language: en]
Determines the begin point for a gufo:ConcreteIndividual, using a xsd:date literal.
In the case of endurants, gufo:asBeginPointInXSDDate determines the time point when the endurant comes into existence. In the case of events, this data property determines the time point when the event starts to take place. In the case of situation, it determines the time point when the situation begins to hold.
Use gufo:hasBeginPoint instead when temporal entities are reified.
Characteristics: hasBe
Functional
Description: hasBeginPointInXSDDate
Equivalent To
SubProperty Of
Domains (intersection)
ConcreteIndividual
Ranges
xsd:date
Disjoint With
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences

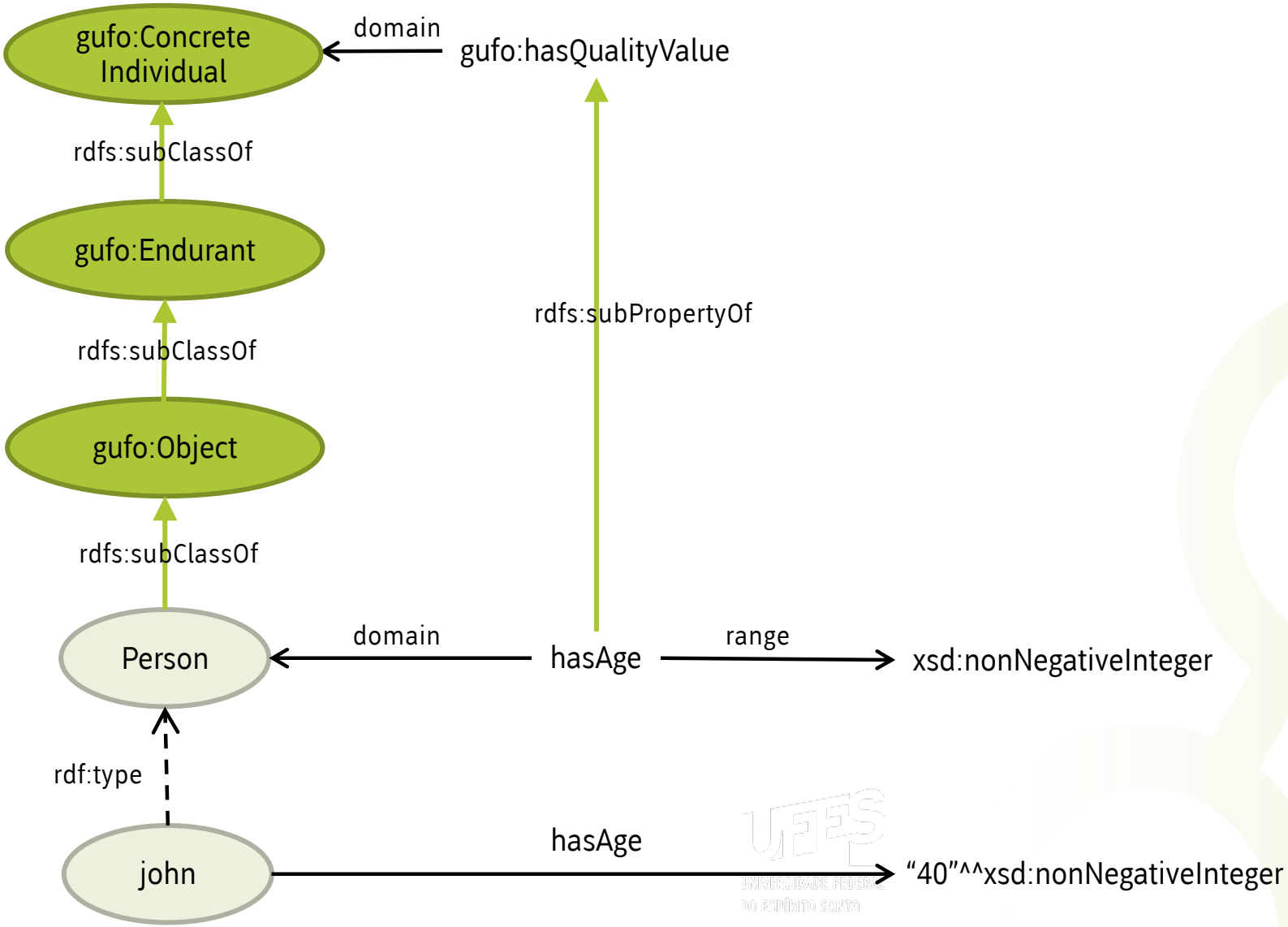

gufo:Concrete Individual
domain
gufo:hasBeginPointInXSDDate
range
xsd:date
rdfs:subClassOf
gufo:Endurant
rdfs:subClassOf
gufo:Object
rdfs:subClassOf
Car

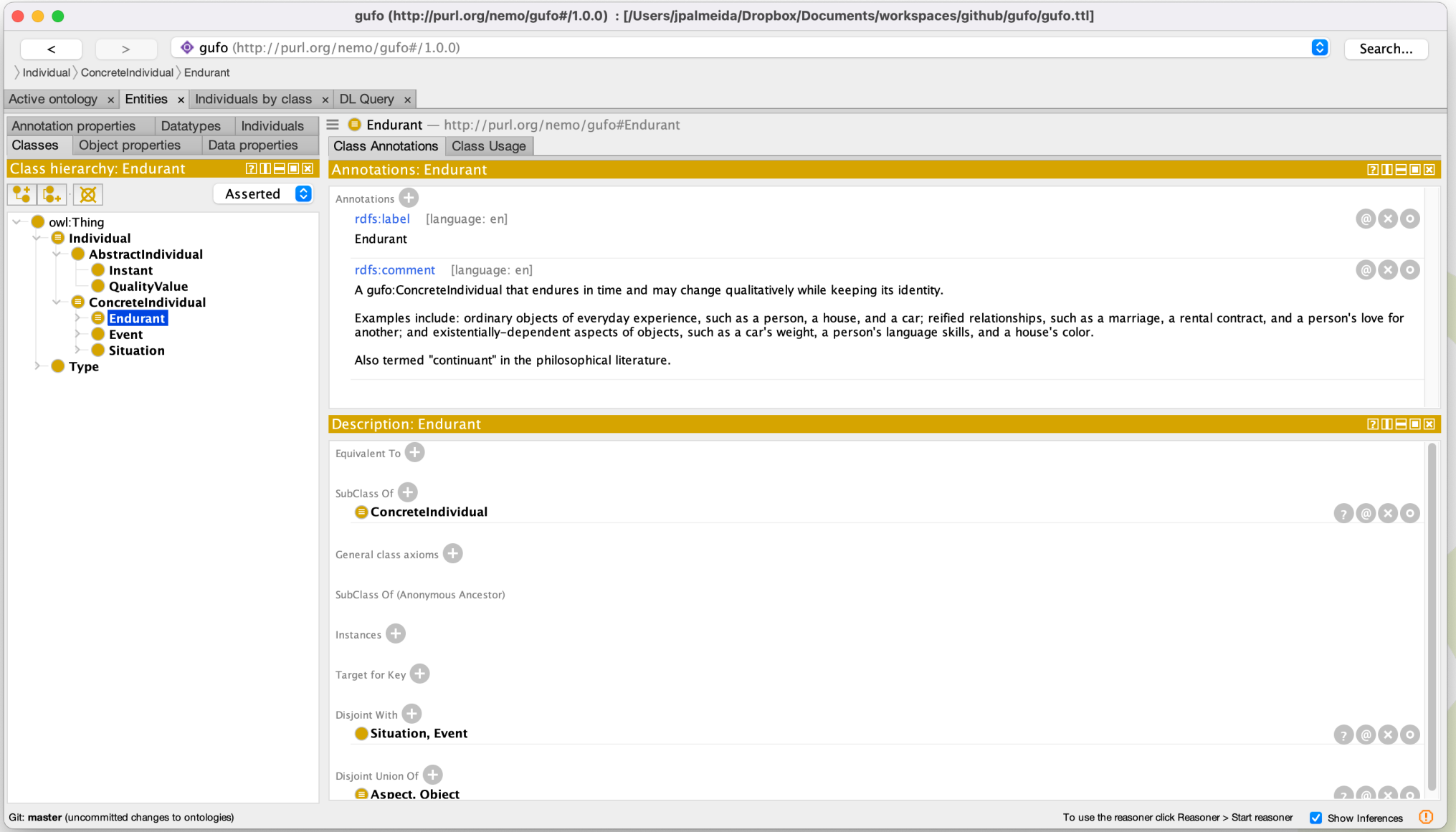

gufo:Concrete Individual
domain
gufo:hasBeginPointInXSDDate
range
xsd:date
rdfs:subClassOf
gufo:Endurant
rdfs:subClassOf
gufo:Object
rdfs:subClassOf
Car
rdf:type
Fiat Panda1
gufo:hasBeginPointInXSDDate
"2016-07-18"^^xsd:date

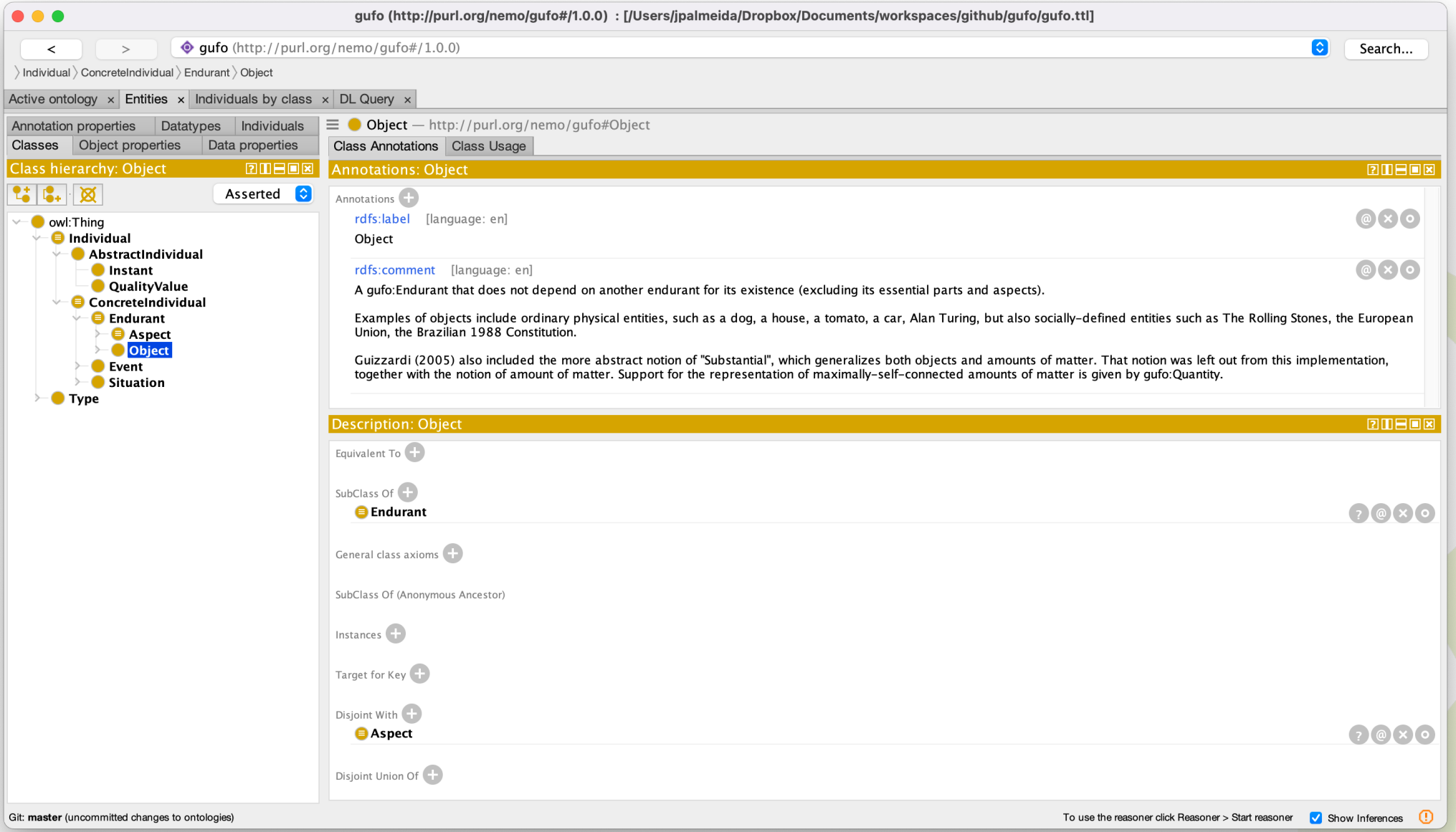

gufo:Concrete Individual
domain
gufo:hasBeginPointInXSDDate
range
xsd:date
rdfs:subClassOf
gufo:Endurant
rdfs:subPropertyOf
rdfs:subClassOf
gufo:Object
rdfs:subClassOf
Car
domain
hasManufacturingDate

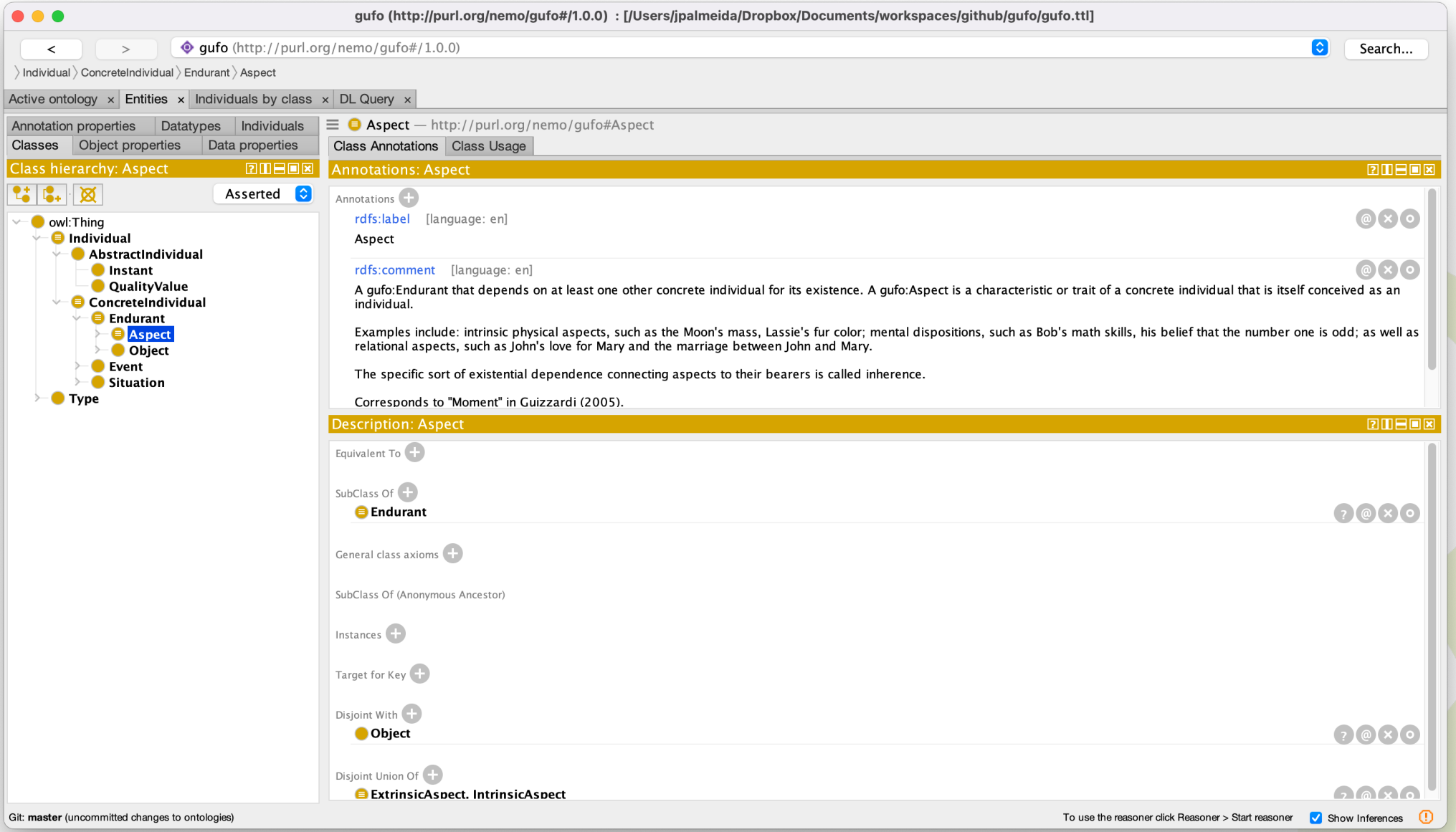

gufo:Concrete Individual
domain
gufo:hasBeginPointInXSDDate
range
xsd:date
rdfs:subClassOf
gufo:Endurant
rdfs:subPropertyOf
rdfs:subClassOf
gufo:Object
rdfs:subClassOf
Car
domain
hasManufacturingDate
rdf:type
Fiat Panda1
hasManufacturingDate
"2016-07-18"^^xsd:date

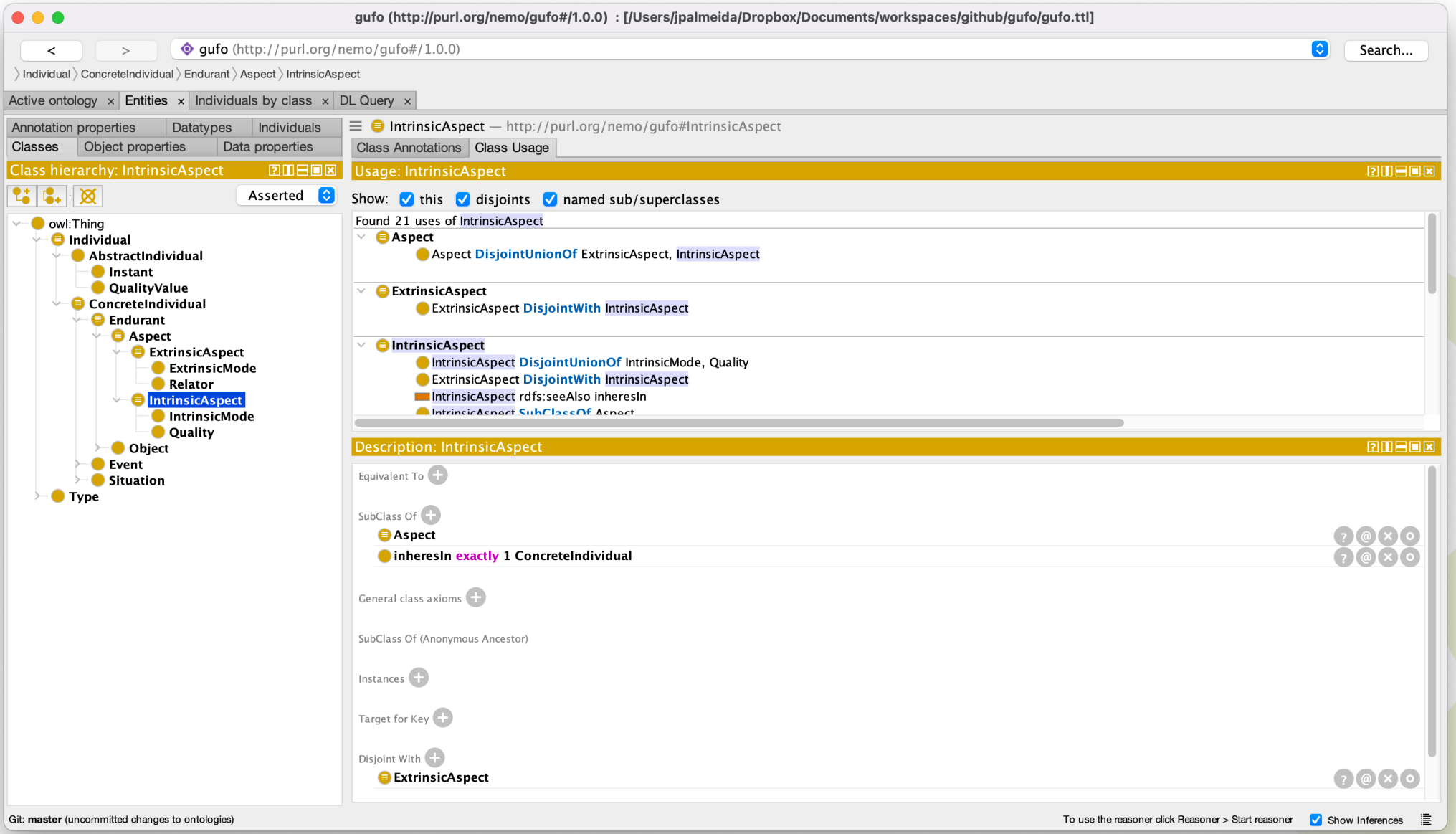

untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294) : [http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294]
untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294)
Search...
hasQualityValue
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Data property hierarchy: hasQuali
Asserted
owl:topDataProperty
concernsQualityValue
hasBeginPointInXSDDate
hasBeginPointInXSDDateTimeStamp
hasEndPointInXSDDate
hasEndPointInXSDDateTimeStamp
hasQualityValue
hasValueComponent
hasQualityValue — http://purl.org/nemo/gufo#hasQualityValue
Annotations
Data Property Usage
Annotations: hasQualityValue
Annotations
rdfs:label [language: en]
hasQualityValue
rdfs:comment [language: en]
Determines a quality value associated with the concrete individual.
Use gufo:hasReifiedQualityValue instead when quality values are reified.
It is recommended that subproperties of gufo:hasQualityValue are created, possibly identifying the datatype to be used. For example, "hasTemperatureValue" could be defined as a sub-property of gufo:hasQualityValue whose domain is "Temperature" (specializing gufo:Quality) and whose range is xsd:double.
rdfs:seeAlso
hasReifiedQualityValue
Characteristics: hasQu
Functional
Description: hasQualityValue
Equivalent To
SubProperty Of
Domains (intersection)
ConcreteIndividual
Ranges
Disjoint With
To use the reasoner click Reasoner > Start reasoner
Show Inferences

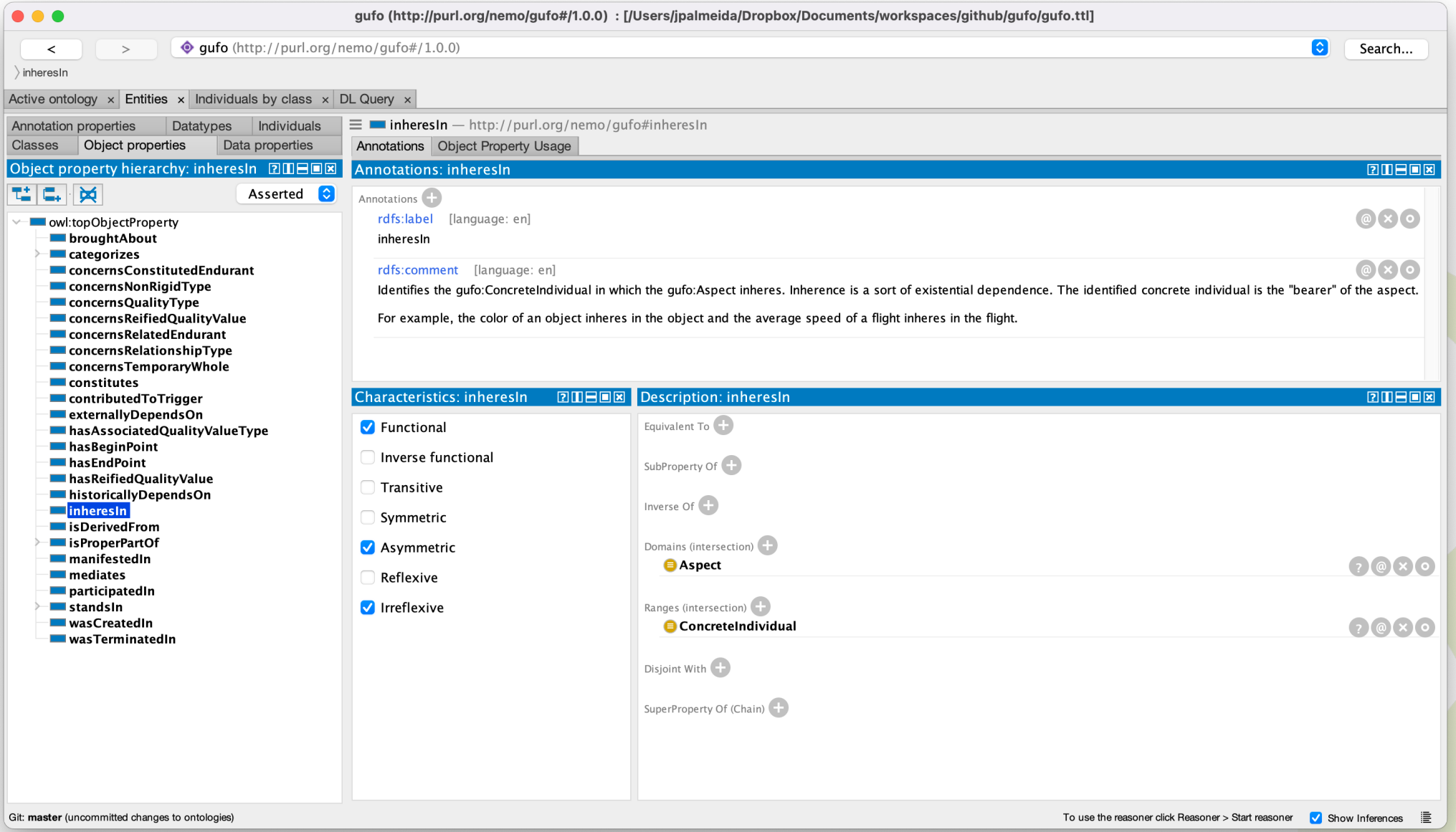

gufo:Concrete Individual
domain
gufo:hasQualityValue
rdfs:subClassOf
gufo:Endurant
rdfs:subPropertyOf
rdfs:subClassOf
gufo:Object
rdfs:subClassOf
Person
domain
hasAge
range
xsd:nonNegativeInteger
rdf:type
hasAge
john
"40"^^xsd:nonNegativeInteger

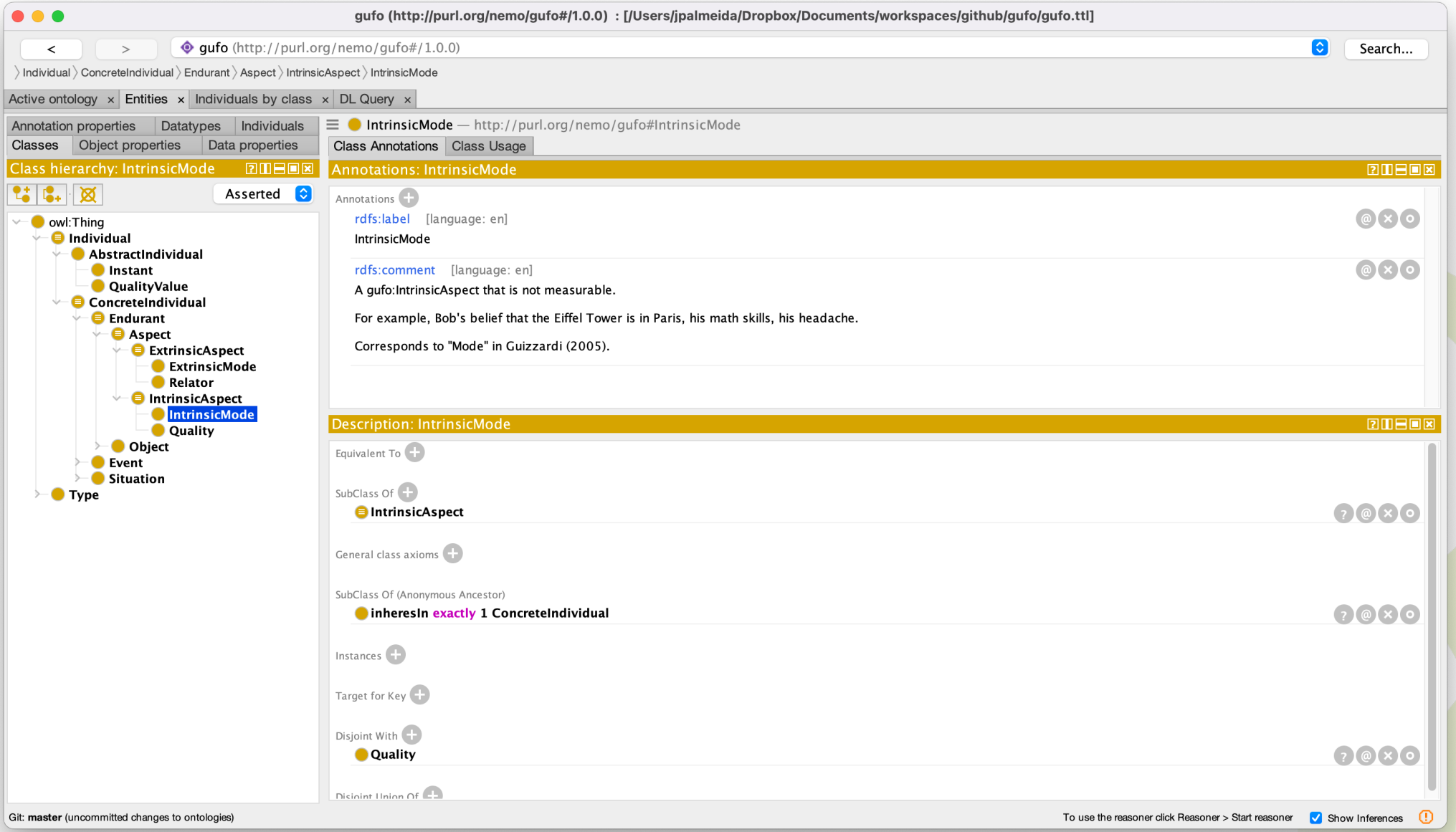

gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual
ConcreteIndividual
Endurant
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: Endurant
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Event
Situation
Type
Endurant — http://purl.org/nemo/gufo#Endurant
Class Annotations
Class Usage
Annotations: Endurant
Annotations
rdfs:label [language: en]
Endurant
rdfs:comment [language: en]
A gufo:ConcreteIndividual that endures in time and may change qualitatively while keeping its identity.
Examples include: ordinary objects of everyday experience, such as a person, a house, and a car; reified relationships, such as a marriage, a rental contract, and a person's love for another; and existentially-dependent aspects of objects, such as a car's weight, a person's language skills, and a house's color.
Also termed "continuant" in the philosophical literature.
Description: Endurant
Equivalent To
SubClass Of
ConcreteIndividual
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
Situation, Event
Disjoint Union Of
Aspect, Object
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences

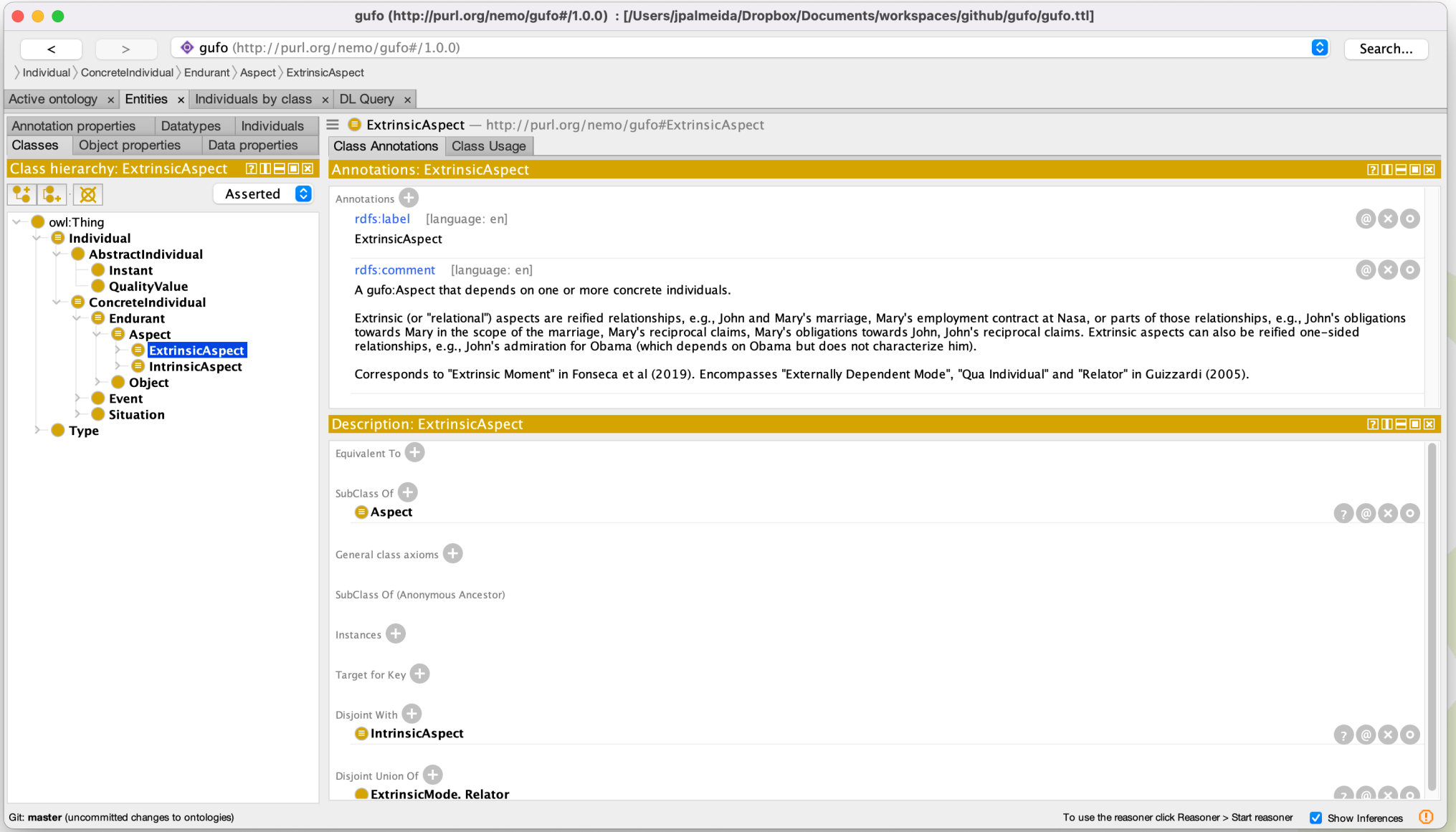

gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual 〉 ConcreteIndividual 〉 Endurant 〉 Object
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: Object
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Aspect
Object
Event
Situation
Type
Object — http://purl.org/nemo/gufo#Object
Class Annotations
Class Usage
Annotations: Object
Annotations
rdfs:label [language: en]
Object
rdfs:comment [language: en]
A gufo:Endurant that does not depend on another endurant for its existence (excluding its essential parts and aspects).
Examples of objects include ordinary physical entities, such as a dog, a house, a tomato, a car, Alan Turing, but also socially-defined entities such as The Rolling Stones, the European Union, the Brazilian 1988 Constitution.
Guizzardi (2005) also included the more abstract notion of "Substantial", which generalizes both objects and amounts of matter. That notion was left out from this implementation, together with the notion of amount of matter. Support for the representation of maximally-self-connected amounts of matter is given by gufo:Quantity.
Description: Object
Equivalent To
SubClass Of
Endurant
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
Aspect
Disjoint Union Of
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences

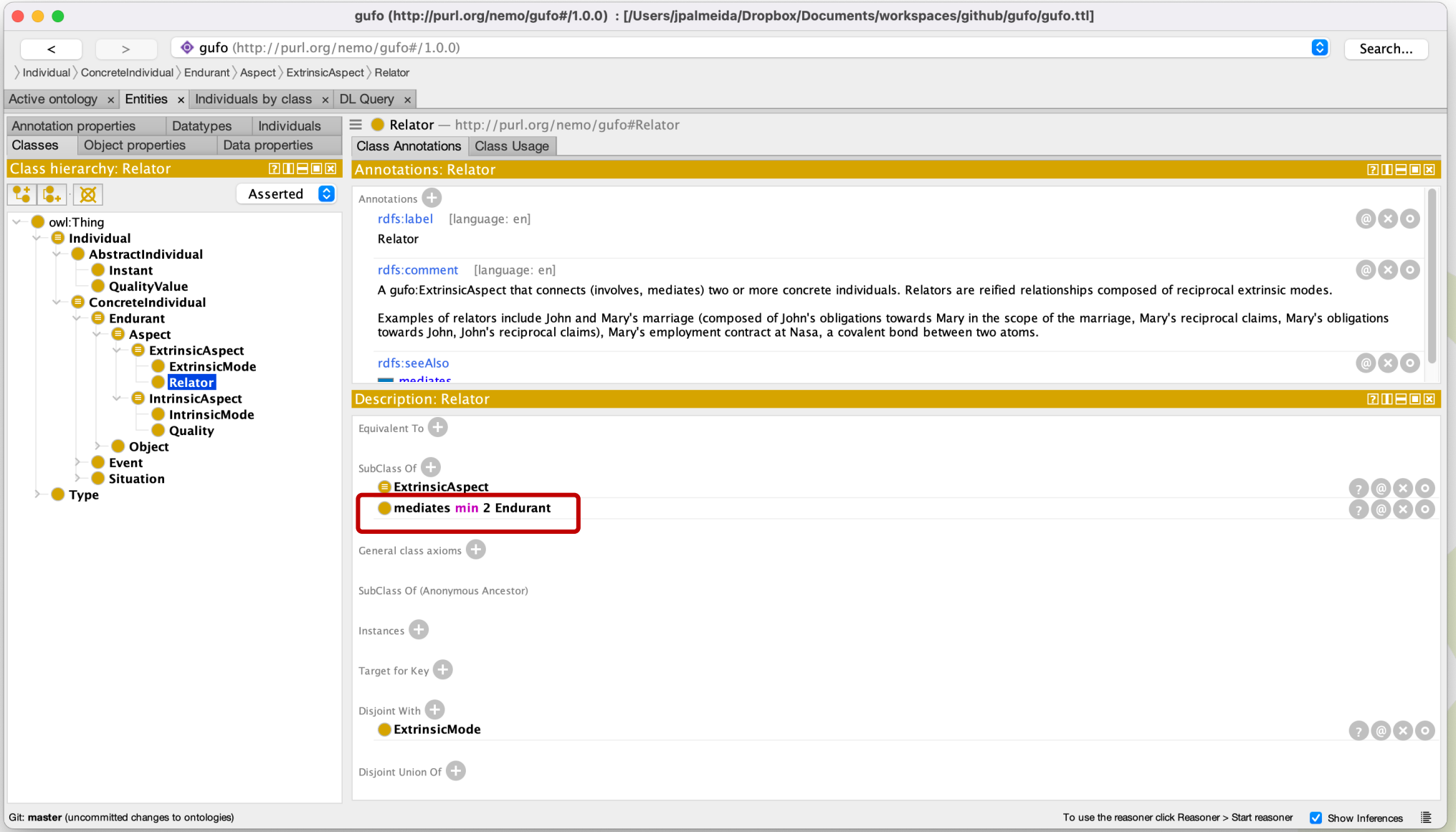

gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual 〉 ConcreteIndividual 〉 Endurant 〉 Aspect
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: Aspect
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Aspect
Object
Event
Situation
Type
Aspect — http://purl.org/nemo/gufo#Aspect
Class Annotations
Class Usage
Annotations: Aspect
Annotations
rdfs:label [language: en]
Aspect
rdfs:comment [language: en]
A gufo:Endurant that depends on at least one other concrete individual for its existence. A gufo:Aspect is a characteristic or trait of a concrete individual that is itself conceived as an individual.
Examples include: intrinsic physical aspects, such as the Moon's mass, Lassie's fur color; mental dispositions, such as Bob's math skills, his belief that the number one is odd; as well as relational aspects, such as John's love for Mary and the marriage between John and Mary.
The specific sort of existential dependence connecting aspects to their bearers is called inherence.
Corresponds to "Moment" in Guizzardi (2005).
Description: Aspect
Equivalent To
SubClass Of
Endurant
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
Object
Disjoint Union Of
ExtrinsicAspect, IntrinsicAspect
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences


gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual 〉 ConcreteIndividual 〉 Endurant 〉 Aspect 〉 IntrinsicAspect
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: IntrinsicAspect
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Aspect
ExtrinsicAspect
ExtrinsicMode
Relator
IntrinsicAspect
IntrinsicMode
Quality
Object
Event
Situation
Type
IntrinsicAspect — http://purl.org/nemo/gufo#IntrinsicAspect
Class Annotations
Class Usage
Usage: IntrinsicAspect
Show: this disjoints named sub/superclasses
Found 21 uses of IntrinsicAspect
Aspect
Aspect DisjointUnionOf ExtrinsicAspect, IntrinsicAspect
ExtrinsicAspect
ExtrinsicAspect DisjointWith IntrinsicAspect
IntrinsicAspect
IntrinsicAspect DisjointUnionOf IntrinsicMode, Quality
ExtrinsicAspect DisjointWith IntrinsicAspect
IntrinsicAspect rdfs:seeAlso inheresIn
Description: IntrinsicAspect
Equivalent To
SubClass Of
Aspect
inheresIn exactly 1 ConcreteIndividual
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
ExtrinsicAspect
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences


gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
inheresIn
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Object property hierarchy: inheresIn
Asserted
owl:topObjectProperty
broughtAbout
categorizes
concernsConstitutedEndurant
concernsNonRigidType
concernsQualityType
concernsReifiedQualityValue
concernsRelatedEndurant
concernsRelationshipType
concernsTemporaryWhole
constitutes
contributedToTrigger
externallyDependsOn
hasAssociatedQualityValueType
hasBeginPoint
hasEndPoint
hasReifiedQualityValue
historicallyDependsOn
inheresIn
isDerivedFrom
isProperPartOf
manifestedIn
mediates
participatedIn
standsIn
wasCreatedIn
wasTerminatedIn
inheresIn — http://purl.org/nemo/gufo#inheresIn
Annotations
Object Property Usage
Annotations: inheresIn
Annotations
rdfs:label [language: en]
inheresIn
rdfs:comment [language: en]
Identifies the gufo:ConcreteIndividual in which the gufo:Aspect inheres. Inherence is a sort of existential dependence. The identified concrete individual is the "bearer" of the aspect.
For example, the color of an object inheres in the object and the average speed of a flight inheres in the flight.
Characteristics: inheresIn
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: inheresIn
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
Aspect
Ranges (intersection)
ConcreteIndividual
Disjoint With
SuperProperty Of (Chain)
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences


gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual ConcreteIndividual Endurant Aspect IntrinsicAspect IntrinsicMode
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: IntrinsicMode
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Aspect
ExtrinsicAspect
ExtrinsicMode
Relator
IntrinsicAspect
IntrinsicMode
Quality
Object
Event
Situation
Type
IntrinsicMode — http://purl.org/nemo/gufo#IntrinsicMode
Class Annotations
Class Usage
Annotations: IntrinsicMode
Annotations
rdfs:label [language: en]
IntrinsicMode
rdfs:comment [language: en]
A gufo:IntrinsicAspect that is not measurable.
For example, Bob's belief that the Eiffel Tower is in Paris, his math skills, his headache.
Corresponds to "Mode" in Guizzardi (2005).
Description: IntrinsicMode
Equivalent To
SubClass Of
IntrinsicAspect
General class axioms
SubClass Of (Anonymous Ancestor)
inheresIn exactly 1 ConcreteIndividual
Instances
Target for Key
Disjoint With
Quality
Disjoint Union Of
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences


gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual 〉 ConcreteIndividual 〉 Endurant 〉 Aspect 〉 ExtrinsicAspect
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: ExtrinsicAspect
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Aspect
ExtrinsicAspect
IntrinsicAspect
Object
Event
Situation
Type
ExtrinsicAspect — http://purl.org/nemo/gufo#ExtrinsicAspect
Class Annotations
Class Usage
Annotations: ExtrinsicAspect
Annotations
rdfs:label [language: en]
ExtrinsicAspect
rdfs:comment [language: en]
A gufo:Aspect that depends on one or more concrete individuals.
Extrinsic (or "relational") aspects are reified relationships, e.g., John and Mary's marriage, Mary's employment contract at Nasa, or parts of those relationships, e.g., John's obligations towards Mary in the scope of the marriage, Mary's reciprocal claims, Mary's obligations towards John, John's reciprocal claims. Extrinsic aspects can also be reified one-sided relationships, e.g., John's admiration for Obama (which depends on Obama but does not characterize him).
Corresponds to "Extrinsic Moment" in Fonseca et al (2019). Encompasses "Externally Dependent Mode", "Qua Individual" and "Relator" in Guizzardi (2005).
Description: ExtrinsicAspect
Equivalent To
SubClass Of
Aspect
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
IntrinsicAspect
Disjoint Union Of
ExtrinsicMode, Relator
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences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gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual 〉 ConcreteIndividual 〉 Endurant 〉 Aspect 〉 ExtrinsicAspect 〉 Relator
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
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Data properties
Class hierarchy: Relator
Asserted
owl:Thing
Individual
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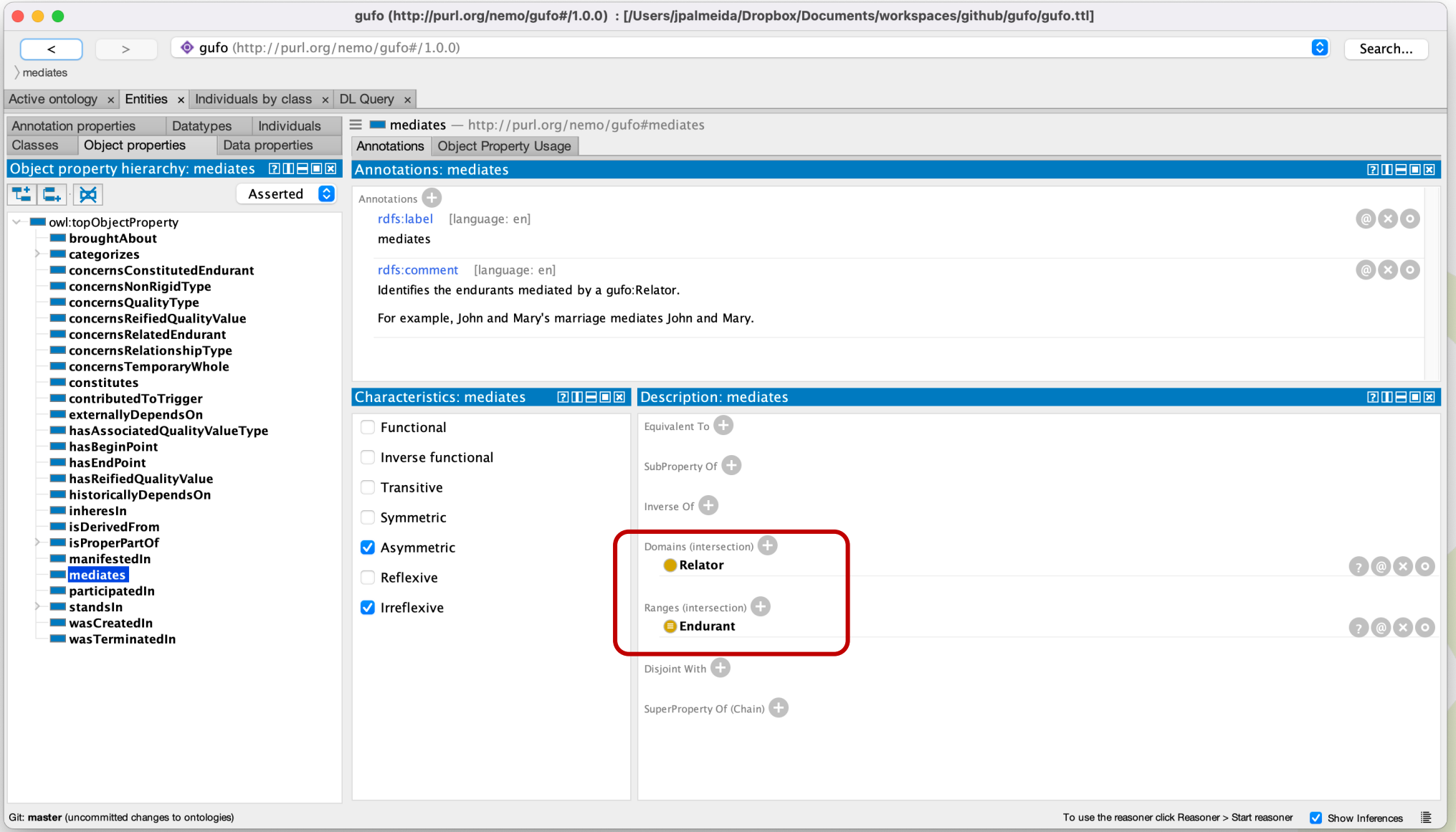
Instant
QualityValue
ConcreteIndividual
Endurant
Aspect
ExtrinsicAspect
ExtrinsicMode
Relator
IntrinsicAspect
IntrinsicMode
Quality
Object
Event
Situation
Type
Relator — http://purl.org/nemo/gufo#Relator
Class Annotations
Class Usage
Annotations: Relator
Annotations
rdfs:label [language: en]
Relator
rdfs:comment [language: en]
A gufo:ExtrinsicAspect that connects (involves, mediates) two or more concrete individuals. Relators are reified relationships composed of reciprocal extrinsic modes.
Examples of relators include John and Mary's marriage (composed of John's obligations towards Mary in the scope of the marriage, Mary's reciprocal claims, Mary's obligations towards John, John's reciprocal claims), Mary's employment contract at Nasa, a covalent bond between two atoms.
rdfs:seeAlso
Description: Relator
Equivalent To
SubClass Of
ExtrinsicAspect
mediates min 2 Endurant
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
ExtrinsicMode
Disjoint Union Of
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences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gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
mediates
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Entities
Individuals by class
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Annotation properties
Datatypes
Individuals
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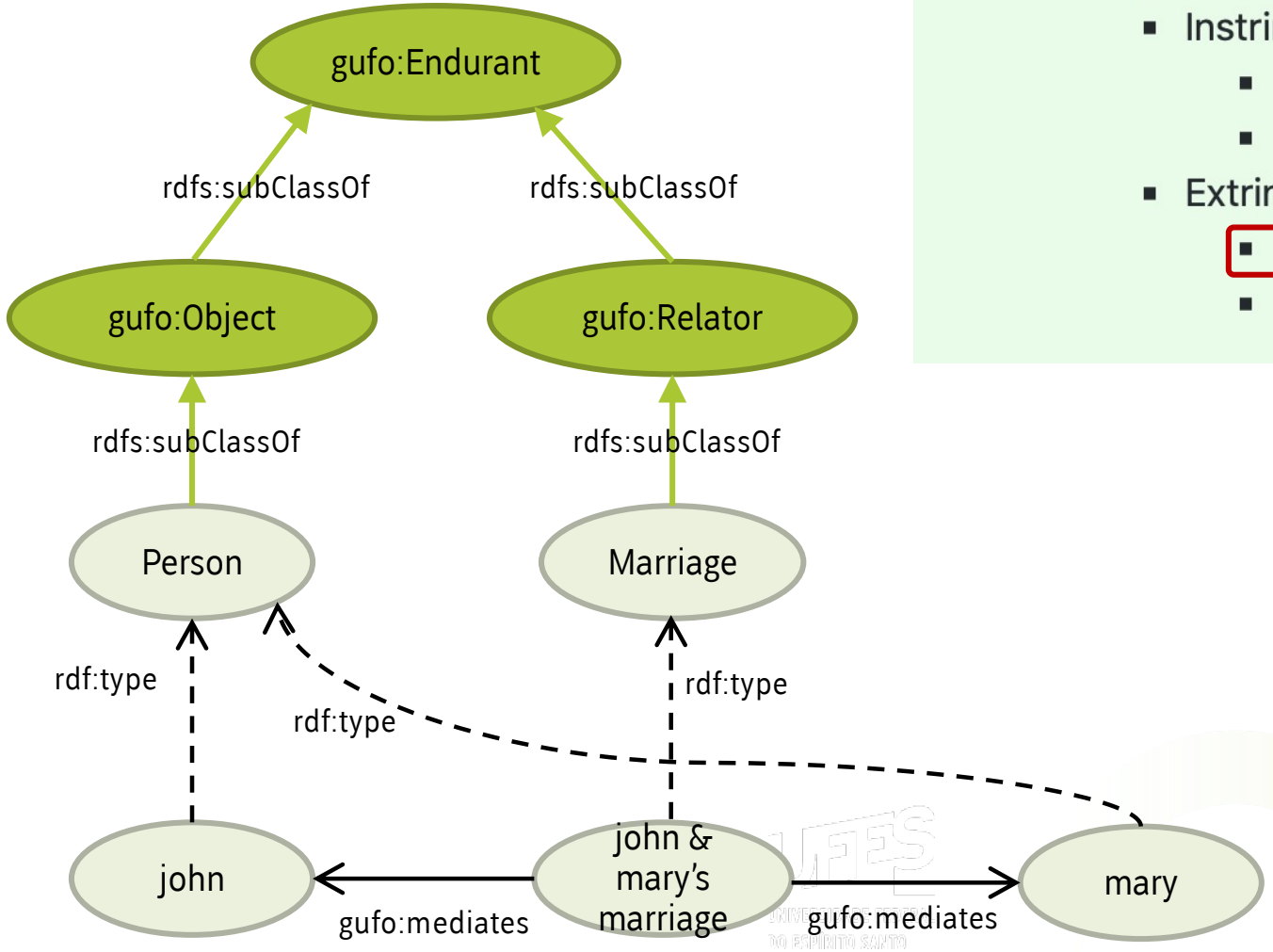
Object properties
Data properties
Object property hierarchy: mediates
Asserted
owl:topObjectProperty
broughtAbout
categorizes
concernsConstitutedEndurant
concernsNonRigidType
concernsQualityType
concernsReifiedQualityValue
concernsRelatedEndurant
concernsRelationshipType
concernsTemporaryWhole
constitutes
contributedToTrigger
externallyDependsOn
hasAssociatedQualityValueType
hasBeginPoint
hasEndPoint
hasReifiedQualityValue
historicallyDependsOn
inheresIn
isDerivedFrom
isProperPartOf
manifestedIn
mediates
participatedIn
standsIn
wasCreatedIn
wasTerminatedIn
mediates — http://purl.org/nemo/gufo#mediates
Annotations
Object Property Usage
Annotations: mediates
Annotations
rdfs:label [language: en]
mediates
rdfs:comment [language: en]
Identifies the endurants mediated by a gufo:Relator.
For example, John and Mary's marriage mediates John and Mary.
Characteristics: mediates
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: mediates
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
Relator
Ranges (intersection)
Endurant
Disjoint With
SuperProperty Of (Chain)
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences

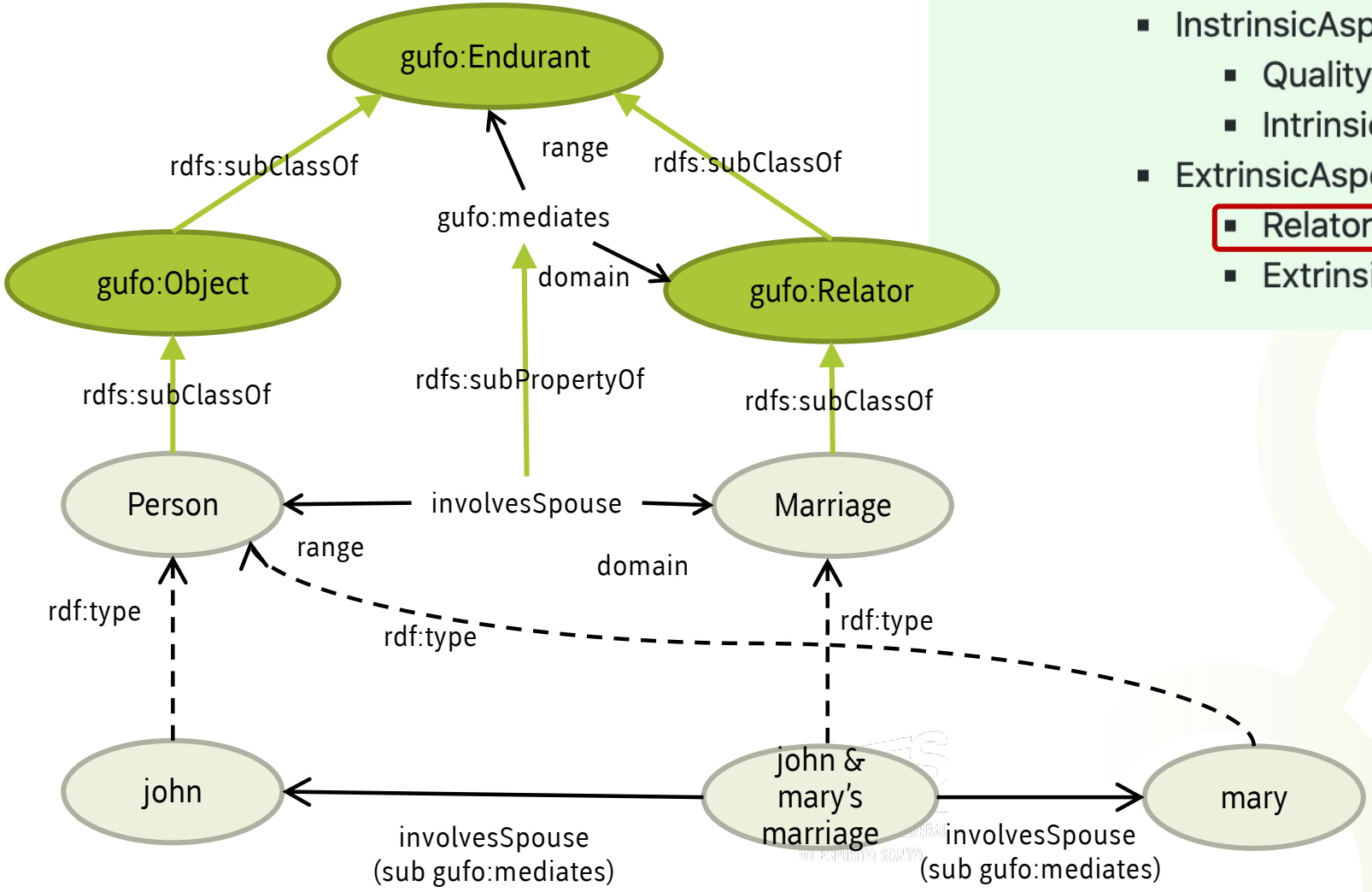
Relationship reification

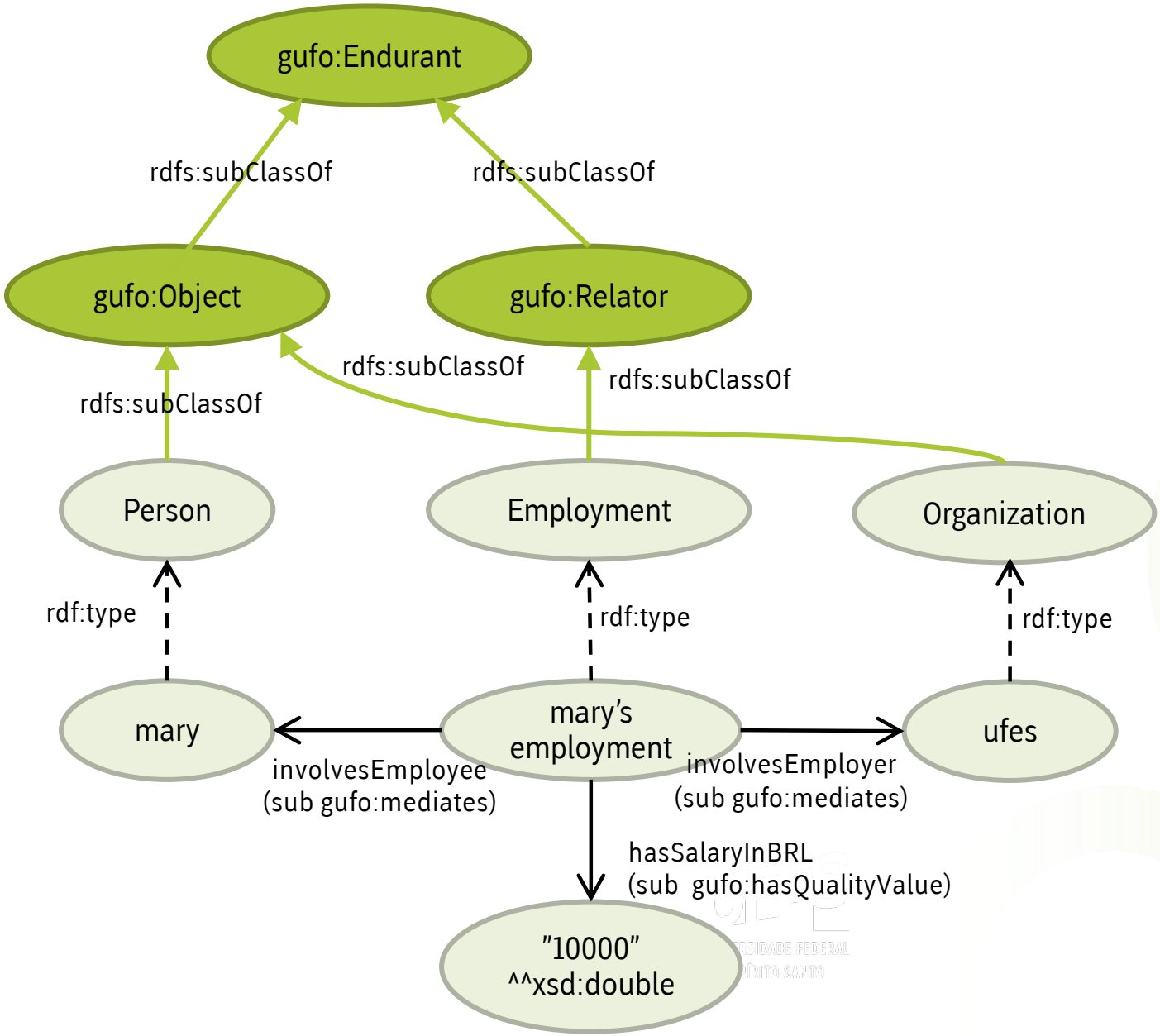


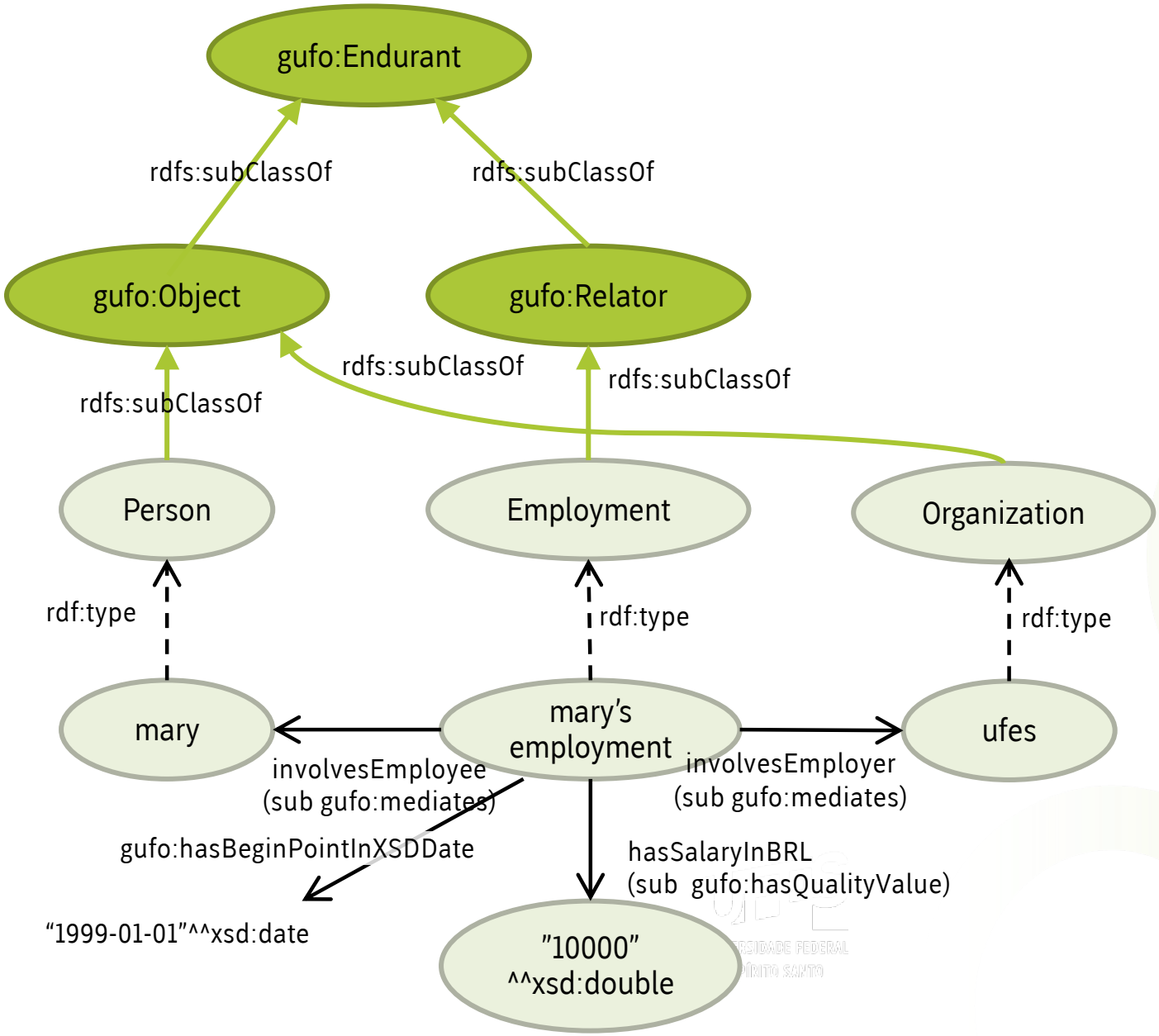
- Endurant
  - Aspect
    - InstrinsicAspect
      - Quality
      - IntrinsicMode
    - ExtrinsicAspect
      - Relator
      - ExtrinsicMode

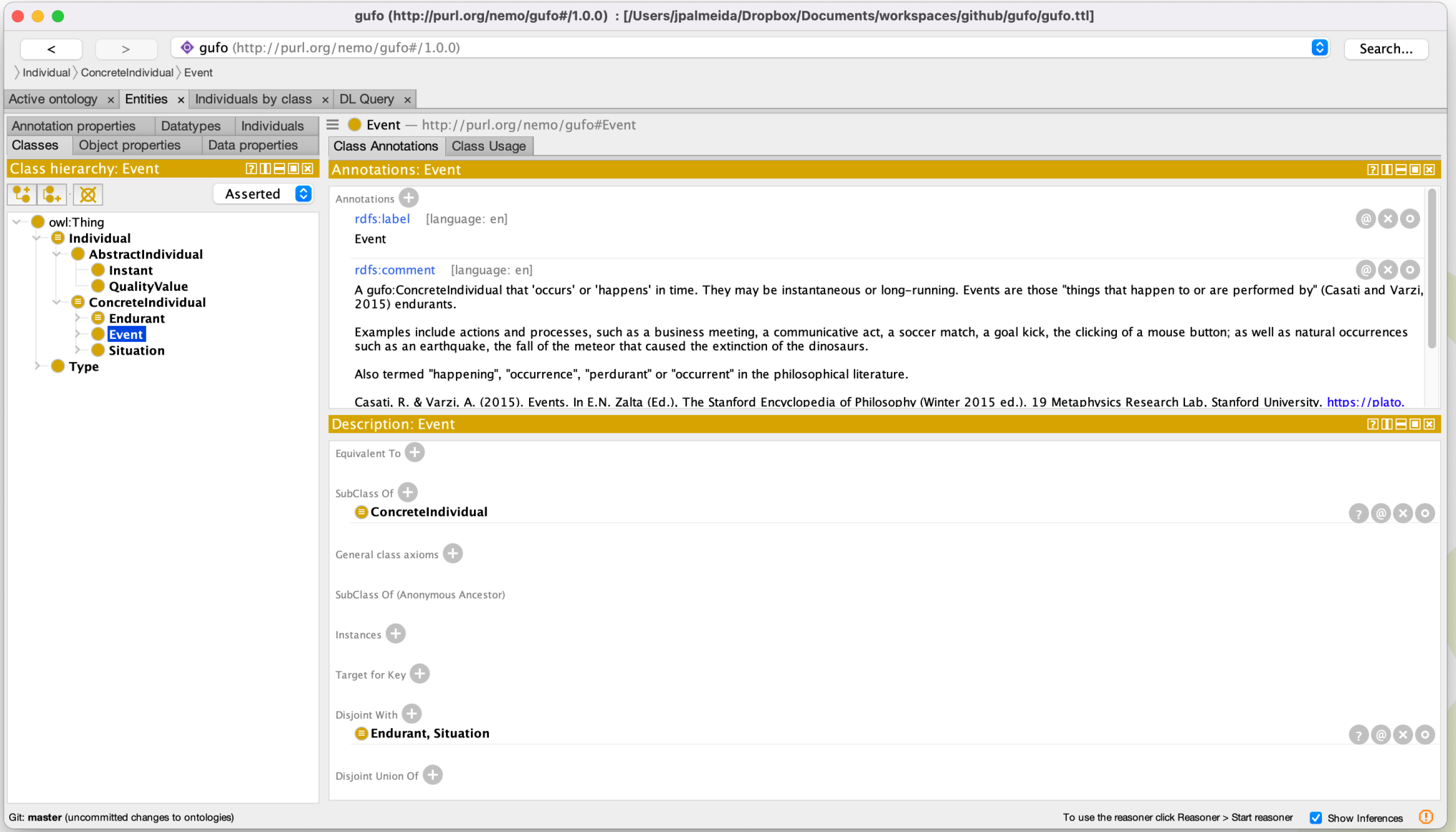
Relationship reification

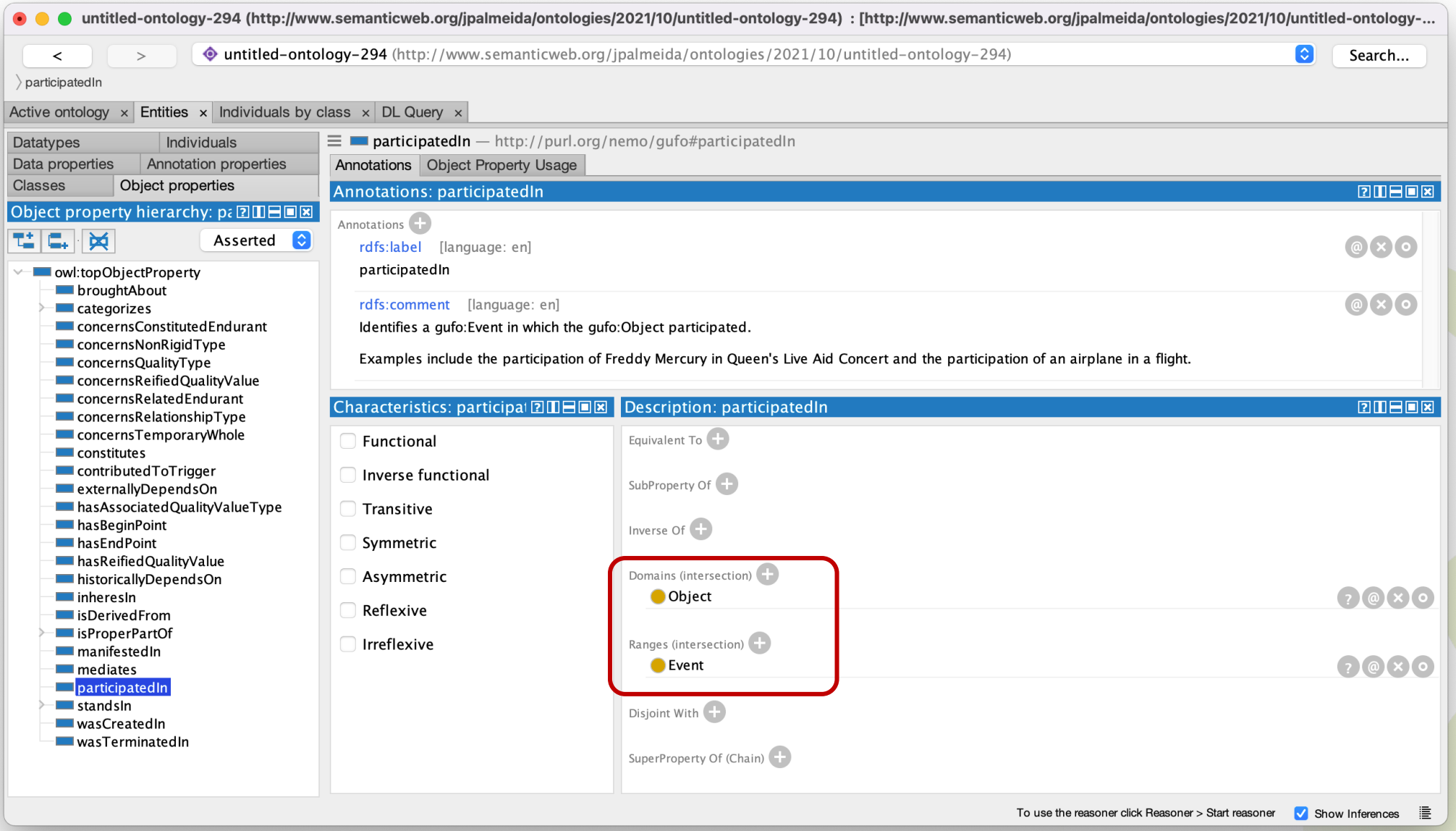
- Endurant
  - Aspect
    - InstrinsicAspect
      - Quality
      - IntrinsicMode
    - ExtrinsicAspect
      - Relator
      - ExtrinsicMode

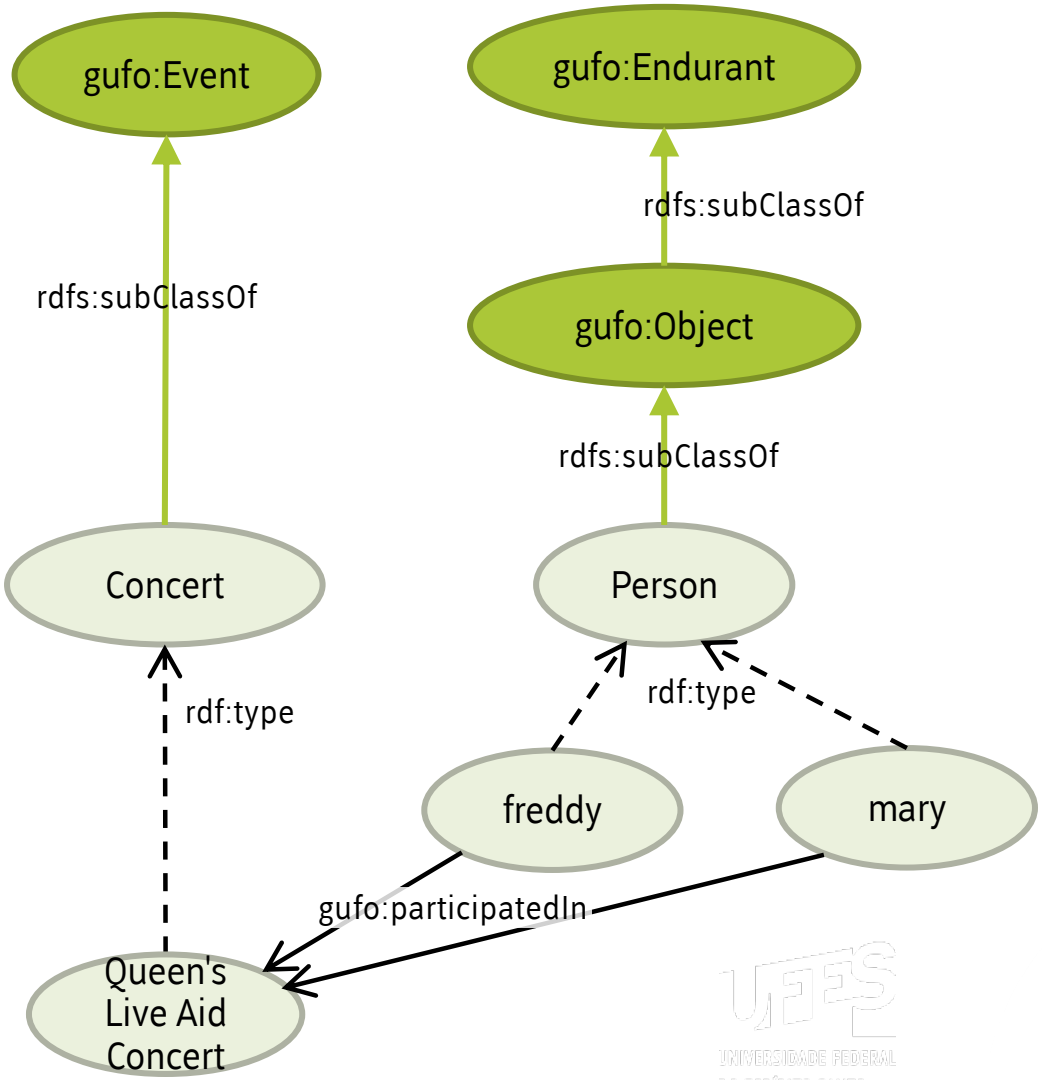


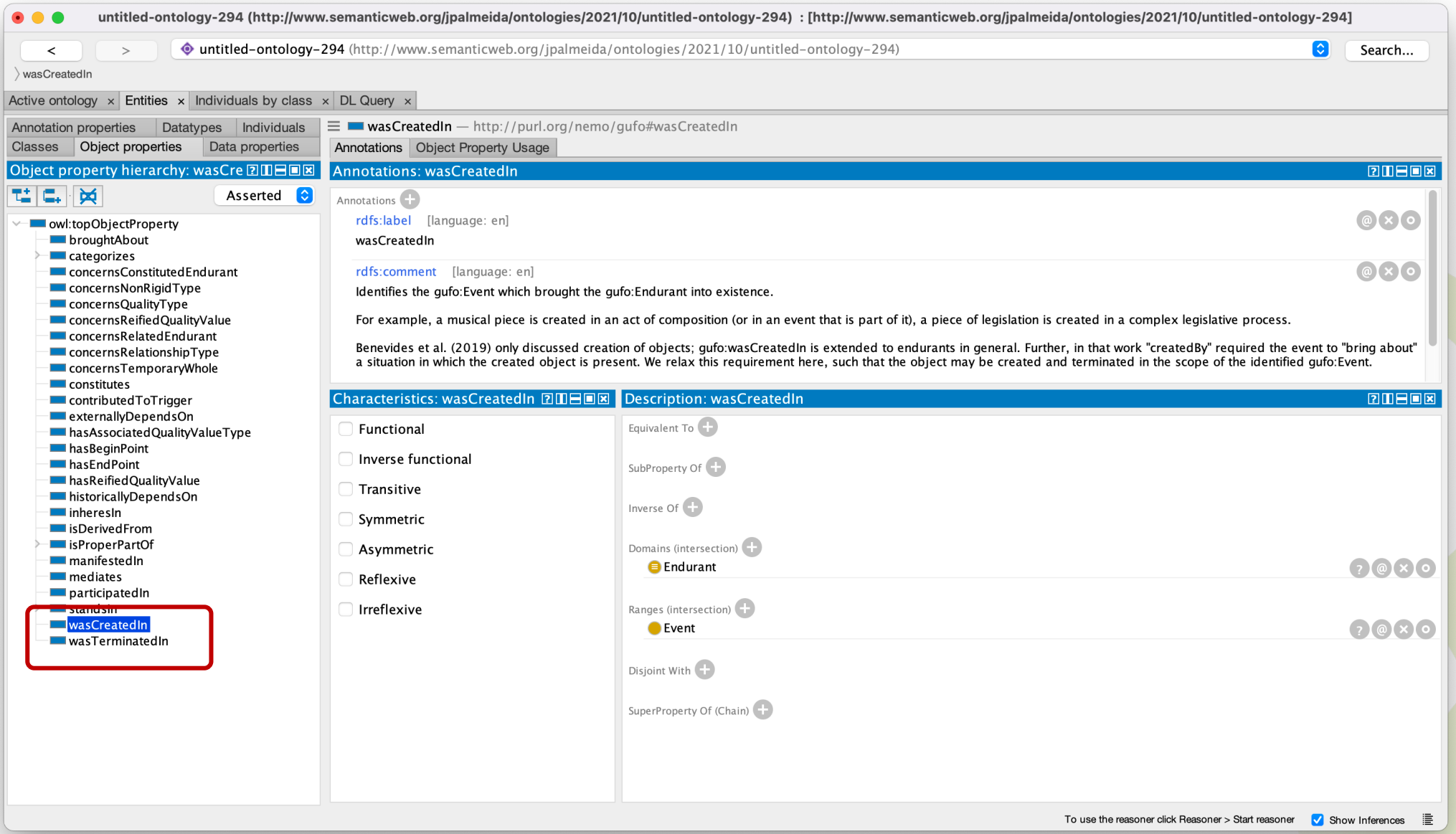

gufo:Endurant
rdfs:subClassOf
rdfs:subClassOf
gufo:Object
gufo:Relator
rdfs:subClassOf
rdfs:subClassOf
rdfs:subClassOf
Person
Employment
Organization
rdf:type
rdf:type
rdf:type
mary
mary's employment
ufes
involvesEmployee
(sub gufo:mediates)
involvesEmployer
(sub gufo:mediates)
hasSalaryInBRL
(sub gufo:hasQualityValue)
"10000"
^^xsd:double

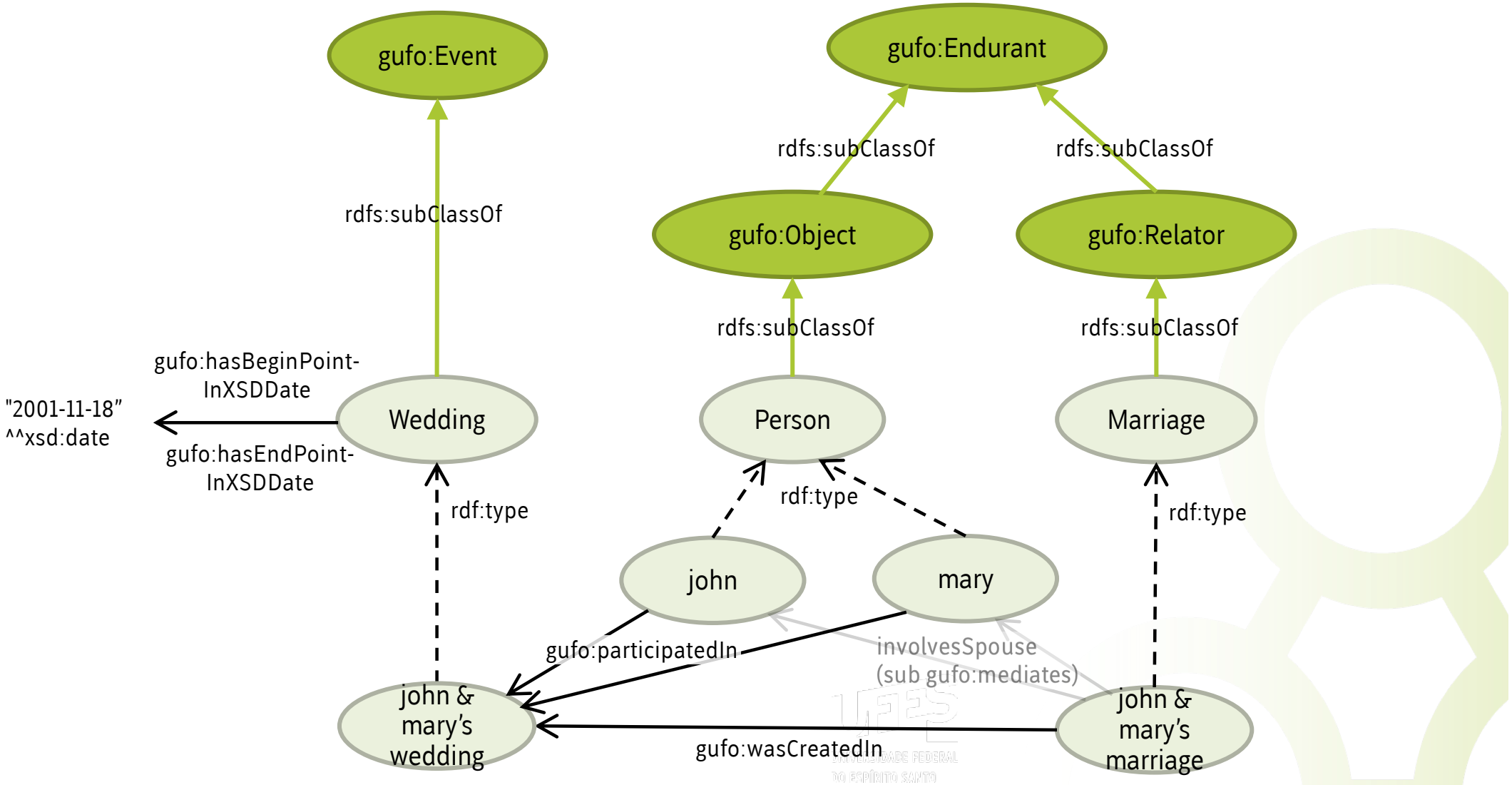

gufo:Endurant
rdfs:subClassOf
rdfs:subClassOf
gufo:Object
gufo:Relator
rdfs:subClassOf
rdfs:subClassOf
rdfs:subClassOf
Person
Employment
Organization
rdf:type
rdf:type
rdf:type
mary
mary's employment
ufes
involvesEmployee
(sub gufo:mediates)
involvesEmployer
(sub gufo:mediates)
gufo:hasBeginPointInXSDDate
hasSalaryInBRL
(sub gufo:hasQualityValue)
"1999-01-01"^^xsd:date
"10000"
^^xsd:double

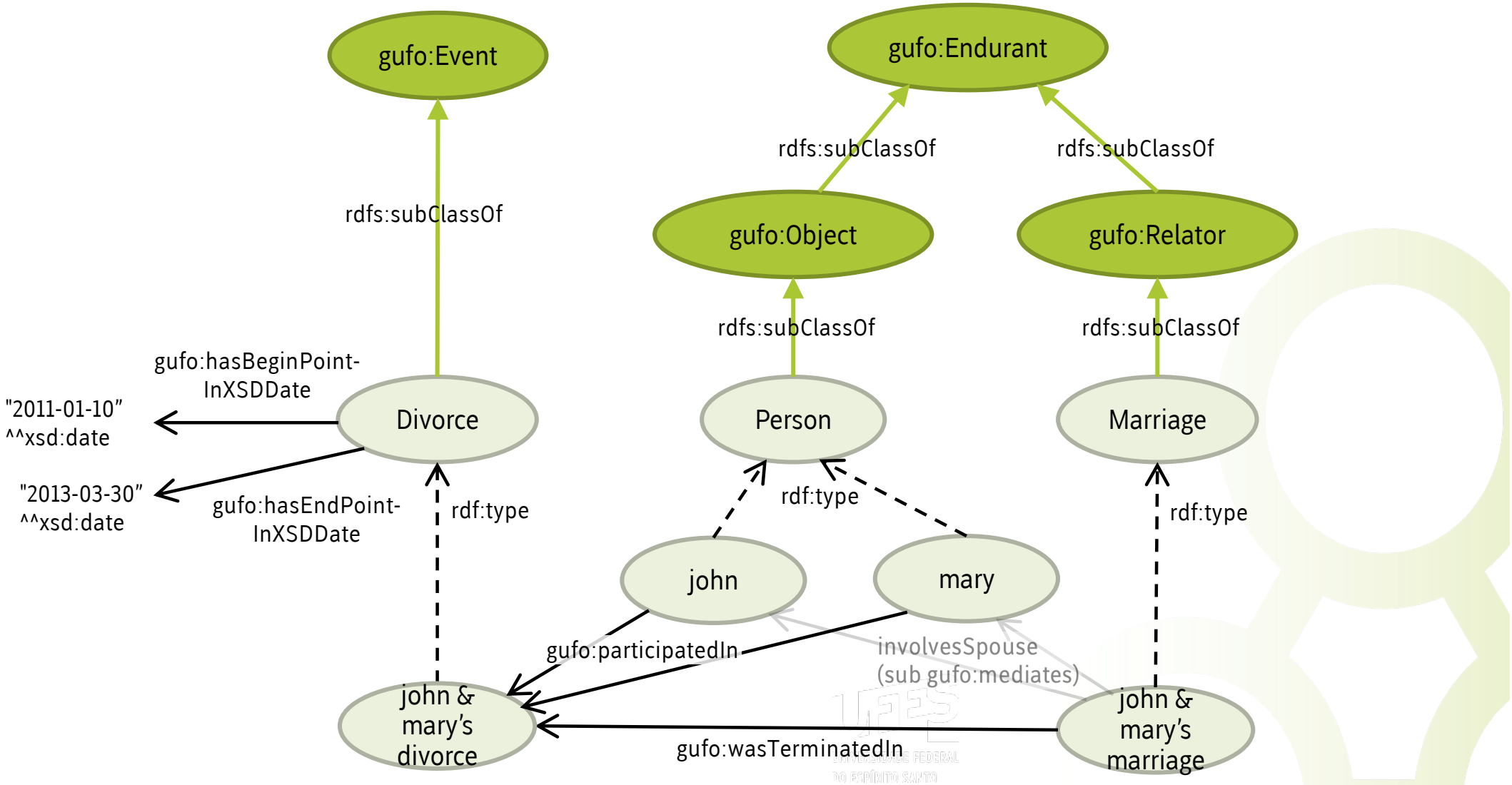

gufo (http://purl.org/nemo/gufo#/1.0.0) : [/Users/jpalmeida/Dropbox/Documents/workspaces/github/gufo/gufo.ttl]
gufo (http://purl.org/nemo/gufo#/1.0.0)
Search...
Individual 〉 ConcreteIndividual 〉 Event
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: Event
Asserted
owl:Thing
Individual
AbstractIndividual
Instant
QualityValue
ConcreteIndividual
Endurant
Event
Situation
Type
Event — http://purl.org/nemo/gufo#Event
Class Annotations
Class Usage
Annotations: Event
Annotations
rdfs:label [language: en]
Event
rdfs:comment [language: en]
A gufo:ConcreteIndividual that 'occurs' or 'happens' in time. They may be instantaneous or long-running. Events are those "things that happen to or are performed by" (Casati and Varzi, 2015) endurants.
Examples include actions and processes, such as a business meeting, a communicative act, a soccer match, a goal kick, the clicking of a mouse button; as well as natural occurrences such as an earthquake, the fall of the meteor that caused the extinction of the dinosaurs.
Also termed "happening", "occurrence", "perdurant" or "occurrent" in the philosophical literature.
Casati, R. & Varzi, A. (2015). Events. In E.N. Zalta (Ed.), The Stanford Encyclopedia of Philosophy (Winter 2015 ed.). 19 Metaphysics Research Lab, Stanford University. https://plato.
Description: Event
Equivalent To
SubClass Of
ConcreteIndividual
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
Target for Key
Disjoint With
Endurant, Situation
Disjoint Union Of
Git: master (uncommitted changes to ontologies)
To use the reasoner click Reasoner > Start reasoner
Show Inferences

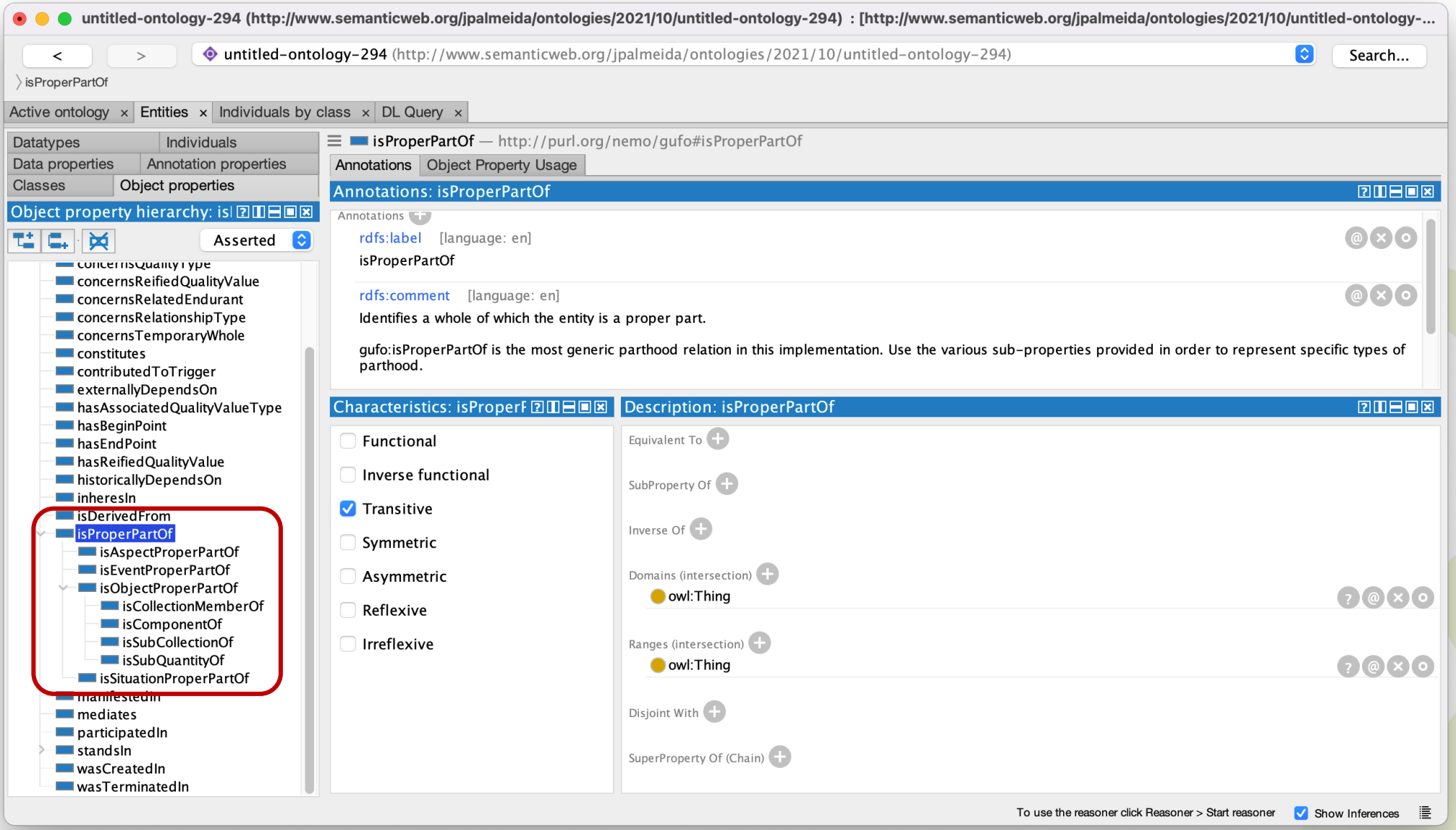

untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294) : [http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-...
untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294)
Search...
participatedIn
Active ontology
Entities
Individuals by class
DL Query
Datatypes
Individuals
Data properties
Annotation properties
Classes
Object properties
Object property hierarchy: pa
Asserted
owl:topObjectProperty
broughtAbout
categorizes
concernsConstitutedEndurant
concernsNonRigidType
concernsQualityType
concernsReifiedQualityValue
concernsRelatedEndurant
concernsRelationshipType
concernsTemporaryWhole
constitutes
contributedToTrigger
externallyDependsOn
hasAssociatedQualityValueType
hasBeginPoint
hasEndPoint
hasReifiedQualityValue
historicallyDependsOn
inheresIn
isDerivedFrom
isProperPartOf
manifestedIn
mediates
participatedIn
standsIn
wasCreatedIn
wasTerminatedIn
participatedIn — http://purl.org/nemo/gufo#participatedIn
Annotations
Object Property Usage
Annotations: participatedIn
Annotations
rdfs:label [language: en]
participatedIn
rdfs:comment [language: en]
Identifies a gufo:Event in which the gufo:Object participated.
Examples include the participation of Freddy Mercury in Queen's Live Aid Concert and the participation of an airplane in a flight.
Characteristics: participa
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: participatedIn
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
Object
Ranges (intersection)
Event
Disjoint With
SuperProperty Of (Chain)
To use the reasoner click Reasoner > Start reasoner
Show Inferences

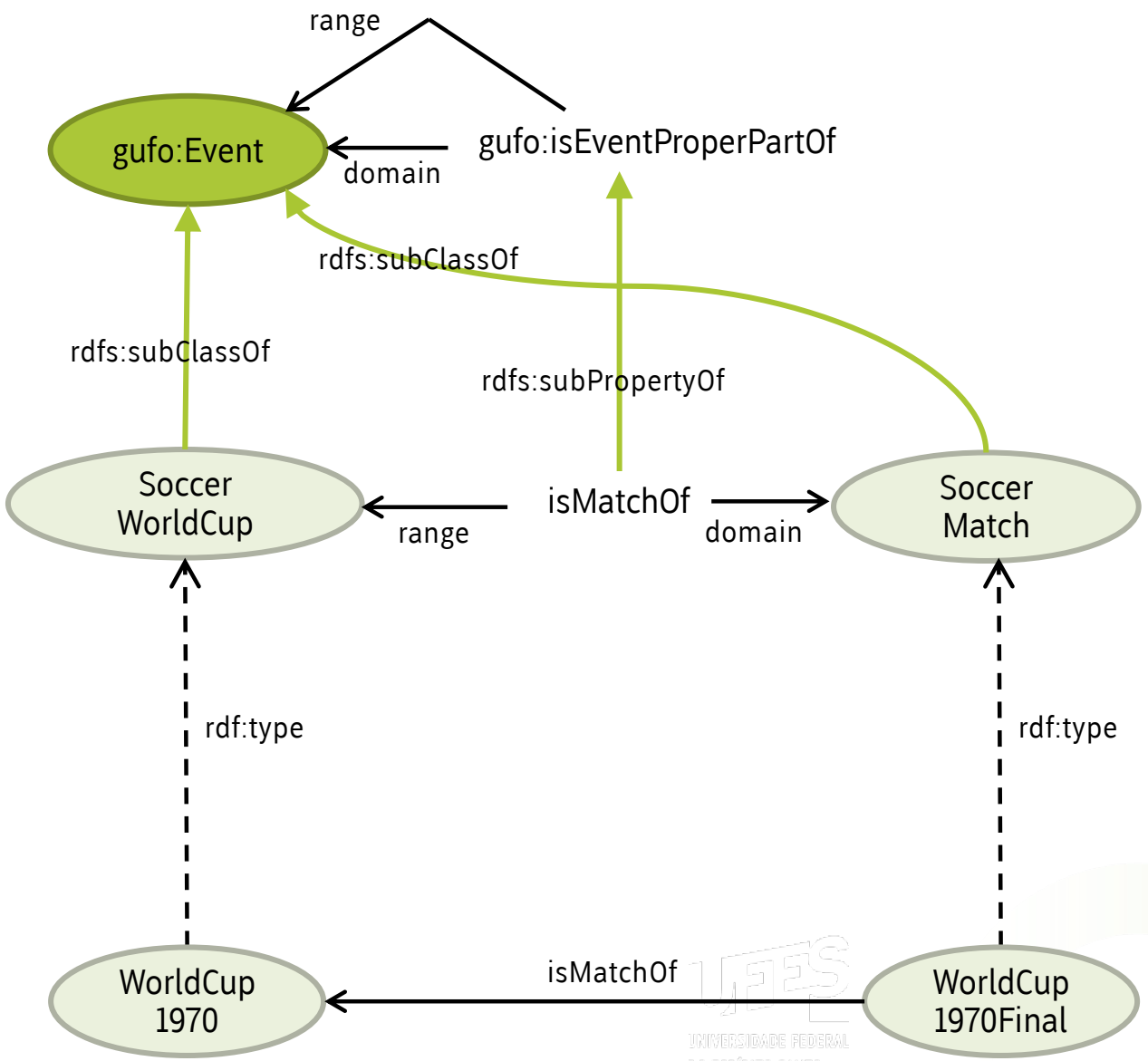

gufo:Event
gufo:Endurant
rdfs:subClassOf
rdfs:subClassOf
gufo:Object
rdfs:subClassOf
Concert
Person
rdf:type
rdf:type
freddy
mary
gufo:participatedIn
Queen's
Live Aid
Concert


untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294) : [http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294]
untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294)
Search...
wasCreatedIn
Active ontology
Entities
Individuals by class
DL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Object property hierarchy: wasCre
Asserted
owl:topObjectProperty
broughtAbout
categorizes
concernsConstitutedEndurant
concernsNonRigidType
concernsQualityType
concernsReifiedQualityValue
concernsRelatedEndurant
concernsRelationshipType
concernsTemporaryWhole
constitutes
contributedToTrigger
externallyDependsOn
hasAssociatedQualityValueType
hasBeginPoint
hasEndPoint
hasReifiedQualityValue
historicallyDependsOn
inheresIn
isDerivedFrom
isProperPartOf
manifestedIn
mediates
participatedIn
wasCreatedIn
wasTerminatedIn
wasCreatedIn — http://purl.org/nemo/gufo#wasCreatedIn
Annotations
Object Property Usage
Annotations: wasCreatedIn
Annotations
rdfs:label [language: en]
wasCreatedIn
rdfs:comment [language: en]
Identifies the gufo:Event which brought the gufo:Endurant into existence.
For example, a musical piece is created in an act of composition (or in an event that is part of it), a piece of legislation is created in a complex legislative process.
Benevides et al. (2019) only discussed creation of objects; gufo:wasCreatedIn is extended to endurants in general. Further, in that work "createdBy" required the event to "bring about" a situation in which the created object is present. We relax this requirement here, such that the object may be created and terminated in the scope of the identified gufo:Event.
Characteristics: wasCreatedIn
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: wasCreatedIn
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
Endurant
Ranges (intersection)
Event
Disjoint With
SuperProperty Of (Chain)
To use the reasoner click Reasoner > Start reasoner
Show Inferences


gufo:Event
gufo:Endurant
rdfs:subClassOf
rdfs:subClassOf
rdfs:subClassOf
gufo:Object
gufo:Relator
rdfs:subClassOf
rdfs:subClassOf
gufo:hasBeginPoint-InXSDDate
"2001-11-18"^^xsd:date
Wedding
Person
Marriage
gufo:hasEndPoint-InXSDDate
rdf:type
rdf:type
rdf:type
john
mary
gufo:participatedIn
involvesSpouse
(sub gufo:mediates)
john & mary's wedding
john & mary's marriage
gufo:wasCreatedIn


gufo:Event
gufo:Endurant
rdfs:subClassOf
rdfs:subClassOf
rdfs:subClassOf
gufo:Object
gufo:Relator
rdfs:subClassOf
rdfs:subClassOf
gufo:hasBeginPoint-
InXSDDate
"2011-01-10"
^^xsd:date
Divorce
Person
Marriage
"2013-03-30"
^^xsd:date
gufo:hasEndPoint-
InXSDDate
rdf:type
rdf:type
rdf:type
john
mary
gufo:participatedIn
involvesSpouse
(sub gufo:mediates)
john &
mary's
divorce
john &
mary's
marriage
gufo:wasTerminatedIn


untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294) : [http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-...
untitled-ontology-294 (http://www.semanticweb.org/jpalmeida/ontologies/2021/10/untitled-ontology-294)
Search...
isProperPartOf
Active ontology
Entities
Individuals by class
DL Query
Datatypes
Individuals
Data properties
Annotation properties
Classes
Object properties
Object property hierarchy: isl
Asserted
concernsReifiedQualityValue
concernsRelatedEndurant
concernsRelationshipType
concernsTemporaryWhole
constitutes
contributedToTrigger
externallyDependsOn
hasAssociatedQualityValueType
hasBeginPoint
hasEndPoint
hasReifiedQualityValue
historicallyDependsOn
inheresIn
isDerivedFrom
isProperPartOf
isAspectProperPartOf
isEventProperPartOf
isObjectProperPartOf
isCollectionMemberOf
isComponentOf
isSubCollectionOf
isSubQuantityOf
isSituationProperPartOf
mediates
participatedIn
standsIn
wasCreatedIn
wasTerminatedIn
isProperPartOf — http://purl.org/nemo/gufo#isProperPartOf
Annotations
Object Property Usage
Annotations: isProperPartOf
Annotations
rdfs:label [language: en]
isProperPartOf
rdfs:comment [language: en]
Identifies a whole of which the entity is a proper part.
gufo:isProperPartOf is the most generic parthood relation in this implementation. Use the various sub-properties provided in order to represent specific types of parthood.
Characteristics: isProperF
Functional
Inverse functional
Transitive
Symmetric
Asymmetric
Reflexive
Irreflexive
Description: isProperPartOf
Equivalent To
SubProperty Of
Inverse Of
Domains (intersection)
owl:Thing
Ranges (intersection)
owl:Thing
Disjoint With
SuperProperty Of (Chain)
To use the reasoner click Reasoner > Start reasoner
Show Inferences


range
gufo:Event
domain
gufo:isEventProperPartOf
rdfs:subClassOf
rdfs:subClassOf
rdfs:subPropertyOf
Soccer
WorldCup
range
isMatchOf
domain
Soccer
Match
rdf:type
rdf:type
WorldCup
1970
isMatchOf
WorldCup
1970Final

Hands on!

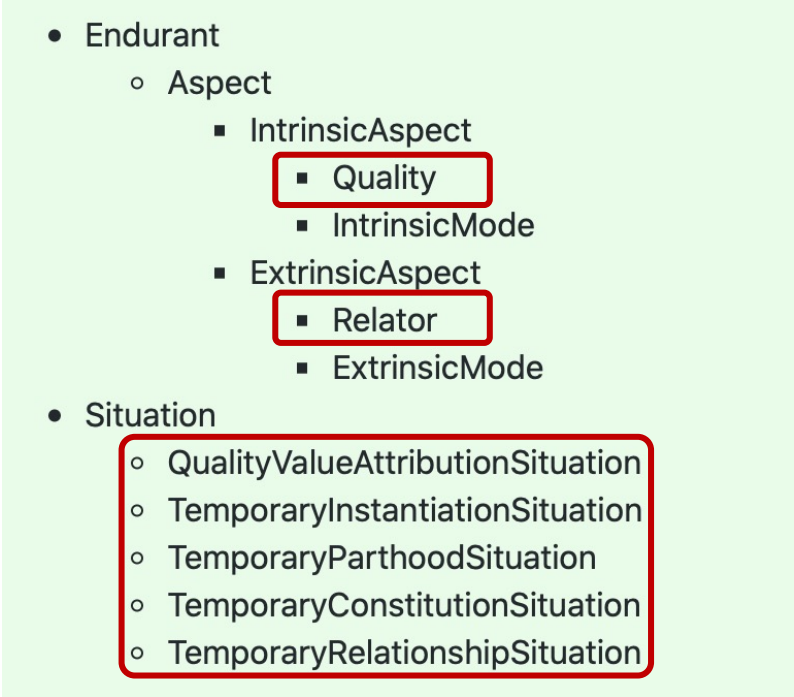
2. Patterns & Advanced Features

“A little semantics goes a long way” – Jim Hendler

“Some more semantics goes further...”

Patterns

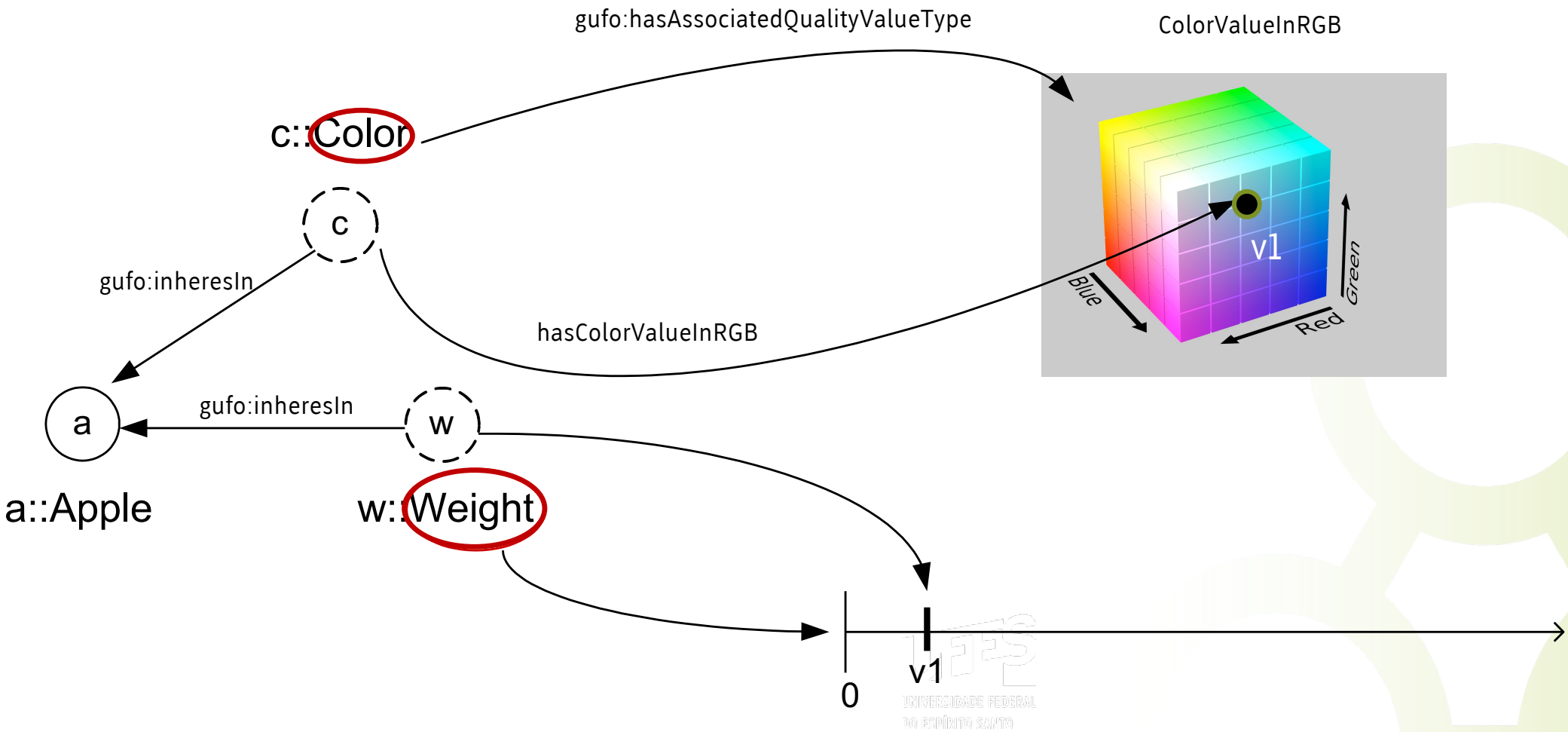
- Quality reification
  - Stability in face of change in measurement schemes for qualities
- Situations
  - Handling changes in objects/aspects in time



Representing qualities

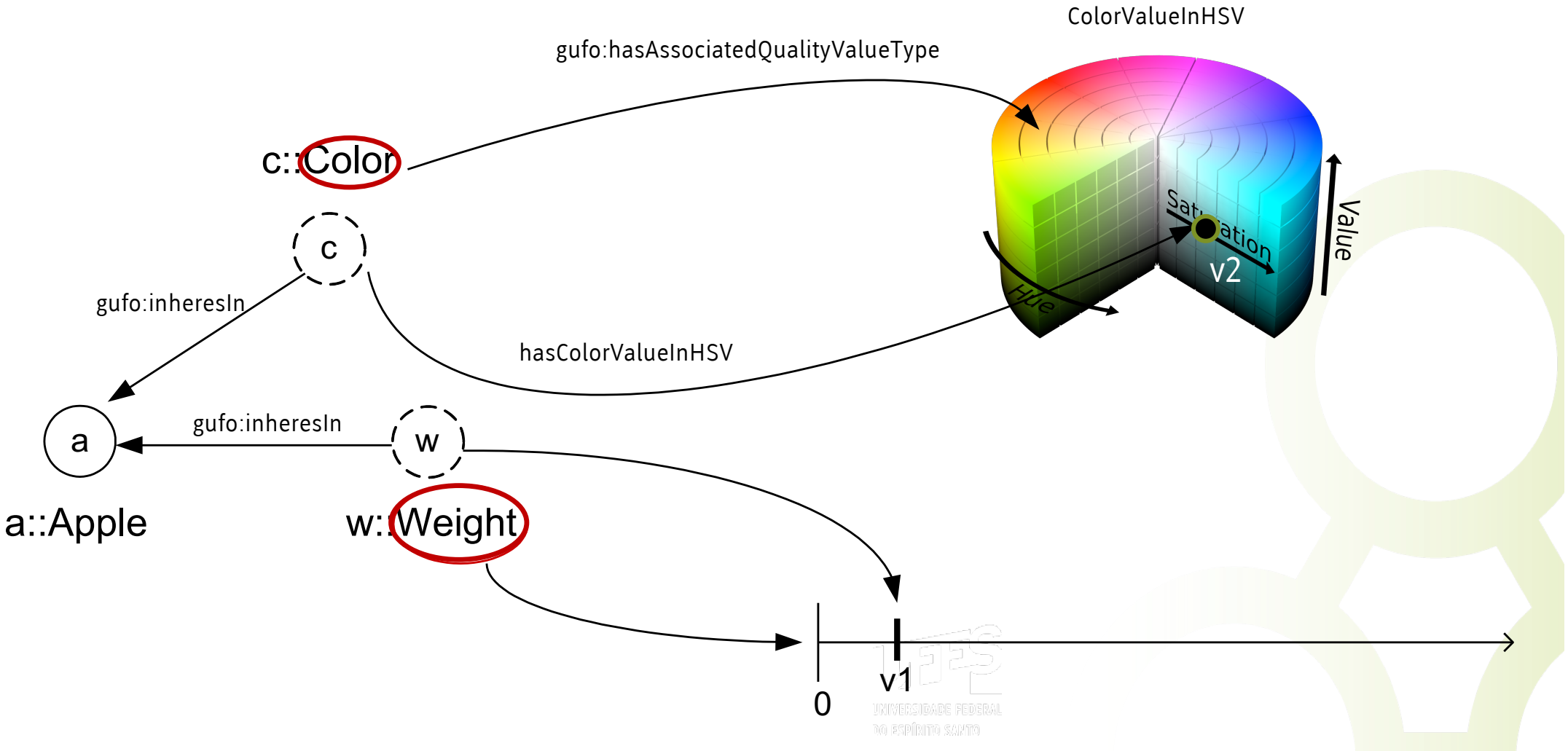
- A range of possibilities depending on scenario:
  - A simple data property (specializing gufo:hasQualityValue)
    - PhysicalObject hasWeight xsd:double
    - hasWeight subPropertyOf gufo:hasQualityValue
  - An object property with a reified quality value
    - In case of enumerations (e.g., ShirtSize subClassOf QualityValue, oneOf S, M, L, XL)
    - or structured values (e.g., hasColorValueInRGB with RGB components)
  - Reified quality and reified quality value
    - The “full” quality pattern

Quality reification

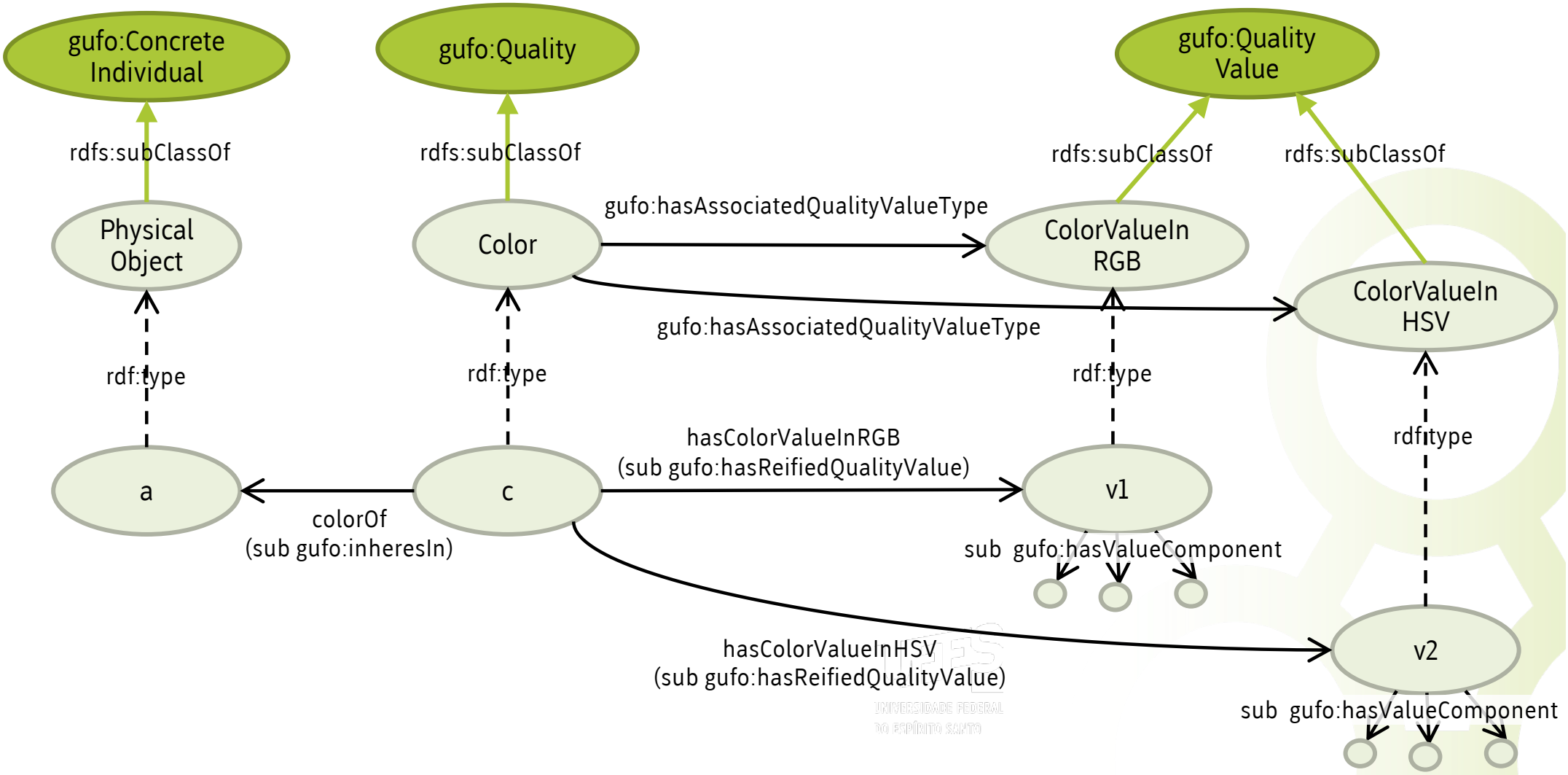


Weight Quality Space

Quality reification



Quality reification in gUFO (full pattern)

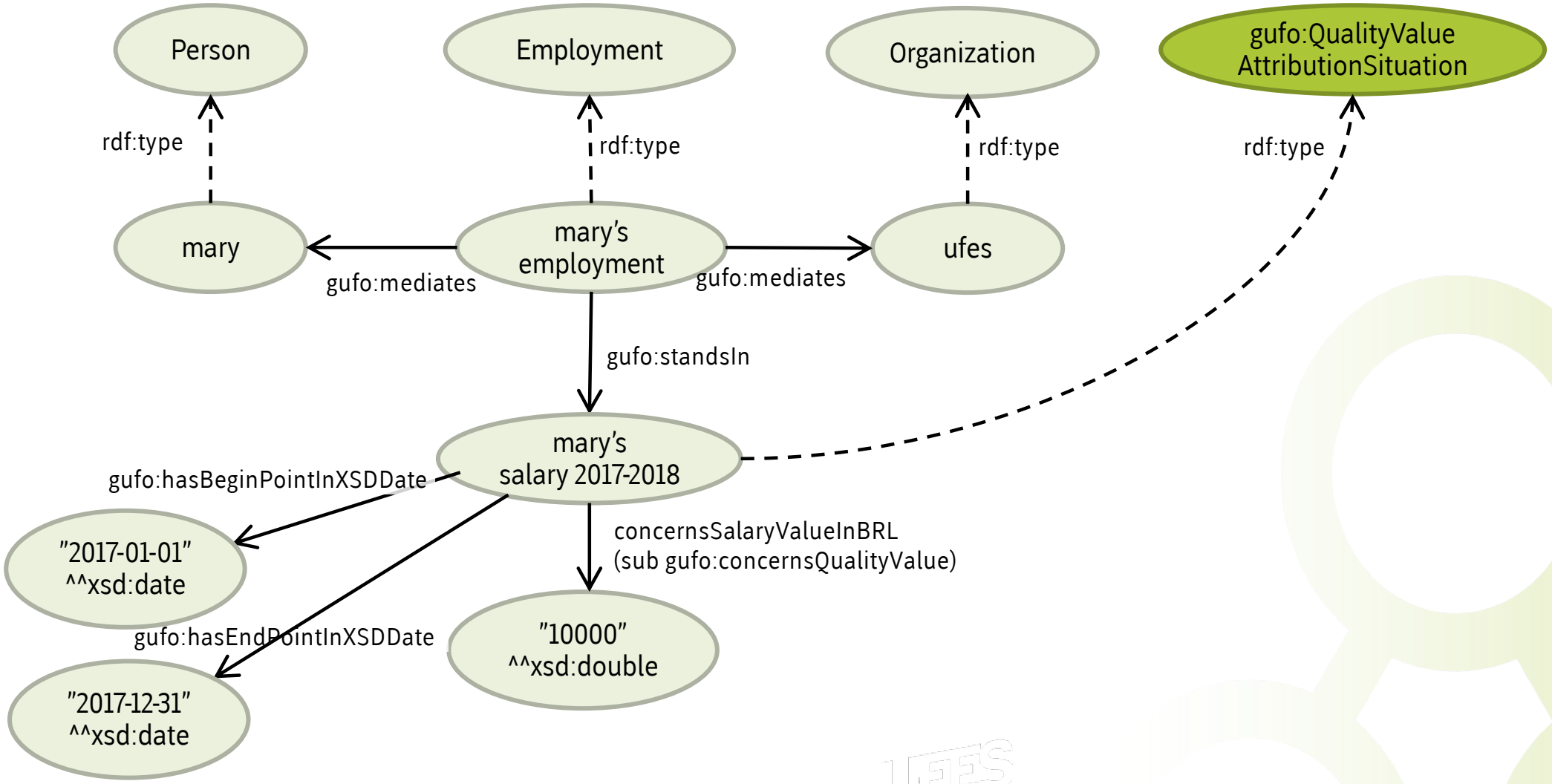


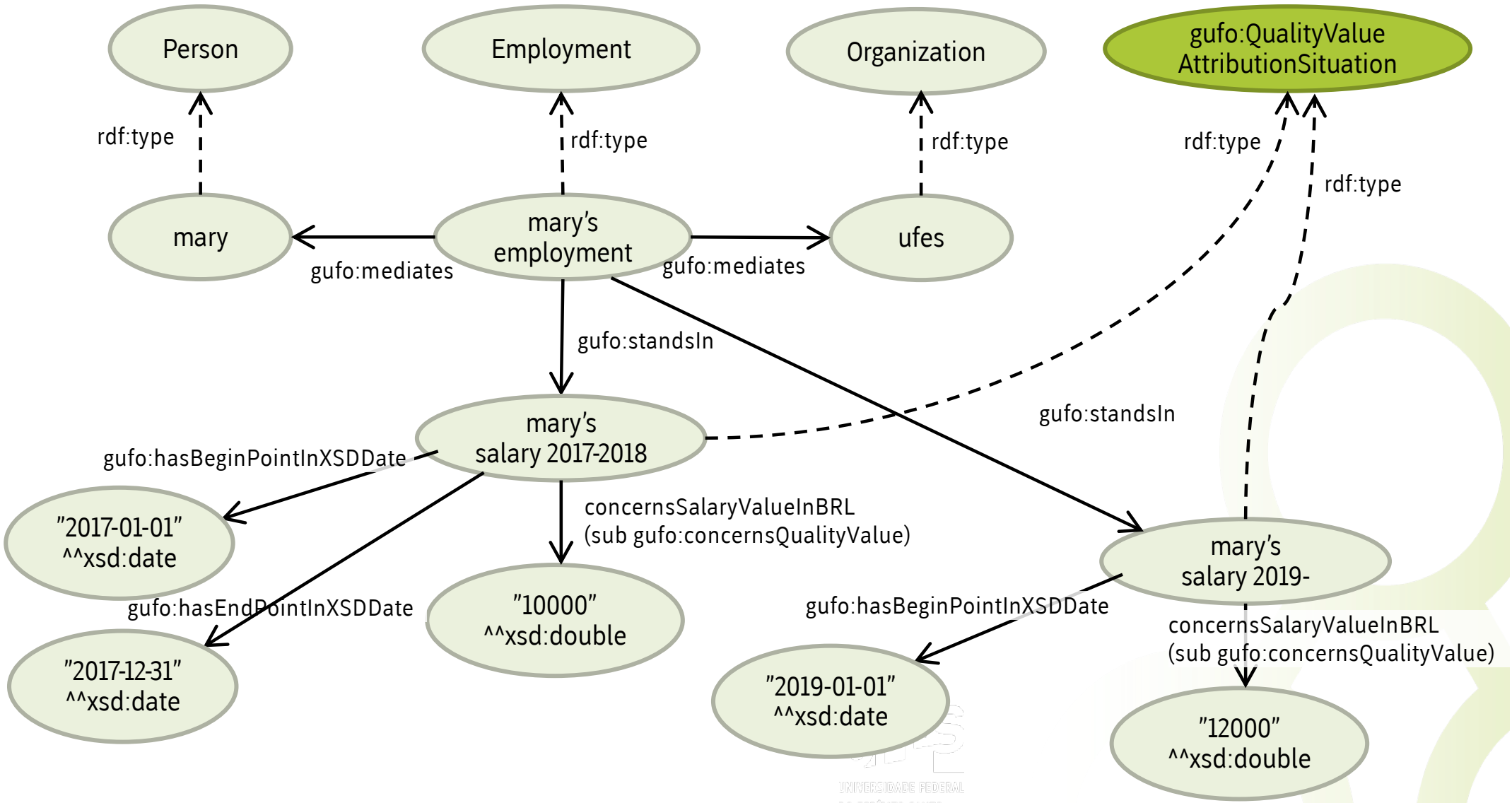
Hands on!

Situations

- No support for change in the Semantic Web
- What about:
  - when a person loses/gains weight?
  - when a rental car is under repair?
  - when a band changes members?
  - when a student graduates?
  - when a president leaves office?

- Endurant
  - Aspect
    - IntrinsicAspect
      - Quality
      - IntrinsicMode
    - ExtrinsicAspect
      - Relator
      - ExtrinsicMode
- Situation
  - QualityValueAttributionSituation
  - TemporaryInstantiationSituation
  - TemporaryParthoodSituation
  - TemporaryConstitutionSituation
  - TemporaryRelationshipSituation


Person
Employment
Organization
gufo:QualityValue
AttributionSituation
rdf:type
rdf:type
rdf:type
rdf:type
mary
mary's
employment
ufes
gufo:mediates
gufo:mediates
gufo:standsIn
mary's
salary 2017-2018
gufo:hasBeginPointInXSDDate
"2017-01-01"
^^xsd:date
concernsSalaryValueInBRL
(sub gufo:concernsQualityValue)
gufo:hasEndPointInXSDDate
"10000"
^^xsd:double
"2017-12-31"
^^xsd:date


Person
Employment
Organization
gufo:QualityValue
AttributionSituation
rdf:type
rdf:type
rdf:type
rdf:type
rdf:type
mary
mary's
employment
ufes
gufo:mediates
gufo:mediates
gufo:standsIn
gufo:standsIn
mary's
salary 2017-2018
gufo:hasBeginPointInXSDDate
"2017-01-01"
^^xsd:date
concernsSalaryValueInBRL
(sub gufo:concernsQualityValue)
gufo:hasEndPointInXSDDate
"2017-12-31"
^^xsd:date
"10000"
^^xsd:double
mary's
salary 2019-
gufo:hasBeginPointInXSDDate
"2019-01-01"
^^xsd:date
concernsSalaryValueInBRL
(sub gufo:concernsQualityValue)
"12000"
^^xsd:double

Hands on!

2.1. Exploring the Taxonomy of Types

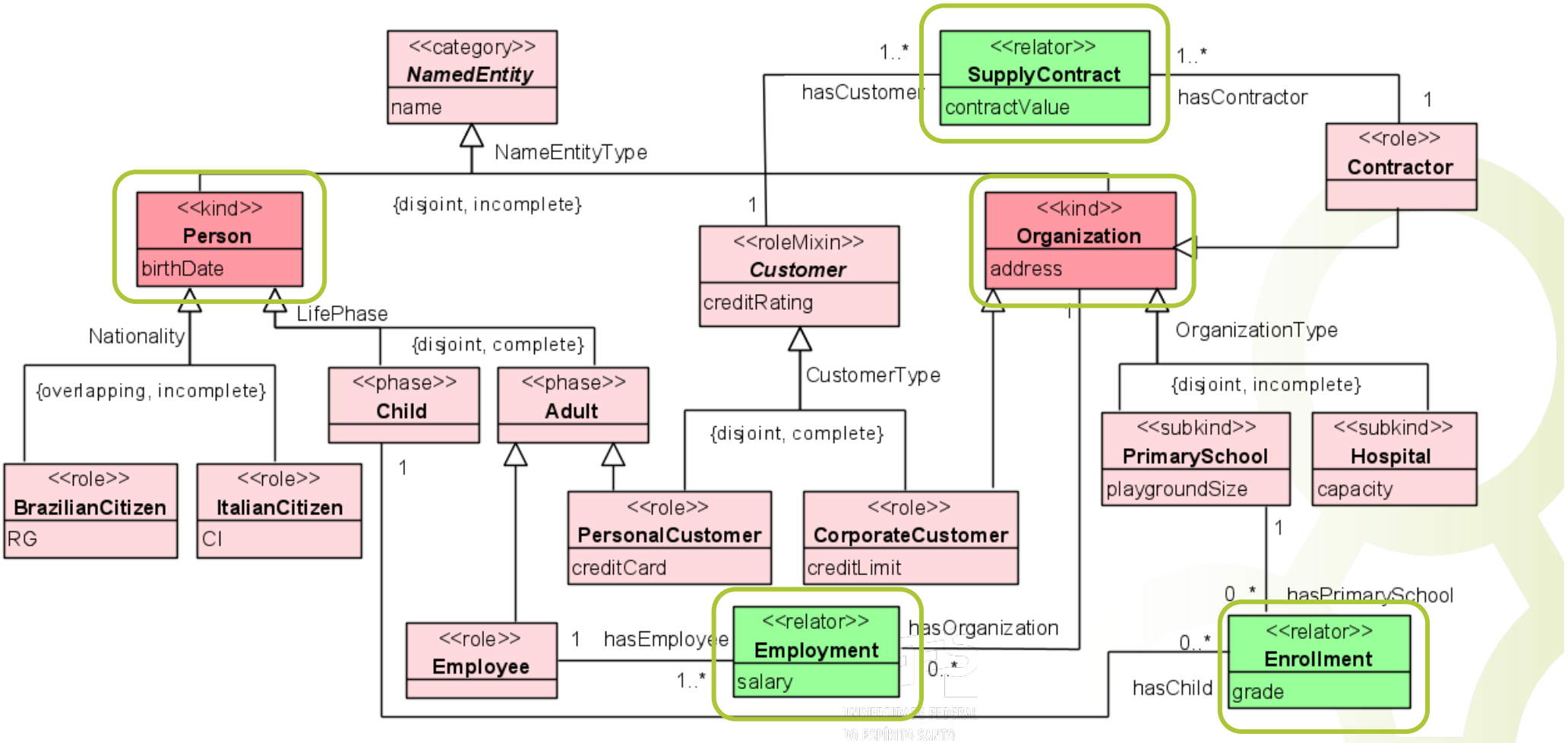
“A little semantics goes a long way” – Jim Hendler

“Some more semantics goes further...”

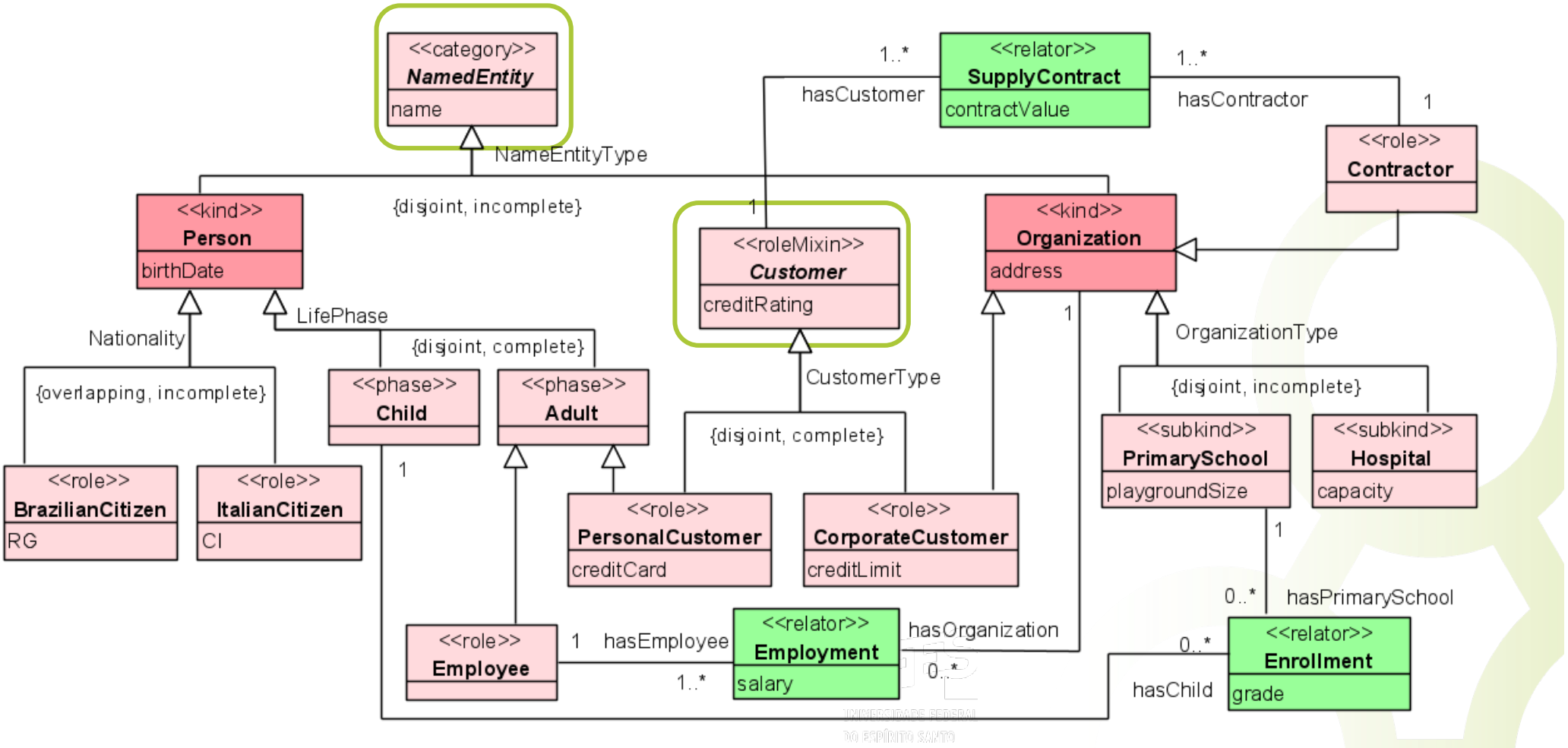
Exploring the taxonomy of types

- Leverage opportunities in the different sorts of classes there are
- OWL only sees “classes”
- UFO (and hence gUFO) sees a variety of types

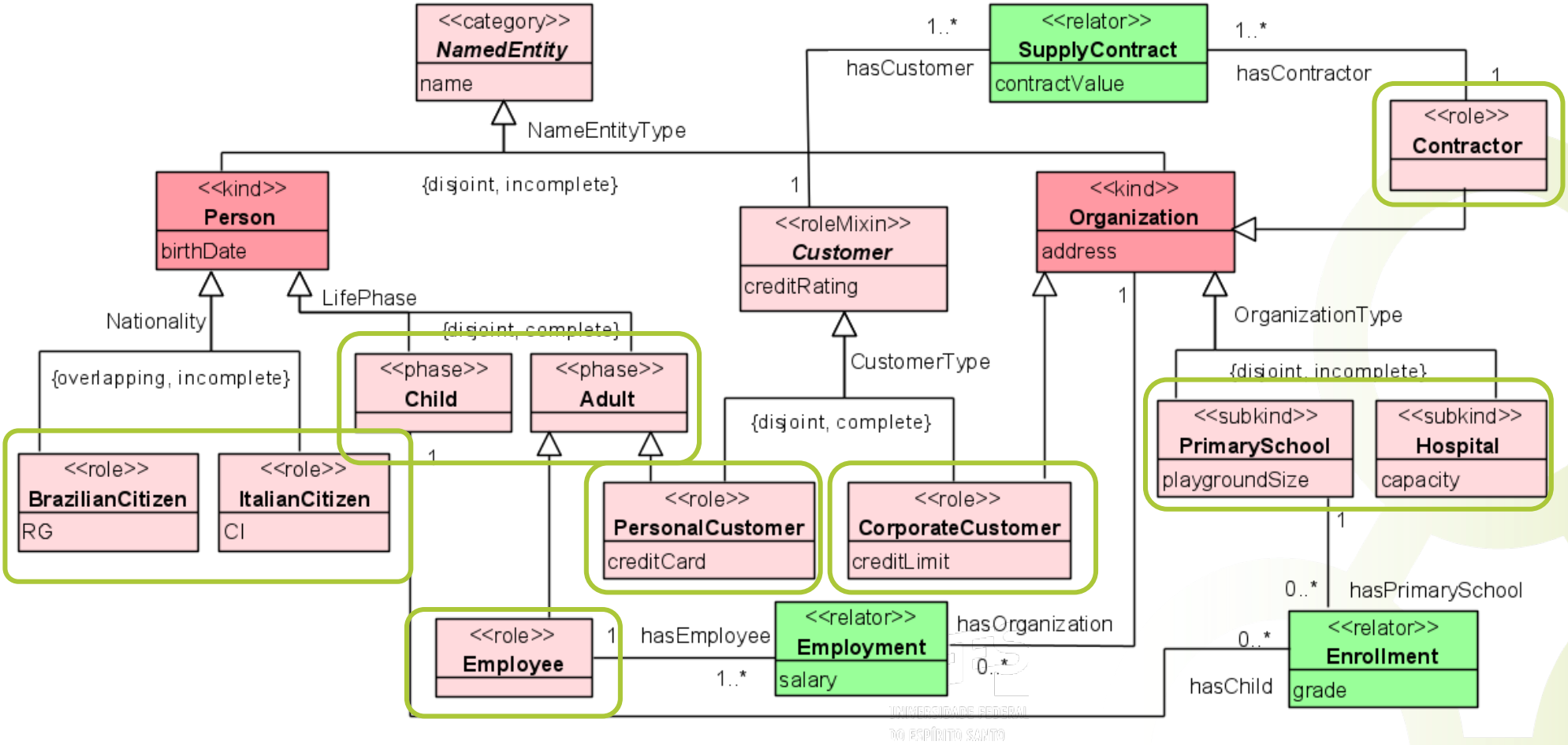
Kinds partition the entities in our domain



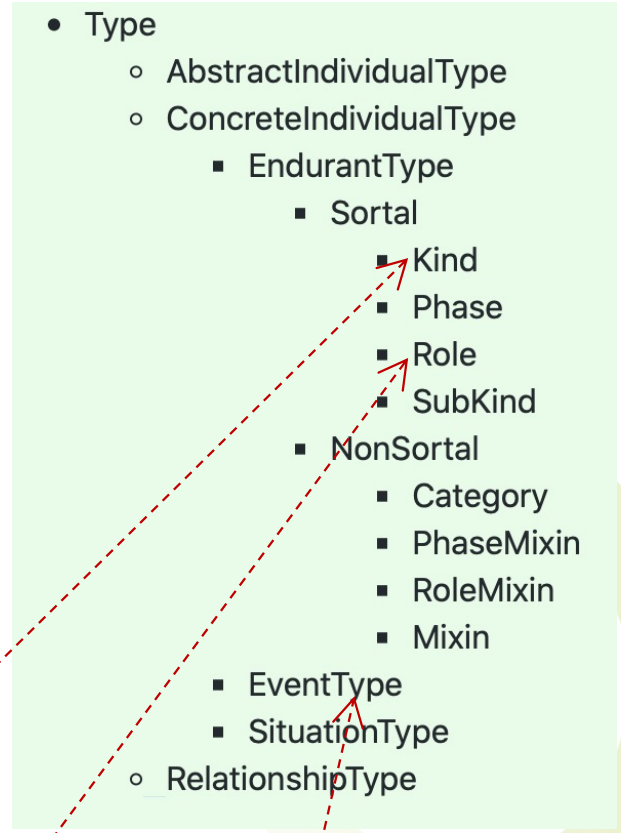
Non-sortals classify entities of different kinds



Sortals specialize a kind in different ways

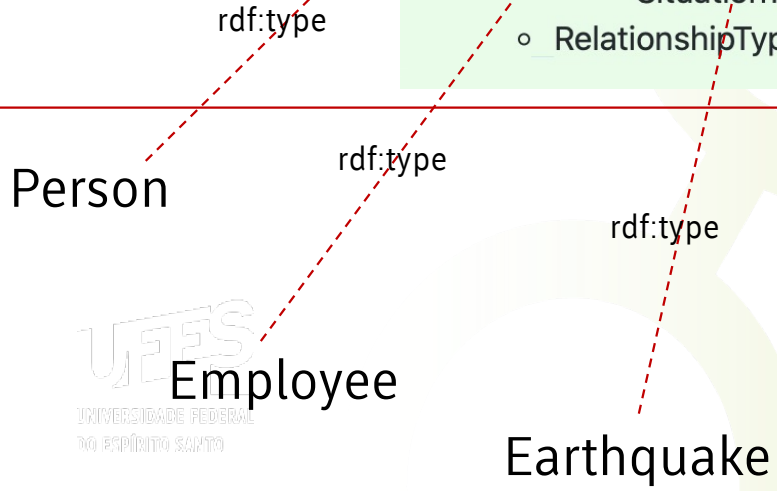


gUFO taxonomy of types



gUFO

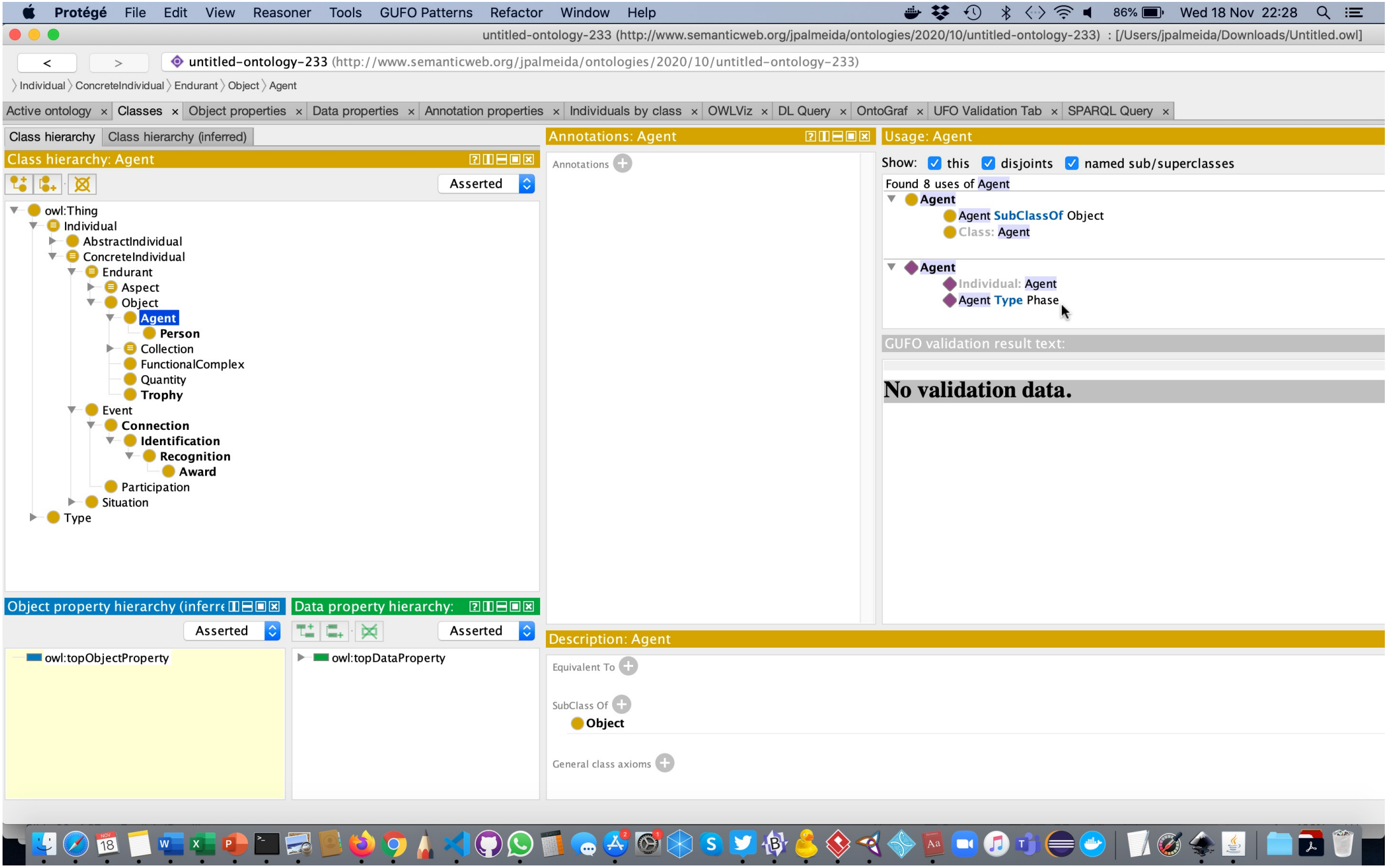
gUFO-based (domain) ontology

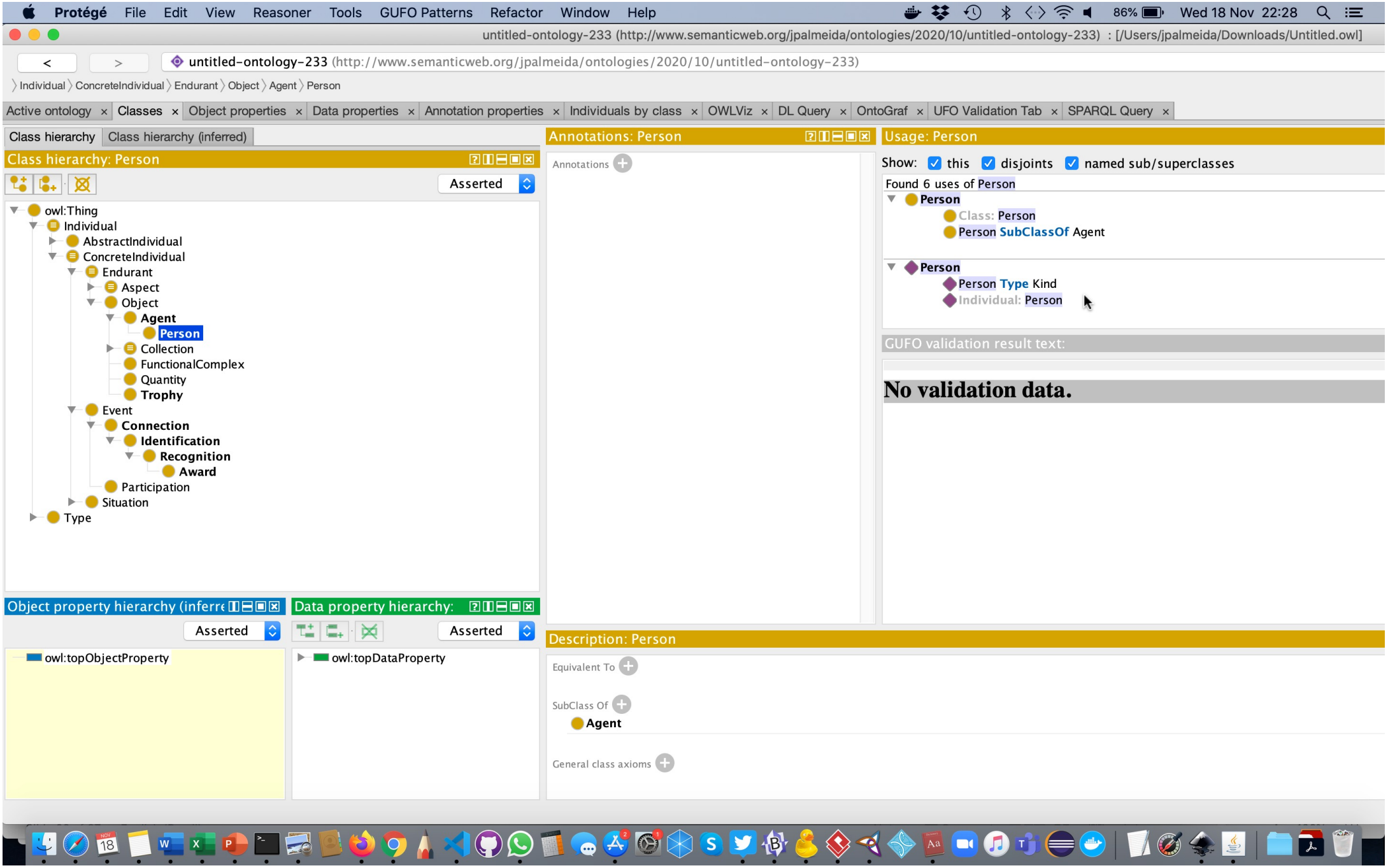


Error detection for endurant types

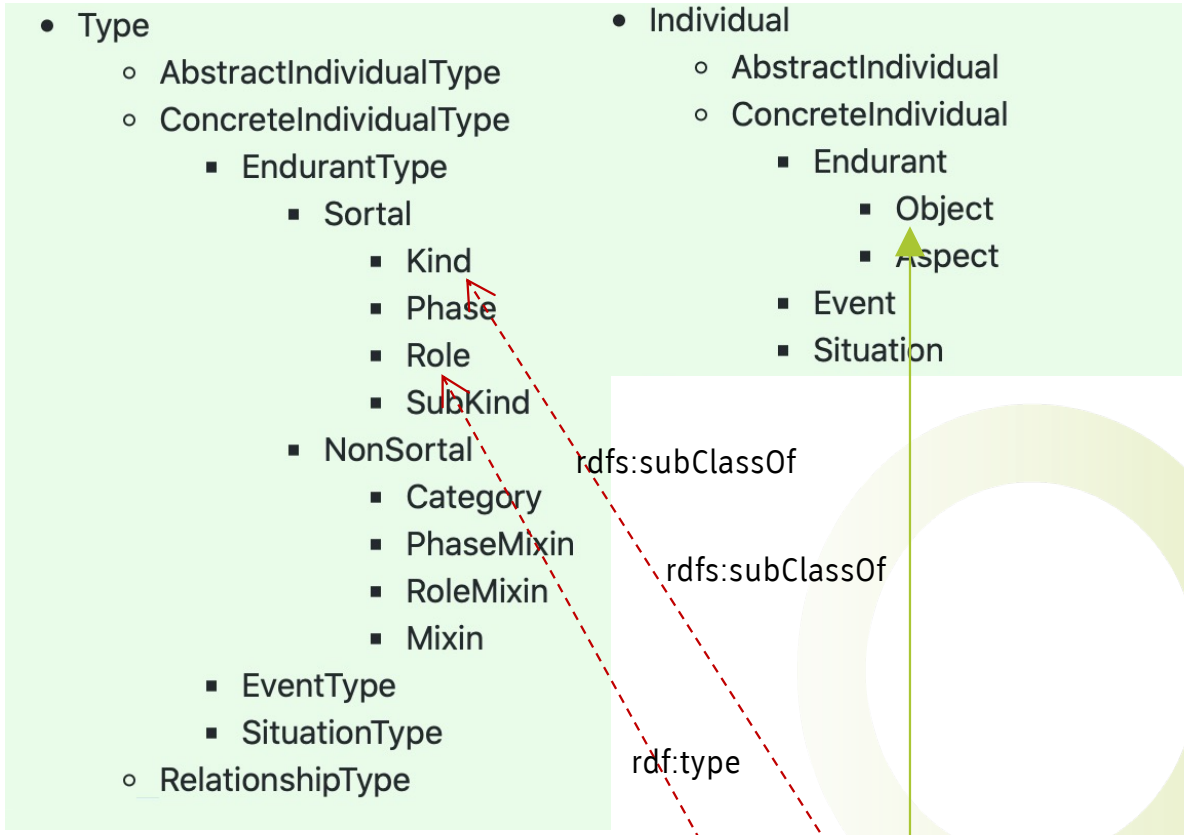
- Non-sortals cannot subclass sortals
- Sortals cannot specialize more than one kind
- Rigid types cannot subclass anti-rigid types
- etc...

- Reflect UFO theorems (with automated proof see ER 2018 paper)
  - https://doi.org/10.1007/978-3-030-00847-5_12
- Operationalize OntoClean's domain-independent metaproperties in analogy with OntoUML syntactic rules
- Verbalize results


Protégé File Edit View Reasoner Tools GUFO Patterns Refactor Window Help
86% Wed 18 Nov 22:28
untitled-ontology-233 (http://www.semanticweb.org/jpalmeida/ontologies/2020/10/untitled-ontology-233) : [/Users/jpalmeida/Downloads/Untitled.owl]
untitled-ontology-233 (http://www.semanticweb.org/jpalmeida/ontologies/2020/10/untitled-ontology-233)
Individual ConcreteIndividual Endurant Object Agent
Active ontology Classes Object properties Data properties Annotation properties Individuals by class OWLViz DL Query OntoGraf UFO Validation Tab SPARQL Query
Class hierarchy Class hierarchy (inferred)
Class hierarchy: Agent
Asserted
owl:Thing
Individual
AbstractIndividual
ConcreteIndividual
Endurant
Aspect
Object
Agent
Person
Collection
FunctionalComplex
Quantity
Trophy
Event
Connection
Identification
Recognition
Award
Participation
Situation
Type
Annotations: Agent
Annotations
Usage: Agent
Show: this disjoints named sub/superclasses
Found 8 uses of Agent
Agent
Agent SubClassOf Object
Class: Agent
Agent
Individual: Agent
Agent Type Phase
GUFO validation result text:
No validation data.
Object property hierarchy (inferre
Asserted
owl:topObjectProperty
Data property hierarchy:
Asserted
owl:topDataProperty
Description: Agent
Equivalent To
SubClass Of
Object
General class axioms


Protégé File Edit View Reasoner Tools GUFO Patterns Refactor Window Help
86% Wed 18 Nov 22:28
untitled-ontology-233 (http://www.semanticweb.org/jpalmeida/ontologies/2020/10/untitled-ontology-233) : [/Users/jpalmeida/Downloads/Untitled.owl]
untitled-ontology-233 (http://www.semanticweb.org/jpalmeida/ontologies/2020/10/untitled-ontology-233)
Individual ConcreteIndividual Endurant Object Agent Person
Active ontology Classes Object properties Data properties Annotation properties Individuals by class OWLViz DL Query OntoGraf UFO Validation Tab SPARQL Query
Class hierarchy Class hierarchy (inferred)
Class hierarchy: Person
Asserted
owl:Thing
Individual
AbstractIndividual
ConcreteIndividual
Endurant
Aspect
Object
Agent
Person
Collection
FunctionalComplex
Quantity
Trophy
Event
Connection
Identification
Recognition
Award
Participation
Situation
Type
Annotations: Person
Annotations
Usage: Person
Show: this disjoints named sub/superclasses
Found 6 uses of Person
Person
Class: Person
Person SubClassOf Agent
Person
Person Type Kind
Individual: Person
GUFO validation result text:
No validation data.
Object property hierarchy (inferre
Asserted
owl:topObjectProperty
Data property hierarchy:
Asserted
owl:topDataProperty
Description: Person
Equivalent To
SubClass Of
Agent
General class axioms

Combining gUFO taxonomies

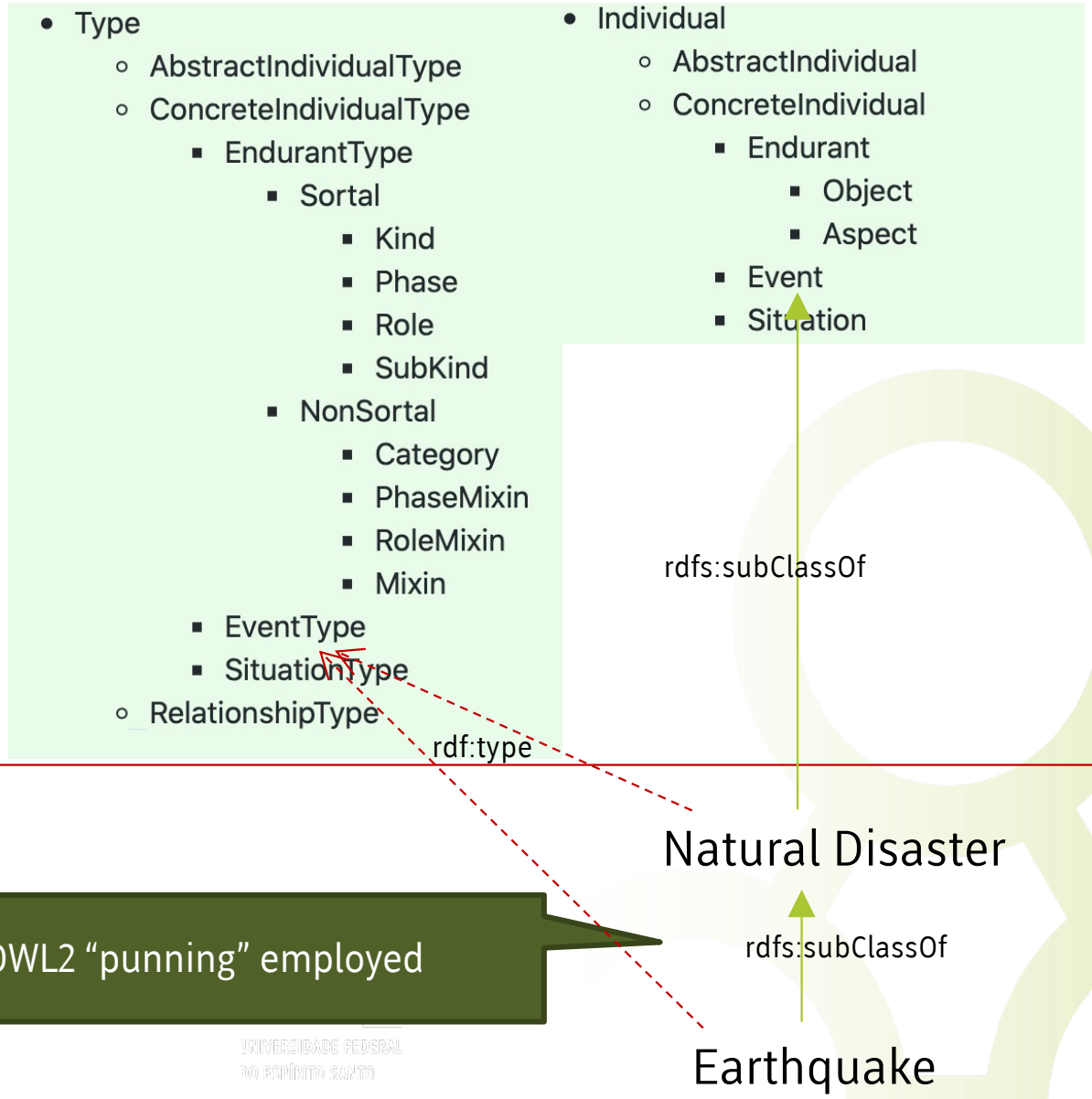


gUFO

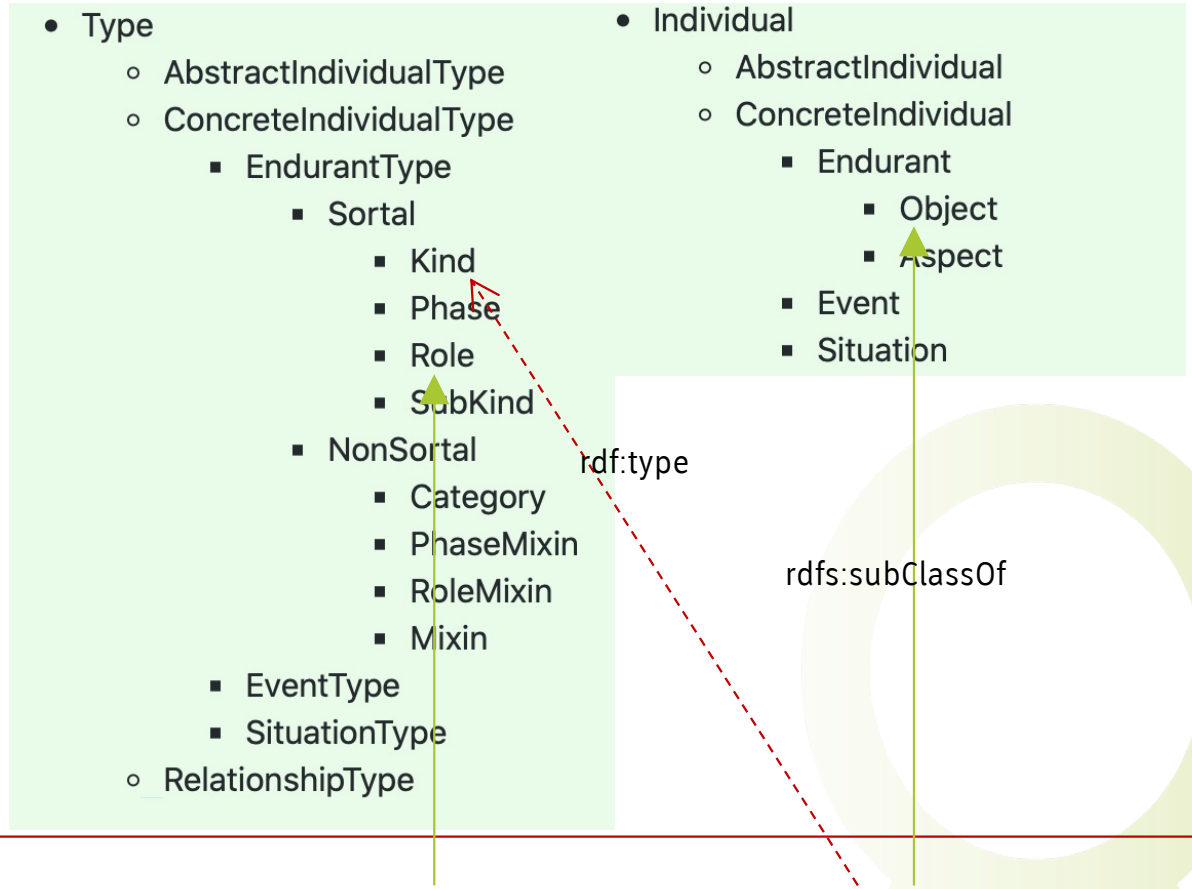
gUFO-based (domain) ontology

OWL2 “punning” employed

Combining gUFO taxonomies



gUFO and high-order types



Hands on!

Conclusions

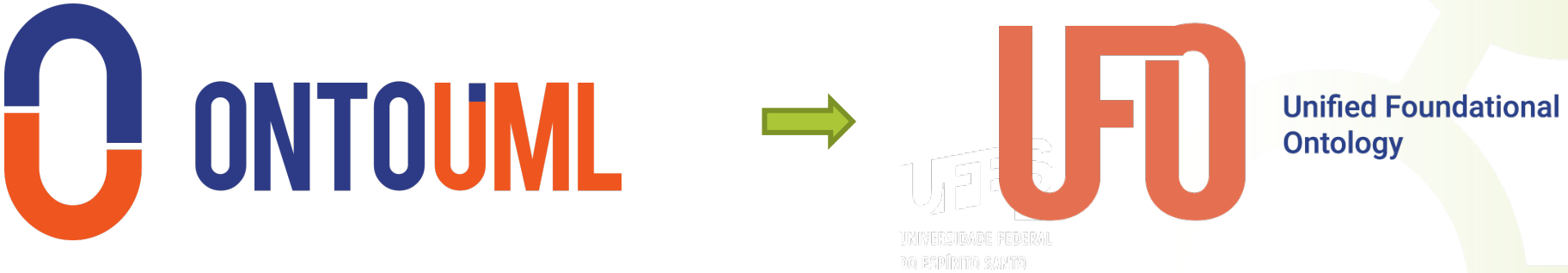
- We need all the help we can get!
  - Rules
  - Reuse
  - Foundational patterns
  - Automation of quality control
- Leverage benefits that were only available to OntoUML users to Semantic Web implementers
- Better integration between the taxonomy of types and taxonomy of individuals than in OntoUML (due to limitations of UML)

How about expressiveness?

- OWL 2 DL fragment employed
- But less expressive fragments possible
  - Application-dependent choices on what restrictions to leave out
  - E.g., punning can be ignored or replaced by annotation properties
- Rules that cannot be expressed in OWL are implemented in the plugin
  - But can be expressed as shape constraints: SHACL

How does it fit in the overall UFO/OntoUML ecosystem?

- OntoUML to gUFO-based OWL transformation
  - incorporated in OntoUML Visual Paradigm plugin
- Using OntoUML as a starting point gives access to simulation, antipattern detection
- gUFO-based Ontology-Based Data Access (OBDA)
  - high-level access to relational data



Ongoing and future work

- gUFO-based publication of water quality data in the Rio Doce (CNPq/CAPES project)
- Pattern-based development in Protégé Plugin
- Reverse engineering OWL ontologies to OntoUML
- gUFO-based implementations of UFO-based reference ontologies:
  - gUFO-C: Intentional and Social Layer (Agent, Goal, Social Relations)
  - gUFO-L: Core Ontology of Legal Aspects (Legal Norm, Legal Relations)
  - gUFO-S: Core Ontology of Services (Service Offering, Agreement, Delivery)
- http://purl.org/nemo/doc/gufo (reference documentation)
- https://github.com/nemo-ufes/gufo (repository and link to videos)
- https://github.com/nemo-ufes/ufo-protege-plugin