OWL abstract syntax
and reasoning examples

Adapted from slides by Raphael Volz, AIFB

OWL Abstract Syntax

- Introduced in OWL Web Ontology Language Semantics and Abstract Syntax
- Useful notation, see here for examples
- Uses a kind of functional notation, e.g.
  - Class(pp:duck partial pp:animal)
  - ObjectProperty(pp:has_pet
    domain(pp:person)
    range(pp:animal))
  - Individual(pp:Walt
    value(pp:has_pet pp:Huey)
    value(pp:has_pet pp:Louie)
    value(pp:has_pet pp:Dewey))

Namespaces

- Namespace(pp = <http://cohse.semanticweb.org/ontologies/people#>)

Partial and complete definitions

- Description logics reason with definitions
  - They prefer to have *complete* descriptions
  - A complete definition includes both **necessary** conditions and **sufficient** conditions
- Often impractical or impossible, e.g. natural kinds
- Primitive definition is partial or incomplete
  - Limits classification that can be done automatically
- Example:
  - Primitive: a Person
  - Defined: Parent = Person with at least one child

Partial and complete definitions in Owl

- Partial definitions typically made using one or more rdfs:subClassOf relations
  - :Parent rdfs:subClassOf :Person
  - Knowing that john is a parent, it is **necessary** that he is a person
- Complete definitions are made with owl:equivalentClass
  - :Parent owl:equivalentClass [a owl:inetrsection (:Person [owl:restriction …])]
  - Knowing that john is a person and has a child is **sufficient** to conclude he is a parent

Definition vs. Assertion

- A **definition** is used to describe *intrinsic* properties of an object. The parts of a description have meaning as a part of a composite description of an object
- An **assertion** is used to describe an *incidental* property of an object. Asserted facts have meaning on their own.
- Example: “a black telephone”

  Could be either a description or an assertion, depending on the meaning and import of “blackness” on the concept telephone.

Definition versus Assertion

- In English, “a black telephone” is ambiguous
  (1) A black telephone is a common sight in an office
  (2) A black telephone is on the corner of my desk
- KR languages should not be ambiguous so typically distinguish between descriptions of classes and descriptions of individuals
- KR languages often also allow additional assertions to be made that are not part of the definition (In OWL called annotation properties)

Classification is very useful

- Classification is a powerful kind of reasoning that is very useful
- Many expert systems can be usefully thought of as doing “heuristic classification”
- Logical classification over structured descriptions and individuals is also quite useful.
- But… can classification ever deduce something about an individual other than what classes it belongs to?
- And what does **that** tell us?

Incidental properties

- If we allow incidental properties (e.g., ones that don't participate in the description mechanism) then these can be deduced via classification
- This is the purpose of owl's annotationProperty
- An annotationProperty can be associated with a definition (partial or complete)
- It is not checked when reasoning about subsumption or instance checking

Declaring classes in OWL

- *Naming a new class "plant":*
  Class(pp:plant partial)

- *Naming some "special plants":*
  Class(pp:grass partial pp:plant)
  Class(pp:tree partial pp:plant)

- *Alternative Declaration:*
  Class(pp:grass partial)
  Class(pp:tree partial)
  SubClassOf(pp:grass pp:plant)
  SubClassOf(pp:tree pp:plant)

Declaring Properties in OWL: I

- *A simple property:*
  ObjectProperty(pp:eaten_by)

- *Properties may be inverse to each other:*
  ObjectProperty(pp:eats
  inverseOf(pp:eaten_by))

- *Domain and Ranges:*
  ObjectProperty(pp:has_pet
  domain(pp:person)
  range(pp:animal))

Declaring Properties in OWL: II

- *Datatype Properties:*
  DataProperty(pp:service_number
  range(xsd:integer))

- *Property Hierarchy:*
  SubPropertyOf(pp:has_pet pp:likes)

- *Algebraic properties:*
  ObjectProperty(pp:married_to Symmetric)
  ObjectProperty(pp:ancestor_of Transitive)
  ObjectProperty(pp:passport_nr Functional)

Individuals in OWL

```
Individual(pp:Tom type(owl:Person))
Individual(pp:Dewey type(pp:duck))
Individual(pp:Rex type(pp:dog)
                value(pp:is_pet_of pp:Mick))
Individual(pp:Mick type(pp:male)
                value(pp:reads pp:NYPost)
                value(pp:drives pp:Fiat_500)
                 value(pp:name "Mick"^xsd:string))
```

Entailment Quiz

What follows from
these descriptions?

Quiz # 1

Class(pp:old+lady complete intersectionOf(pp:elderly
pp:female pp:person))

Class(pp:old+lady partial
intersectionOf(restriction(pp:has_pet
allValuesFrom(pp:cat)) restriction(pp:has_pet
someValuesFrom(pp:animal))))

Quiz #1 - Solution

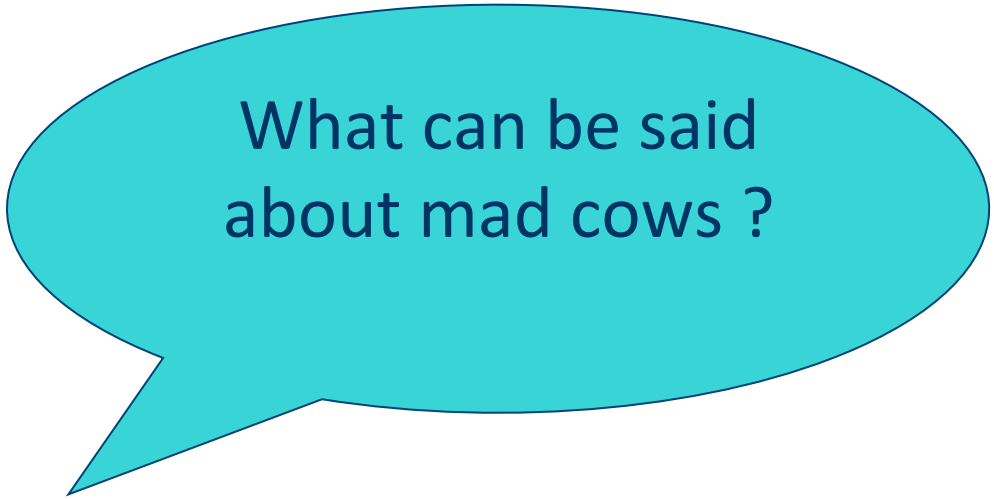
Every old lady must have a pet cat.

(Because she must have some pet and all her pets must be cats.)

Quiz #2

Class(pp:cow partial pp:vegetarian)

Class(pp:mad+cow complete
intersectionOf(pp:cow restriction(pp:eats
someValuesFrom(intersectionOf(pp:brain
restriction(pp:part_of someValuesFrom
pp:sheep))))))



Quiz # 2 - Solution

There can be no mad cows.

(Because cows, as vegetarians, don't eat anything that is a part of an animal.)

Quiz #3

What are Minnie and Tom ?

ObjectProperty(pp:has_pet domain(pp:person)
range(pp:animal))

Class(pp:old+lady complete intersectionOf(pp:elderly
pp:female pp:person))

Class(pp:old+lady partial
intersectionOf(restriction(pp:has_pet
allValuesFrom(pp:cat)) restriction(pp:has_pet
someValuesFrom(pp:animal))))

Individual(pp:Minnie type(pp:elderly) type(pp:female)
value(pp:has_pet pp:Tom))

Quiz #3 - Solution

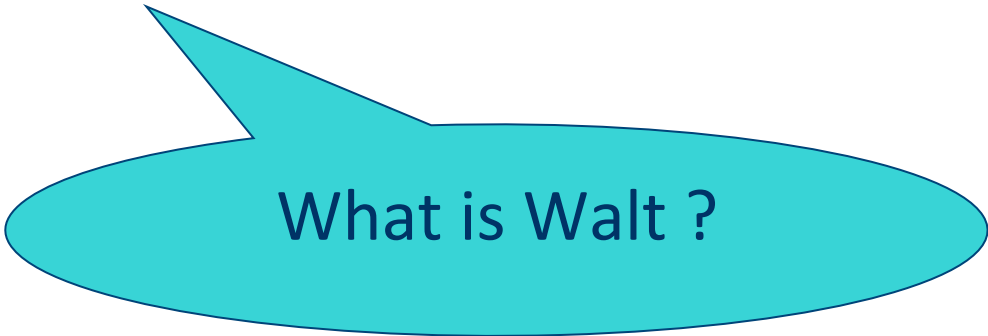
Minnie must be a person (because pet owners are human) and thus is an old lady. Thus Tom must be a cat (because all pets of old ladies are cats).

Quiz #4

Class(pp:animal+lover complete
intersectionOf(pp:person
restriction(pp:has_pet minCardinality(3))))

Individual(pp:Walt type(pp:person)
value(pp:has_pet pp:Huey) value(pp:has_pet
pp:Louie) value(pp:has_pet pp:Dewey))

DifferentIndividuals(pp:Huey pp:Louie pp:Dewey)



Quiz #4 - Solution

Walt must be an animal lover. Note that stating that Walt is a person is redundant.

Quiz #5

What are Mick and the National_ Enquirer ?

Class(pp:van partial pp:vehicle)

Class(pp:driver partial pp:adult)

Class(pp:driver complete
intersectionOf(restriction(pp:drives someValuesFrom(pp:vehicle))
pp:person))

Class(pp:white+van+man complete intersectionOf(pp:man
restriction(pp:drives someValuesFrom(intersectionOf(pp:white
+thing pp:van)))))

Class(pp:white+van+man partial restriction(pp:reads
allValuesFrom pp:tabloid))

Individual(pp:Q123+ABC type(pp:white+thing) type(pp:van))

Individual(pp:Mick type(pp:male) value(pp:reads
pp:National_Enquirer) value(pp:drives pp:Q123+ABC))

Quiz #5 - Solution

Mick drives a white van, so he must be an adult (because all drivers are adults). As Mick is male, thus he is a white van man, so any paper he reads must be a tabloid, thus the National Enquirer is a tabloid.