

Ontologies et

Web Sémantique

Les Ontologies – Mise en Œuvre avec Protégé

Plan du cours

1. Protégé
2. Exemple: L'ontologie «African Wildlife »
3. Description de classes, propriétés, instances, en Protégé
4. Restrictions sur les propriétés en Protégé
5. Raisonnements sur les ontologies en Protégé

Présentation de Protégé

Protégé – IDE Ontologies OWL

- Protégé est un système permettant la création d'ontologies très populaire développé à l'Université de Stanford.
- Protégé est développé en Java.
- Protégé fonctionnant sur la machine virtuelle Java, est multiplateformes (linux, Windows, MacOS, ...)
- Protégé est gratuit et son code source est publié sous une licence libre (Mozilla Public License).
- Protégé peut lire et sauvegarder des ontologies dans la plupart des formats d'ontologies : RDF, RDFS, OWL, Turtle, JSON-LD, etc.
- Lien de téléchargement : <https://protege.stanford.edu/>
- Web Protégé : <https://webprotege.stanford.edu/>

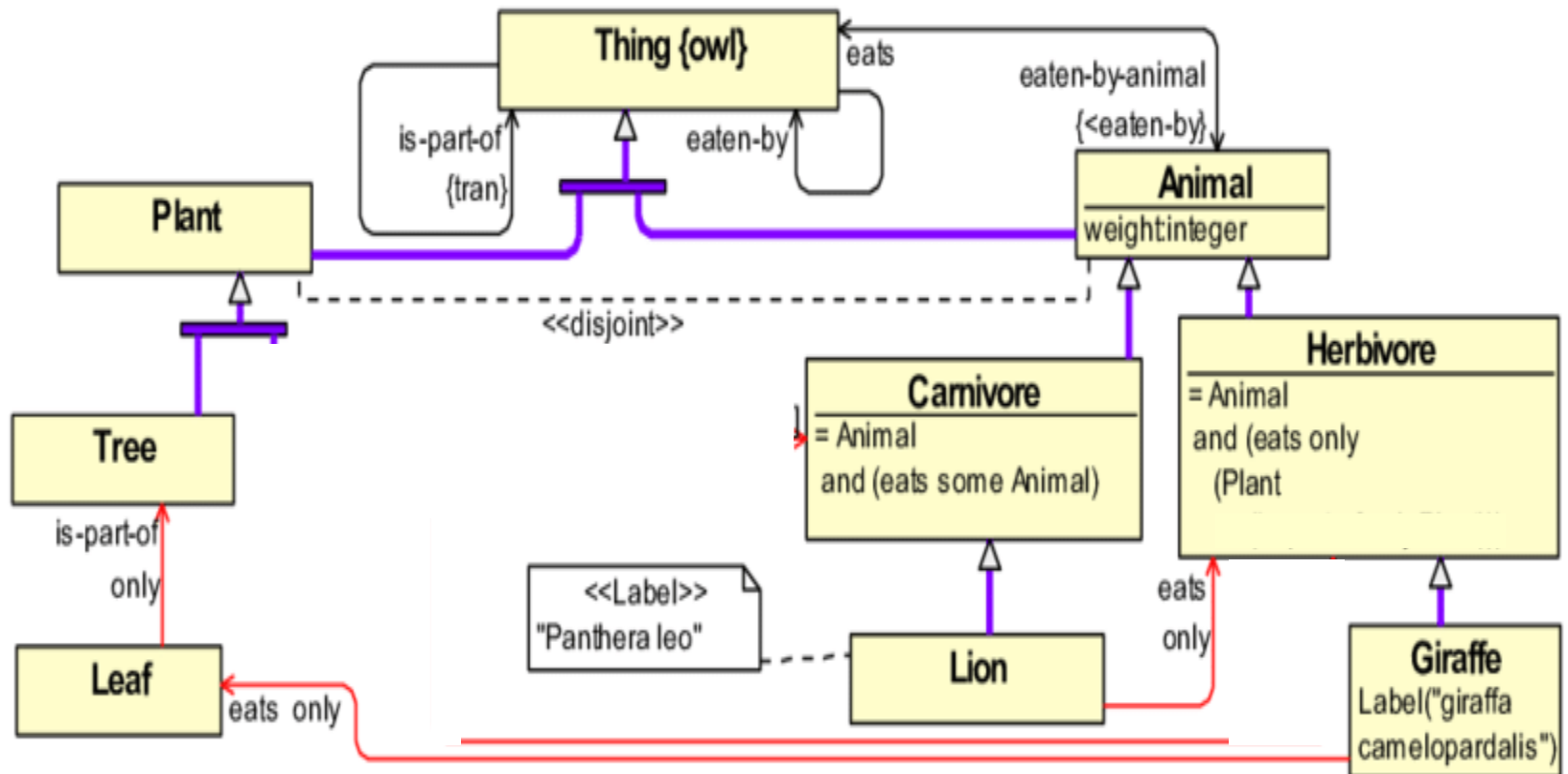
Présentation de Protégé

Protégé – IDE Ontologies OWL

- A télécharger depuis : <https://protege.stanford.edu/>
- Création classes / sous-classes.
- Création de propriétés.
- Restrictions classes / propriétés.
- Paramétrages .
- Création d'instances de classes.
- Vérifier l'ontologie. Reasoning.
- Visualisation en graphe. Interrogation SPARQL.
- Etc.

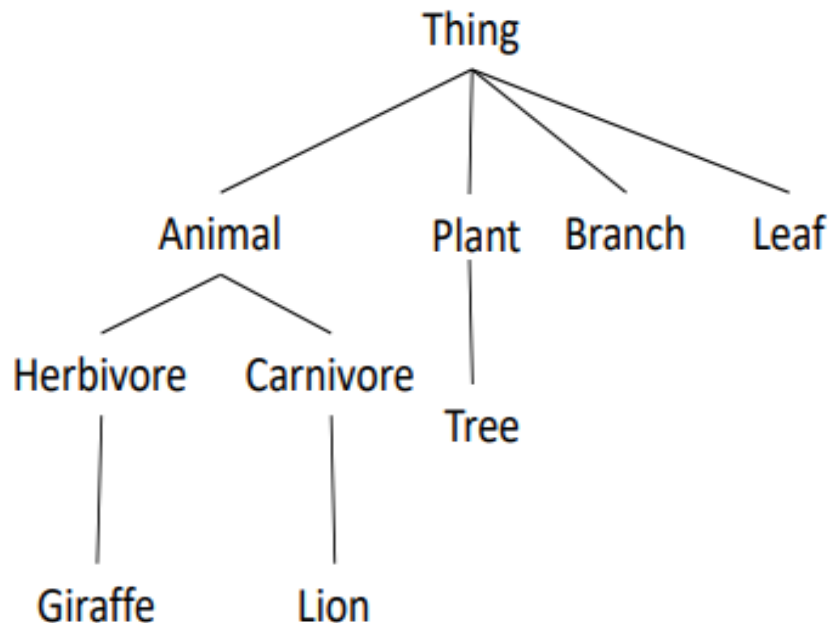
Exemple - African Wildlife Ontology

- **Source** : Antoniou, G, van Harmelen, F. A Semantic Web Primer. MIT Press, 2003.
- Réadaptée.

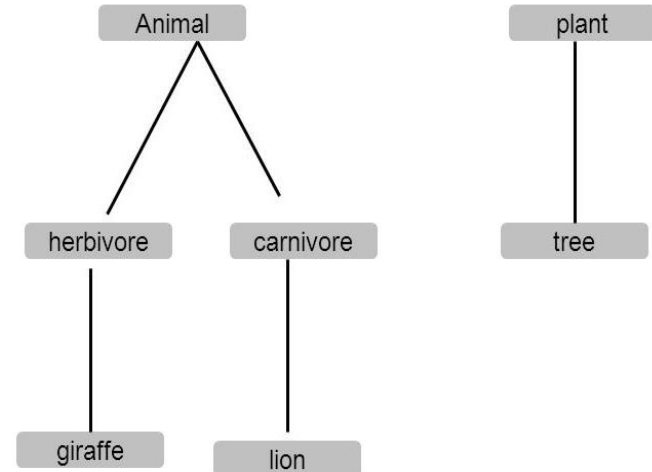


Exemple - African Wildlife Ontology

- **Source** : Antoniou, G, van Harmelen, F. A Semantic Web Primer. MIT Press, 2003. *Réadaptée*.
- **Objet** : Cette ontologie décrit la vie animale en Afrique avec :
 - des animaux: carnivores (des lions) et herbivores (des girafes)
 - des plantes telles que des arbres composés de branches et de feuilles



An African Wildlife Ontology – Class Hierarchy



Exemple - African Wildlife Ontology

▪ Déclaration de **Classes** :

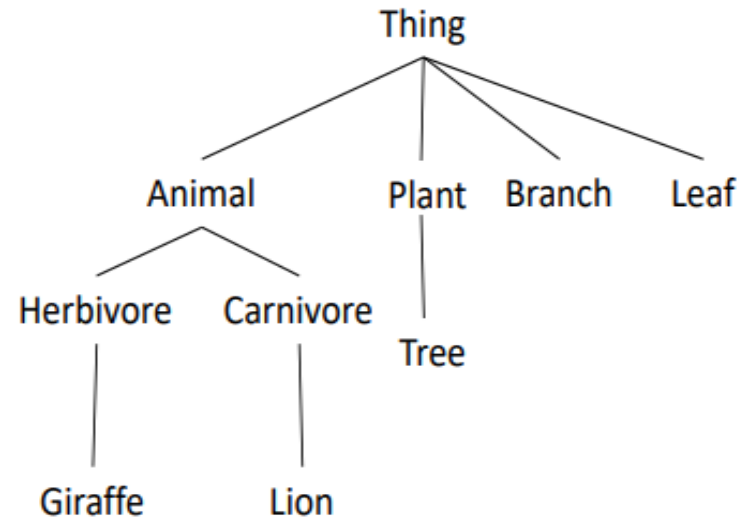
```
<owl:Class rdf:ID="Animal"/>
```

```
<owl:Class rdf:ID="Herbivore">  
  <rdfs:subClassOf rdf:resource="#Animal"/>  
</owl:Class>
```

```
<owl:Class rdf:ID="Carnivore">  
  <rdfs:subClassOf rdf:resource="#Animal"/>  
</owl:Class>
```

```
<owl:Class rdf:ID="Lion">  
  <rdfs:subClassOf rdf:resource="#Carnivore"/>  
</owl:Class>
```

```
<owl:Class rdf:ID="Giraffe">  
  <rdfs:subClassOf rdf:resource="#Herbivore"/>  
</owl:Class>
```



Exemple - African Wildlife Ontology

▪ Déclaration de **Classes** :

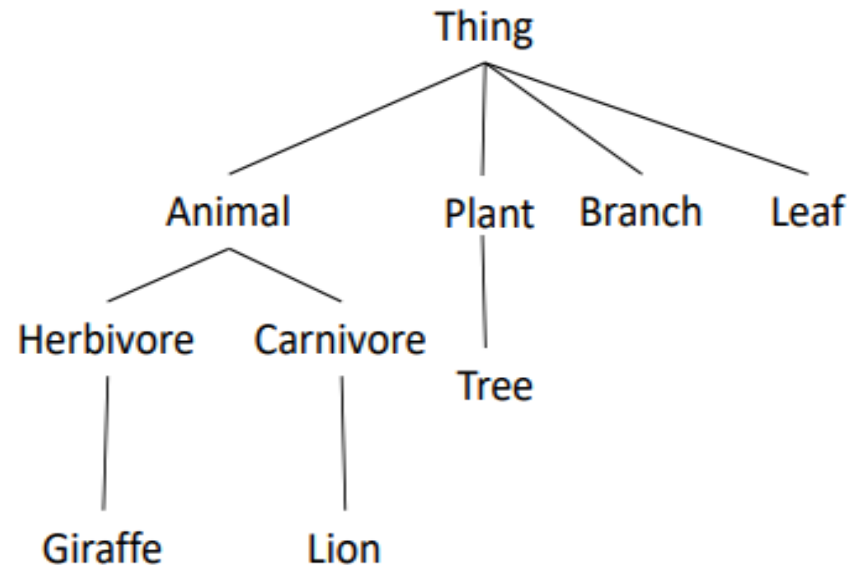
...

```
<owl:Class rdf:ID="Plant"/>
```

```
<owl:Class rdf:ID="Tree">  
  <rdfs:subClassOf rdf:resource="#Plant"/>  
</owl:Class>
```


```
<owl:Class rdf:ID="Branch"/>
```

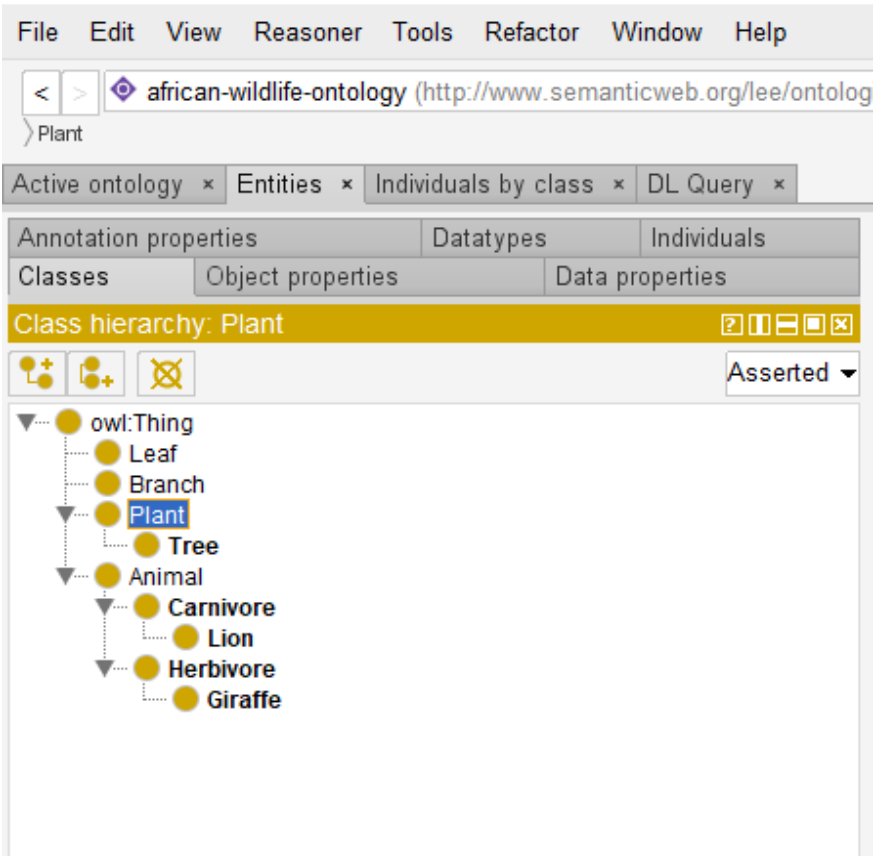
```
<owl:Class rdf:ID="Leaf"/>
```



Exemple - African Wildlife Ontology

▪ Déclaration de **Classes** : dans Protégé

 african-wildlife-ontology (<http://www.semanticweb.org>)



File Edit View Reasoner Tools Refactor Window Help

< > african-wildlife-ontology (<http://www.semanticweb.org/lee/ontology>)

Plant

Active ontology x Entities x Individuals by class x DL Query x

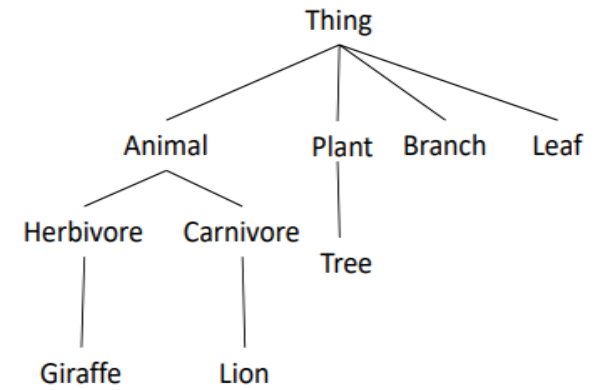
Annotation properties Datatypes Individuals


Classes Object properties Data properties

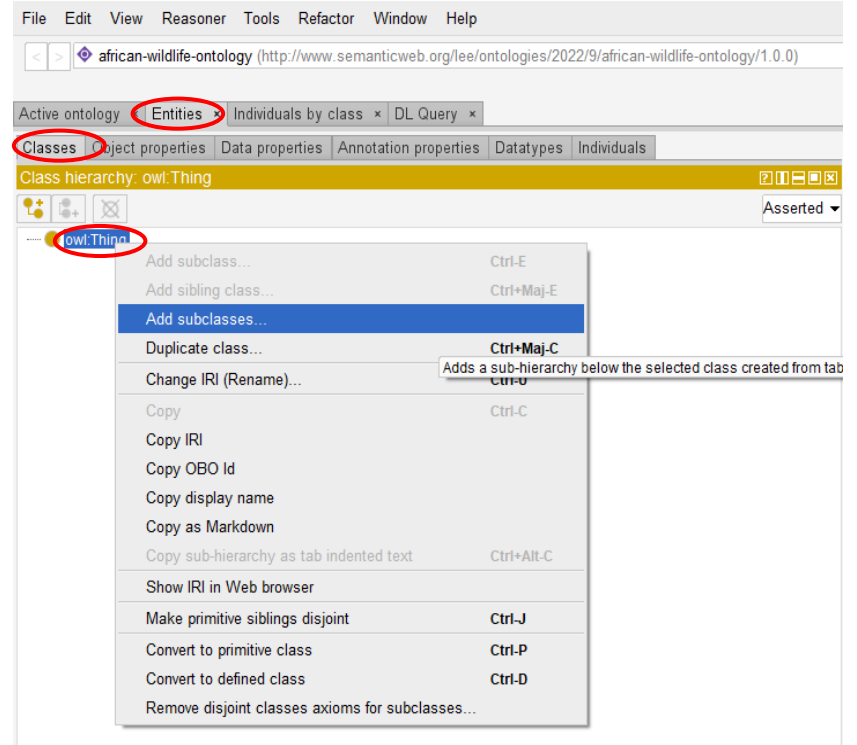
Class hierarchy: Plant

Asserted

- owl:Thing
 - Leaf
 - Branch
 - Tree
 - Animal
 - Carnivore
 - Lion
 - Herbivore
 - Giraffe



 african-wildlife-ontology (<http://www.semanticweb.org/lee/ontologies/2022/9/african-wildlife-ontology/1.0.0>)



File Edit View Reasoner Tools Refactor Window Help

< > african-wildlife-ontology (<http://www.semanticweb.org/lee/ontologies/2022/9/african-wildlife-ontology/1.0.0>)

Active ontology x Entities x Individuals by class x DL Query x

Classes Object properties Data properties Annotation properties Datatypes Individuals

Class hierarchy: owl:Thing

Asserted

- owl:Thing
 - Leaf
 - Branch
 - Tree
 - Animal
 - Carnivore
 - Lion
 - Herbivore
 - Giraffe

Context menu options:

- Add subclass... (Ctrl-E)
- Add sibling class... (Ctrl+Maj-E)
- Add subclasses...
- Duplicate class... (Ctrl+Maj-C)
- Change IRI (Rename)... (Adds a sub-hierarchy below the selected class created from tab)
- Copy (Ctrl-C)
- Copy IRI
- Copy OBO Id
- Copy display name
- Copy as Markdown
- Copy sub-hierarchy as tab indented text (Ctrl+Alt-C)
- Show IRI in Web browser
- Make primitive siblings disjoint (Ctrl-J)
- Convert to primitive class (Ctrl-P)
- Convert to defined class (Ctrl-D)
- Remove disjoint classes axioms for subclasses...

Exemple - African Wildlife Ontology

- Déclaration de **Propriétés** : **ObjectProperty**

```
<owl:ObjectProperty rdf:ID="is-part-of" >  
  <rdf:type rdf:resource="&owl;#TransitiveProperty"/>  
  <rdf:type rdf:resource="&owl;#ReflexiveProperty"/>  
</owl:ObjectProperty>
```

```
<owl:ObjectProperty rdf:ID="eats">  
  <rdfs:domain rdf:resource="#Animal"/>  
</owl:ObjectProperty>
```

```
<owl:ObjectProperty rdf:ID="eaten-by">  
  <owl:inverseOf rdf:resource="#eats"/>  
  <rdf:type rdf:resource="&owl;#ReflexiveProperty"/>  
</owl:ObjectProperty>
```

Exemple - African Wildlife Ontology

- Déclaration de **Propriétés** : DatatypeProperty

```
<owl:DatatypeProperty rdf:about="weight">
```

```
  <rdfs:domain rdf:resource="#Animal"/>
```

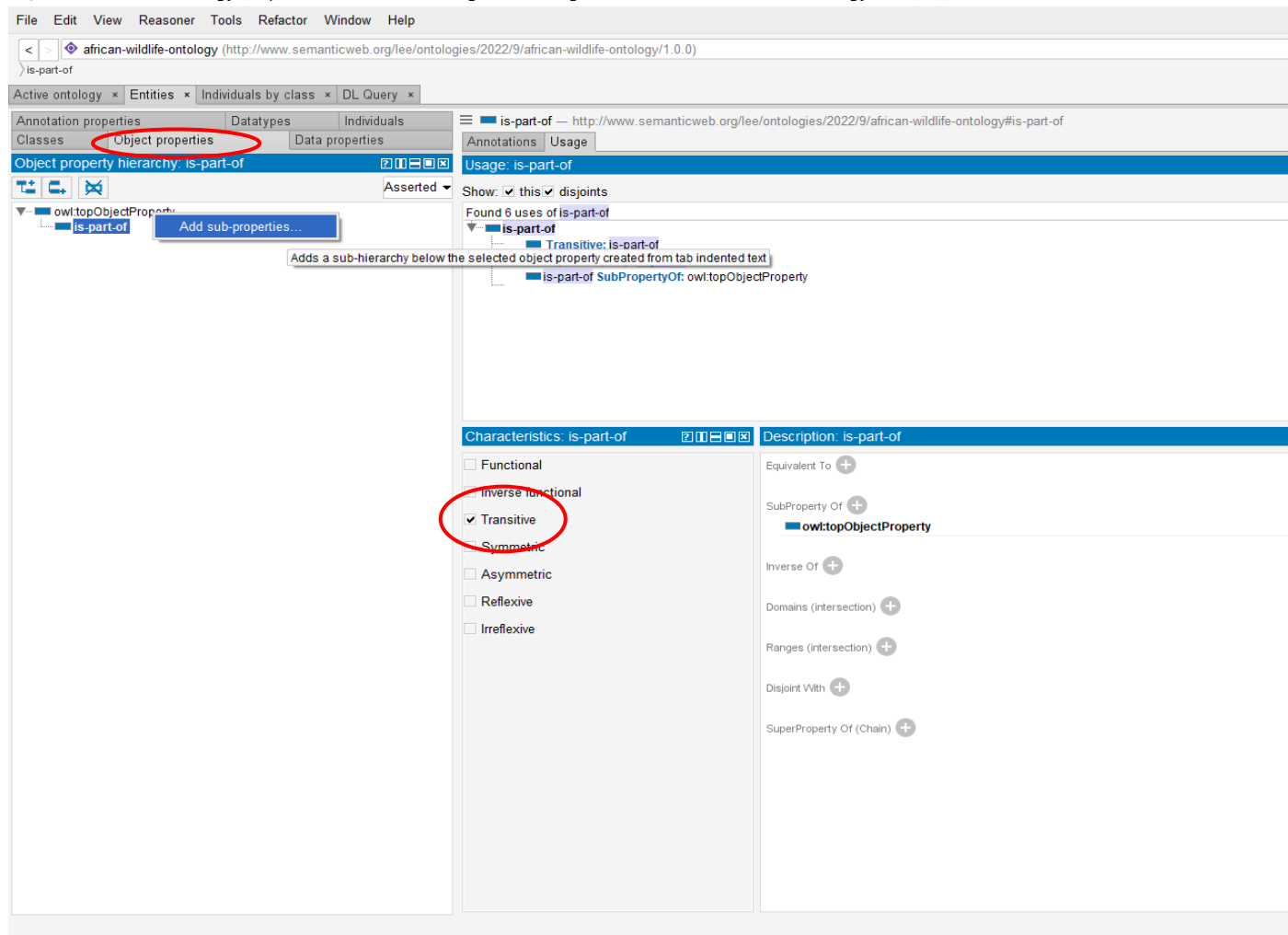
```
  <rdfs:range rdf:resource=  
    "http://www.w3.org/2001/XMLSchema#nonNegativeInteger"/>
```

```
</owl:DatatypeProperty>
```



Exemple - African Wildlife Ontology

■ Déclaration de **Propriétés** : dans Protégé



Exemple - African Wildlife Ontology

■ Déclaration de **Propriétés** : dans Protégé

The screenshot displays the Protégé ontology editor interface for the African Wildlife Ontology. The top navigation bar includes tabs for 'Active ontology', 'Entities', 'Individuals by class', and 'DL Query'. Below this, the 'Object properties' tab is selected and circled in red. The left sidebar shows the 'Object property hierarchy' for 'eats', with 'eaten-by' and 'is-part-of' listed as sub-properties. The main panel shows the 'Usage: eats' section, which lists 10 uses of the property. The 'Characteristics: eats' section on the right lists various property characteristics, with 'Domains (intersection)' circled in red and 'Animal' listed as the domain. The 'Description: eats' section on the right shows the property's description, including 'Equivalent To', 'SubProperty Of', 'Inverse Of', 'Domains (intersection)', 'Ranges (intersection)', 'Disjoint With', and 'SuperProperty Of (Chain)'.

Active ontology x Entities x Individuals by class x DL Query x

Annotation properties x Datatypes x Individuals x Classes x **Object properties** x Data properties

Object property hierarchy: eats

owl:topObjectProperty

- eaten-by
- eats**
- is-part-of

Annotations Usage

Usage: eats

Show: ☒ this ☒ disjoints

Found 10 uses of eats

- eaten-by
 - eaten-by InverseOf eats
- eats
 - eaten-by InverseOf eats
 - ObjectProperty: eats
 - eats SubPropertyOf: owl:topObjectProperty
 - eats Domain Animal

Characteristics: eats

☐ Functional

☐ Inverse functional

☐ Transitive

☐ Symmetric

☐ Asymmetric

☐ Reflexive

☐ Irreflexive

Description: eats

Equivalent To +

SubProperty Of +

owl:topObjectProperty

Inverse Of +

eaten-by

Domains (intersection) +

Animal

Ranges (intersection) +

Disjoint With +

SuperProperty Of (Chain) +

Exemple - African Wildlife Ontology

■ Déclaration de **Propriétés** : dans Protégé

The screenshot displays the Protégé ontology editor interface. The top navigation bar includes tabs for 'Active ontology', 'Entities', 'Individuals by class', and 'DL Query'. The left sidebar shows the 'Object property hierarchy' for 'eaten-by', with a tree structure including 'owl:topObjectProperty', 'eaten-by', 'eats', and 'is-part-of'. The main area is divided into two panes. The top pane, titled 'Usage: eaten-by', shows 'Found 4 uses of eaten-by' and lists 'ObjectProperty: eaten-by' and 'eaten-by SubPropertyOf: owl:topObjectProperty'. The bottom pane, titled 'Description: eaten-by', contains a list of characteristics (Functional, Inverse functional, Transitive, Symmetric, Asymmetric, Reflexive, Irreflexive) and a list of relationships (Equivalent To, SubProperty Of, Inverse Or, Domains (intersection), Ranges (intersection), Disjoint With, SuperProperty Of (Chain)). The 'Inverse Or' relationship is highlighted with a red circle, and the 'eats' property is listed as its inverse.

Active ontology × Entities × Individuals by class × DL Query ×

Annotation properties | Datatypes | Individuals | **Classes** | Object properties | Data properties

Object property hierarchy: eaten-by [?] [] [] [] []

Annotations | Usage

Usage: eaten-by

Show: ☒ this ☒ disjoints

Found 4 uses of eaten-by

▼ eaten-by

- ObjectProperty: eaten-by
- eaten-by SubPropertyOf: owl:topObjectProperty

Characteristics: eaten-by [?] [] [] [] []

- ☐ Functional
- ☐ Inverse functional
- ☐ Transitive
- ☐ Symmetric
- ☐ Asymmetric
- ☐ Reflexive
- ☐ Irreflexive

Description: eaten-by

- Equivalent To +
- SubProperty Of +
 - owl:topObjectProperty
- Inverse Or +**
 - eats**
- Domains (intersection) +
- Ranges (intersection) +
- Disjoint With +
- SuperProperty Of (Chain) +

Exemple - African Wildlife Ontology

▪ Déclaration de **Classes** :

ies/2022/9/african-wildlife-ontology/1.0.0)

Animal — <http://www.semanticweb.org/lee/ontologies/2022/9/african-wildlife-ontology#Animal>

Annotations Usage

Usage: Animal

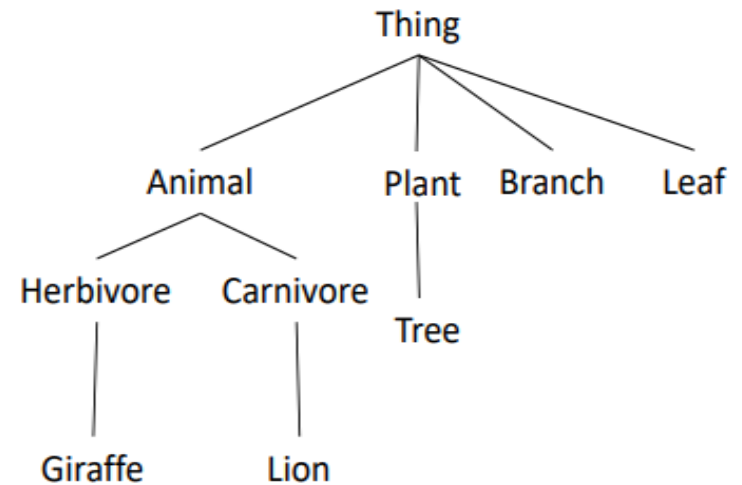
Show: ☒ this ☒ disjoints ☒ named sub/superclasses

Found 6 uses of Animal

- Animal
 - Class: Animal
- Carnivore
 - Carnivore SubClassOf Animal
- Herbivore
 - Herbivore SubClassOf Animal

Description: Animal

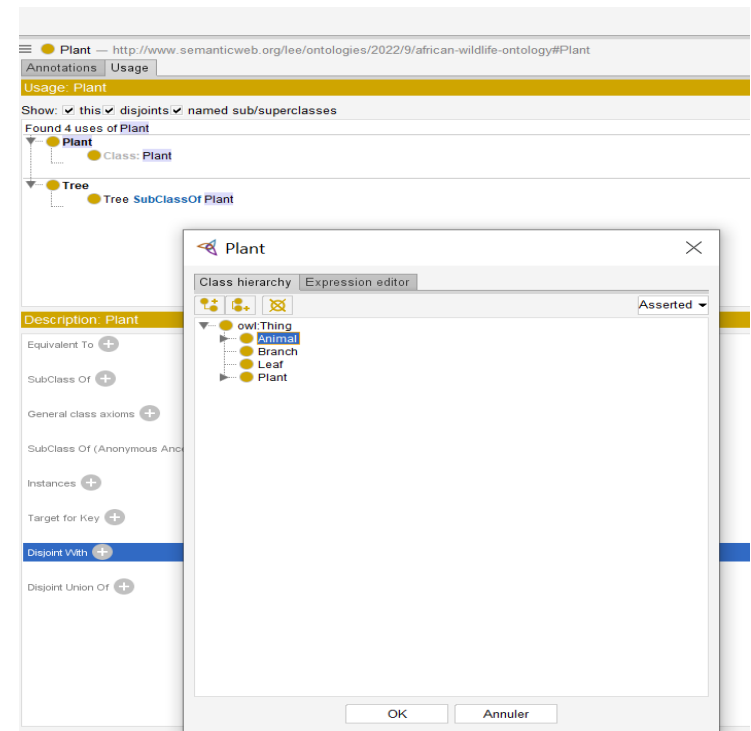
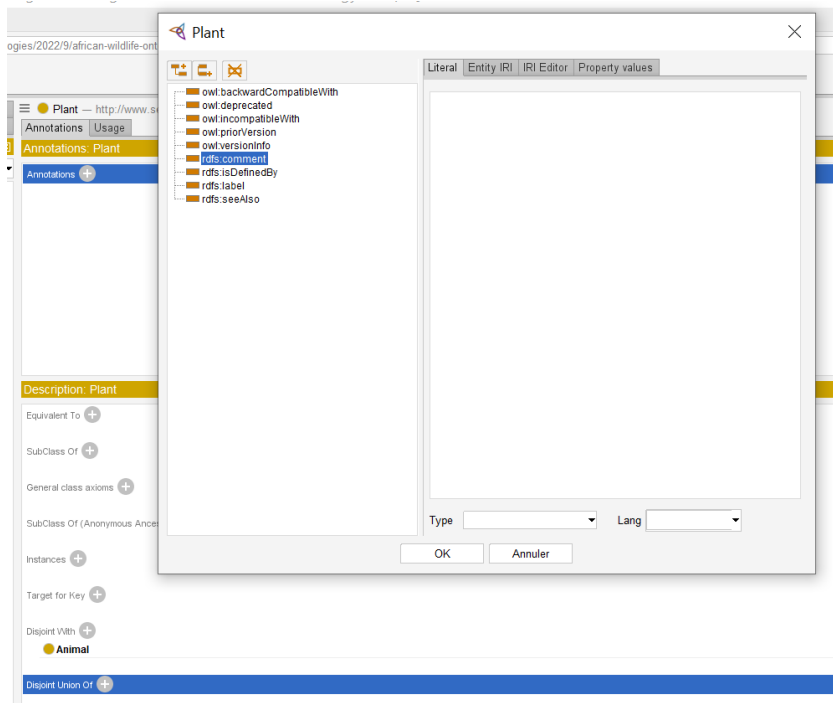
- Equivalent To +
- SubClass Of +
- General class axioms +
- SubClass Of (Anonymous Ancestor)
- Instances +
- Target for Key +
- Disjoint With +
- Disjoint Union Of +



Exemple - African Wildlife Ontology

■ Déclaration de **Classes** : sur Protégé

```
<owl:Class rdf:ID="Plant">  
  <rdfs:comment>Plants are disjoints from animals  
</rdfs:comment>  
  <owl:disjointWith rdf:resource="#Animal"/>  
</owl:Class>
```



Exemple - African Wildlife Ontology

- **Déclaration de Classes** : restrictions sur les propriétés

```
<owl:Class rdf:ID="Carnivore">
```

```
<rdfs:subClassOf rdf:resource="#Animal"/>
```

```
<rdfs:subClassOf>
```

```
<owl:Restriction>
```

```
<owl:onProperty rdf:resource="#eats"/>
```

```
<owl:someValuesFrom rdf:resource="#Animal"/>
```

```
</owl:Restriction>
```

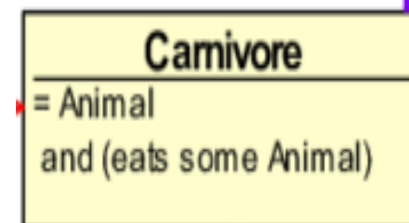
```
</rdfs:subClassOf>
```

```
<rdfs:comment>
```

Carnivores are those animals that eat also animals.

```
</rdfs:comment>
```

```
</owl:Class>
```



Exemple - African Wildlife Ontology

- **Déclaration de **Classes**** : restrictions sur les propriétés – dans Protégé

The screenshot shows the Protégé interface for the African Wildlife Ontology. The main window displays the 'Carnivore' class hierarchy and its description. A 'Description: Carnivore' panel on the left shows 'SubClass Of' relationships with 'Animal' and 'eats some Animal'. A 'Data restriction creator' dialog box is open, showing the 'Object restriction creator' tab. The dialog shows a restricted property 'eats' with a restriction filler 'Animal' and a restriction type 'Some (existential)'.

Class hierarchy: Carnivore

- owl:Thing
 - Leaf
 - Branch
 - Plant
 - Tree
 - Animal
 - Carnivore**
 - Lion
 - Herbivore
 - Giraffe

Description: Carnivore

Equivalent To +

SubClass Of +

- Animal
- eats some Animal

Data restriction creator

Restricted property: owl:topObjectProperty

- eaten-by
- eats
- is-part-of

Restriction filler:

- owl:Thing
 - Animal**
 - Branch
 - Leaf
 - Plant

Restriction type: Some (existential) Cardinality: 1

Exemple - African Wildlife Ontology

- **Déclaration de Classes** : restrictions sur les propriétés

```
<owl:Class rdf:ID="Leaf">
```

```
  <rdfs:comment>
```

```
    Leafs are parts of trees.
```

```
</rdfs:comment>
```

```
  <rdfs:subClassOf>
```

```
    <owl:Restriction>
```

```
      <owl:onProperty rdf:resource="#is-part-of"/>
```

```
      <owl:allValuesFrom rdf:resource="#Tree"/>
```

```
    </owl:Restriction>
```

```
  </rdfs:subClassOf>
```

```
</owl:Class>
```



Exemple - African Wildlife Ontology

- **Déclaration de Classes** : restrictions sur les propriétés

```
<owl:Class rdf:about="#Animal">  
  
  <rdfs:subClassOf>  
    <owl:Restriction>  
      <owl:onProperty rdf:resource="hasAge"/>  
      <owl:cardinality  
        rdf:datatype=&xsd;nonNegativeInteger>  
        1  
      </owl:cardinality>  
    </owl:Restriction>  
  </rdfs:subClassOf>  
  
</owl:Class>
```

Exemple - African Wildlife Ontology

- **Déclaration de Classes** : restrictions sur les propriétés – dans Protégé

The screenshot displays the Protégé ontology editor interface for the 'Animal' ontology. The main window shows the 'Class hierarchy: Animal' on the left, with 'Animal' selected. The 'Annotations: Animal' tab is active, showing the annotation 'Animals form a class.' The 'Description: Animal' tab is also visible, showing the 'SubClass Of' relationship with 'Plant'.

A dialog box titled 'Animal' is open, showing the 'Data restriction creator' tab. The 'Restricted property' is 'hasAge' (under 'owl:topDataProperty'). The 'Restriction filler' list includes various XSD datatypes, with 'xsd:nonNegativeInteger' selected. The 'Restriction type' is set to 'Exactly (exact cardinality)' with a cardinality of '1'.

Description: Animal

Equivalent To +

SubClass Of +

General class axioms +

SubClass Of (Anonymous Ancestor) +

Instances +

Target for Key +

Disjoint With +

Disjoint Union Of +

SubClass Of

- Plant

SubClass Of

- hasAge exactly 1 xsd:nonNegativeInteger

Restricted property

owl:topDataProperty

- hasAge

Restriction filler

- xsd:name
- xsd:NCName
- xsd:negativeInteger
- xsd:NMTOKEN
- xsd:nonNegativeInteger**
- xsd:nonPositiveInteger
- xsd:normalizedString
- xsd:positiveInteger
- xsd:short
- xsd:string
- xsd:token
- xsd:unsignedByte
- xsd:unsignedInt
- xsd:unsignedLong
- xsd:unsignedShort

Restriction type

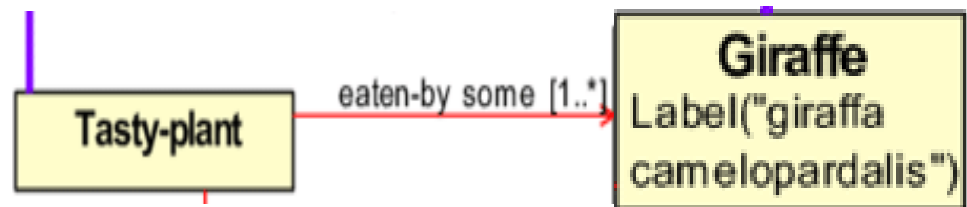
Exactly (exact cardinality) Cardinality 1

OK Annuler

Exemple - African Wildlife Ontology

- **Déclaration de Classes** : restrictions sur les propriétés

```
<owl:Class rdf:about="#Giraffe">  
  
  <rdfs:subClassOf>  
    <owl:Restriction>  
      <owl:onProperty rdf:resource="eaten-by"/>  
      <owl:minCardinality  
        rdf:datatype=&xsd;nonNegativeInteger>  
        1  
      </owl:minCardinality>  
    </owl:Restriction>  
  </rdfs:subClassOf>  
  
</owl:Class>
```



Exemple - African Wildlife Ontology

- **Déclaration de **Classes**** : intersectionOf

```
<owl:Class rdf:ID="Omnivore">
```

```
  <owl:equivalentClass>
```

```
    <owl:Class>
```

```
      <owl:intersectionOf rdf:parseType="Collection">
```

```
        <owl:Class rdf:about="#Herbivore"/>
```

```
        <owl:Class rdf:about="#Carnivore"/>
```

```
      </owl:intersectionOf>
```

```
    </owl:Class>
```

```
  </owl:equivalentClass>
```

```
</owl:Class>
```

Exemple - African Wildlife Ontology

- **Déclaration de Classes** : intersectionOf – dans Protégé

The screenshot displays the Protégé interface for the African Wildlife Ontology. The main window shows the class hierarchy for 'Omnivore', which is a subclass of 'Animal'. The 'Omnivore' class is highlighted in blue. The 'Description' tab for 'Omnivore' is active, showing the 'Equivalent To' section with the expression 'Carnivore and Herbivore'. A red circle highlights the 'Equivalent To' section. A modal dialog titled 'Omnivore' is open, showing the 'Class expression editor' tab. The dialog contains the text 'Carnivore and Herbivore' and has 'OK' and 'Annuler' buttons at the bottom.

afican-wildlife-ontology (<http://www.semanticweb.org/lee/ontologies/2022/9/afican-wildlife-ontology/1.0.0>)

Animal > Carnivore > Omnivore

Active ontology x Entities x Individuals by class x DL Query x

Annotation properties Datatypes Individuals
Classes Object properties Data properties

Annotations Usage

Class hierarchy: Omnivore

Annotations: Omnivore

Annotations +

owl:Thing
Leaf
Branch
Plant
Tree
Animal
Carnivore
Omnivore
Lion
Herbivore
Omnivore
Giraffe

Description: Omnivore

Equivalent To +
Carnivore and Herbivore

SubClass Of +

General class axioms +

SubClass Of (Anonymous Ancestor)
eats some Animal
hasAge exactly 1 xsd:nonNegativeInteger

Instances +

Target for Key +

Omnivore

Object restriction creator Class expression editor Data restriction creator Class hierarchy

Carnivore and Herbivore

Help...

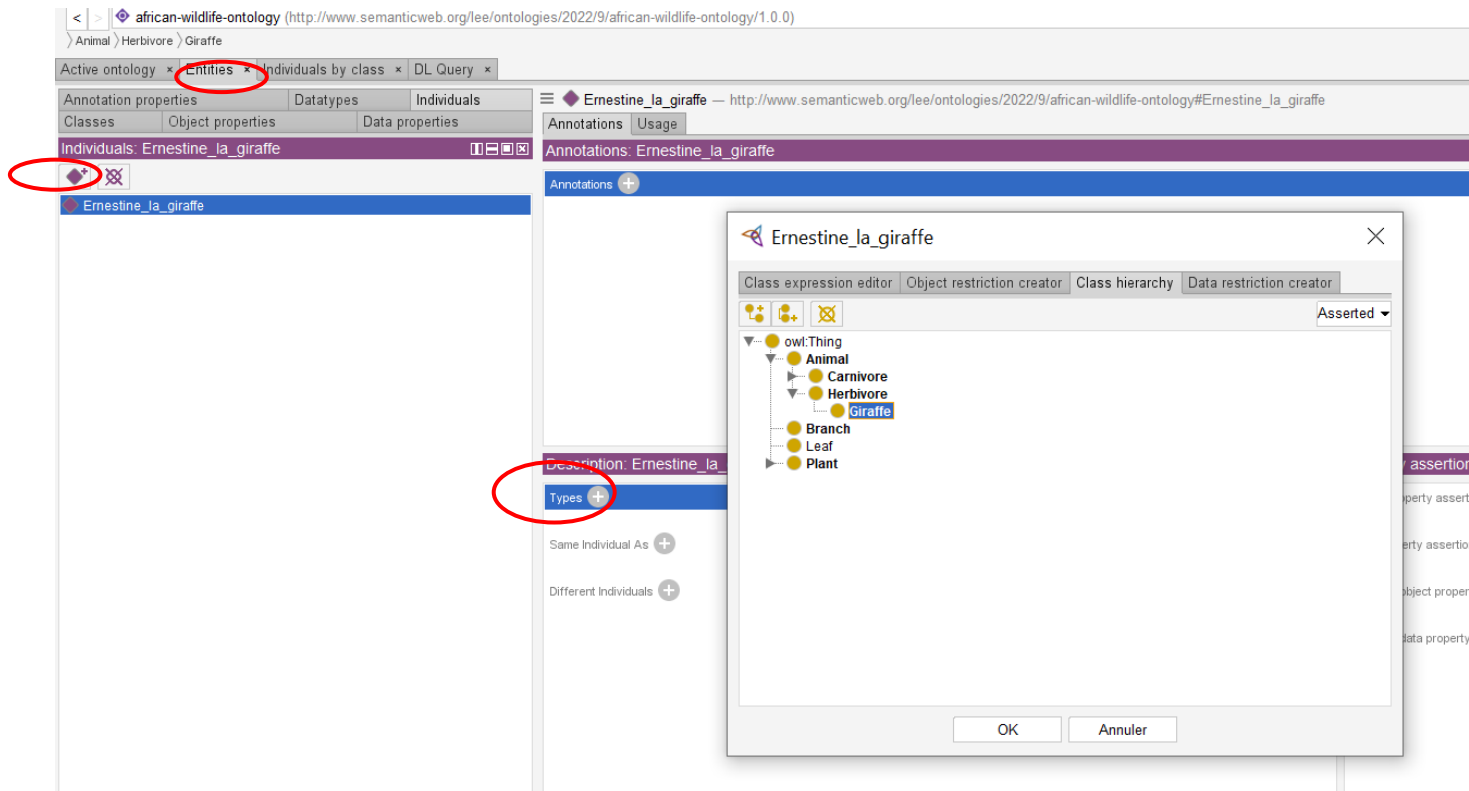
OK Annuler

Exemple - African Wildlife Ontology

- Déclaration des **instances (individuals)** : dans Protégé

```
<Giraffe      rdf:ID="Ernestine_la_girafe"/>
```

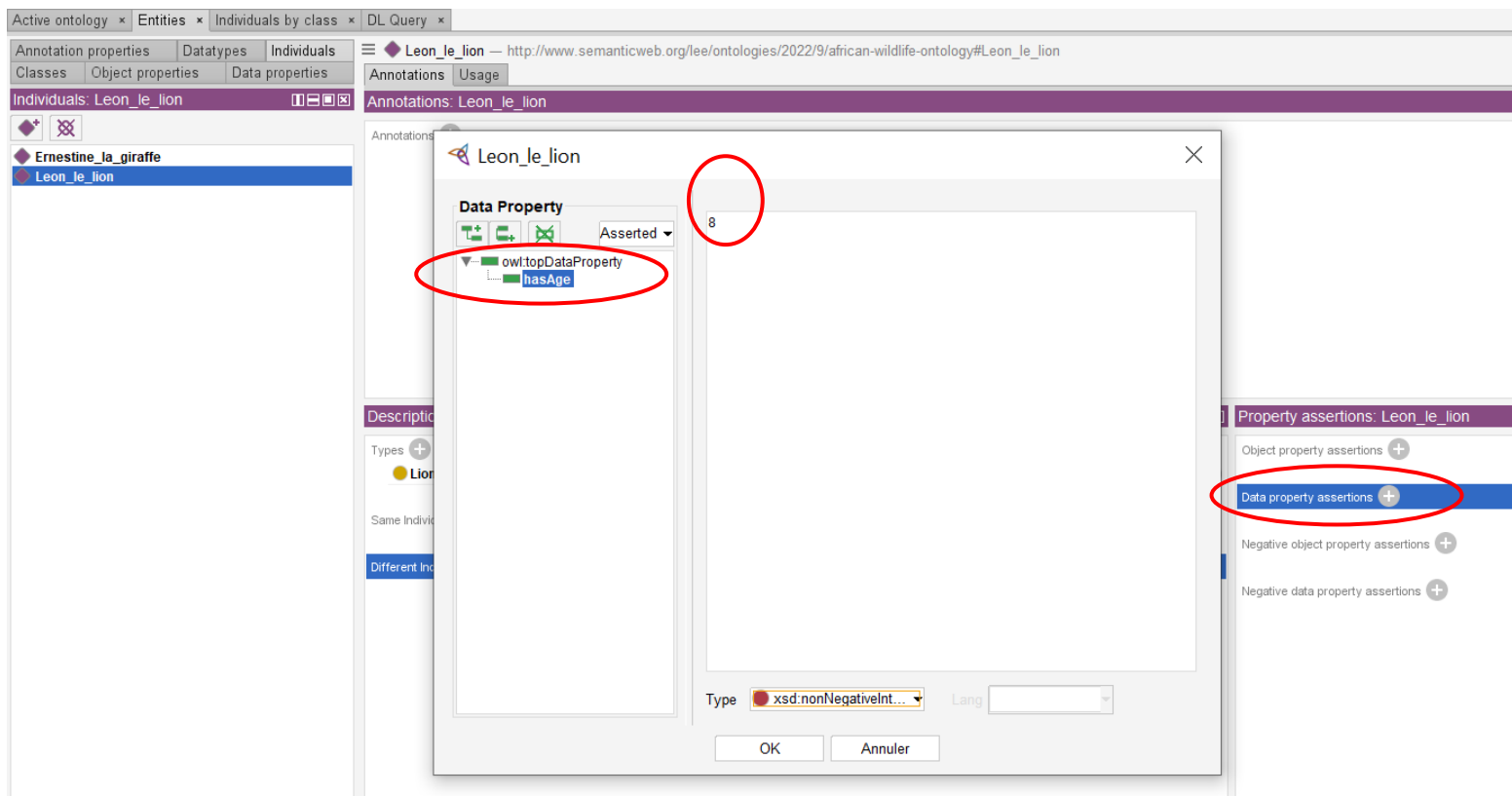
```
<Lion         rdf:ID="Leon_le_lion"/>
```



Exemple - African Wildlife Ontology

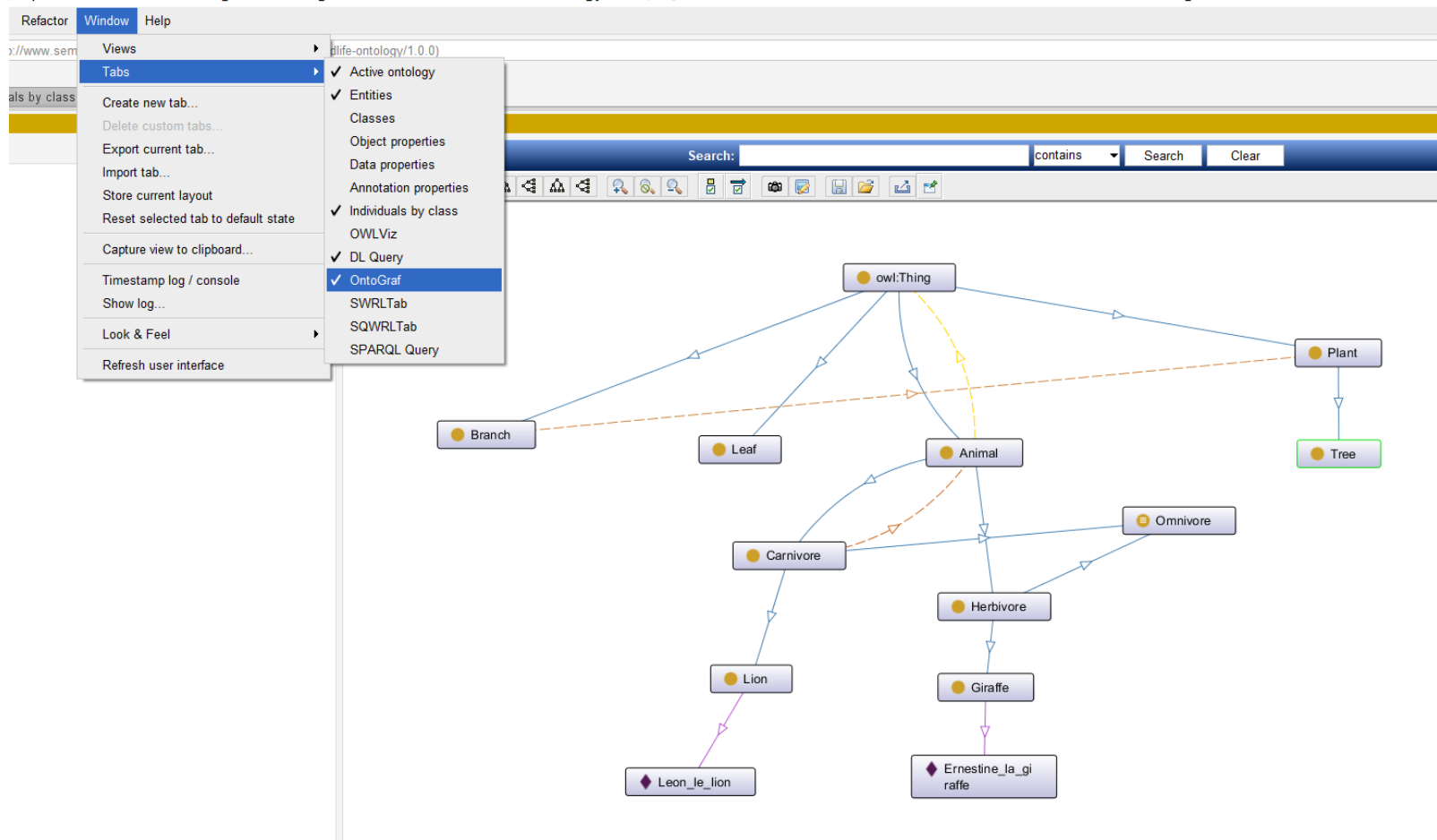
- **Déclaration des instances** : hasAge - dans Protégé

```
<Lion      rdf:about="Leon_le_lion"/>
  <hasAge  rdf:datatype="&xsd;integer">8</hasAge>
</Lion>
```



Exemple - African Wildlife Ontology

■ Visualisation de l'ontologie : OntoGraph - dans Protégé



Exemple - African Wildlife Ontology

▪ Requetes: SPARQL Query - dans Protégé

Active ontology x Entities x Individuals by class x DL Query x OntoGraf x SPARQL Query x

SPARQL query:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX local: <http://www.semanticweb.org/lee/ontologies/2022/9/african-wildlife-ontology#>
```

```
SELECT ?lions ?giraffes
```

```
WHERE {
    ?lions rdf:type local:Lion .
    ?giraffes rdf:type local:Giraffe
}
```

PREFIX local:

<http://www.semanticweb.org/lee/ontologies/2022/9/african-wildlife-ontology#>

SELECT ?lions ?giraffes

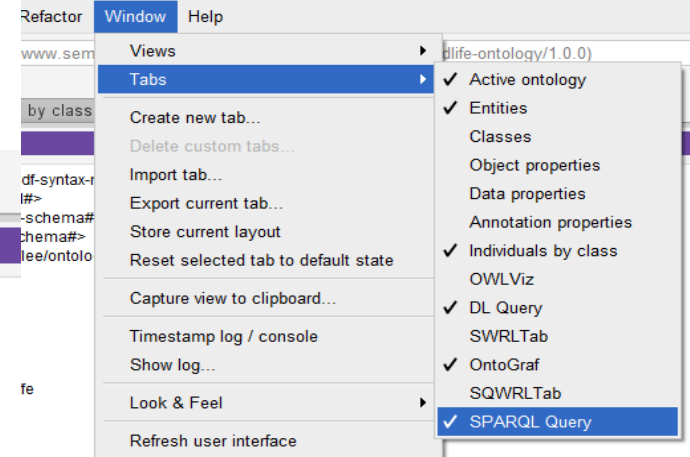
WHERE {

 ?lions rdf:type local:Lion .
 ?giraffes rdf:type local:Giraffe

}

lions		giraffes	
Leon_le_lion		Ernestine_la_giraffe	

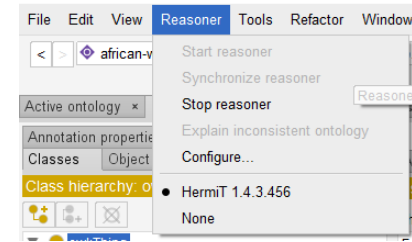
http://www.semanticweb.org/lee/ontologies/2022/9/african-wildli



Raisonnement sur les ontologies

- Pourquoi raisonner sur les ontologies :
 - Pour **vérifier** la cohérence d'une ontologie.
 - Pour **inférer** de nouvelles connaissances, on peut utiliser un raisonneur.
- Exemple : *Vérifier*
- Supposons qu'on crée une nouvelle instance *Test_Instance*, de type Carnivore et Herbivore, qui sont déclarées disjointes.
- Si on lance le « raisonneur » de Protégé, on obtient:

Raisonnement sur les ontologies



A screenshot of the Protege interface showing an inconsistent ontology. The main window displays the 'Test_Instance' ontology. The 'Individuals' tab is active, showing a list of individuals: Ernestine_la_giraffe, Leon_le_lion, and Test_Instance. The 'Test_Instance' individual is highlighted. The 'Annotations' tab is also visible, showing 'Annotations: Test_Instance'. A red circle highlights the 'Test_Instance' individual in the list. Another red circle highlights the 'Help for inconsistent ontologies' dialog box, which is open and displays the following text:

Help for inconsistent ontologies

Your ontology is inconsistent which means that the OWL reasoner will no longer be able to provide any useful information about the ontology.

You have several options at this point:

- Click the Explain button to try the Protege explanation facility.
- If you think you know what the problem is, click Cancel to fix the ontology yourself.
- Some reasoners come with command line tools that will provide complete explanations for inconsistent ontologies.

At the bottom of the dialog box are two buttons: 'Explain' and 'Cancel'.

In the background, the 'Types' section of the 'Test_Instance' individual is visible, showing 'Carnivore' and 'Herbivore' as types, which are also circled in red.

Raisonnement sur les ontologies

- Pourquoi raisonner sur les ontologies :
 - Pour **vérifier** la cohérence d'une ontologie.
 - Pour **inférer** de nouvelles connaissances, on peut utiliser un raisonneur.
- Exemple : *inférer*
- Supposons qu'*Ernestine_la_girafe* mange (*eats*) *Leon_le_lion*.
- Si on lance le « raisonneur » de Protégé, on obtient:



Raisonnement sur les ontologies

Property assertions: Leon_le_lion

Object property assertions +

eaten-by Ernestine_la_giraffe ? @

Data property assertions +

hasAge "8"^^xsd:nonNegativeInteger ? @ x o

Negative object property assertions +

Negative data property assertions +

Inferred

Description: eats

Equivalent To +

SubProperty Of +

owl:topObjectProperty

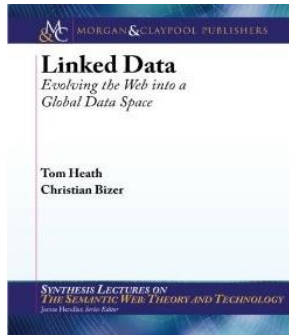
Inverse Of +

eaten-by

Domains (intersection) +

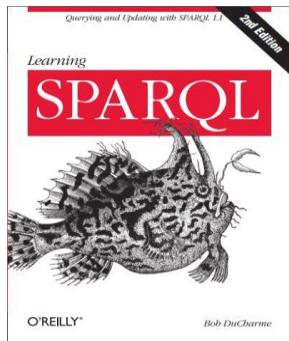
Animal

Références



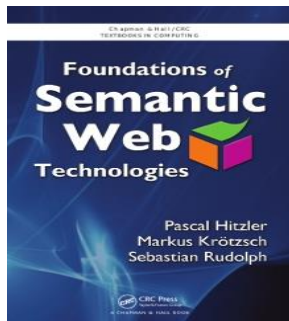
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- ✓ Éditeur : CRC Press/Chapman and Hall
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