DAML: Ontology, Services and Rules

Stuart Aitken

Artificial Intelligence Applications Institute

W3C + DAML

- W3C standards
  - XML
  - RDF - Resource Description Framework
  - RDFS - RDF Schema
- Ontology languages
  - DAML-O - ontology
  - DAML-S - services
  - DAML-R - rules

W3C initiatives

- XML
- RDF
  - Extends XML
  - Represents semantics as triples
- RDF Schema
  - Encodes the type hierarchy

RDF

- Identify ‘things’ through URIs, and
- describe them in terms of simple properties and property values
- Triples: subject predicate object
  - http://www.example.org/index.html
  - http://purl.org/dc/elements/1.1/creator
  - http://www.example.org/staffid/85740
- Subjects and objects are viewed as nodes, predicates as links in a graph
- Predicates are defined - ontology
- `rdf:type` - objects can have types
  - a defined predicate

RDFS

- RDF Properties: represent relationships between resources
- No way to describe these properties, or relationships between these properties and other resources
- RDFS: specify Classes and the domain and range of properties:
  - author - domain:Document

    - range: Person

RDFS

- `rdfs:Resource` the class of everything
- `rdfs:Class` the class of classes
- `rdfs:Literal` the class of literal values e.g. string and integer
- `rdf:Property` instance of `rdfs:Class`
- `rdfs:domain` instance of `rdf:Property`
- `rdfs:range` instance of `rdf:Property`
- `rdfs:subClassOf`
- `rdfs:subPropertyOf`

DAML-O

- A DAML+OIL knowledge-base is a collection of RDF triples
- DAML+OIL prescribes the meaning of triples that use DAML+OIL vocabulary
- Adds 12 classes and 26 properties to RDFS (axiomatised)

DAML-O

- `daml:Class` a class element - refers to a class name (URI) may contain:
  - `rdfs:subClassOf`
  - `daml:disjointWith`
  - boolean combination of class expressions
  - enumeration elements
- Class expression
  - class name (URI)
  - enumeration of classes
  - property restriction
  - boolean combination of the above

DAML-O

Property restrictions: qualify a defined class, `A`, by stating `(quant.)property.C`

`e.g. RedWine:= Wine/\hasColour.RED`

- `daml:toClass` for all x, if property(x,y) holds of an element y, y is in C
- `daml:hasClass` for some x, property(x,y) holds of an element y of C

DAML-O

- Cardinality constraints
  - N values of property
  - Max values
  - Min values
  - E.g. Wine has exactly one colour
- Description Logic reasoners exist for DAML-O
- DL is good for defining concepts, computing the subsumption relation, but
- Expressivity is intentionally limited.

DAML-O

Description Logic: Syntax and Semantics

atomic construct	A	A is a subset of the Universal set
atomic role	R	R subset U * U
conjunction	C /\ D	intersection of C and D
disjunction	C \/ D	set union of C and D
negation	-C	complement of C (U\C)
exists restriction	Some R.C	{x|exists y <x,y> in R, y in C}
value restriction	All R.C	{x|all y <x,y> in R => y in C}
role hierarchy	R [S	R subset S

DAML-O

Description Logic: Subsumption

C:= Person /\ All eats.Meat

O:= Person /\ Some eats.Meat

V:= Person /\ All eats.-Meat

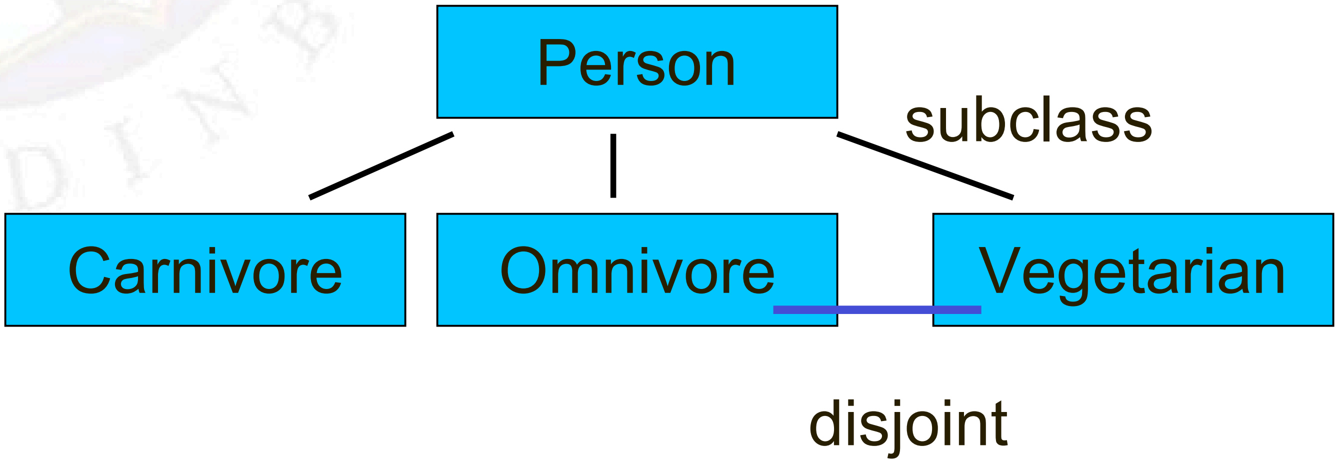
Q1. Is O a subclass of C ?

Q2. Are C and V disjoint ?

Q3. Are O and V disjoint ?

DAML-O

Description Logic: Subsumption



DAML-S

- Semantic mark-up for web services
- Agents should be able to
  - discover,
  - invoke,
  - compose, and
  - monitor web resources.
- Ontology - expressed in DAML-O
  - A Service
    - presents a Service Profile (what is on offer)
    - described by a Service Model (how it is achieved)
    - supports a Service Grounding (implementation details)

DAML-S

- **Service Profile**

  serviceName; textDescription; contactInformation

- **Actor**

  name; title; phone, fax….

- **‘Functional’ characteristics of Service Profiles and Service Models**
  - **input/output (Parameter Description)**
  - **precondition/effect (Parameter Description)**

DAML-S

- Service Model: Process Ontology
  - Atomic, Simple, Composite Process
- Control Construct
  - Sequence, Split, Choice, If-Then-Else
- Data flow/Parameter Bindings
  - There are no variables in the language to allow instances to be equated
  - E.g. item1 is input; item1 is output, but we can only specify the type as input/output
  - Annotation is used:

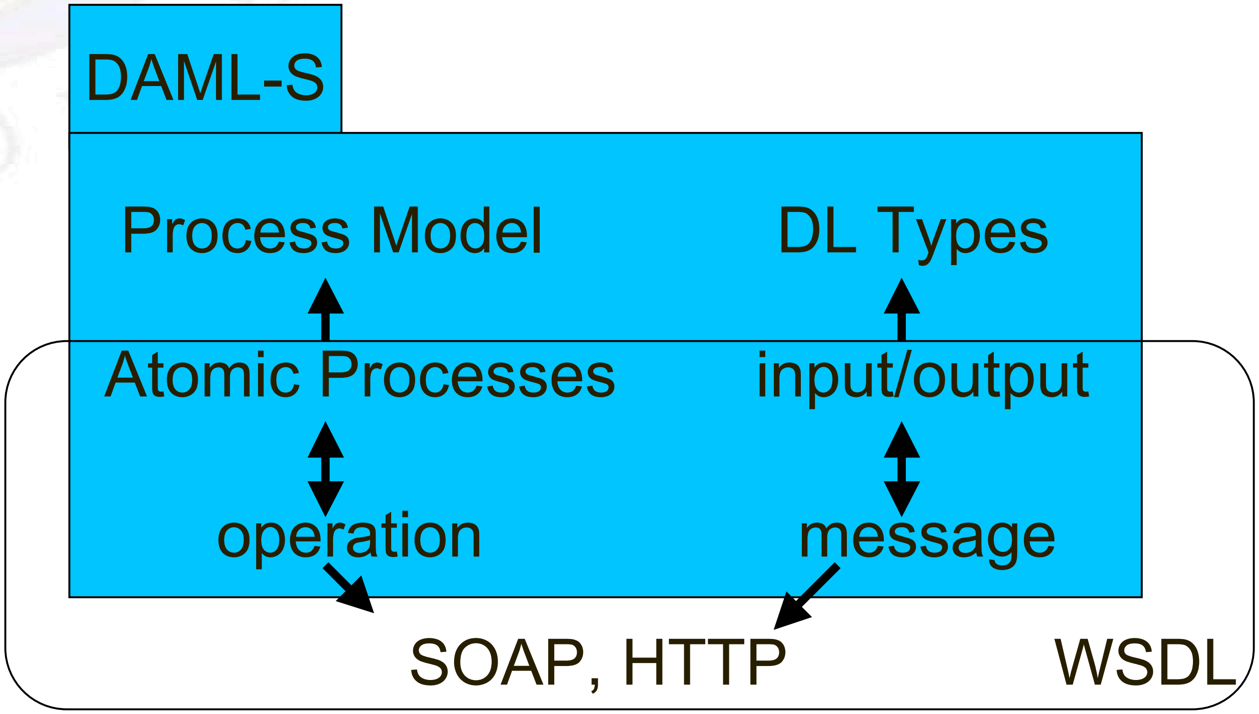
    sameValues(Process, [(valueOf Class,Parameter),….])

DAML-S

- Formalisation of the Process Ontology is weak
  - Classes
  - No/few axioms
- Alternative formalisations of the execution semantics exist
  - Narayanan & McIlraith: situation calculus + petri nets
  - Ankolekar, Huch & Sycara: pi calculus/ functional programming
- Declarative Semantics for a CycL Process Ontology may be relevant
- Uses: Verification, Simulation, Composition

DAML-S

At the ‘implementation level’ DAML-S specs will map to WSDL, SOAP…



DAML-R

Introduce Rules to solve the instance identification (variable) problem - this is a general problem with DL

- RuleML
- Grosof & Horrocks ‘Logic Programming + DL’
- Others…