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
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”
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
    - $(multivalued-slot \text{has\_child} (\text{value instance\_of\_lion\_1234567}))$
    - 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 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
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 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

- 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

Annotation:
rep:Lion ➔
author VALUE rector

Domain Ontology
(subj:Lion has_CITES_status SOME Endangered)

Domain Ontology
(subj:Endangered_species ⇔
subj:Species AND
has_CITES_status SOME Endangered)

Generate derived
is_subclass_of hierarchy

ABox: rep:Lion
TBox: rep:ALRClass
rep:Meta Ontology

TBox: {rep:Lion}
ABox: rep:Lion, rep:Elsie

ABox: Elsie
TBox: rep:ALRClass
rep:Meta Ontology

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