

# *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-esience.org](http://www.clinical-esience.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?

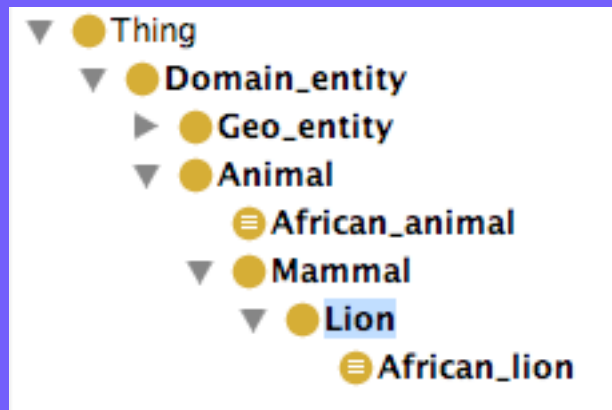
- **Frames**

- **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*

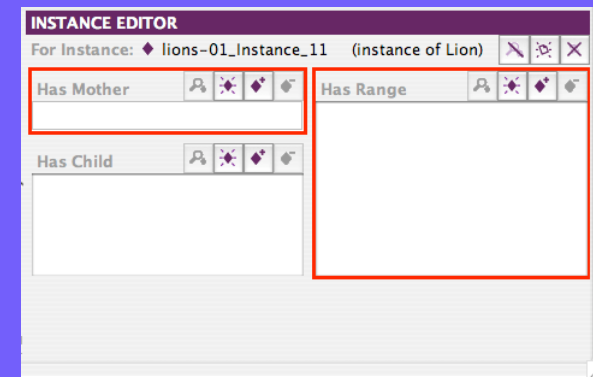
The screenshot shows a query execution interface. At the top, there is a yellow header labeled "Query:". Below it, a text box contains the query: "Animal and not (has\_diet some Herbivorous)". A button labeled "Execute" is positioned below the text box. Underneath the button, there is a section titled "Query results". Within this section, there is a sub-section labeled "Sub classes" which contains a single entry: a yellow circle followed by the text "Lion".

# What's false of all lions?

## Prior constraints vs post hoc restrictions

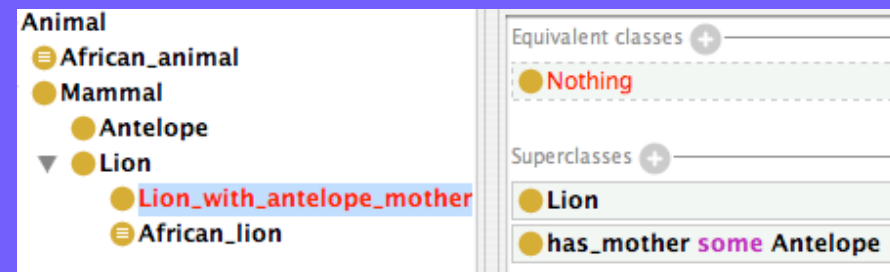
- Frames

- 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?

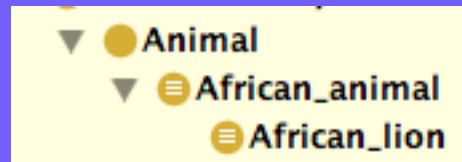
- **Frames**

- **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: 'CLASS BROWSER' and 'CLASS EDITOR'. The 'CLASS BROWSER' on the left displays a class hierarchy starting from ':THING', going down to ':SYSTEM-CLASS', then 'Animal', 'Mammal', and finally 'Lion'. The 'CLASS EDITOR' on the right is for the class 'Lion' and shows fields for 'Name' (Lion), 'Role' (Concrete), and 'Author' (Alan Rector). Below these fields is a 'Template Slots' table with columns for Name, Cardinality, and Type. The table lists slots: has\_child, has\_mother, and has\_range.

The 'Class Annotations: Lion' panel shows a list of annotations for the class 'Lion', including 'has\_author' with the value 'Alan Rector'. The 'Class Description: Lion' panel shows a list of 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

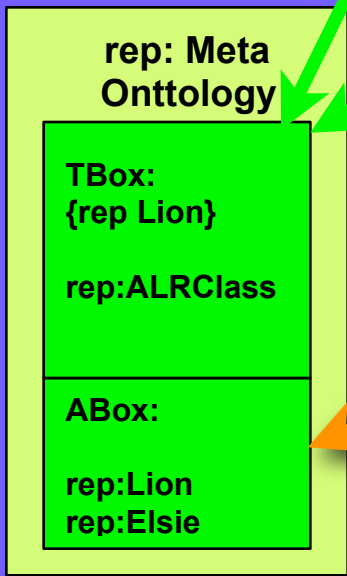
- **Frames**
  - **Immediate feedback**
    - **Everything you need to know is transparently visible**
      - Analogous to scripting / interpreted environments
- **OWL**
  - **Delayed feedback**
    - **What you need to know can only be determined by classification**
      - Analogous to a compiled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

# A possible synthesis

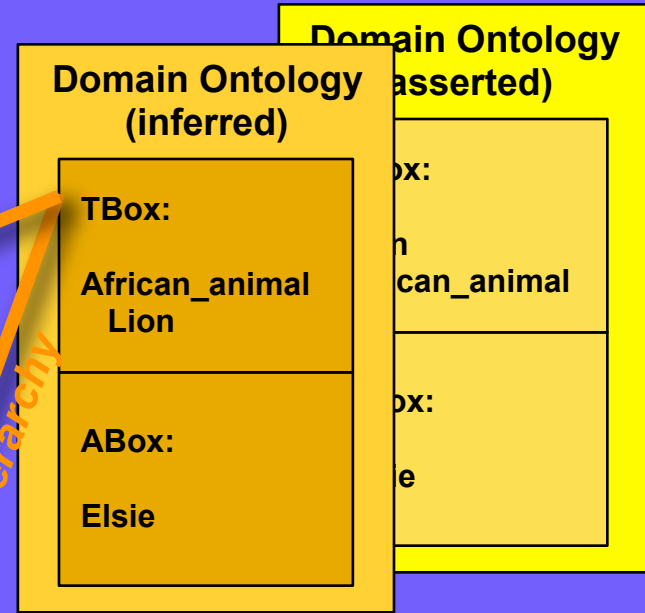
- **Requirements**
  - **Composition and rich first order inference from OWL**
  - **Metamodelling and transparency from frames**
    - Clear simple query for “what can I say about ...”
    - Separation of editorial metadata and higher order information
- **Method**
  - **Multiple layered models**
    - 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



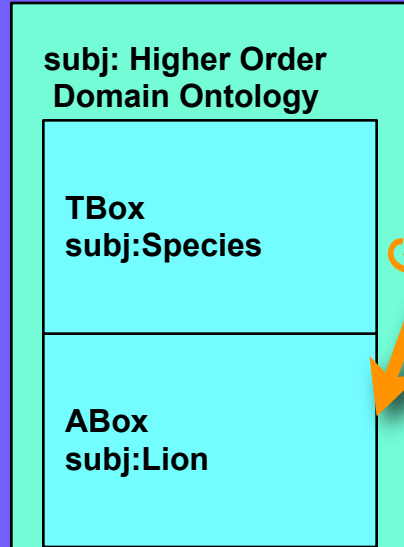
rep:ALRClass ⇔  
 Class AND  
 author VALUE rector



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