

# *Frames and OWL*

## *A principled analysis*

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with special acknowledgment to the CO-ODE & Protege Teams & Natasha

[www.co-ode.org](http://www.co-ode.org)

[www.clinical-escience.org](http://www.clinical-escience.org)

[www.opengalen.org](http://www.opengalen.org)



# Protege-OWL

- **Original goal**
  - **A synthesis of frames and OWL**
    - **Seemed plausible,**  
**but has so far produced two parallel approaches**
      - Not easy to move between frames and OWL
        - » Why?
        - » Is a synthesis possible?
          - Analysis
          - A modest proposal

# Frames & OWL: Look roughly similar

For Project: ●

For Class: ● Lion (instance of authored-class)

Class Hiera [Icons]

- :THING
- :SYSTEM-CLASS
- Animal
  - Mammal
    - Lion
      - African\_lion
    - African\_animal
      - African\_lion
  - Geo\_entity

Name: Lion

Role: Concrete ●

Author: Alan Rector

Documentation

Template Slots

Name	Cardinality	Type
(*) has_child	multiple	Instance of Lion
(=) has_mother	required single	Instance of Lion
(=) has_range	required multip...	Instance of Geo_entity

Inferred class hierarchy: Lion

- Thing
  - Nothing
  - Domain\_entity
    - Animal
      - African\_animal
        - African\_lion
      - Mammal
        - Lion
          - African\_lion
    - Geo\_entity

Class Annotations: Lion

Annotations +

has\_author  
Alan Rector

Class Annotations | Class Usage

Class Description: Lion

Equivalent classes +

Superclasses +

- Mammal
- has\_child only Lion
- has\_mother only Lion

Inherited anonymous classes

- has\_geo\_range some Geo\_entity
- has\_mother exactly 1 Mammal
- has\_child only Mammal
- has\_geo\_range only Geo\_entity
- has\_mother only Mammal

# ...but, more different than they look

- **An ontology in Frames is...**
  - **A set of “templates”**
    - **A meta-model for the ontology**
      - Statements are functions on the information objects - the frames
        - » Disguised meta-statements
    - **Classes (and meta-classes) are first class entities**
    - **Everything asserted**
- **An Ontology in OWL is...**
  - **A set of definition and constraint (“restriction”) axioms**
    - **A model of the domain**
      - Statements about the domain entities - the things in the world
        - » Disguised first order axioms
          - All members of this class ...
          - Anything that satisfies these conditions... is a member if this class
    - **Classes cannot be referred to directly**
      - without going into OWL-full
    - **Require a reasoner to interpret their consequences**
      - Asserted and inferred models
        - » annotation provides a weak mechanism for meta-data

# Consequences...

- **Many differences follow**
  - Differences in structure
  - Differences in what can be asked and answered
- **Consider our simple ontology**
  - **Frames**
    - **Animal**
      - Mammal
        - Lion
          - African\_lion
      - African\_animal
        - African\_lion
    - **Individuals**
      - Elsie the lioness

# Permission vs Prohibition

- **Frames**
  - **Everything is forbidden until it is permitted**
    - by an entry in a template
- **OWL**
  - **Everything is permitted until it is forbidden**
    - by a constraint (restriction) axiom
      - (or the implications of several axioms)

# Enumeration vs Composition

- **Frames**

- **All classes and individuals must be enumerated manually in advance**

- **Must make “African animal”, “Indian animal”, “Sumatran animal”, “North American animal”, etc. all explicitly**

- Can lead to combinatorial explosions
  - » The “exploding bicycle”
- Leads to maintenance issues
  - » Lion hierarchy and geographic region hierarchy must both be maintained in step
    - Duplication of effort
    - Errors - poor software engineering

- **OWL**

- **Definitions allow new classes to be composed from old**

- **Create animal with whatever ranges are needed**

- The animal hierarchy will change automatically with the geography hierarchy

- ***Supports notion of a “normalised ontology”***

- See <http://www.cs.man.ac.uk/~rector/papers/rector-modularisation-kcap-2003-distrib.pdf>

# Meta-Model vs Annotations

- **Frames**

- **Metadata is first class data**

- **No difference in principle between classes and individuals**

- Everything is an instance of some class
      - Uniform mechanism for information about classes and members of classes
        - » dc:author can be just an ordinary slot

- **OWL**

- **Metadata is annotation or ( “puns” )**

- **Annotation properties**

- dc:author must be an annotation property but requires special care
        - » Not recognised by the reasoner
          - Many seemingly arbitrary restrictions

- **Puns**

- a new OWL 1.1 construct
        - » No experience yet - Much controversy



# Closed vs Open Worlds / Unique name assumption vs differentiating axioms

- **Frames**

- **Assume that all that is relevant is represented**
  - **Failure to find something is taken as negation**
    - No explicit negation
      - » “Negation as failure”
- **If two entities have different names they are different**
  - **All individual are distinct**
  - **Classes are assumed disjoint unless they have a common subclass**

- **OWL**

- **Assume that anything consistent with the axioms may be true**
  - **Failure to find something just means we don't know**
    - Explicit negation
      - » “Negation as impossibility”
- **Any two individuals may be the same;  
Any two classes may overlap**
  - **Unless there are explicit differentFrom() or disjoint() axioms**

# Explicit individuals vs Under-specification

- **Frames**

- To say that “Elsie has a cub” we must create an individual “Lion cub” and make it Elsie’s child
  - *(multivalued-slot has\_child (value instance\_of\_lion\_1234567))*
  - Only what is explicitly represented exists
    - “Skolem Constants”

- **OWL**

- To say that “Elsie has a cub” we say that “There is something that is Elsie’s cub”
  - *Elsie has\_child SOME Lion*
    - We don’t have to represent the cub explicitly
      - » Can also further describe it  
“Elsie has a cub that has a cub”
        - *Elsie has\_child SOME (Lion THAT has\_child SOME Lion)*

# Local vs global inference

- **Frames**

- **All inference is local**

- **To the class, its superclasses, subclasses, and instances**
      - effects easy to predict
    - **“Meaning” of the ontology can be read off the class hierarchy without inference.**

- **OWL**

- **All axioms are global**

- **A class can be affected by axioms from the whole ontology**
      - Large animals with claws are dangerous.  
Lions are large and animals and have claws.  
Elsie is a Lion  
Therefore Elsie is a dangerous animal
    - **Meaning of the ontology can only be determined after using a “reasoner”**
      - The meaning can (almost) be read off the inferred hierarchy
        - » Can export the inferred hierarchy

# Acquisition vs Inference

- **Protege**

- **Optimised for knowledge acquisition**

- **Evolved from knowledge acquisition systems**

- Everything you need to know to avoid errors is transparently visible
      - For individuals, what is needed is usually in a form

- **OWL**

- **Optimised for inference**

- **Evolved from logic representations and theorem provers**

- What you need to know must be opaque and must be inferred
        - » Protege-frames-like forms are not currently available
          - ( but we are working on it)

**What questions can be asked?  
How can they be or answered?**

# What are the kinds of Lion? What are lions a kind of?

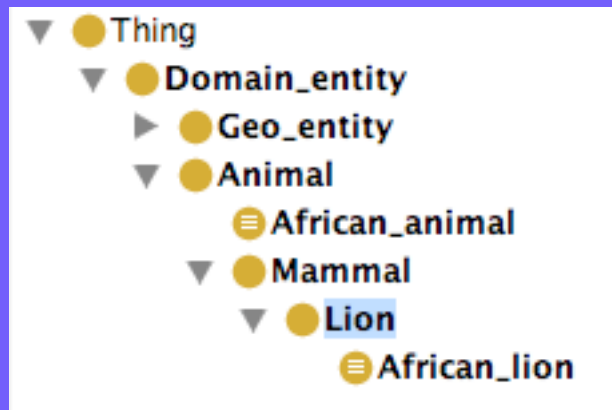
- **Frames**

- **Look up and down the (asserted) hierarchy**
  - (there is no inferred hierarchy)



- **OWL**

- **Look up and down the inferred hierarchy**
  - **The asserted hierarchy is not enough**
    - African lions will be found to be African Animals



# What can be said about Lions? a lion?

## “Sanctioning”

- **Frames**

- **“Slot attachment” is a formal operation**

- Can ask what *can* be said

- What can't be said is implied by what isn't in the template

- **Look at the template - including ancestor classes' templates**

- Usually presented as a “form”

- **OWL**

- **“Slot attachment” is not in the language**

- Can ask what *cannot* be said but not what can be said

- Except as the difference

- » Not built into reasoners

- “Non-standard reasoning”

# What's true of all lions?

- **Frames**
  - **Value of a slot**
    - **(multi-slot has\_mother (allowed-classes Lion))**
      - The slot has\_mother must be filled by something from the class Lion
- **OWL**
  - **A restriction**
    - **has\_mother SOME Lion**
      - All lions have a lion and only a lion as a mother



# What is false of all lions? A lion?

- Frames

- No way to express negation explicitly
  - Only ask what is not stated to be true
    - Or sometimes use max cardinality 0

- OWL

- What can be proved false of all lions

- NOT (has\_diet SOME Herbivorous)
  - All lions have non-herbivorous diets
    - » ... or it might have been proved through nonlocal axioms
- Or prove it

- *PROPERTY has\_diet FUNCTIONAL*  
*Diet ← [Herbivorous Carnivorous] allDisjoint*  
*Lion → has\_diet SOME Carnivorous*

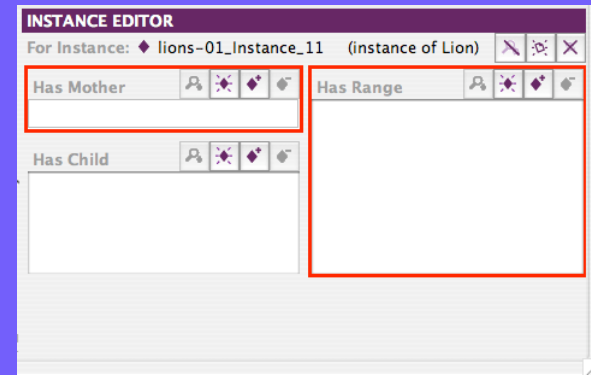
The screenshot shows a query interface with a yellow header labeled "Query:". Below the header, there is a text input field containing the query: "Animal and not (has\_diet some Herbivorous)". Below the input field is a button labeled "Execute". Below the button is a section labeled "Query results" which contains a sub-section labeled "Sub classes" with a single entry: "Lion" next to a yellow circle icon.

# What's false of all lions?

## Prior constraints vs post hoc restrictions

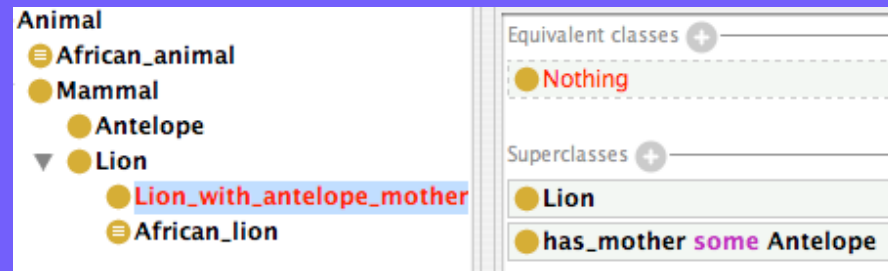
- Frames

- Constraints limit what can be entered
  - Errors flagged at data entry
    - (multi-slot has\_mother (allowed-classes Lion))
      - » The slot has\_mother must be filled by something from the class Lion



- OWL

- Restrictions constraint what is consistent
  - Anything can be entered
    - but violations will be flagged as inconsistent when the reasoner is run
- Lion has\_mother ONLY Lion



# What is *unknown* about about all lions? a lion? What is *missing*?

- Frames

- **Missing: A mandatory slot without a value**
  - Will cause an error
    - On an individual the form will be bordered in red
- **Unknown: ??ill defined**
- **An optional slot without a value?**
  - No - most queries will return “no” or equivalent
    - closed world - what is represented is all there is

- OWL

- **Unknown: More than one option is satisfiable**
  - Cannot be proved either true or false
- **Missing: ??Usually ill defined?**
  - A “SOME” restriction without a value?**
    - No, a value will be inferred to exist
    - Only if a required value *could not* exist
      - An organism has exactly 2 parents; one mother and one father.
        - » Smith has two female parents. Smith’s father is “missing”

# What kinds of animals live in Africa?

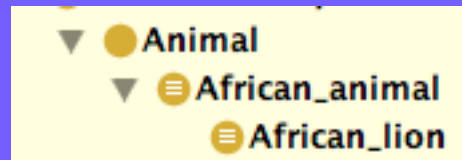
- **Frames**

- **Look down the subclass hierarchy from *African\_animal***
  - And perhaps check by running a query defined outside the ontology

- **OWL**

- **Run the reasoner -**

- then look down the *inferred* subclass hierarchy from *African\_animal*
  - Any animal that has *\_range* in Africa will be classified under *African\_animal*
    - » Whether or not it is asserted explicitly.



# What is typically true of lions?

## “Lions are typically tawny”

- **Frames**

- **Traditionally - what frames were about - Defaults with over-riding**

- “Tweety the ostrich”

- **In Protege-frames**

- **Can set a default value**

- Can over-ride it for any one individual
- Cannot easily over-ride it for some subclass and its subclasses

- **OWL**

- **All statements are universal**

- **Can only weaken the premise**

- **“All birds except members of the ostrich and penguin families fly”**

- Soon becomes difficult to maintain

# How do I refer to lions in descriptions like “Books about lions”?

- **Frames**
  - **By using the class Lion as a value**
    - e.g. (...skos:subject (value Lion))
- **In OWL**
  - **Can refer to “books about some lion(s)”**
  - **Cannot refer to “books about Lion” in OWL-DL**
    - **Nothing can be both a class and an individual in OWL-DL**
      - (Although the same name can be used for a class and an individual in OWL 1.1 - a “pun”)
- **NB usually the librarian’s intended meaning of “books about lions” is**
  - **“Books about lions OR books about some Lion(s)”**

# Who is the author of the class Lion?

## Editorial meta-statements about the ontology

- **Frames**
  - **A statement about the frame for the class Lion**
    - **An “own slot”**
      - Not inherited because it is about the frame itself
  - **A statement like any other in the ontology**
    - **Classes are just instances of the class Class**
- **OWL**
  - **An annotation on the class for Lion**
    - **Only loosely linked to the ontology**
      - and severely restricted
  - **Cannot be a normal statement in the ontology**
    - **Puns may be a work around in OWL 1.1**
      - but very weak

# Meta-data and Annotations

The screenshot shows a software interface with two main panels. On the left is the 'CLASS BROWSER' showing a class hierarchy: :THING, :SYSTEM-CLASS, Animal, Mammal, Lion, African\_animal, and Geo\_entity. On the right is the 'CLASS EDITOR' for the class 'Lion'. It includes fields for Name (Lion), Role (Concrete), and Author (Alan Rector). Below these is a 'Template Slots' table with columns for Name, Cardinality, and Type. The table lists slots: has\_child (cardinality: 1), has\_mother (cardinality: 1), and has\_range (cardinality: 1).

This panel shows two sub-panels. The top one is 'Class Annotations: Lion', which lists an annotation 'has\_author' with the value 'Alan Rector'. The bottom one is 'Class Description: Lion', which lists 'Equivalent classes' and 'Superclasses'. The superclasses listed are: Mammal, has\_diet some Carnivorous, has\_child only Lion, and has\_mother only Lion.

- Simple cases
  - Good enough
- Language, provenance, versioning, ...
  - Need richer model than OWL allows
  - Not viable for higher order information



# Are lions an endangered species?

## Higher order statements about the domain

- **Frames**

- **A statement about the frame for the class Lion**

- **No way to distinguish from editorial domain knowledge**

- No way to tell if a statement about a class is about the representation or the thing represented

- » A “use-mention” error

- **OWL**

- **No real equivalent - nasty hack:**

- **All lions have the property of being members of an endangered species**

- Higher order reasoning requires OWL-Full

- » But still does not distinguish between editorial metadata and higher order information

# Summary

- **Natural in frames - rich meta modelling & knowledge acquisition**
  - **What is it sensible to say - “sanctioning”**
    - explicit slot attachment
  - **Metaclasses, reference to subjects, etc.**
  - **What’s missing, incomplete**
- **Natural in OWL - rich first order inference**
  - **Composition and definition**
  - **Global inference**
  - **Existential quantification & underspecification**
- **Natural in both**
  - **Subclass/superclasses, Inheritance (without exceptions)**
- **Natural in Neither**
  - **Typical information / “Defaults with exceptions”**

# Effect on the experience

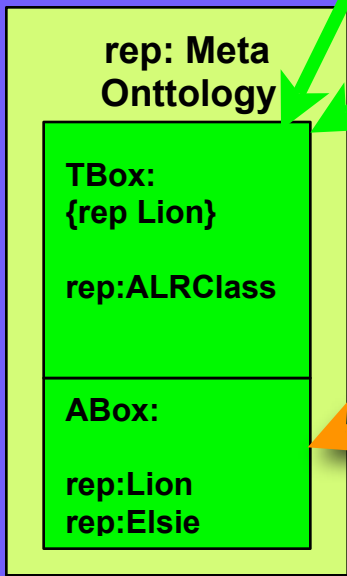
- **Frames**
  - **Immediate feedback**
    - **Everything you need to know is transparently visible**
      - Analogous to scripting / interpreted environments
- **OWL**
  - **Delayed feedback**
    - **What you need to know can only be determined by classification**
      - Analogous to a compiled language / batch environment

# A possible synthesis

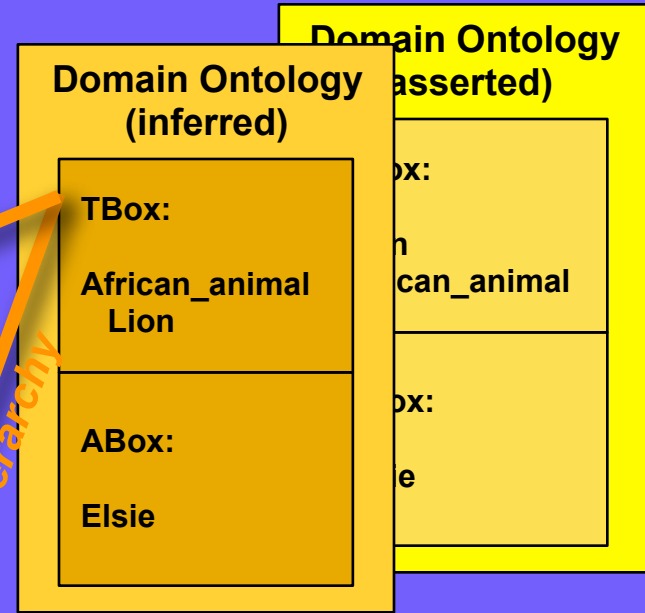
- **Requirements**
  - **Composition and rich first order inference from OWL**
  - **Metamodelling and transparency from frames**
    - Clear simple query for “what can I say about ...”
    - Separation of editorial metadata and higher order information
- **Method**
  - **Multiple layered models**
    - Domain Ontology
    - Meta-ontology - representation of the ontology artefact
    - Higher order domain ontology - the categories represented by the ontology

# Possible Synthesis

Meta model of representation:  
 ({rep:Animal} OR is\_subclass\_of rep SOME {rep:Animal}) →  
 attached\_property VALUE rep:has\_mother



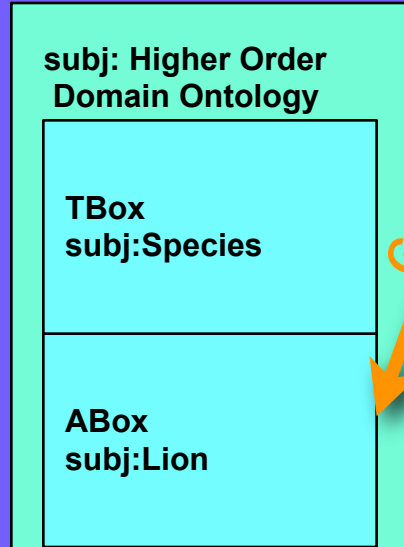
rep:ALRClass ⇔  
 Class AND  
 author VALUE rector



Generate derived  
 is\_subclass\_of hierarchy

Generate derived  
 is\_subclass\_of hierarchy

Annotation:  
 rep:Lion →  
 author VALUE rector



subj:Endangered\_species ⇔  
 subj:Species AND  
 has\_CITES\_status SOME Endangered

subj:Lion has\_CITES\_status SOME Endangered  
 ext:myBook skos:subject VALUE subj:Lion

# Summary

- **Frames** are Templates  
**OWL** is a set of axioms
- **Frames** provide rich meta representation  
**OWL** provides rich first order representation plus composition, inference, and normalisation
- **Frames** are closed world & Uniquely Named  
**OWL** is open world and must have differentiating axioms
- **Metadata** is about representations  
**Higher order information** is about the domain
  - and probably the right thing to use for “subjects” (SKOS)
- A **synthesis** ought to be possible
  - Now: messy but relatively quick with current technology
  - Future: significant problems to be solved for fully logically sound solution