Knowledge Representation & Processing

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Formalisation

Previously...

- We started the **knowledge acquisition** process...
  - to elicit tacit knowledge
  - in a variety of ways
  - about a set of terms (or concepts)
- But even there we could get **more explicit**
  - normalising terms (e.g., “symmetry or symmetric”?)
  - hierarchy (and other direct relations between terms)
  - categorizing terms (e.g., as modifiers or self-standing)
  - **constraining** and **defining** terms
- 2 important next steps
  1. getting even more explicit and precise
     - Refining our proto-representation
  2. getting actionable
     - Building a representation

Term extraction

- Highlight the **relevant, domain-dependent** terms in:
  - There are several sorts of domesticated animals, though by far the most are mammals (like us!). For example, our faithful pets, cats and dogs, are clearly domesticated (or we would not keep such dangerous carnivores in our homes), as is the delicious cow which is farmed in ever increasing numbers.

Step 1: Term extraction

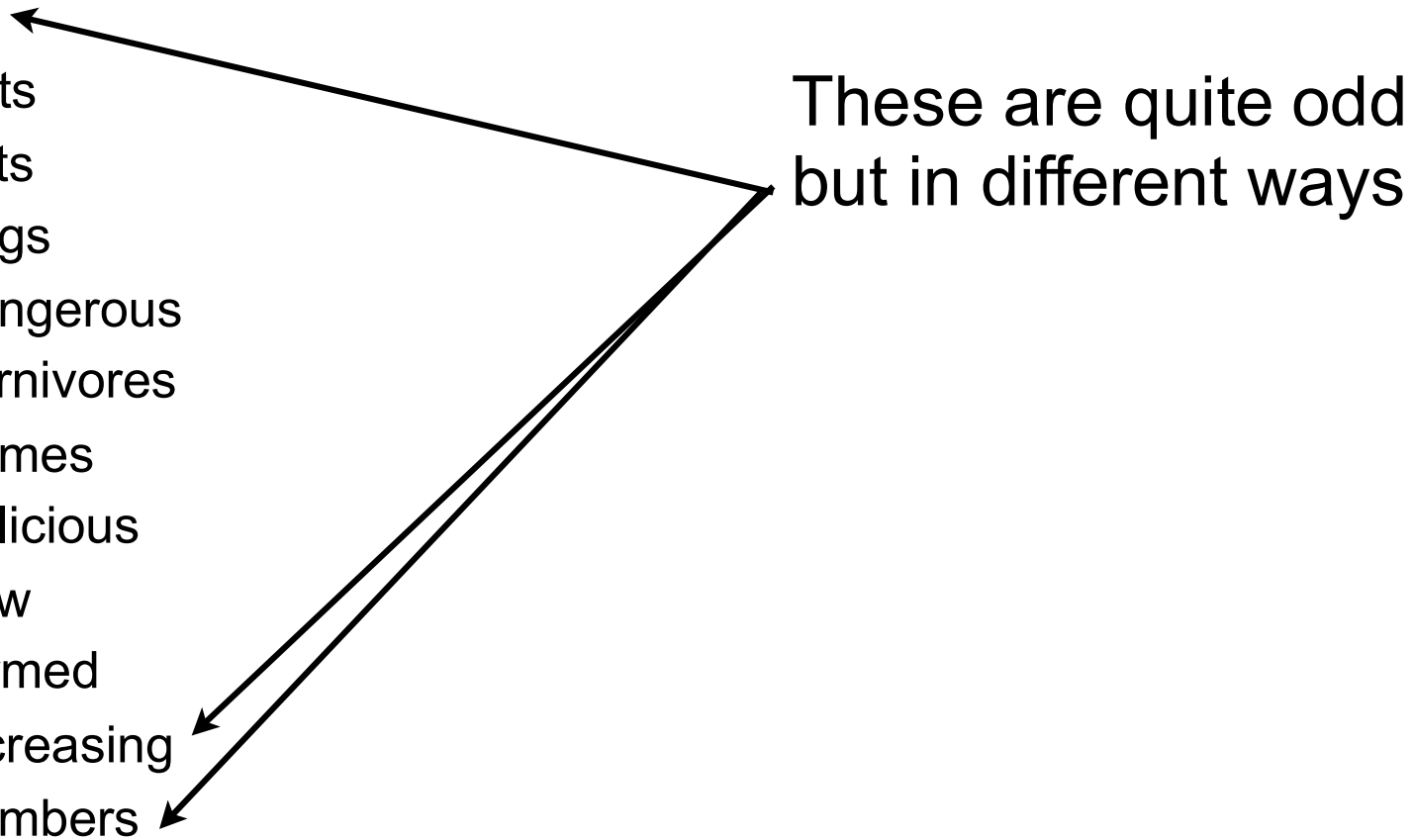
- Highlight the **relevant, domain-dependent** terms in:
  - There are several sorts of domesticated animals, though by far the most are mammals (like us!). For example, our faithful pets, cats and dogs, are clearly domesticated (or we would not keep such dangerous carnivores in our homes), as is the delicious* yet docile cow which is farmed in ever increasing numbers.

Step 1: Term extraction

- We pull these out
  - domesticated
  - animals
  - mammals
  - us
  - pets
  - cats
  - dogs
  - dangerous
  - carnivores
  - homes
  - delicious
  - cow
  - farmed
  - increasing
  - numbers

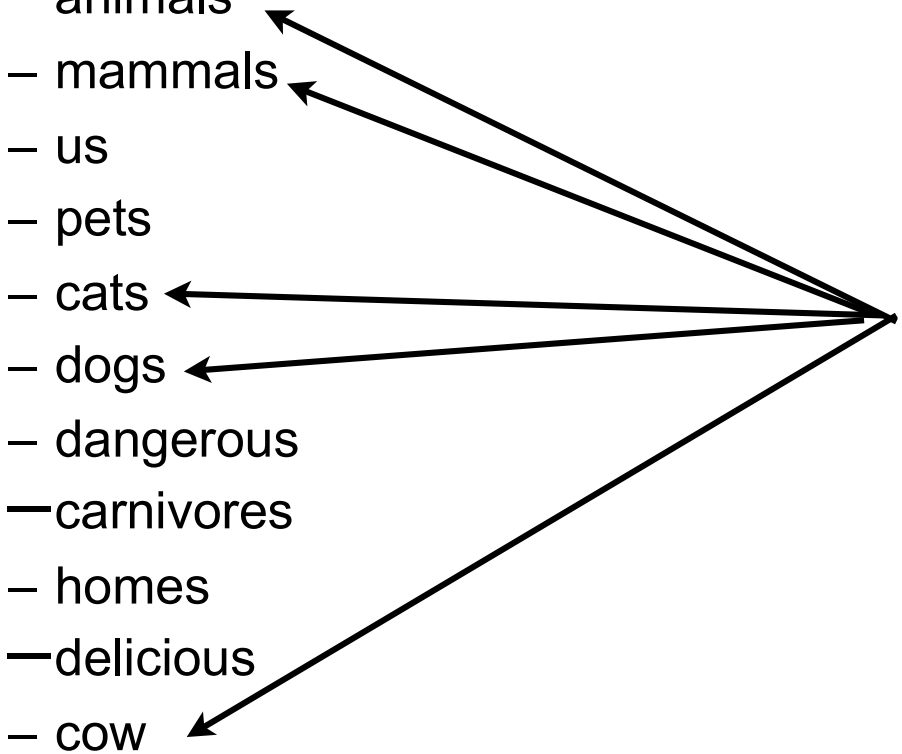
Step 1: Term extraction

- We pull these out and **ponder**:
  - domesticated
  - animals
  - mammals
  - us
  - pets
  - cats
  - dogs
  - dangerous
  - carnivores
  - homes
  - delicious
  - cow
  - farmed
  - increasing
  - numbers



Step 1: Term extraction

- We pull these out and **ponder some more**:
  - domesticated
  - animals
  - mammals
  - us
  - pets
  - cats
  - dogs
  - dangerous
  - carnivores
  - homes
  - delicious
  - cow
  - farmed
  - increasing
  - numbers



These are similar
but have different levels
of generality, and
non-uniform spelling

Step 2: Grouping

- Base animal categories (noun-y terms)
  - animals
  - cats
  - dogs
  - mammals
  - cow
  - us
- Ways an animal can be (adjective-y terms)
  - domesticated
  - pets
  - dangerous
  - carnivores
  - delicious
  - farmed
- Stuff
  - homes
  - increasing
  - numbers

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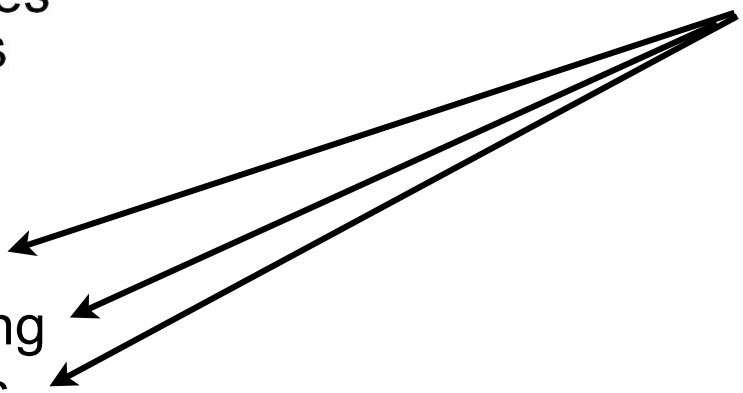

Should we care about these?

A Key Slogan

to determine which terms to care about:

Representations are context sensitive & interest relative

- Context sensitive?
  - for which (kind of) application do we build KR?
- Interests?
  - Application needs
    - Teaching, categorising, data acquisition
  - Audience
    - Children, lay people, different disciplines, clinicians vs. researchers
- Establish context and relevant interests
  - Here: **context** is this class
  - Here: **interests** is to work up a reasonable example

Step 2: Grouping

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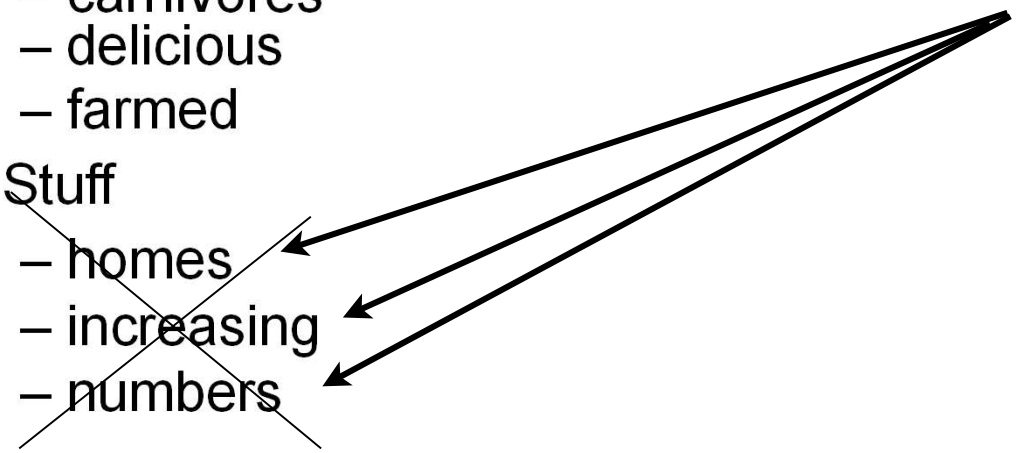

Should we care about these?

No! (Why?)

Step 3: Normalise Terms

- Base animal categories (noun-y terms)
  - animals
  - cats
  - dogs
  - mammals
  - cow
  - us

Unify number & spelling

- Ways an animal can be (adjective-y terms)
  - domesticated
  - pets
  - dangerous
  - carnivores
  - delicious
  - farmed

Step 3: Normalise Terms

- Base animal categories (noun-y terms)
  - Animal
  - Cat
  - Dog
  - Mammal
  - Cow
  - us

Give a good name

- Ways an animal can be (adjective-y terms)
  - domesticated
  - pets
  - dangerous
  - carnivores
  - delicious
  - farmed

Step 3: Normalise Terms

- Base animal categories (noun-y terms)
  - Animal
  - Cat
  - Dog
  - Mammal
  - Cow
  - Human
- Ways an animal can be (adjective-y terms)
  - domesticated
  - pets
  - dangerous
  - carnivores
  - delicious
  - farmed

Unify grammatical form & spelling

Step 3: Normalise Terms

- Base animal categories (noun-y terms)
  - Animal
  - Cat
  - Dog
  - Mammal
  - Cow
  - Human
- Ways an animal can be (adjective-y terms)
  - Domesticated
  - Pet
  - Dangerous
  - Carnivorous
  - Delicious
  - Farmed

We have some background knowledge we can use to "round out" these terms

Step 3: Normalise Terms

- Base animal categories (noun-y terms)
  - Animal
  - Cat
  - Dog
  - Mammal
  - Cow
  - Human
- Ways an animal can be (adjective-y terms)
  - Domesticated
  - Pet
  - Dangerous
  - Carnivorous
  - Omnivorous
  - Herbivorous
  - Delicious
  - Wild
  - Farmed

Step 4: Organise Terms

- Base animal categories (noun-y terms)
  - Animal
  - Mammal
  - Cat
  - Dog
  - Cow
  - Human

General

Specific

- Ways an animal can be (adjective-y terms)
  - Domesticated
  - Wild
  - Dangerous
  - Carnivorous
  - Omnivorous
  - Herbivorous
  - Delicious
  - Pet
  - Farmed

General

Contraries!

Contraries?

Specific

Step 4: Organise Terms

- Base animal categories (noun-y terms)
  - General:
    - Animal
    - Mammal
  - Specific:
    - Cat
    - Dog
    - Cow
    - Human
- Ways an animal can be (adjective-y terms)
  - General:
    - Domesticated
    - Wild
    - Dangerous
    - Carnivorous
    - Omnivorous
    - Herbivorous
    - Delicious
  - Specific:
    - Pet
    - Farmed

Next:
What terms are definable?

Interlude: what is a definition?

- Mini-exercise:
- in the next 3 minutes,
  agree with your neighbour on a **definition** for
  - pet
  - table (furniture)

Interlude: what is a definition?

- a statement that describes/fixes the meaning of a term
- can be
  - extensional: enumerate all elements a term describes e.g., good for “EU countries”
  - intensional: often using genus–differentia pattern
    i.e., giving the next more general term (genus) plus differentiating features for this term and its siblings
    e.g., “An **endotherm** is an organism that maintains its body at a metabolically favourable temperature.”

Two consequences:
if Bob is an endotherm, then I know that…
if I find an organism that maintains its temperature…, then ….

Step 4: Organise Terms

- Base animal categories (noun-y terms)
  - General:
    - Animal
    - Mammal
  - Specific:
    - Cat
    - Dog
    - Cow
    - Human
- Ways an animal can be (adjective-y terms)
  - General:
    - Domesticated
    - Wild
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    - Omnivorous
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    - Delicious
  - Specific:
    - Pet
    - Farmed

Which terms are **easily** definable?

Which Terms are Definable?

- Base animal categories (noun-y terms)
  - General:
    - Animal = eats some Stuff
    - Mammal = has MammGlands
  - Specific:
    - Cat
    - Dog
    - Cow = eats only Grass
    - Human = Omnivore

- Ways an animal can be (adjective-y terms)
  - General:
    - Domesticated
    - Wild
    - Dangerous
    - Carnivorous = eats only Meat
    - Omnivorous = eats Meat & Plants
    - Herbivorous = eats only Plants
    - Delicious = tastes good
  - Specific:
    - Pet = lives with Humans
    - Farmed = is eaten/used

New Terms:
eats, lives, tastes…
= , only, &
Stuff
Plants, Meat,…

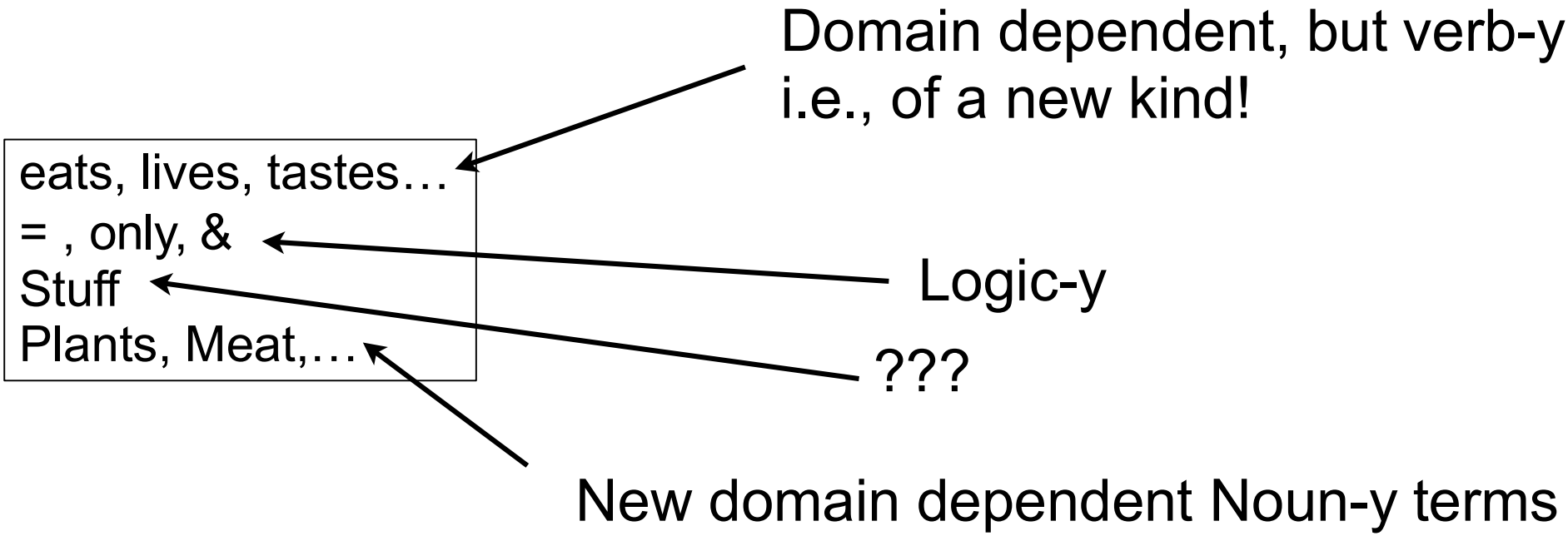
A first regimentation

- Base animal categories (noun-y terms)
  - General:
    1. Animal = eats some Stuff
    2. Mammal = has MammGlands
  - Specific:
    - Cat
    - Dog
    3. Cow = eats only Grass
    4. Human = Omnivore

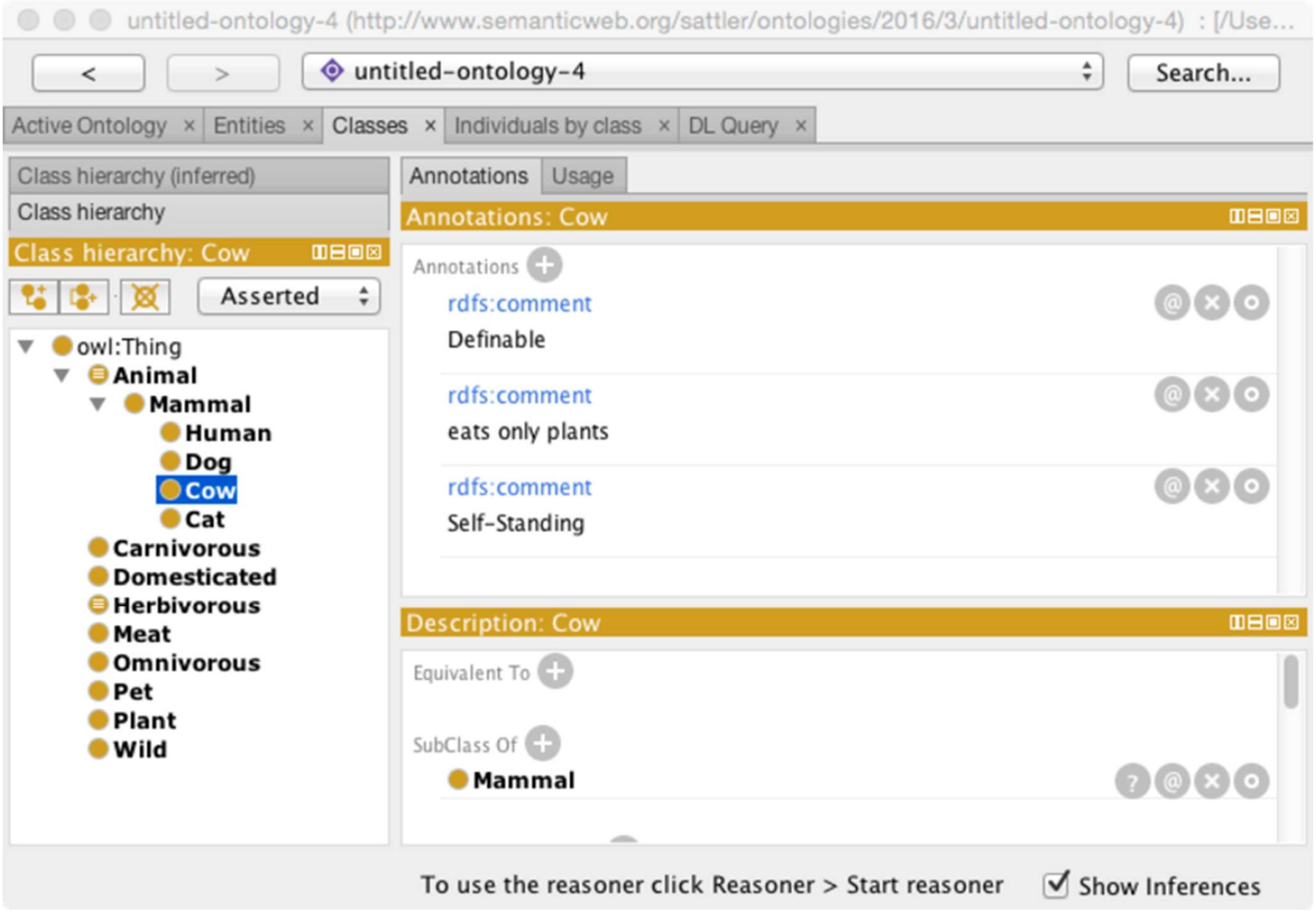
- Ways an animal can be (adjective-y terms)
  - General:
    - Domesticated
    - Wild
    - Dangerous
    5. Carnivorous = eats only Meat
    6. Omnivorous = eats Meat & Plants
    7. Herbivorous = eats only Plants
    8. Delicious = tastes good
  - Specific:
    9. Pet = lives with Humans
    10. Farmed = is eaten/used

Which of these definitions is really good?
I.e., is really a definition?

What about these new terms?



Let’s try to formalise!



Underlying OWL Language

Class: Cow
  Annotations: (解释说明)
    rdfs:comment "eats only Plants",
    rdfs:comment "Definable",
    rdfs:comment "SelfStanding"
  SubClassOf:
    Mammal

常要其他引号定义
如心脏是一组织

OWL has many syntaxes;
this is one of them called **Manchester Syntax**

Recall the regimentation

- Base animal categories (noun-y terms)
  - General:
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  - Specific:
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    - Dog
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  - Specific:
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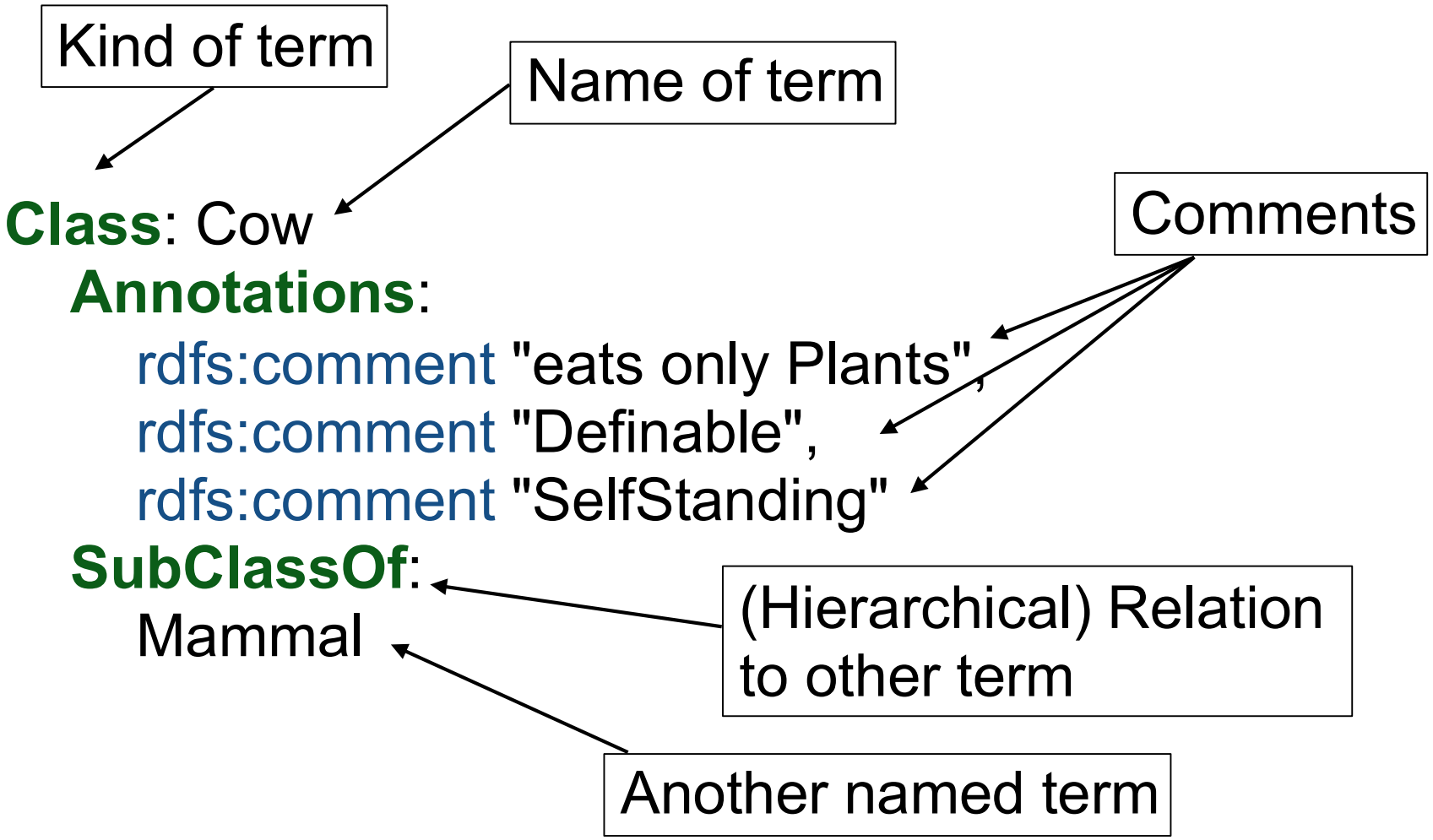
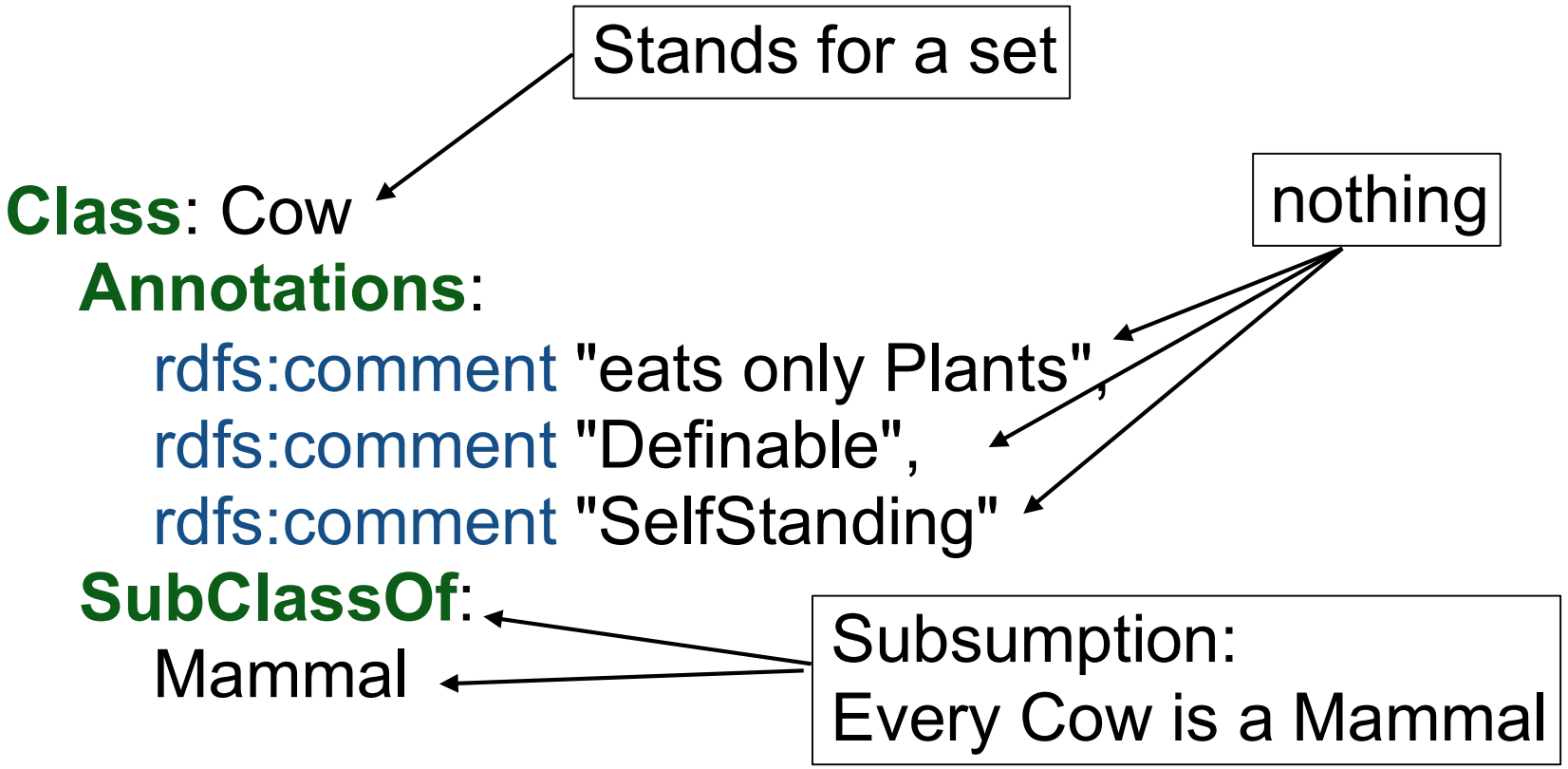
Our mini-formalisation

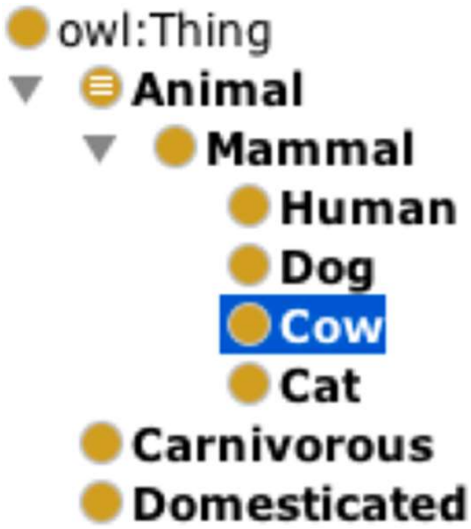


Meaning? Semantics?



Benefits of this formalisation?

Class: Cow
  Annotations:
    rdfs:comment "eats only Plants",
    rdfs:comment "Definable",
    rdfs:comment "SelfStanding"
  SubClassOf:
    Mammal



- Gives some structure to our set of terms:
  - a hierarchy that we can browse
  - we can retrieve classes
  - we can search for comments

Side note: A “Computer View”

Class: Blah
  Annotations:
    rdfs:comment “b123 623 7y3",
    rdfs:comment "mch345",
    rdfs:comment "lkjherhjhhhh"
  SubClassOf:
    Foo

Better Annotations

Class: Cow
  Annotations:
    rdfs:comment "eats only Plants",
    isDefinable True
    hasGrammaticalType SelfStanding
  SubClassOf:
    Mammal

Use good annotation properties

For less string-hackery and easier data-entry

A Better Definition

Class: Cow
  Annotations:
    isDefinable True
    hasGrammaticalType SelfStanding
  EquivalentTo:
    eats **only** Plant
  SubClassOf:
    Mammal

…exact meaning/semantic later!

We Need a Syntax!

- A simple grammar for **descriptions** (aka class expressions)
- Examples
  - Animal that eats only Animal
  - eats some (not Animal)
  - not (eats only Animal and some Animal)

description ::= **conjunction** 'or' **conjunction** { 'or' **conjunction** }
| **conjunction**

conjunction ::= **classIRI** 'that' ['not'] **restriction**
{ 'and' ['not'] **restriction** }
| **primary** 'and' **primary** { 'and' **primary** }
| **primary**

primary ::= ['not'] (**restriction** | **atomicClass**)

restriction ::= **Property** 'some' **primary**
| **Property** 'only' **primary**

atomicClass ::= [A-Z][a-zA-Z]* *(in camel case)*

Property ::= [a-z][a-zA-Z]* *(in camel case)*

Grammar is a slightly modified subset of the one given in: http://www.w3.org/TR/owl2-manchester-syntax/

We Need More Syntax!

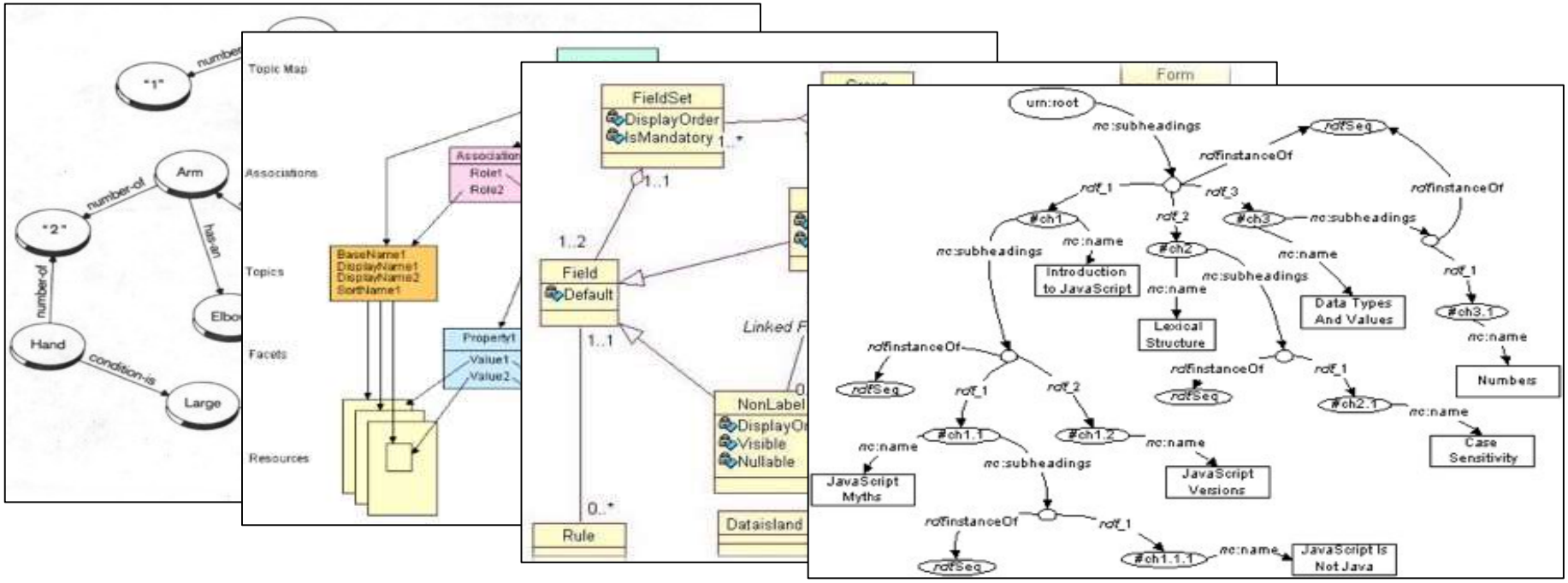
- A simple grammar for **axioms** (aka propositions, statements)
- Examples
  - —Class: CarnivorousAnimal EquivalentTo: Animal that eats only Animal
  - – Class: Cow SubClassOf: eats some (not Animal)
  - —Class: ConfusedCow SubClassOf:
    not (eats only Animal and some Animal)
- What does it all mean!?
- Coming in 10 minutes…

classFrame ::= 'Class:' **atomicClass**
{ 'Annotations:' **annotation** { ',' annotation }
| 'SubClassOf:' **description** { ',' annotation }
| 'EquivalentTo:' **description** { ',' annotation } }

Which Syntax?

textual is better

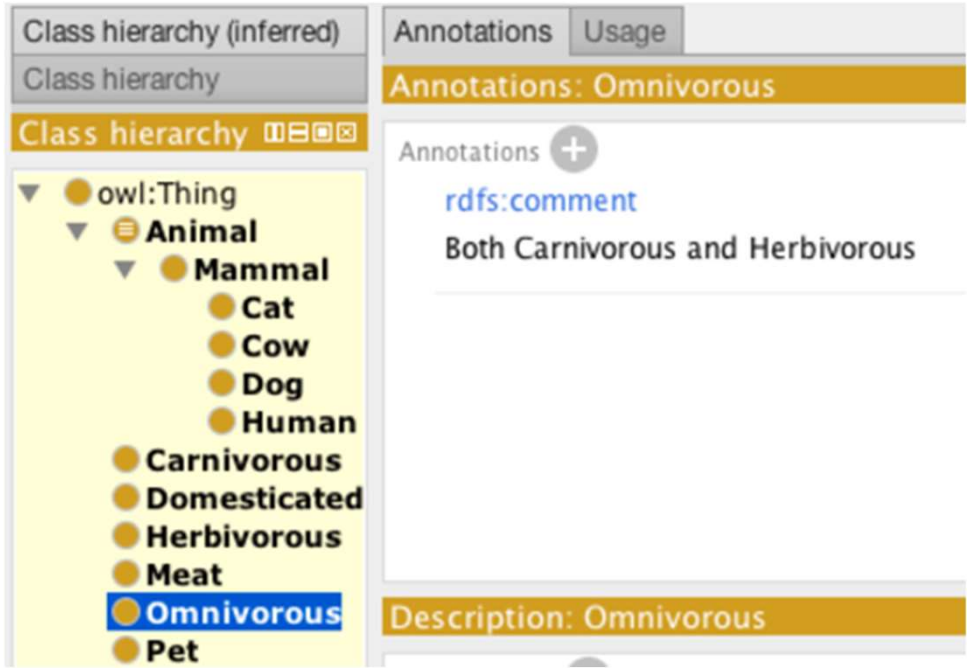
- OWL is textual - would a graphical be better?
- In OWL, an ontology is a (web) **document** that we can
  - parse, import, syntax check and
  - draw graphs for!



Exploring Benefits

- E.g., Omnivorous
  - Annotations: comment "Carnivorous and Herbivorous"
  - has no meaning
  - so let's be explicit:
    - add definition in class description
    - run reasoner
    - check inferred class hierarchy

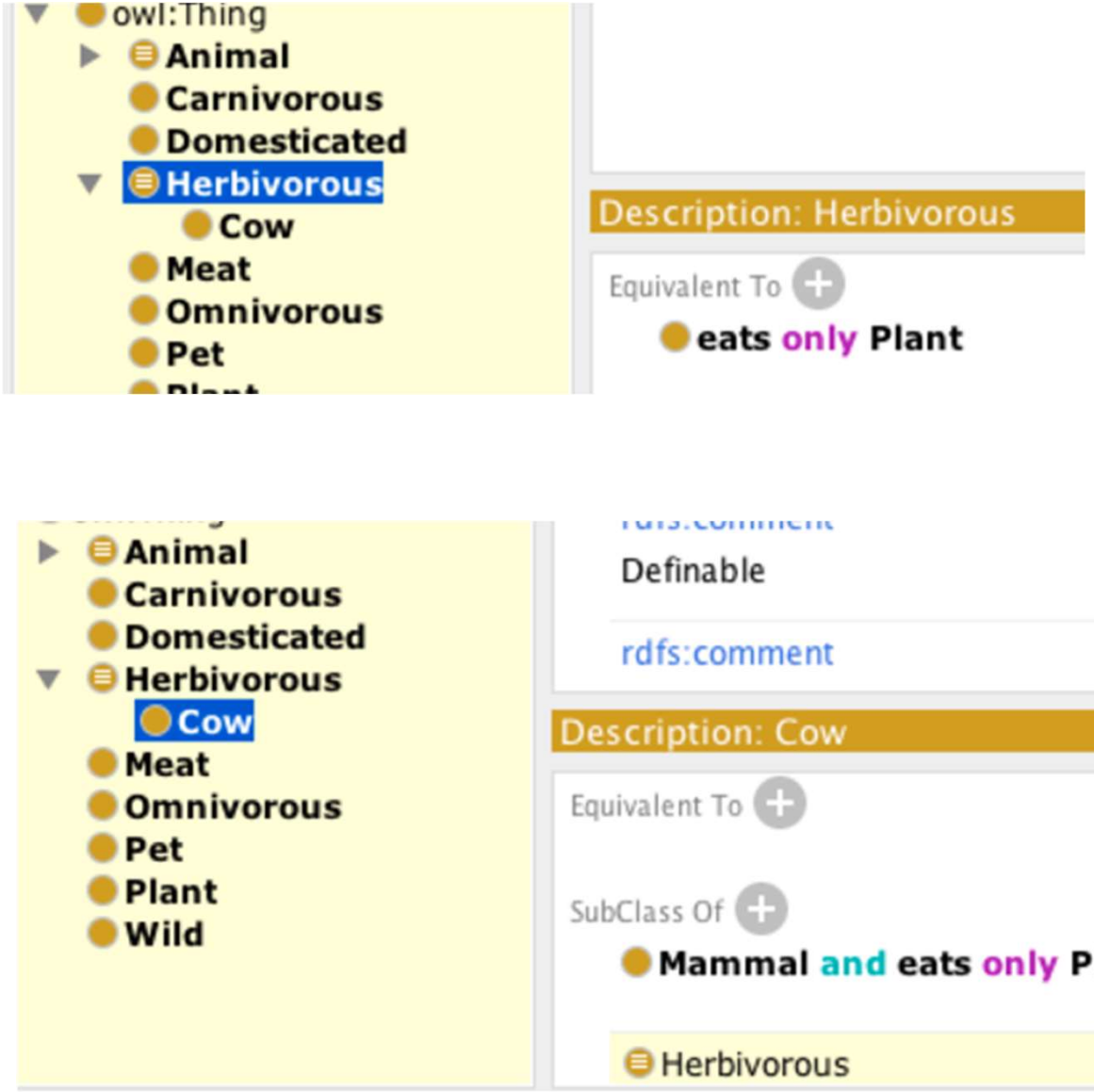
➡our definition was wrong!



Exploring Benefits II

- E.g., Cows
  - Annotations: comment “Animal that eats only Plants”
  - has no meaning
  - so let’s be explicit:
    - add definition in class description
    - run reasoner
    - check inferred class hierarchy

➡our class hierarchy is improved: Cows are indeed herbivores!



First Benefits!

- Links for “free”
  - Tools make **implicit** links **explicit**
  - We don’t have to encode every link ourselves
  - Different modality
    - Instead of is-a/subsumption relations...focus on **meanings**
    - …we can think local rather than global
- Verification
  - Definitions have **consequences**
    - Wrong links
    - Detectable problems
      - Links so wrong they are never right