Inferencing

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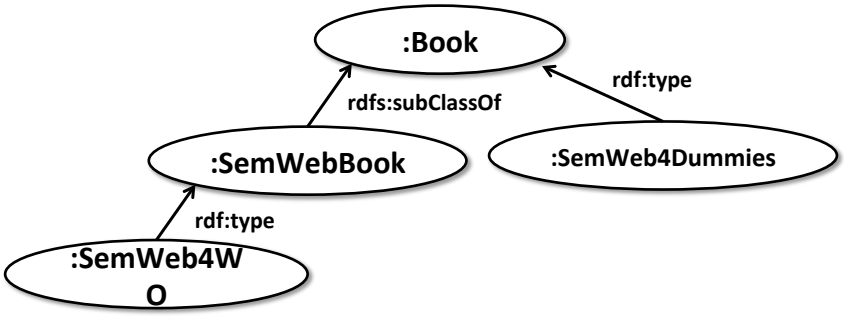
Notes from "Semantic Web for the Working Ontologist" Book

Inferencing in Semantic Web

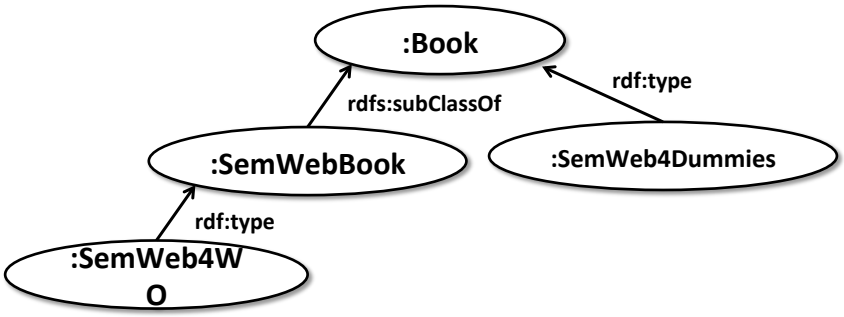
- Given some information
  - Determine other/related information
  - Discovering new relationships based on the data and based on some additional information in the form of a vocabulary, e.g. a set of rules (w3c)

Example



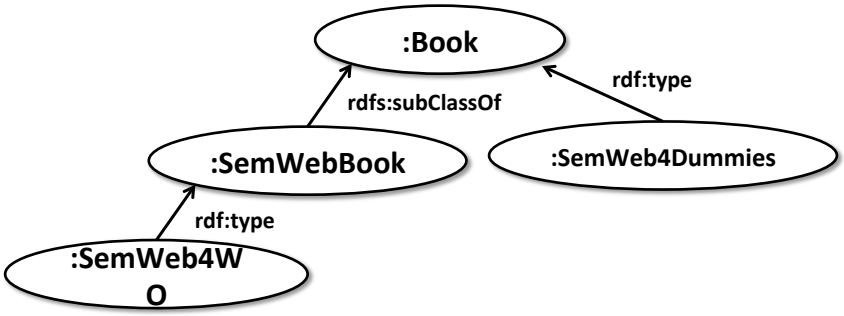
- Books?
- SELECT ?item WHERE { ?item a :Book}

Example



- SELECT ?item WHERE { ?item a :Book}
  :SemWeb4Dummies
  :SemWeb4WO

Example



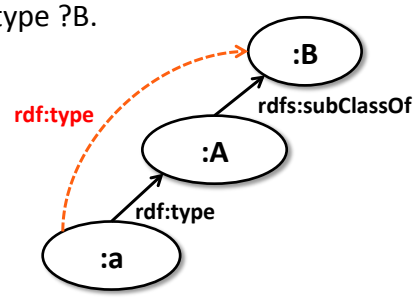
- Rule: all members of the subclass are also members of the superclass

Inferencing

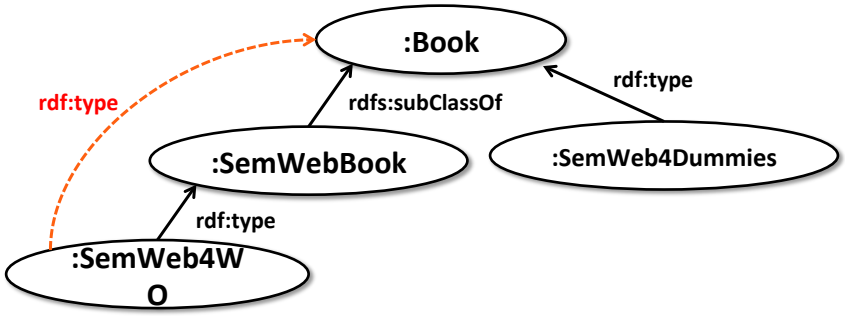
- Rule: all members of the subclass are also members of the superclass
- Meaning of rdfs:subClassOf

  IF ?A rdfs:subClassOf ?B. AND ?x rdf:type ?A. *(given)*

  THEN ?x rdf:type ?B. *(implied)*



Example



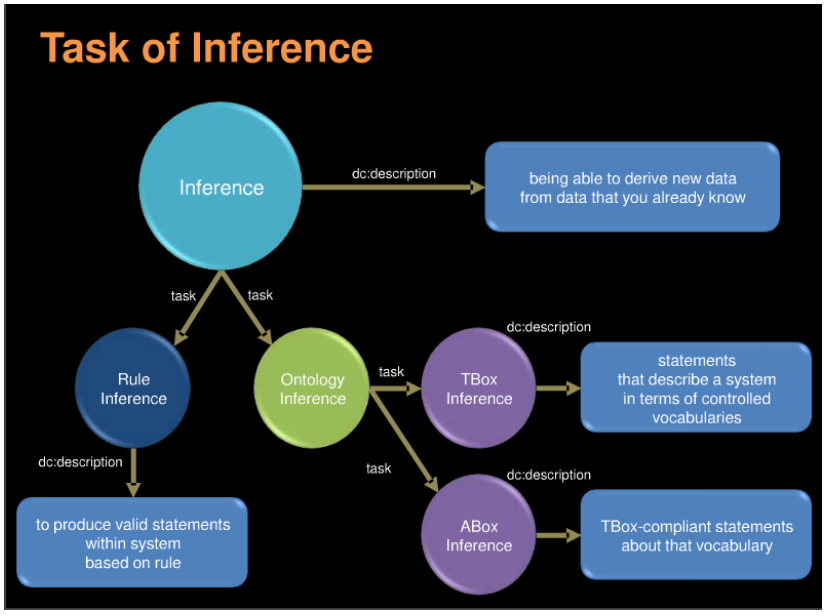
- SELECT ?item WHERE { ?item a :Book}
  :SemWeb4Dummies
  :SemWeb4WO

Inferencing

- Why?
- How?
- When?

Why inference?

- To get more information
- To keep less information
- To align/integrate/link to more information (on the web)
- …



http://www.slideshare.net/onlyjiny/inference-on-the-semantic-web

TBox inferencing

- Discovering new statements that describe the system in terms of controlled vocabularies
- Ex:

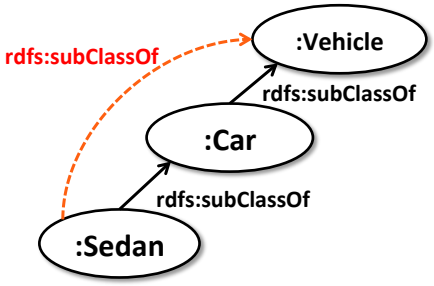
Given

:A rdfs:subClassOf :B

:B rdfs:subClassOf :C

Then

:A rdfs:subClassOf :C



ABox inferencing

- Tbox-complaint statements about the vocabulary
- Ex:

Given

:Sedan rdfs:subClassOf :Car

:Car rdfs:subClassOf :Vehicle

:VWSedan rdf:type :Sedan

Then

:VWSedan rdf:type :Car

:VWSedan rdf:type :Vehicle

Rule inferencing

- To produce valid statements based on rules
- Ex: defining hasWife/hasHusband relationships as a rule

  If hasParent(**?x**, ?y) and hasParent(**?x**,?z)
  and Man(?y) and Woman(?z)

  Then hasWife(?y,?z), hasHusband(?z,?y)
- Syntax?
  - Rule languages

Asserted vs. Inferred Triples

- Asserted triples
  - Triples (statements) in the original RDF store/ model
- Inferred triples
  - Additional triples that were asserted by the inference rules
  - Inferred triple could be asserted before!
  - No logical distinction between the two

Example

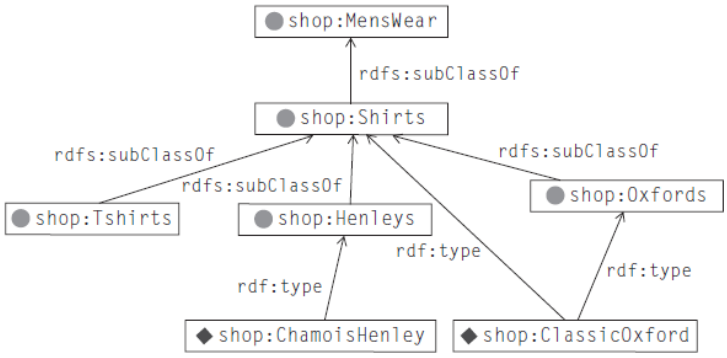


FIGURE 6.2

Asserted triples in the catalog model.

Example

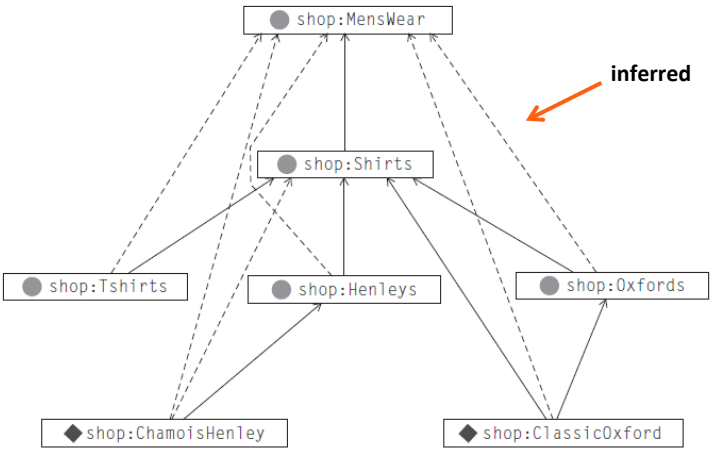


FIGURE 6.3

All triples in the catalog model. Inferred triples are shown as dashed lines.

How?

- SPARQL
  - express rules in general and the inference rules of RDFS and OWL by **using SPARQL CONSTRUCT**
  - a CONSTRUCT query specifies new triples based on a graph pattern of triples found in the data

```
CONSTRUCT { ?r rdf:type ?B }
WHERE { ?A rdfs:subClassOf ?B .
        ?r rdf:type ?A }
```

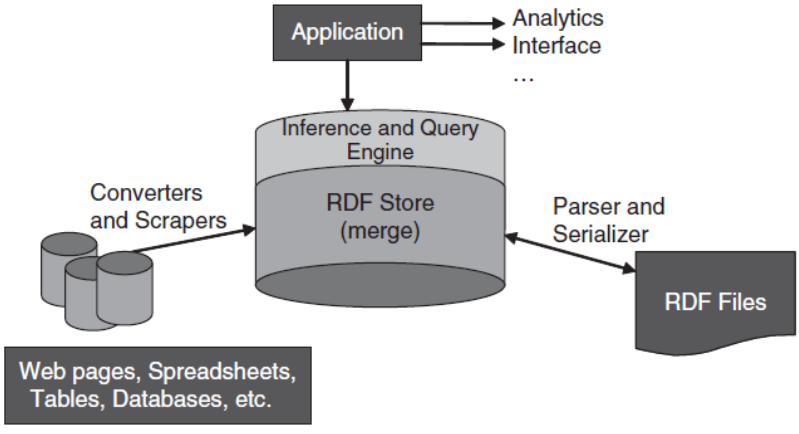
Inference when?

- When should the inferencing be done?
- Outside the definition of RDFS/OWL
- But important
- Differs from implementation to implementation

Inferencing when?

- **Cached inferencing**
  - Store all statements (triples) in a single store whether asserted or inferred
  - Risk: explosion of triples in the store
  - Risk: when removing a triple, should we remove inferred triples and how?
- **Just in time inferencing**
  - Never store any inferred triples
  - Inference in response to queries only (computed at the latest possible moment)
  - Risk: duplicating inference work

Inference-based SW App Architecture



More on RDFS inferencing

- rdfs:subPropertyOf propagation

```
CONSTRUCT { ?x ?r ?y }
WHERE  { ?x ?q ?y .
          ?q rdfs:subPropertyOf ?r.
        }
```

Example

TBox

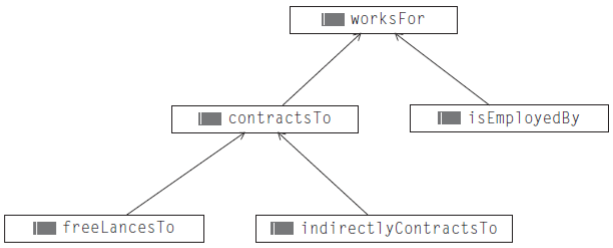


FIGURE 7.1

`rdfs:subPropertyOf` relations for workers in the firm.

ABox

```
:Goldman :isEmployedBy :TheFirm.
:Spence :freeLancesTo :TheFirm.
:Long :indirectlyContractsTo :TheFirm.
```

Inferred

```
:Goldman :worksFor :TheFirm.
:Spence :contractsTo :TheFirm.
:Spence :worksFor :TheFirm.
:Long contractsTo :TheFirm.
:Long :worksFor :TheFirm.
```

domain and range

- rdfs:domain inferrence

```
CONSTRUCT {?x rdf:type ?D .}
WHERE {?P rdfs:domain ?D .
       ?x ?P ?y .}
```

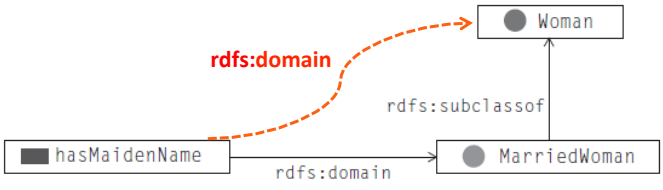
- rdfs:range inferrence

```
CONSTRUCT {?y rdf:type ?D .}
WHERE {?P rdfs:range ?D .
       ?x ?P ?y .}
```

More

- rdfs:domain and rdfs:subClassOf

```
CONSTRUCT {?P rdfs:domain ?C .}
WHERE {?P rdfs:domain ?D .
       ?D rdfs:subClassof ?C .}
```



Class intersection

- Given
  - :C rdfs:subClassOf :A
  - :C rdfs:subClassOf :B
- and
  - :x rdf:type :C
- We can infer
  - :x rdf:type :A
  - :x rdf:type :B

$$C \subseteq A \cap B$$

$$A \cap B \subseteq C$$

```
:Surgeon rdfs:subClassOf :Staff.
:Surgeon rdfs:subClassOf :Physician.
:Kildare rdf:type :Surgeon.
```

then we can infer that

```
:Kildare rdf:type :Staff.
:Kildare rdf:type :Physician.
```

Class union

- Given
  - :A rdfs:subClassOf :C
  - :B rdfs:subClassOf :C.
- and
  - :x rdf:type :A

  or
  - :x rdf:type :B
- implies
  - :x rdf:type :C

$$A \cup B \subseteq C$$

OWL inferencing

```
CONSTRUCT {?y ?q ?x}
WHERE {?p owl:inverseOf ?q .
       ?x ?p ?y . }

CONSTRUCT {?p owl:inverseOf ?p. }
WHERE {?p a owl:SymmetricProperty . }


CONSTRUCT {?x ?p ?z .}
WHERE {?x ?p ?y .
       ?y ?p ?x .
       ?p a owl:TransitiveProperty . }
```

owl:equivalentClass

```
CONSTRUCT {?r rdf:type ?b .}
WHERE {?a owl:equivalentClass ?b .
       ?r rdf:type ?a . }

CONSTRUCT {?r rdf:type ?a .}
WHERE {?a owl:equivalentClass ?b .
       ?r rdf:type ?b . }

owl:equivalentClass rdf:type owl:SymmetricProperty.
```

owl:sameAs

```
CONSTRUCT {?s ?p ?x. }
WHERE {?s ?p ?y.
       ?x owl:sameAs ?y .}
CONSTRUCT {?x ?p ?o. }
WHERE {?y ?p ?o .
       ?x owl:sameAs ?y .}
CONSTRUCT {?s ?x ?o. }
WHERE {?s ?y ?o .
       ?x owl:sameAs ?y .}
owl:sameAs rdf:type owl:SymmetricProperty.
```

owl:FunctionalProperty

```
CONSTRUCT {?a owl:sameAs ?b . }
WHERE {?p rdf:type owl:FunctionalProperty .
       ?x ?p ?a .
       ?x ?p ?b . }
```

```
CONSTRUCT {?a owl:sameAs ?b . }
WHERE {?p rdf:type owl:InverseFunctionalProperty .
       ?a ?p ?x .
       ?b ?p ?x . }
```