DOL and Hets - Tools for modular and heterogeneous ontologies

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Assume you need to build an ontology

Three challenges for aspiring ontologist

1. Evaluate against requirements / competency questions
2. Reuse of ontologies
3. Diversity of languages

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Intended Consequences in DOL

```
ontology Family1 =
  Class: Person
  Class: Woman SubClassOf: Person
  ObjectProperty: hasChild
  Class: Mother
     EquivalentTo: Woman and hasChild some Person
  Individual: john Types: Person
  Individual: mary Types: Woman Facts: hasChild john
then %implies
  Individual: mary Types: Mother
end
```

Intended Consequences in DOL

```
ontology Family1 =
  <http:purl.org/myFamilyOntology>
then %implies
  Individual: mary Types: Mother
end
```

Scone

Scone = Language/tool for cucumber-like competency questions and their translation to DOL

Feature: Family relationships
The user should be able query the data on using "male", "female", "parent of", "grandparent of", "father of","mother of", "older than"

Scenario: Relative age between family members
Given Chris is a parent of Dora.
And Amy is a parent of Chris.
And Amy is a parent of Berta.
Then infer Chris is older than Dora.
And infer Amy is older than Dora.

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Reuse of ontologies

Reuse is hard

- Terminology is “wrong”
- Ontology is too wide
- Different ontologies pieces don’t fit to each other

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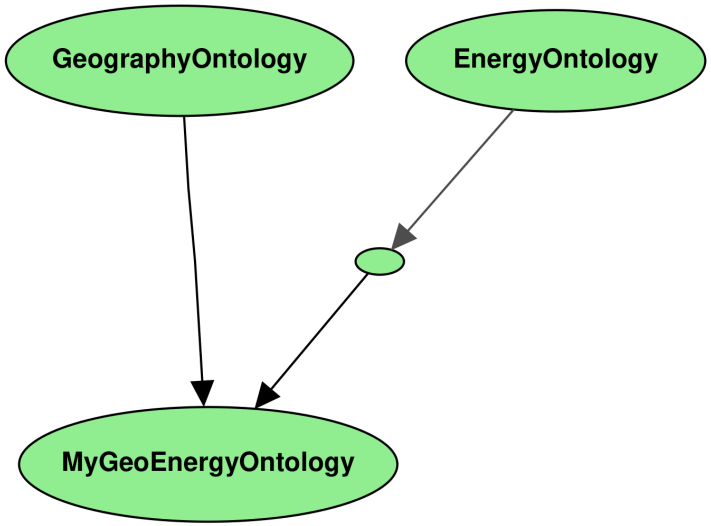
Modifying local copies of ontologies leads to maintenance issues

Example of a re-use in DOL

```
ontology MyGeoEnergyOntology =
   <http://purl.org/EnergyOntology>
      reveal Energy, Generator |-> Powerplant
and
   <http://purl.org/GeographyOntology> reveal Region
end
```



Alignment of Bioportal Ontologies

```
logic OWL
%prefix(
  ontologies: <https://ontohub.org/bioportal/>
  obo: <http://purl.obolibrary.org/obo/> )%
alignment ZFA2MA : ontologies:ZFA to ontologies:MA =
%% ZFA: zebrafish anatomical ontology
%% MA: adult mouse anatomy
  obo:synovial joint = obo:synovial joint,
  obo:pars intermedia = obo:pars intermedia,
  obo:kidney = obo:kidney,
  obo:gonad = obo:gonad,
  obo:oral epithelium = obo:oral epithelium,
  obo:head = obo:head,
  obo:cardiovascular system = obo:cardiovascular system,
  obo:locus coeruleus = obo:locus coeruleus,
  obo:gustatory system = obo:gustatory system  end
ontology combination = %cons
  combine ZFA2MA   end
```

Alignment of Upper Ontologies

```
%prefix(   gfo: <http://www.onto-med.de/ontologies/>
           dolce: <http://www.loa-cnr.it/ontologies/>
           bfo: <http://www.ifomis.org/bfo/>                )%

logic OWL

alignment DolceLite2BFO :  dolce:DOLCE-Lite.owl to bfo:1.1 =
 endurant = IndependentContinuant,
 physical-endurant = MaterialEntity,
 physical-object = Object,   perdurant = Occurrent,
 process = Process,          quality = Quality,
 spatio-temporal-region = SpatiotemporalRegion,
 temporal-region = TemporalRegion,  space-region = SpatialRegion
```

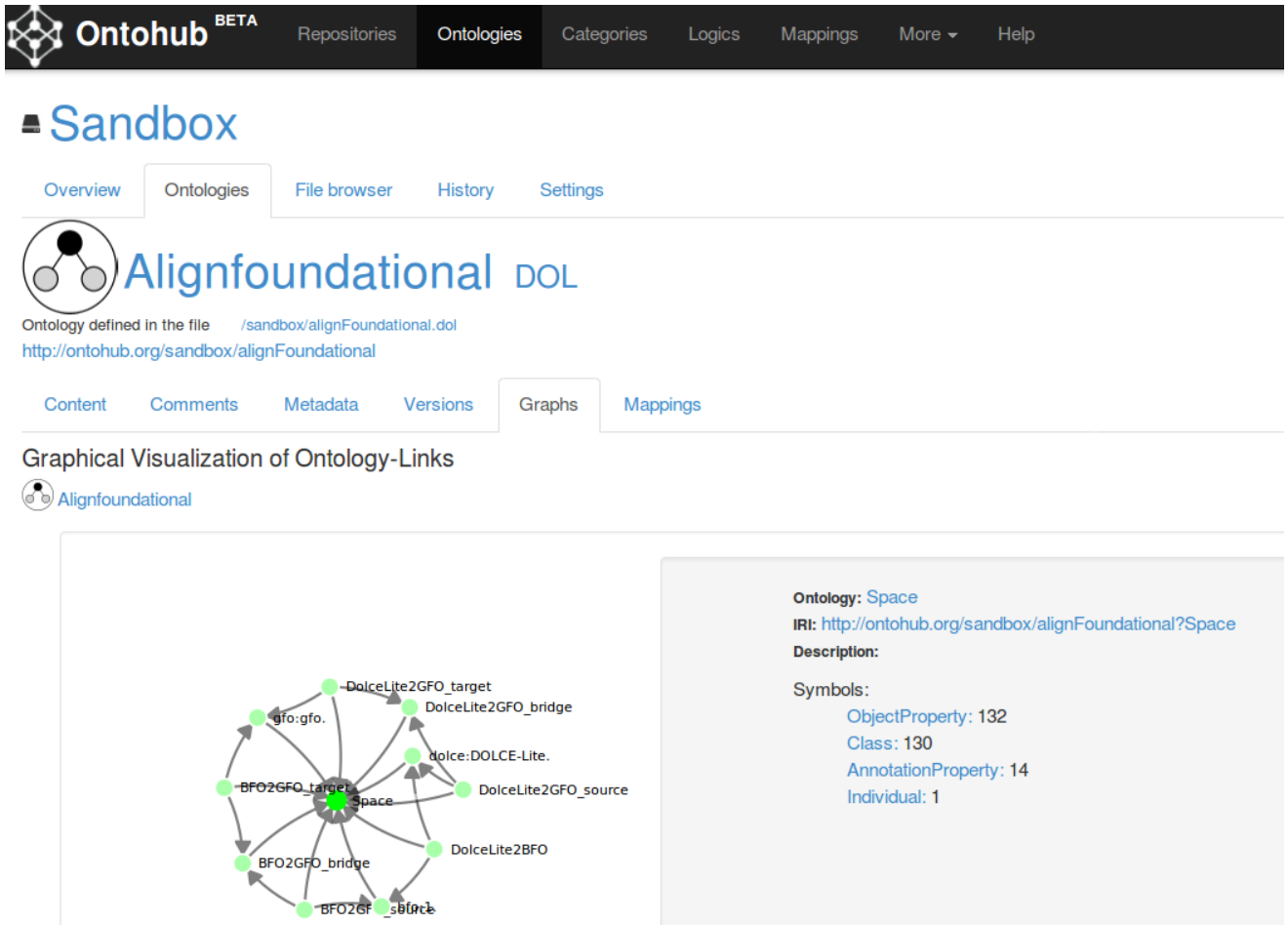
Alignment of Upper Ontologies (cont'd)

```
alignment DolceLite2GFO : dolce:DOLCE-Lite.owl to gfo:gfo.owl =
  particular = Individual, endurant = Presential,
  physical-object = Material_object,
  amount-of-matter = Amount_of_substrate,
  perdurant = Occurrent,  quality = Property,
  time-interval = Chronoid, generic-dependent < necessary_for,
  part < abstract_has_part, part-of < abstract_part_of,
  proper-part < has_proper_part,
  proper-part-of < proper_part_of,
  generic-location < occupies,
  generic-location-of < occupied_by

alignment BFO2GFO :  bfo:1.1 to gfo:gfo.owl =
 Entity = Entity, Object = Material_object,
 ObjectBoundary  = Material_boundary, Role < Role ,
 Occurrent = Occurrent,  Process = Process, Quality = Property
 SpatialRegion = Spatial_region,
 TemporalRegion = Temporal_region
```

Alignment of Upper Ontologies — Combination

```
ontology Space =
 combine BFO2GFO, DolceLite2GFO, DolceLite2BFO
```



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Diversity of Ontology Languages

Languages that have been used for ontological modelling:

- First-order logic
- Higher-order logic
- OWL (Lite, EL, QL, RL, DL, Full), other DLs
- UML (e.g. class diagrams)
- Entity Relationship Diagrams
- Other languages: SWRL, RIF, ORM, BPMN, ...

Which language should I use?

Example 1: DTV: Can you use these tools together?

The OMG Date-Time Vocabulary (DTV) is a heterogenous* ontology:

- SBVR: very expressive, readable for business users
- UML: graphical representation
- OWL DL: formal semantics, decidable
- Common Logic: formal semantics, very expressive

Benefit: DTV utilizes advantages of different languages

* heterogenous = components are written in different languages

Example 2: Relation between OWL and FOL ontologies

Common practice: annotate OWL ontologies with informal FOL:

- Keet's mereotopological ontology [1],
- Dolce Lite and its relation to full Dolce [2],
- BFO-OWL and its relation to full BFO.

OWL gives better tool support, FOL greater expressiveness.

But: informal FOL axioms are not available for machine processing!

[1] C.M. Keet, F.C. Fernández-Reyes, and A. Morales-González. Representing mereotopological relations in OWL ontologies with ontoparts. In *Proc. of the ESWC'12*, vol. 7295 *LNCS*, 2012.

[2] C. Masolo, S. Borgo, A. Gangemi, N. Guarino, and A. Oltramari. Descriptve ontology for linguistic and cognitive engineering. `http://www.loa.istc.cnr.it/DOLCE.html`.

A multi-language example in DOL

```
logic OWL
ontology Mereology =
  ObjectProperty: isPartOf
  ObjectProperty: isProperPartOf
   Characteristics: Asymmetric SubPropertyOf: isPartOf
  with translation OWL22CASL
then logic CASL :  {
  forall x,y,z:Thing .
     isProperPartOf(x,y) /\ isProperPartOf(y,z)
       => isProperPartOf (x,z) }
   %% transitivity; can't be expressed in OWL together
   %% with asymmetry
end
```

DOL – An OMG standard

- DOL = Distributed Ontology, Model, and Specification Language
- OMG Specification
- Available at `http://www.omg.org/spec/DOL/`

DOL metalanguage capabilities

DOL enables reusability and interoperability.
DOL is a meta-language:

- Literally **reuse** existing ontologies
- Operations for **modifying**/reusing ontologies
- Declaration of **relations** between ontologies
- Declaration of **intended relationships** between ontologies
- Support for **heterogenous** ontologies

All this is fully semantically grounded!

Overview of DOL: Toolkit in Summary

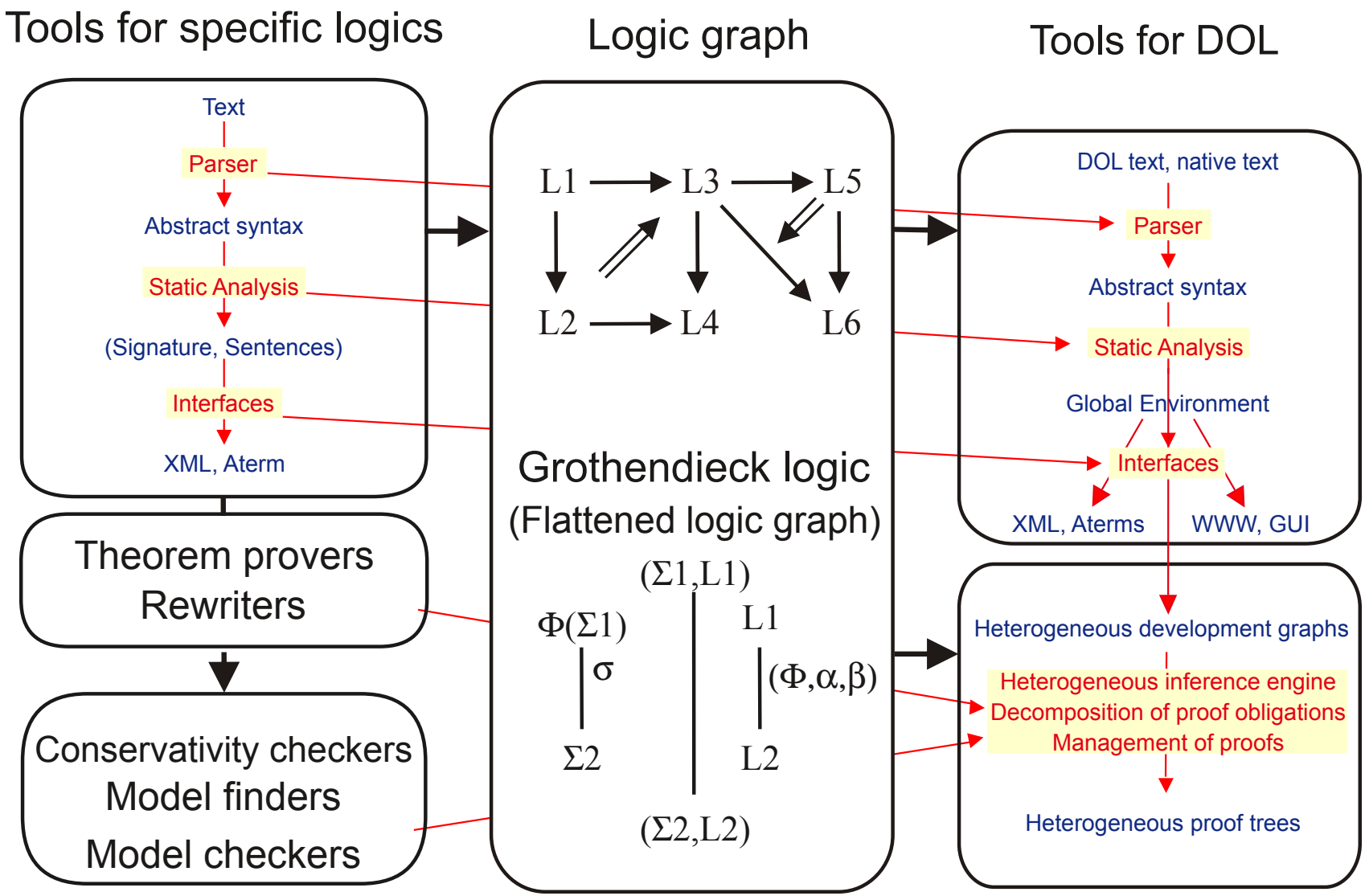
1. ontologies
   - basic ontologies
   - references to named ontologies
   - extensions, unions, translations
   - reductions, minimization, maximization
   - approximations, module extractions, filterings
   - combinations of networks
2. ontology mappings (between ontologies)
   - interpretations, refinements, alignments, ...
3. ontology networks (based on ontologies and mappings)
4. ontology libraries (based on ontologies, mappings, networks)
   - ontology definitions (giving a name to an ontology)
   - definitions of interpretations, refinements, alignments
   - definitions of networks, entailments, equivalences, ...
5. DOL extension GDOL: ontology design patterns

Tools & Ressources

Tool support for DOL: Heterogeneous Tool Set (Hets)

- available at `http://hets.eu`
  try it online: `http://rest.hets.eu`
- open source under AGPL, see
  `https://github.com/spechub/Hets`
- speaks many languages: DOL, propositional logic, OWL, CASL, Common Logic, QBF, modal logic, MOF, QVT, and others
- parsing and analysis
- computation of combinations
- management of proof obligations
- interfaces to OWL reasoners, theorem provers, model checkers, model finders for various logics

Architecture of the heterogeneous tool set Hets



DOL Resources

- `http://dol-omg.org` Central page for DOL
- `http://hets.eu` Analysis and Proof Tool Hets, speaking many ontology languages and DOL
- `http://ontohub.org` Ontohub web platform, speaking many ontology languages and DOL (currently not maintained)
- `http://ontohub.org/dol-examples` DOL examples
- `http://ontoiop.org` Initial standardization initiative
- Hets: `http://hets.eu`
  try it online: `http://rest.hets.eu`
  sources: `https://github.com/spechub/Hets`