MANCHESTER 1824

The University of Manchester

Frames and OWL
A principled analysis

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

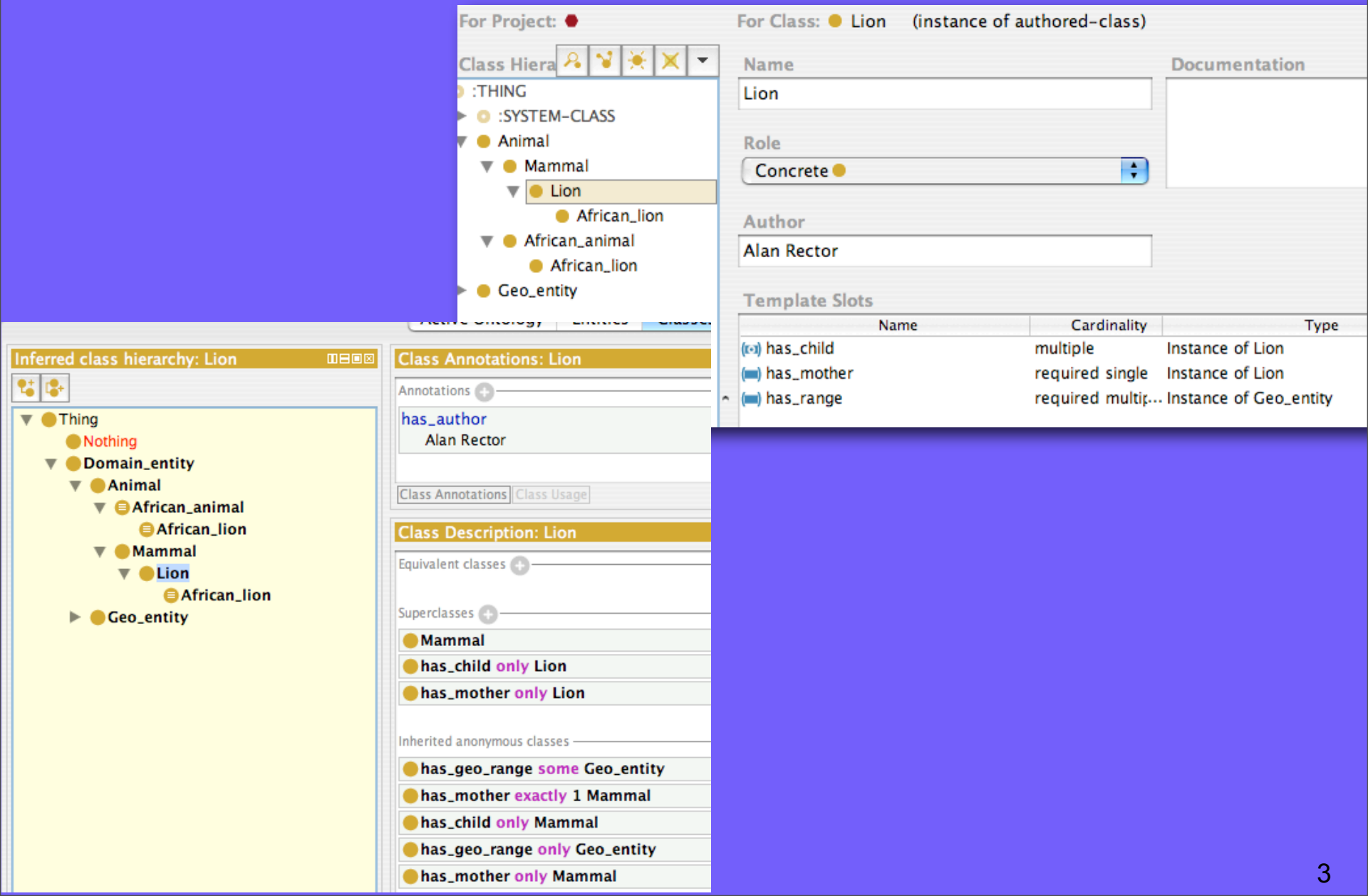
www.co-ode.org
www.clinical-escience.org
www.opengalen.org

NIBHI

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



...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

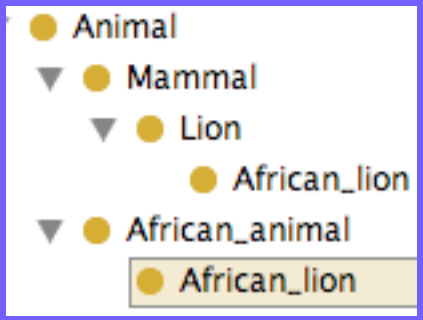
- **Frames**
  - **All inference is local**
    - **To the class, its superclasses, subclasses, and instances**
      - effects easy to predict
    - **"Meaning" of the ontology can be read off the class hierarchy without inference.**
- **OWL**
  - **All axioms are global**
    - **A class can be affected 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

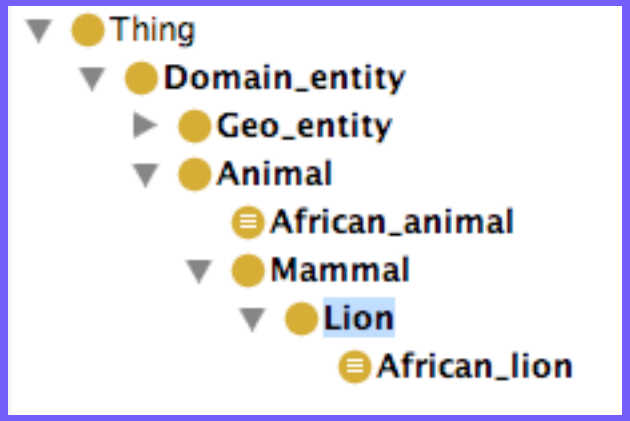
- **Protege**
  - **Optimised for knowledge acquisition**
    - **Evolved from knowledge acquisition systems**
      - Everything you need to know to avoid errors is transparently visible
      - For individuals, what is needed is usually in a form
- **OWL**
  - **Optimised for inference**
    - **Evolved from logic representations and theorem provers**
      - What you need to know must be is opaqe 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?

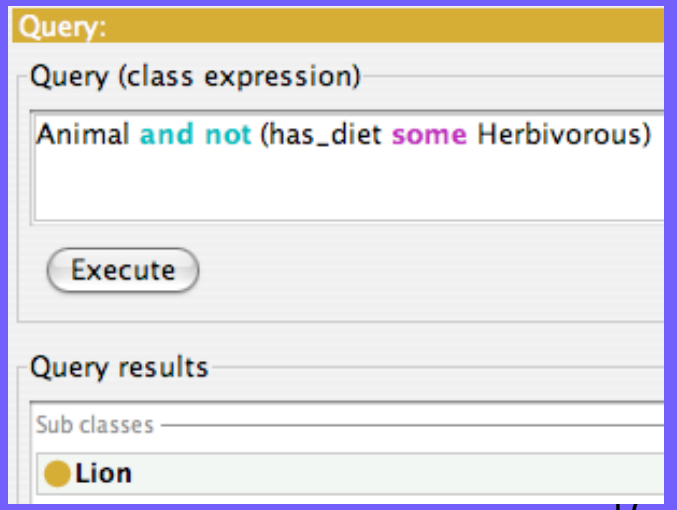
- **Frames**
  - **Value of a slot**
    - **(multi-slot has_mother (allowed-classes Lion))**
      - The slot has_mother must be filled by something from the class Lion

- **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?

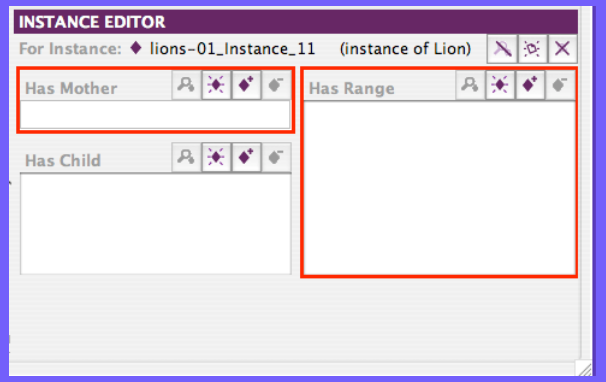
- **Frames**
  - **No way to express negation explicitly**
    - **Only ask what is not stated to be true**
      - Or sometimes use max cardinality 0
- **OWL**
  - **What can be proved false of all lions**
    - **NOT (has_diet SOME Herbivorous)**
      - All lions have non-herbivorous diets
        - » ... or it might might have been proved through nonlocal axioms
    - **Or prove it**

- ***PROPERTY has_diet FUNCTIONAL***
  Diet ←[Herbivorous Carnivorous] allDisjoint
  Lion → has_diet SOME Carnivorous

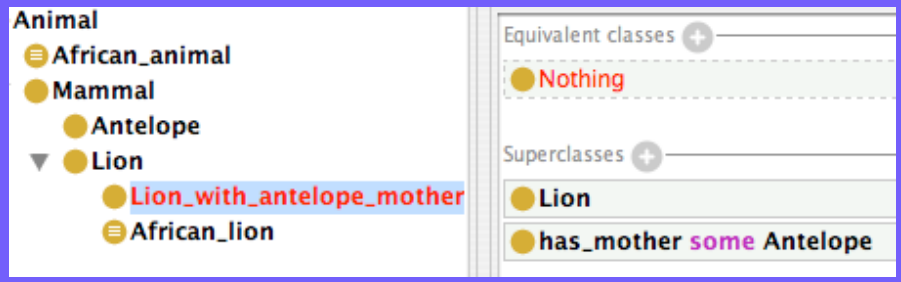


What's false of all lions?
Prior constraints vs post hoc restrictions

- **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 consisten**
    - **Anything can be entered**
      - but violations will be flagged as inconsistent when the reasoner is run
      - Lion has_mother ONLY Lion



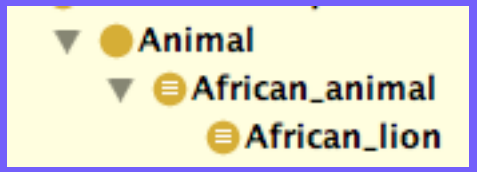
What is *unknown* about about all lions? a lion? What is *missing*?

- **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

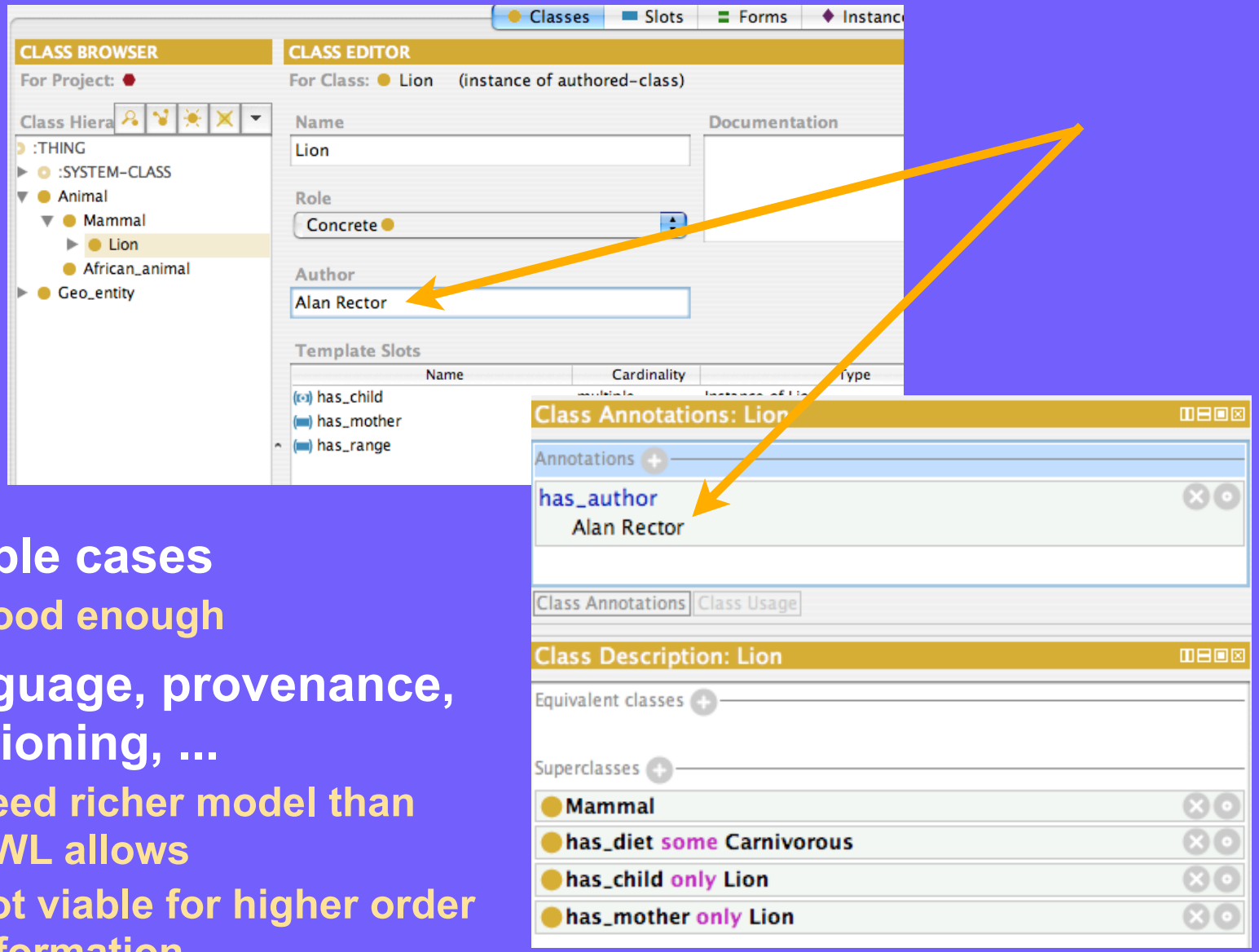
How do I refer to lions in descriptions like "Books about lions"?

- 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 restructed
  - **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



- 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 endagered 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

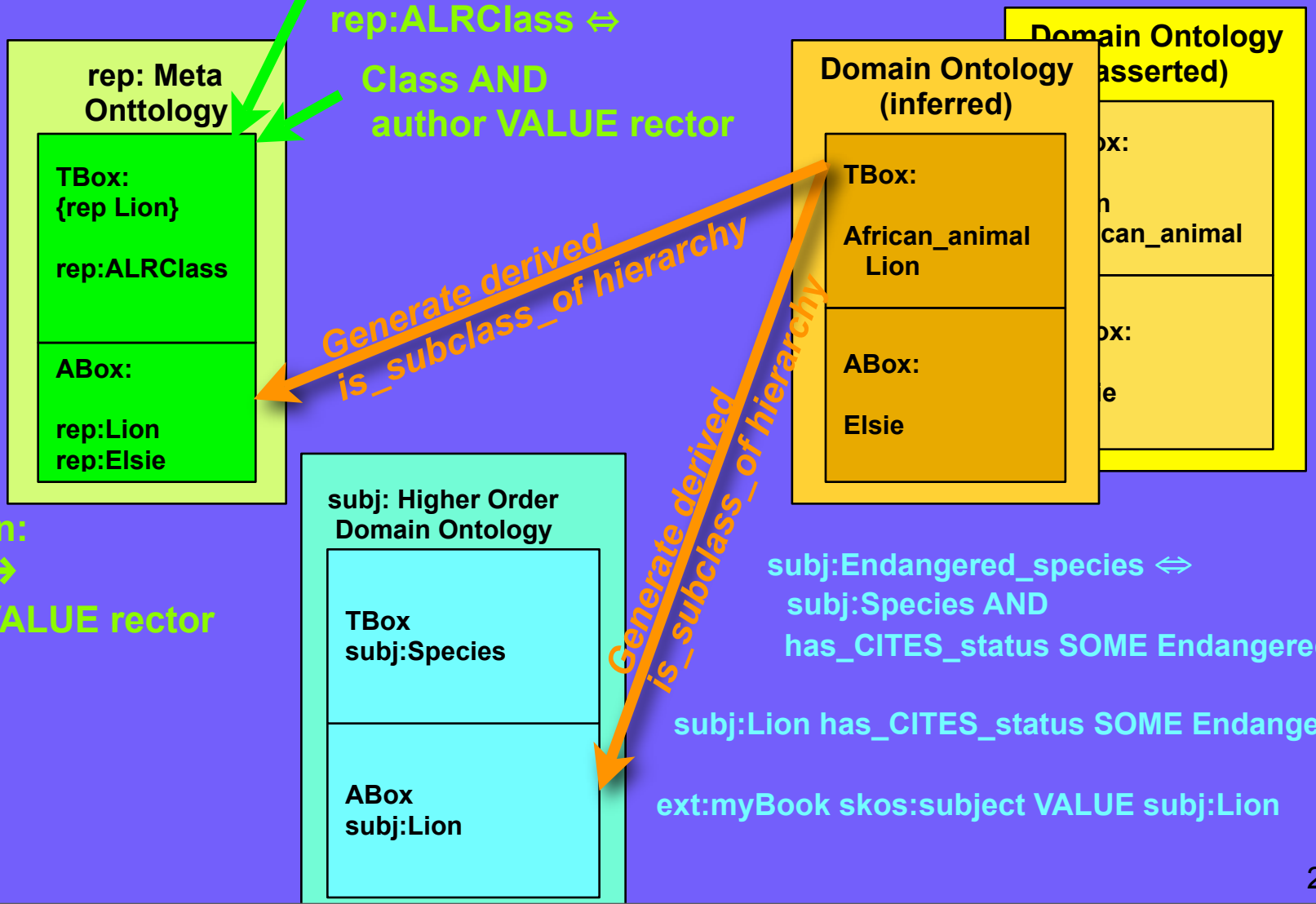
- **Frames**
  - **Immediate feedback**
    - **Everything you need to know is transparently visible**
      - Analogous to scripting / interpreted environments
- **OWL**
  - **Delayed feedback**
    - **What you need to know can only be determined by classification**
      - Analogous to a compiled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



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