RDF & RDFS
Basics, Semantics, Schema, Vocabulary, and Usage

BASICS

Syntax

Subject — Property/Predicate — Object

URI Prefix: Shorthand for namespace URI (written as: @prefix dbpedia: <http://dbpedia.org/resource/>)

dbpedia:TheHague dbo:areaCode "015"^^xsd:double .

'Type' operator

If unspecified, 'string' will be assumed by RDF

Short form:

dbpedia:The_Hague rdfs:label "The Hague"@en .
dbpedia:The_Hague rdfs:label "Den Haag"@nl .

Tag: Provides further information about literals

A full usage example is here:

dbpedia:The_Hague dbo:areaCode "015"@en ;
rdfs:label "The Hague"@en ,
"Den Haag"@nl .

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Possible Components

An RDF graph is a set of triples like this.

Triples can be made up of...

This creates "hypergraphs"—another dimension that connects to predicate and defines it (i.e., the resource page of the predicate itself, and the connections to it, etc). This is an important feature of RDF.

	Subject	Property/Predicate	Object
URI References	✔	✔	✔
Literals	✖	✖	✔
Blank Nodes	✔	✖	✔

Literals as subjects is not officially allowed in RDF specification, but it could arguably still be possible/make sense in some cases. E.g., "10 isA number"

A blank node as a predicate would be just too meaningless; the relation between two things should be somehow specified.

Formal definition of the syntax of RDF:

RDF = (URI U blankNodes) X (URI) X (URI U blankNodes U literals)

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Example RDF File

```
@prefix vcard: <http://www.w3.org/2006/vcard/ns#>
@prefix sn: <http://www.snee.com/hr/>

sn:employee1 vcard:given-name "Heidi" .
sn:employee2 vcard:given-name "John" .
sn:employee3 vcard:given-name "Francis" .
sn:employee4 vcard:given-name "Jane" .

sn:employee1 vcard:family-name "Smith" .
sn:employee2 vcard:family-name "Smith" .
sn:employee3 vcard:family-name "Jones" .
sn:employee4 vcard:family-name "Berger" .

sn:employee1 vcard:title "CEO" .
sn:employee2 vcard:title "Engineer" .
sn:employee3 vcard:title "Vice President" .
sn:employee4 vcard:title "Sales" .

sn:employee1 sn:hiring-date "2018-01-13" .
sn:employee2 sn:hiring-date "2018-01-28" .
sn:employee3 sn:hiring-date "2018-02-13" .
sn:employee4 sn:hiring-date "2018-03-10" .

sn:employee1 vcard:orientation-date "2018-01-30" .
sn:employee2 vcard:orientation-date "2018-01-30" .
```

Official w3.org vocabulary

User-created, custom vocabulary

Full expression: <http://www.w3.org/2006/vcard/ns#given-name>

Assigning a prefix at the beginning of file allows writing a shorthand as: vcard:given-name

Further RDF syntax specifications in the dedicated 'Turtle Syntax' sheet.

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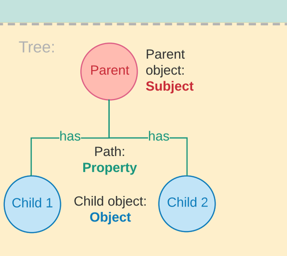
From Tables and Trees to Triples

Any information type can be transformed into triples

	Subject	Property	Object
Tables	row id	column name	cell
Trees	parent	path	child



Column title: Property

Employee ID	given-name	family-name	title	hiring-date	orientation-date
employee1	Heidi	Smith	CEO	2018-01-13	2015-01-30
employee2	John	Smith	Engineer	2018-01-28	2015-01-30
employee3	Francis	Jones	Vice President	2018-02-13	
employee4	Jane	Berger	Sales	2018-03-10	

Row identifier: Subject

Cell: Object

sn:employee3 vcard:title "Vice President" .

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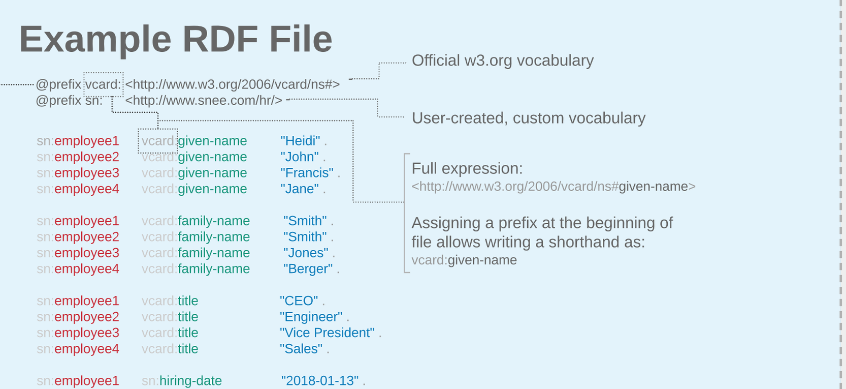
Blank Nodes

```
dbpedia:VU   dbo:address [
     dbo:place  dbpedia: Amsterdam ;
     dbo:street  "De Boelelaan" ;
     dbo:number       "1081" ;
     dbo:postcode       "1081 HV" ;
]
```



Blank Node
An object that has no URI, and is used in a similar fashion to the connector element of UML schemas. It serves as a terminal or intermediary between two or more elements.

Use them when resource is unknown, or has no natural identifier—when we cannot/don't want to give a name to an object

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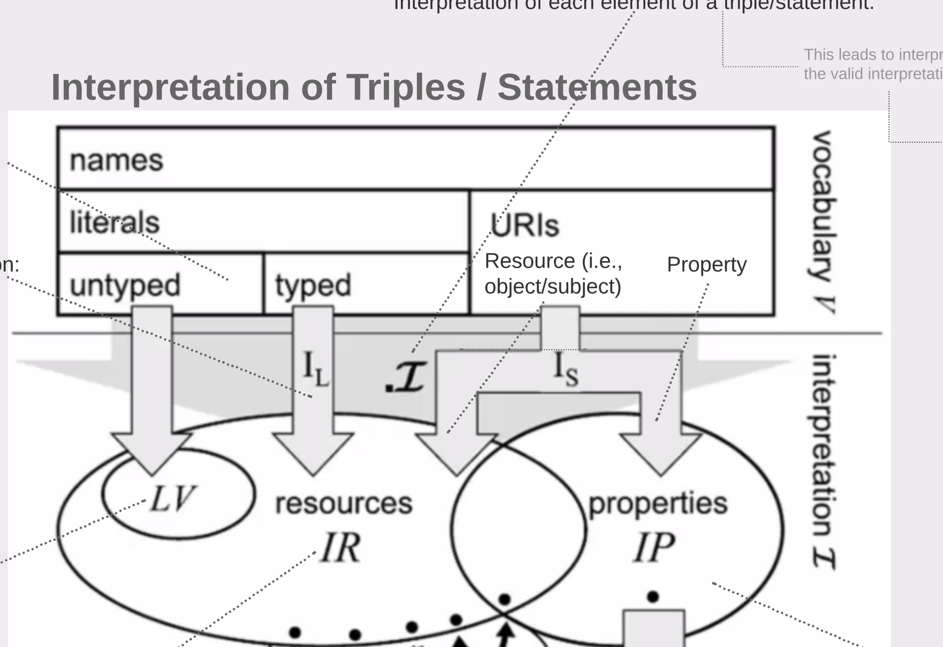
SEMANTICS

Interpretation of each element of a triple/statement.

This leads to interpretations of a knowledge graph, and the valid interpretations are used to model the statement.

Interpretation of Triples / Statements



Blank nodes?

Interpretation: Literal

Non-object resources. These tend to be literals.

Interpretation: Resource (Things that are interpreted as a resource)

The universe of relationships: This universe is an intersection of the objects from the IR universe whose relationships are defined by the IP universe, and the IP universe.

Interpretation: Property

Interpretation of the relationship that specific properties define (e.g., transitive relationship, symmetrical relationship, range, etc...).

This specificity of properties is not the case in Simple Knowledge Graph Logic (SKGL); but is the case in RDF. SKGL creates graphs while RDF creates Hypergraphs—graphs in which properties are also linked as objects and subjects while their properties is being defined.

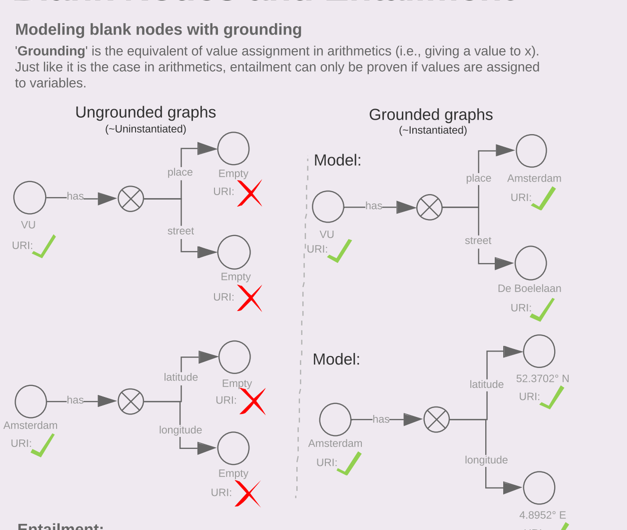
Interpretation and Models

A model of a graph is an interpretation that satisfies all its triples.

Blank Nodes and Entailment

Modeling blank nodes with grounding

'**Grounding**' is the equivalent of value assignment in arithmetics (i.e., giving a value to x). Just like it is the case in arithmetics, entailment can only be proven if values are assigned to variables.



Entailment:

largeGraph ⊨ smallGraph if and only if largeGraph ⊨ smallGraph(grounded) is true for at least in one grounded instance of the smallGraph

i.e., Models of graphs is created by assigning URIs to blank nodes, and thus by grounding them. After grounding, if all models of largeGraph is also a model of at least one grounding of smallGraph, then largeGraph entails smallGraph.

i.e., Nothing in the smallGraph (i.e., a version of it that has its variables replaced by values) violates anything in the largeGraph; and everything that is true in the largeGraph is true for the smallGraph.

~Ungrounded: lion as species

~Grounded: Lion as specimen

Analogous to saying that nothing that applies to a specimen of a lion violates anything that applies to mammals; and everything that is true for mammals is true for (at least) this sample specimen, and thus, it must be true for mammals. Mammals entail this lion specimen; thus, mammals entail lion species.

From the instructors: Theorem (calculus): A graph G(grounded) is entailed by a graph G if G(grounded) can be rewritten into a subset of G, where rewriting means assigning a URI to a blank node.

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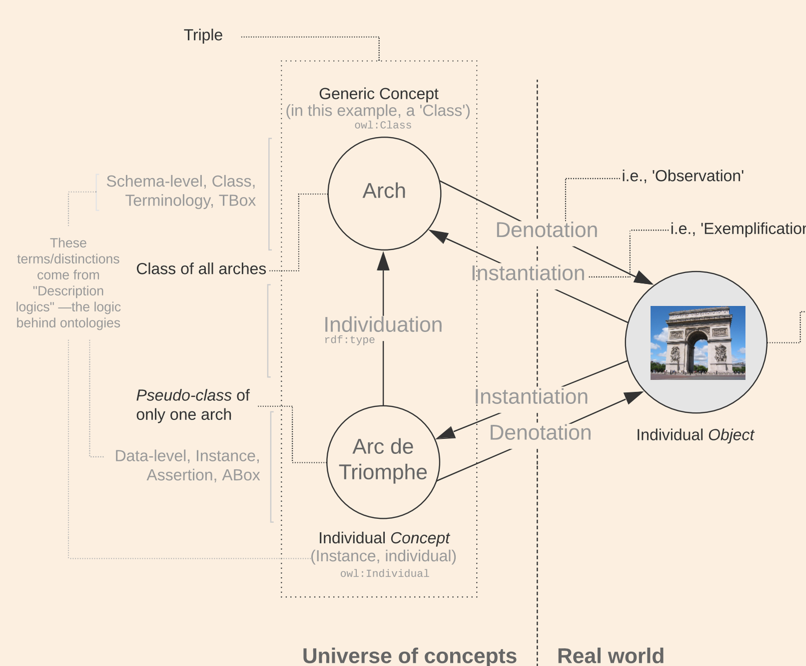
SCHEMA

Knowledge Representation

Class, Type, Instance, Individual, Denotation, Concept, Object



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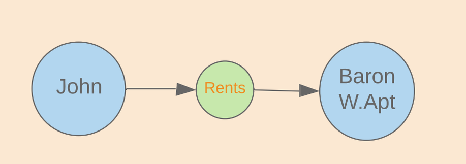
RDF

Resource description framework



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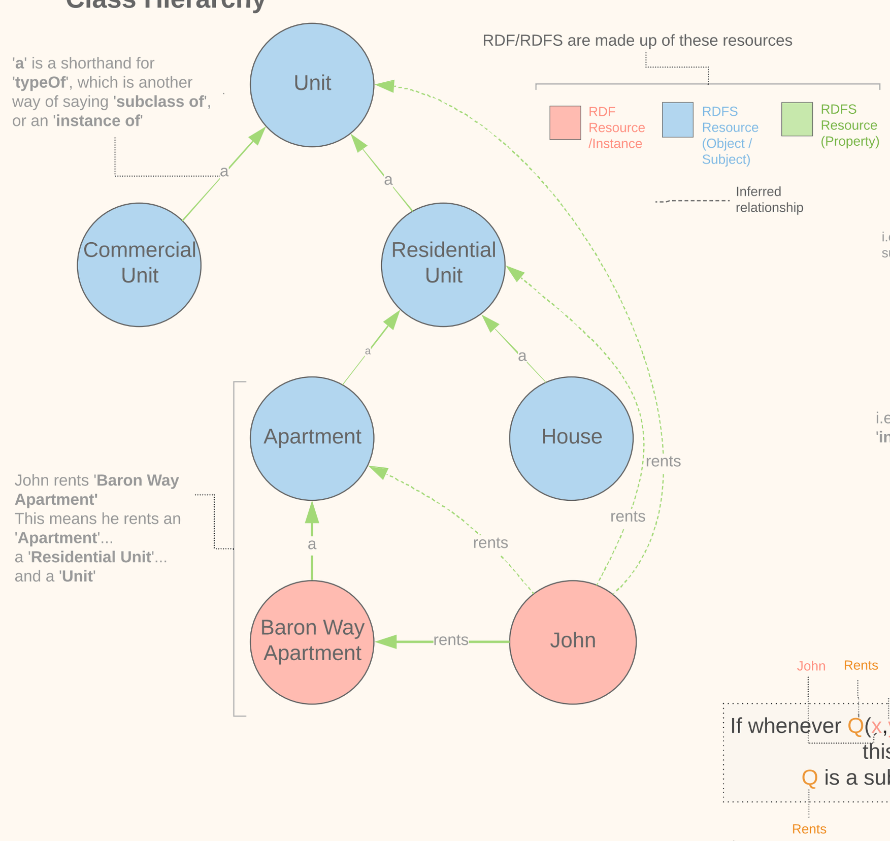
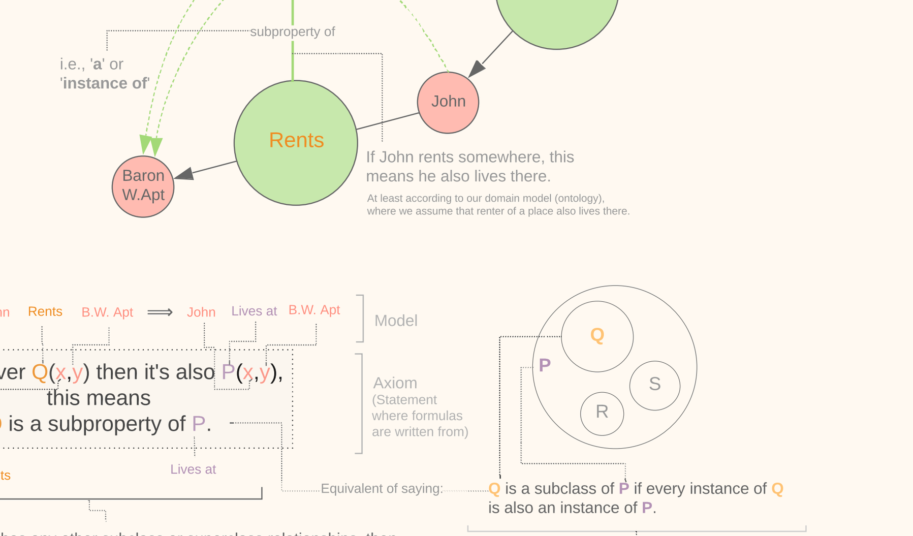
RDFS (RDF Schema)

RDFS is a basic ontology for formally defining relationships in RDF. It is more limited, but also more efficient (e.g., when calculating entailments) than full-fledged ontology languages such as OWL.

Class Hierarchy



Property Hierarchy



John Rents B.W. Apt ⟹ John Lives at B.W. Apt — Model

If whenever Q(x,y) then it's also P(x,y), this means Q is a subproperty of P. — Axiom (Statement where formulas are written from)

Equivalent of saying: Q is a subclass of P if every instance of Q is also an instance of P.

A different way to visualize these property hierarchies...

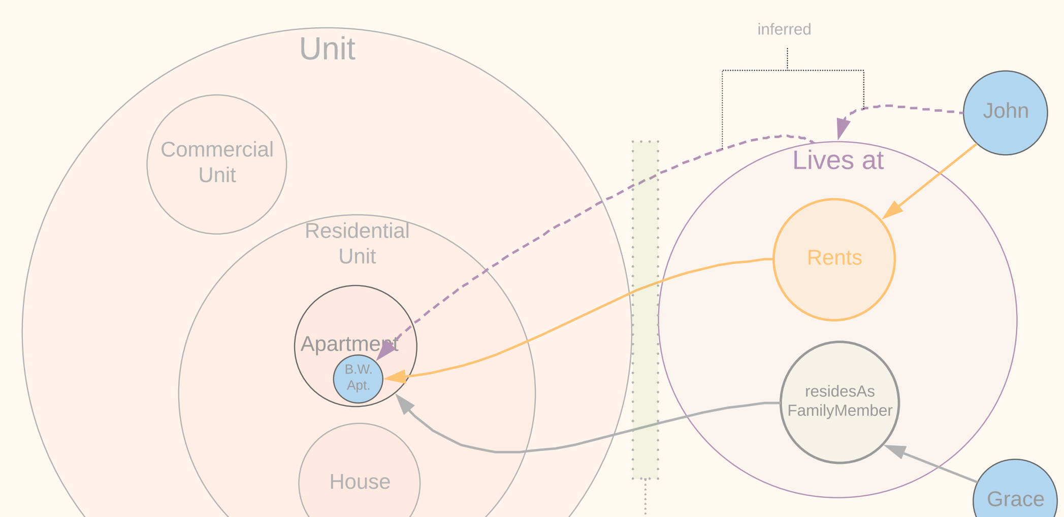
Of course, if neither Q or P has any other subclass or superclass relationships, then their relationship with each other could be simply a 'same as' relationship. (However, this may only be momentarily true due to a lack of instances for one of the subclasses, which would make it empty and perhaps even undefined/undetected.)

e.g., this subproperty could have been momentarily empty

⟺

Class hierarchy:

Property hierarchy:



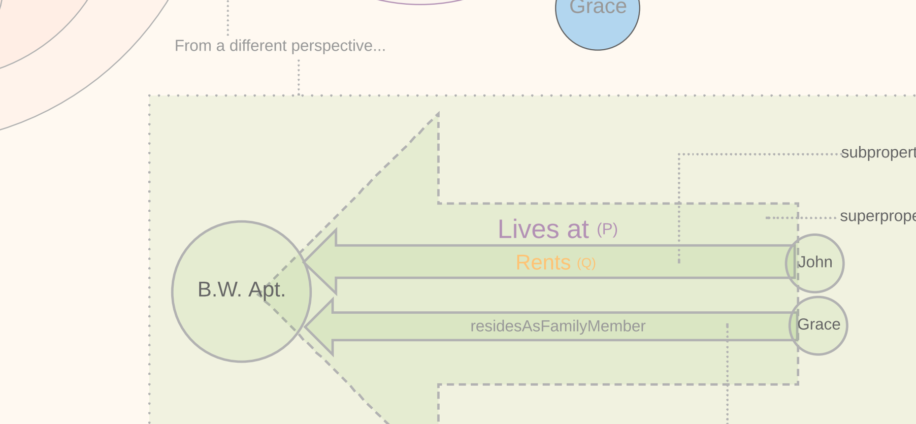
Rents is a subproperty of Lives at because everytime ——— it's also - - - - -

i.e., Because everytime someone rents a place, he also lives in it (at least in this example).

This means:
If property P can be used to replace all property paths of Q (but not vice versa), P is the superclass between the two. — 'subclassOf'

And:
If property P can be used to replace all property paths of Q, and Q can do the same for P, then they are equivalent (i.e., 'sameAs' each other). — 'sameAs'

From a different perspective...



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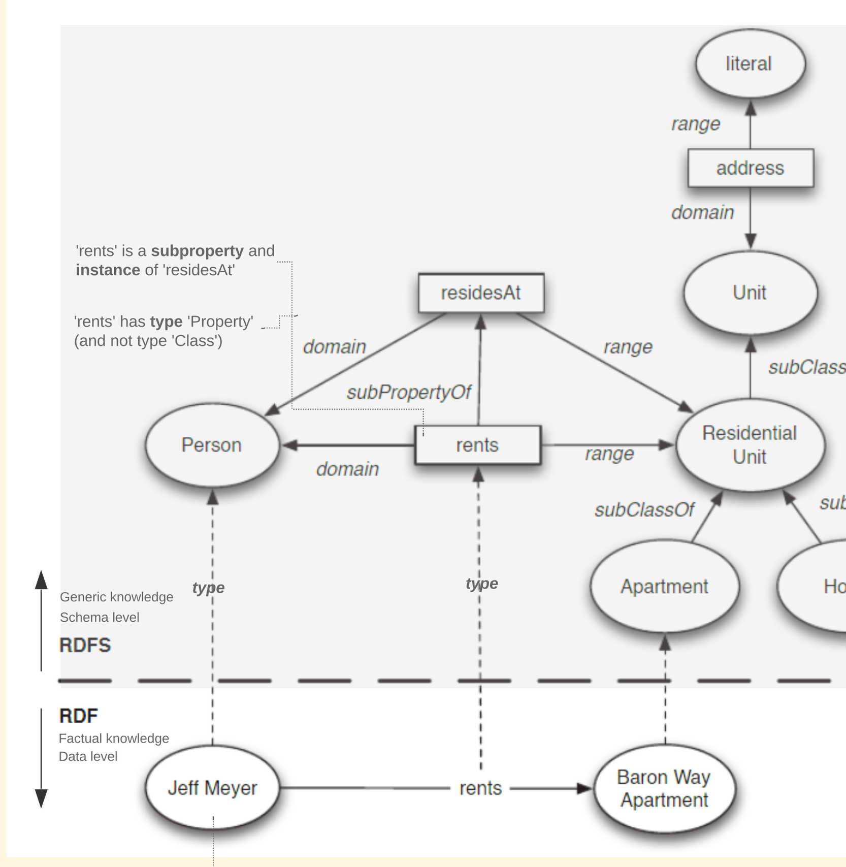
RDFS Example

An example RDF statement

@prefix swp:<http://www.semanticwebprimer.org/ontology/apartments.ttl#>.
@prefix rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix rdfs:<http://www.w3.org/2000/01/rdf-schema#>.

swp:JeffMeyer swp:rents swp:BaronWayApartment .



'House' is an **instance** and **subclass** of 'Residential Unit'

'Jeff Meyer' or 'Baron Way Aparment' is an **instance** (but **not a subclass**) of 'Person'

An example RDFS

@prefix swp:<http://www.semanticwebprimer.org/ontology/apartments.ttl#>.
@prefix rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix rdfs:<http://www.w3.org/2000/01/rdf-schema#>.

```
swp:Person             rdf:type            rdfs:Class .
swp:Person             rdfs:comment        "The class of people" .

swp:Unit               rdf:type            rdfs:Class .
swp:Unit               rdfs:comment        "A self contained section of accommodations in a larger building or group of buildings." .

swp:ResidentialUnit    rdf:type            rdfs:Class .
swp:ResidentialUnit    rdfs:subClassOf     swp:Unit .
swp:ResidentialUnit    rdfs:comment        "The class of all units or places where people live." .

swp:Apartment          rdf:type            rdfs:Class .
swp:Apartment          rdfs:subClassOf     swp:ResidentialUnit .
swp:Apartment          rdfs:comment        "The class of apartments" .

swp:House              rdf:type            rdfs:Class .
swp:House              rdfs:subClassOf     swp:ResidentialUnit .
swp:House              rdfs:comment        "The class of houses" .

swp:residesAt          rdf:type            rdfs:Property .
swp:residesAt          rdfs:comment        "Relates persons to their residence" .
swp:residesAt          rdfs:domain         swp:Person .
swp:residesAt          rdfs:range          swp:ResidentialUnit .

swp:rents              rdf:type            rdfs:Property .
swp:rents              rdfs:comment        "It inherits its domain (swp:Person) and range (swp:ResidentialUnit) from its superproperty (swp:residesAt)." .

swp:rents              rdfs:subPropertyOf  swp:residesAt .

swp:address            rdf:type            rdfs:Property .
swp:address            rdfs:comment        "Is a property of units and takes literals as its value" .
swp:address            rdfs:domain         swp:Unit .
swp:address            rdfs:range          rdf:Literal .
```

'House' has **type** 'Class' and is a **subclassOf** 'Residential Unit'

'**type**' property defines the relationship between **class** and **instance**.

'**subclass**' property defines the relationship between **class** and **superclass** (and not between class and instance).

Example in Action: Class-based (weak) Inference with RDFS

Turtle File:

```
@prefix fb: <https://graph.facebook.com/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

fb:594486635        fb:likes      fb:289482145973 , fb:109327925759703.

fb:109327925759703  fb:name       "Waking Life"@en ;
                    fb:category   fb:movie .

fb:32985985640      fb:name       "Zeitgeist"@en ;
                    fb:category   fb:community .

fb:movie            rdfs:label    "Movie"@en .
fb:community        rdfs:label    "Community"@en .

fb:community        rdfs:subClassOf    fb:movie .
fb:category         rdfs:subPropertyOf rdf:type .
```

This triple allowed Zeitgeist to be inferred as a movie (as it specified that each community is also a movie). Without this line, only 'Waking Life' would have returned.

SPARQL Query:

```
PREFIX fb: <https://graph.facebook.com/>

SELECT ?title WHERE {
    ?movie a      fb:movie ;
           fb:name  ?title .
}
```

Query Result:

?title
"Waking Life"@en
"Zeitgeist"@en

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VOCABULARY

RDF, RDFS and Other Vocabularies

Resource Description Framework
Resource Description Framework Schema

prefix rdf <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
prefix rdfs <http://www.w3.org/2000/01/rdf-schema#>

RDF/RDFS Classes

Core Classes	Container Classes
rdfs:Resource	*rdf*:Bag
rdfs:Class	*rdf*:Seq
rdfs:Literal	*rdf*:Alt
rdfs:Property	rdfs:Container
rdfs:Statement	
rdfs:Datatype	

RDF/RDFS Properties

Defining Relationships	Restricting Properties	Utility	Reification
rdf:type	rdfs:domain	rdfs:seeAlso	*rdf*:subject
rdfs:subClassOf	rdfs:range	rdfs:isDefinedBy	*rdf*:predicate
rdfs:subPropertyOf		rdfs:comment	*rdf*:object
		rdfs:label	

```
geo:Amsterdam    rdf:type   rdf:Resource .
geo:containedIn  a          rdf:Property .
rdf:type         a          rdf:Property .
```

FOAF

Friend of a Friend

prefix foaf <http://xmlns.com/foaf/0.1/>

Important Elements
foaf:Person
foaf:name
foaf:mbox
foaf:knows

```
vu:Rinke_Hoekstra rdf:type foaf:Person ;
                  foaf:knows vu:Albert_Merono ;
                  foaf:name "Rinke Hoekstra" .
```

DC/DCT

Dublin Core / Dublin Core Terms

prefix dct <http://purl.org/dc/terms>

Important Elements
dct:creator
dct:created
dct:description
dct:title

```
vu:SWPrimer  dct:creator  vu:Rinke_Hoekstra ;
             dct:created  "2012"^^xsd:date,
             dct:title    "A Semantic Web ..." .
```

SKOS

Simple Knowledge Organization System

prefix skos <http://www.w3.org/2004/02/skos/core#>

Important Elements
skos:exactMatch

Good for using things that are *almost* the same. This is an informal way of establishing sameness.

```
fb:594486635    fb:likes          fb:105638652803531 .
fb:105638652803531 skos:exactMatch imdb:tt0120669 .
```

For common prefixes and their namespaces: http://prefix.cc

Social Side of Semantics

Berners-Lee: Using shared vocabularies is the key to establishing consistent semantics.

URI's may not always be unique. They are not a global identification service, but simply strings.

Rule of Thumb: "Only create vocabularies/URIs in a namespace within your own domain." (Important for trust).

Example in Action: Linking Vocabularies

Turtle File:

```
@prefix fb: <https://graph.facebook.com/> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

fb:594486635        fb:likes      fb:289482145973 , fb:109327925759703.

fb:109327925759703  fb:name       "Waking Life"@en ;
                    fb:category   fb:movie .

fb:32985985640      fb:name       "Zeitgeist"@en ;
                    fb:category   fb:community .

fb:movie            rdfs:label    "Movie"@en .
fb:community        rdfs:label    "Community"@en .

fb:community        rdfs:subClassOf    fb:movie .
fb:category         rdfs:subPropertyOf rdf:type .
```

This is Facebook's way of definig a 'type' relationship. It is used instead of 'rdf:type'.

This is triple aligns Facebook and RDF schema by bringing Facebook's 'category' property in line with 'type' property of of RDF.

Without this triple, results of the example SPARQL would have been empty, as there would not be any 'rdf:type' properties in the Turtle file. However, now that 'fb:category' is related to 'rdf:type', asking for 'rdf:type' in SPARQL also returns all categories.

SPARQL Query:

```
PREFIX fb: <https://graph.facebook.com/>

SELECT ?title WHERE {
    ?movie a      fb:movie ;
           fb:name  ?title .
}
```

Query Result:

?title
"Waking Life"@en
"Zeitgeist"@en

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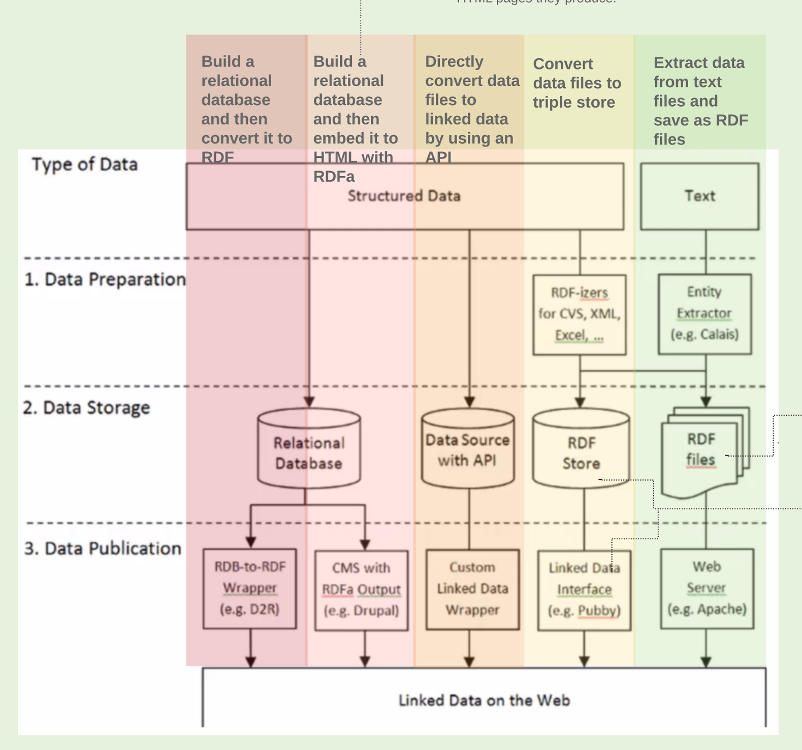
USE CASES

Accessing and Publishing RDF & Linked Data

Many CMSs add RDFa to HTML pages they produce.



File publishing
This does not allow queries if not first serialized

Triple store publishing
This allows users to **query** with a query API like a SPARQL endpoint

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