

# Knowledge Graph Engineering

Knowdive Research Group

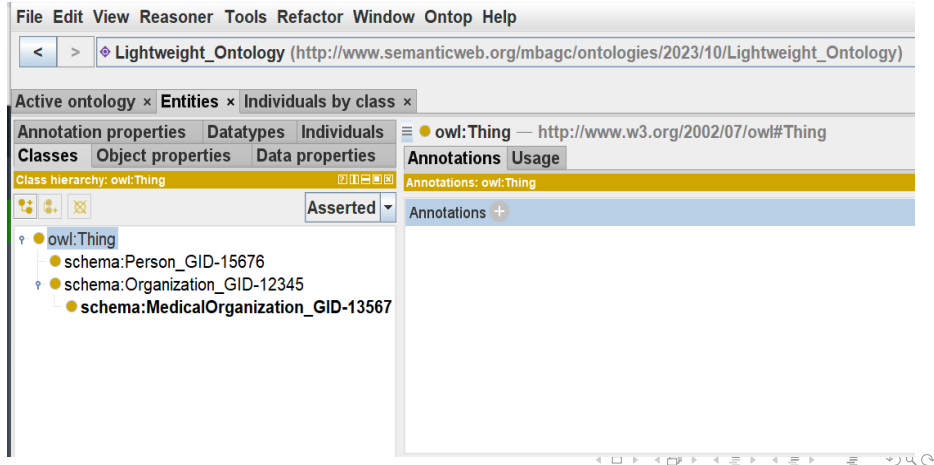
November 8, 2023

# Knowledge Definition - Practical

## *kTelos* Process - Recap

- The concrete steps for modelling knowledge as teleologies and teleontologies is via the **kTelos** process. It is as follows:
  - 1 **Top-Down:** reuse of a Lightweight Ontology (aligned to the UKC)
  - 2 **Bottom-Up:** modelling of a Teleology (aligned to the requirements modelled as CQs)
  - 3 **Middle-Out:** aligning of a Teleology grounded into the Lightweight Ontology to generate a Teleontology.
  - 4 Finally, the **knowledge annotation** of a Teleontology.
- **Note:** All the above knowledge artefacts can **reuse concepts** from existing knowledge resources.

# Top-Down - Illustration



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< > ◆ Lightweight\_Ontology ([http://www.semanticweb.org/mbagc/ontologies/2023/10/Lightweight\\_Ontology](http://www.semanticweb.org/mbagc/ontologies/2023/10/Lightweight_Ontology))

Active ontology × Entities × Individuals by class ×

Annotation properties Datatypes Individuals owl:Thing — <http://www.w3.org/2002/07/owl#Thing>

Classes Object properties Data properties Annotations Usage

Class hierarchy: owl:Thing ⓘ ⓘ ⓘ ⓘ

Annotations: owl:Thing

Annotations +

Asserted ▾

- owl:Thing
  - schema:Person\_GID-15676
  - schema:Organization\_GID-12345
    - schema:MedicalOrganization\_GID-13567

## Top-Down - Description

- The small Lightweight Ontology illustrated above (Slide - 4) encodes the following concepts reused from schema.org (aligned to the UKC):
  - 1 Person
  - 2 Organization
  - 3 MedicalOrganization

# Bottom-Up - Illustration

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< > **Teleology** (<http://www.semanticweb.org/mbagc/ontologies/2023/10/Teleology>)

> fhir:Patient\_GID-1567689

Active ontology x Entities x Individuals by class x

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

Annotations Usage

Class hierarchy: fhir:Patient\_GID-1567689 **Usage: fhir:Patient\_GID-1567689**

Asserted

Show:  this  disjoints  named sub/superclasses

Found 11 uses of fhir:Patient\_GID-1567689

- fhir:Patient.Gender\_GID-89789
  - fhir:Patient.Gender\_GID-89789 Domain fhir:Patient\_GID-1567689
- fhir:Patient.Identifier\_GID-678678
  - fhir:Patient.Identifier\_GID-678678 Domain fhir:Patient\_GID-1567689
- fhir:Patient.Name\_GID-567567
  - fhir:Patient.Name\_GID-567567 Domain fhir:Patient\_GID-1567689
- fhir:Patient\_GID-1567689
  - Class: fhir:Patient\_GID-1567689
  - fhir:Patient\_GID-1567689 rdfs:label "fhir:Patient\_GID-1567689"@en
- IsAdmittedTo\_GID-345676
  - IsAdmittedTo\_GID-345676 Domain fhir:Patient\_GID-1567689

owl:Thing

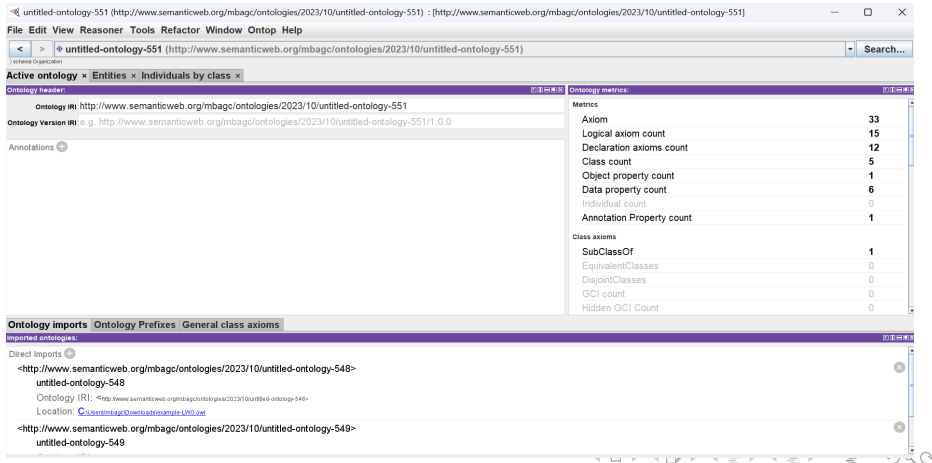
- fhir:Patient\_GID-1567689
- schema:Hospital\_GID-14789

Navigation icons: back, forward, search, etc.

## Bottom-Up - Description

- The small Teleology illustrated above (Slide - 6) encodes the following concepts reused from schema.org and fhir (aligned to the UKC):
  - 1 Patient, Hospital (classes)
  - 2 IsAdmittedTo (Object Property)
  - 3 Patient Name, Hospital Address, etc. (Data Properties)
- It answers CQs such as:
  - 1 Which patients are admitted to a hospital X?
  - 2 List out all the female patients of a hospital X?
  - 3 .... etc.

# Middle-Out - Illustration (1)



untitled-ontology-551 (http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-551) : [http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-551]

File Edit View Reasoner Tools Refactor Window Ontop Help

< > untitled-ontology-551 (http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-551) Search...

Active ontology x Entities x Individuals by class x

Ontology header: **Ontology IRI** <http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-551>  
**Ontology Version IRI** e.g. <http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-551/1.0.0>  
 Annotations +

Ontology metrics:

Metrics	
Axiom	33
Logical axiom count	15
Declaration axioms count	12
Class count	5
Object property count	1
Data property count	6
Individual count	0
Annotation Property count	1
Class axioms	
SubClassOf	1
EquivalentClasses	0
DisjointClasses	0
GCI count	0
Hidden GCI Count	0

Ontology imports | Ontology Prefixes | General class axioms

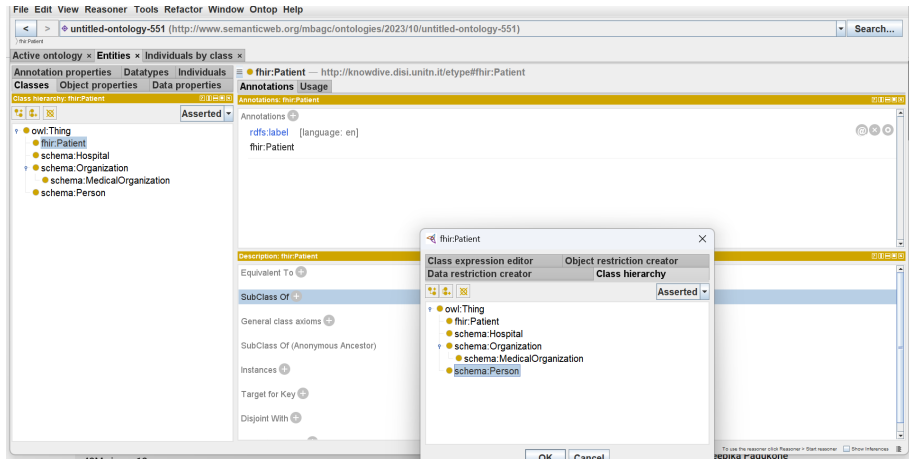
Imported ontologies:

Direct imports +

- <<http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-548>>  
 untitled-ontology-548  
 Ontology IRI: <<http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-548>>  
 Location: <C:\Users\mbagc\Documents\omptc-LWD.owl>
- <<http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-549>>  
 untitled-ontology-549



# Middle-Out - Illustration (2)



The screenshot shows the Protégé ontology editor interface. The main window displays the ontology 'untitled-ontology-551' with the class 'fhir:Patient' selected. The left sidebar shows the class hierarchy, including 'owl:Thing', 'fhir:Patient', 'schema:Hospital', 'schema:Organization', 'schema:MedicalOrganization', and 'schema:Person'. The right sidebar shows the 'Annotations' for 'fhir:Patient', including 'rdfs:label' and 'fhir:Patient'. A dialog box titled 'fhir:Patient' is open, showing the 'Class expression editor' tab. The dialog box displays the same class hierarchy as the sidebar, with 'schema:Person' selected. The dialog box also has 'OK' and 'Cancel' buttons at the bottom.

# Middle-Out - Illustration (3)

Active ontology × Entities × Individuals by class ×

Annotation properties Datatypes Individuals  
Classes Object properties Data properties

Annotations Usage

Class hierarchy: fhir:Patient\_GID-1567689

Usage: fhir:Patient\_GID-1567689

Asserted

owl:Thing

- schema:Organization\_GID-12345
  - schema:MedicalOrganization\_GID-13567
    - schema:Hospital\_GID-14789
    - fhir:Patient\_GID-1567689
- schema:Person\_GID-15676
  - fhir:Patient\_GID-1567689

Show:  this  disjoints  named sub/superclasses

Found 12 uses of fhir:Patient\_GID-1567689

- fhir:Patient\_Gender\_GID-89789
  - fhir:Patient.Gender\_GID-89789 Domain fhir:Patient\_GID-1567689
- fhir:Patient.Identifier\_GID-678678
  - fhir:Patient.Identifier\_GID-678678 Domain fhir:Patient\_GID-1567689
- fhir:Patient.Name\_GID-567567
  - fhir:Patient.Name\_GID-567567 Domain fhir:Patient\_GID-1567689
- fhir:Patient\_GID-1567689
  - Class: fhir:Patient\_GID-1567689
  - fhir:Patient\_GID-1567689 SubClassOf schema:Person\_GID-15676
- isAdmittedTo\_GID-345676
  - isAdmittedTo\_GID-345676 Domain fhir:Patient\_GID-1567689

Description: fhir:Patient\_GID-1567689

Equivalent To +

SubClass Of +

- schema:Person\_GID-15676

## Middle-Out - Description

- The Teleontology illustrated above (Slide - 10) is achieved via the following middle-out alignment process:
  - 1 Import the Lightweight Ontology and the Teleology via Direct Imports (Slide - 8)
  - 2 Semantically align Teleology concepts (e.g., patient) to the more general Lightweight Ontology concepts (e.g., person) via SubClass Of (Slide - 9).
  - 3 Repeat the above step for all relevant classes, object properties and data properties, one at a time.
  - 4 The resultant output of the alignment is a teleontology (Slide - 10)

## Knowledge Annotation - Recap

- Finally, each teleontology concept: {entity type, object property and data property}, one at a time, is checked with the Language Annotation spreadsheet to identify its GID.
- Once the GID is identified, the concept in Protégé should be updated with the GID and re-written.
- There can be two syntactical cases of the re-writing:
  - 1 if concept exists in Language Annotation spreadsheet, then the re-writing syntax would be, e.g., `schema:Person_GID-15676`, OR,
  - 2 if you add a new concept in the teleontology from another reference standard/ontology (e.g., from FHIR), the syntax would be, e.g., `dc_contributor`.
- See examples: Slide - 13, 14 and 15.

# Knowledge Annotation - Illustration (1)


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< > **untitled-ontology-563** (<http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-563>)

Active ontology x **Entities** x Individuals by class x

Annotation properties Datatypes Individuals **owl:Thing** — <http://www.w3.org/2002/07/owl#Thing>

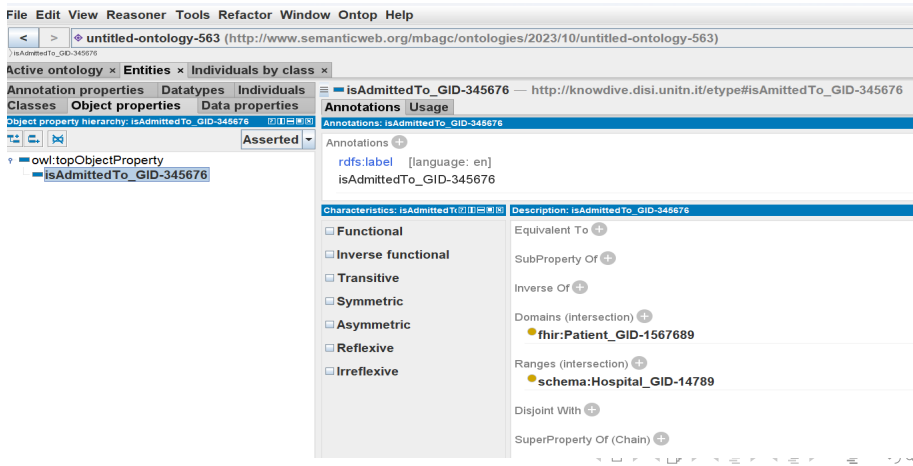
Classes Object properties Data properties **Annotations Usage**

Class hierarchy: owl:Thing  Annotations: owl:Thing

 **Asserted** Annotations +

- owl:Thing
  - ↳ ● schema:Organization\_GID-12345
    - ↳ ● schema:MedicalOrganization\_GID-13567
      - ↳ ● schema:Hospital\_GID-14789
  - ↳ ● schema:Person\_GID-15676
    - ↳ ● fhir:Patient\_GID-1567689

# Knowledge Annotation - Illustration (2)



The screenshot shows a web-based knowledge graph editor. The main window displays the definition of the property `isAdmittedTo_GID-345676`. The interface includes a menu bar (File, Edit, View, Reasoner, Tools, Refactor, Window, Ontop, Help), a browser address bar, and a toolbar. The left sidebar shows the ontology structure, with `owl:topObjectProperty` expanded to show `isAdmittedTo_GID-345676`. The main area is divided into several panels:

- Annotations:** Shows the property's label in English: `rdfs:label [language: en] isAdmittedTo_GID-345676`.
- Characteristics:** A list of checkboxes for property characteristics:
  - Functional
  - Inverse functional
  - Transitive
  - Symmetric
  - Asymmetric
  - Reflexive
  - Irreflexive
- Description:** A list of relationships and domains/ranges:
  - Equivalent To (+)
  - SubProperty Of (+)
  - Inverse Of (+)
  - Domains (intersection) (+):
    - `fhir:Patient_GID-1567689`
  - Ranges (intersection) (+):
    - `schema:Hospital_GID-14789`
  - Disjoint With (+)
  - SuperProperty Of (Chain) (+)

# Knowledge Annotation - Illustration (3)

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

< > **untitled-ontology-563** (<http://www.semanticweb.org/mbagc/ontologies/2023/10/untitled-ontology-563>)





schema:Telephone\_GID-601234

Active ontology x **Entities** x Individuals by class x





Annotation properties Datatypes Individuals **schema:Telephone\_GID-601234** — [http://knowdive.disi.unitn.it/etype#schema:Telephone\\_GID-601234](http://knowdive.disi.unitn.it/etype#schema:Telephone_GID-601234)

Classes Object properties Data properties **Annotations Usage**


Data property hierarchy: schema:Telephone\_GID-601234    


   **Asserted** Annotations 


- owl:topDataProperty
  - fhir:Patient.Gender\_GID-89789
  - fhir:Patient.Identifier\_GID-678678
  - fhir:Patient.Name\_GID-567567
  - schema:Address\_GID-234234
  - schema:OpeningHours\_GID-498498
  - schema:Telephone\_GID-601234**

Characteristics: schema:Telep     Description: schema:Telephone\_GID-601234


Functional

Equivalent To 

SubProperty Of 

Domains (Intersection) 

- schema:Hospital\_GID-14789

Ranges 

- xsd:string

## References