Semantic Web

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KIT Karlsruhe Institute of Technology, Germany
Institute AIFB
ACTIVE Summer School, September 2009

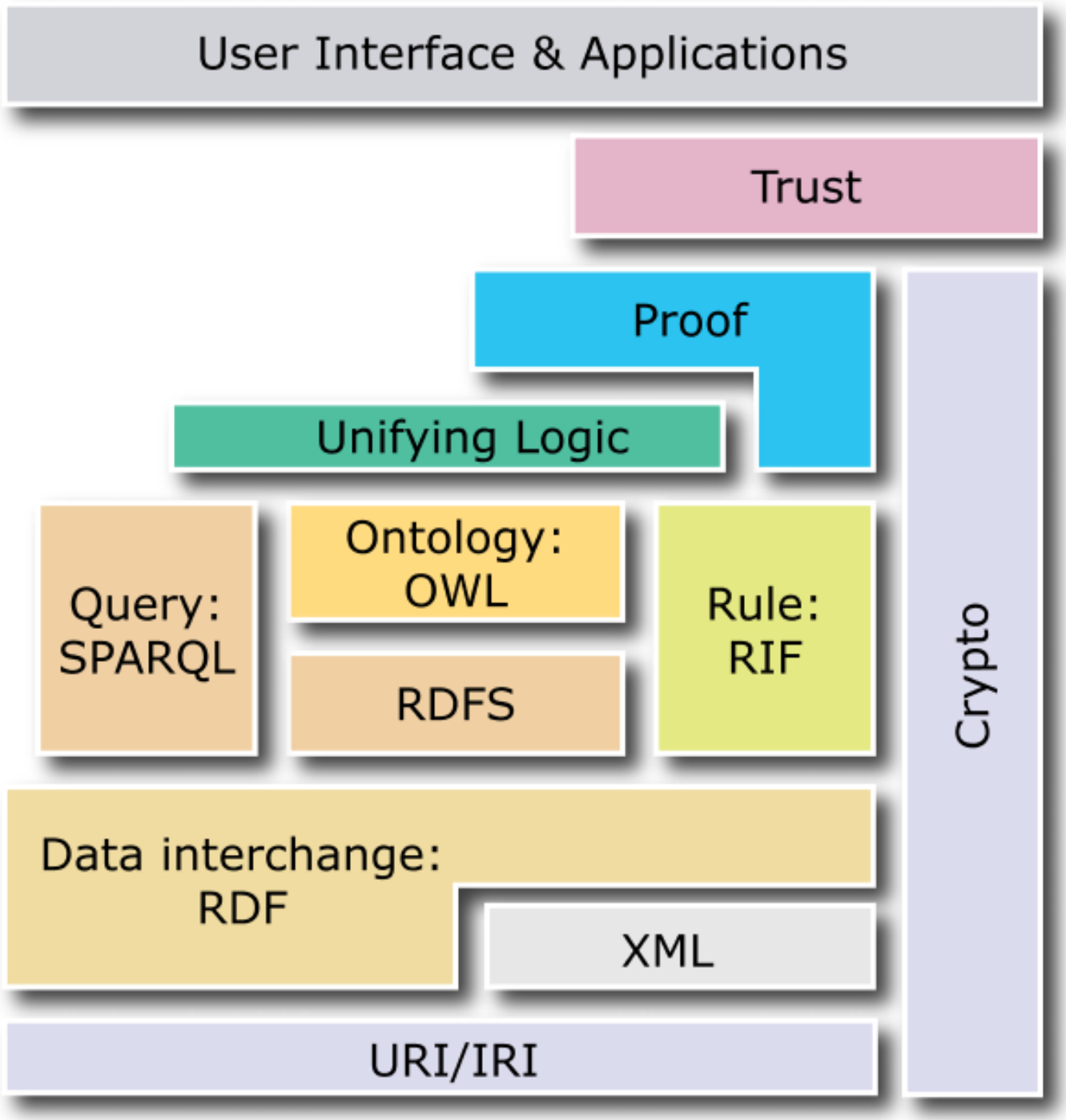
Agenda

- Vision of the Semantic Web
- OWL

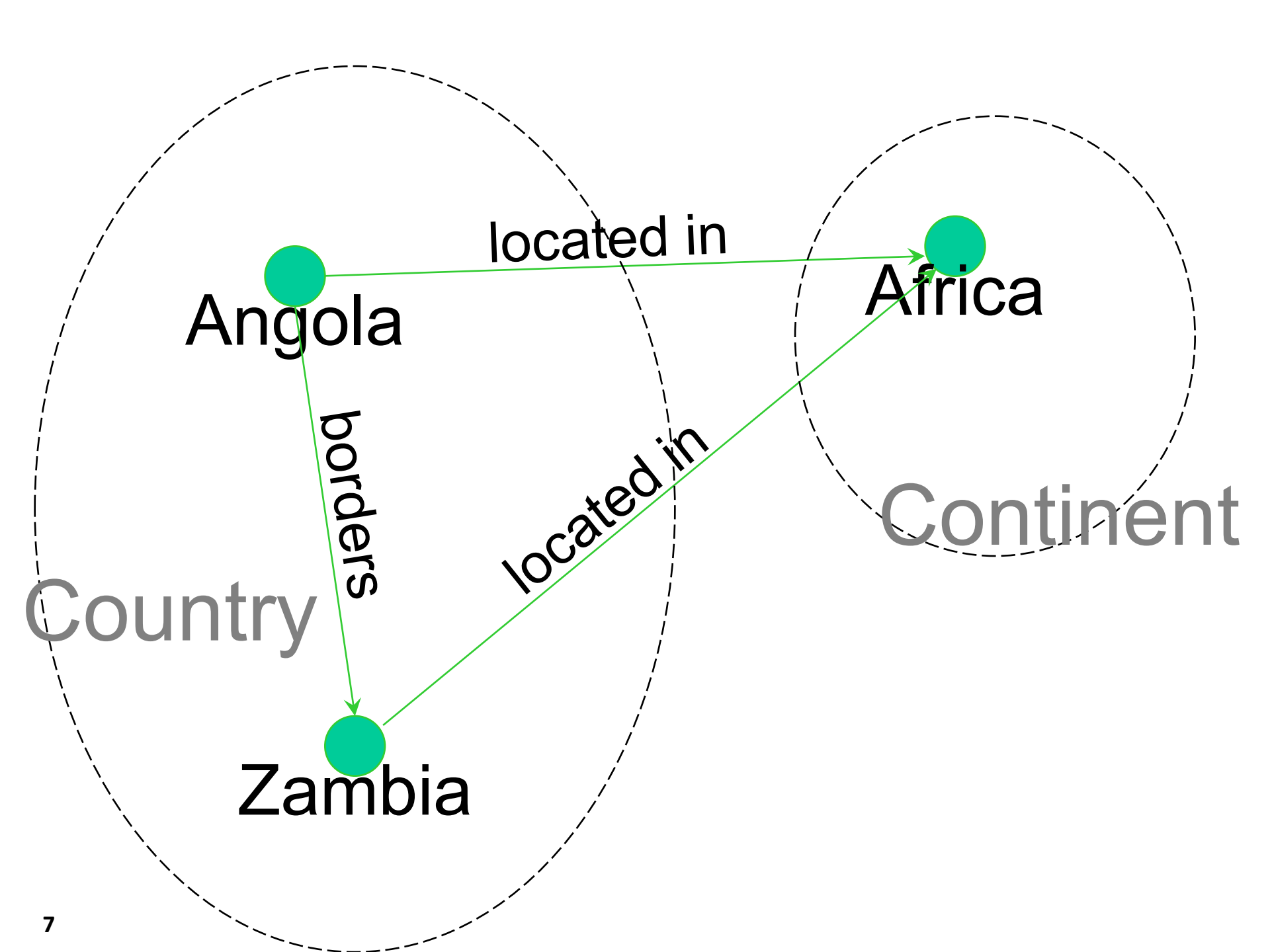
Universal Access to All Knowledge

Brewster Kahle

Semantic Web


User Interface & Applications
Trust
Proof
Unifying Logic
Query: SPARQL
Ontology: OWL
RDFS
Rule: RIF
Crypto
Data interchange: RDF
XML
URI/IRI

Data interchange:
RDF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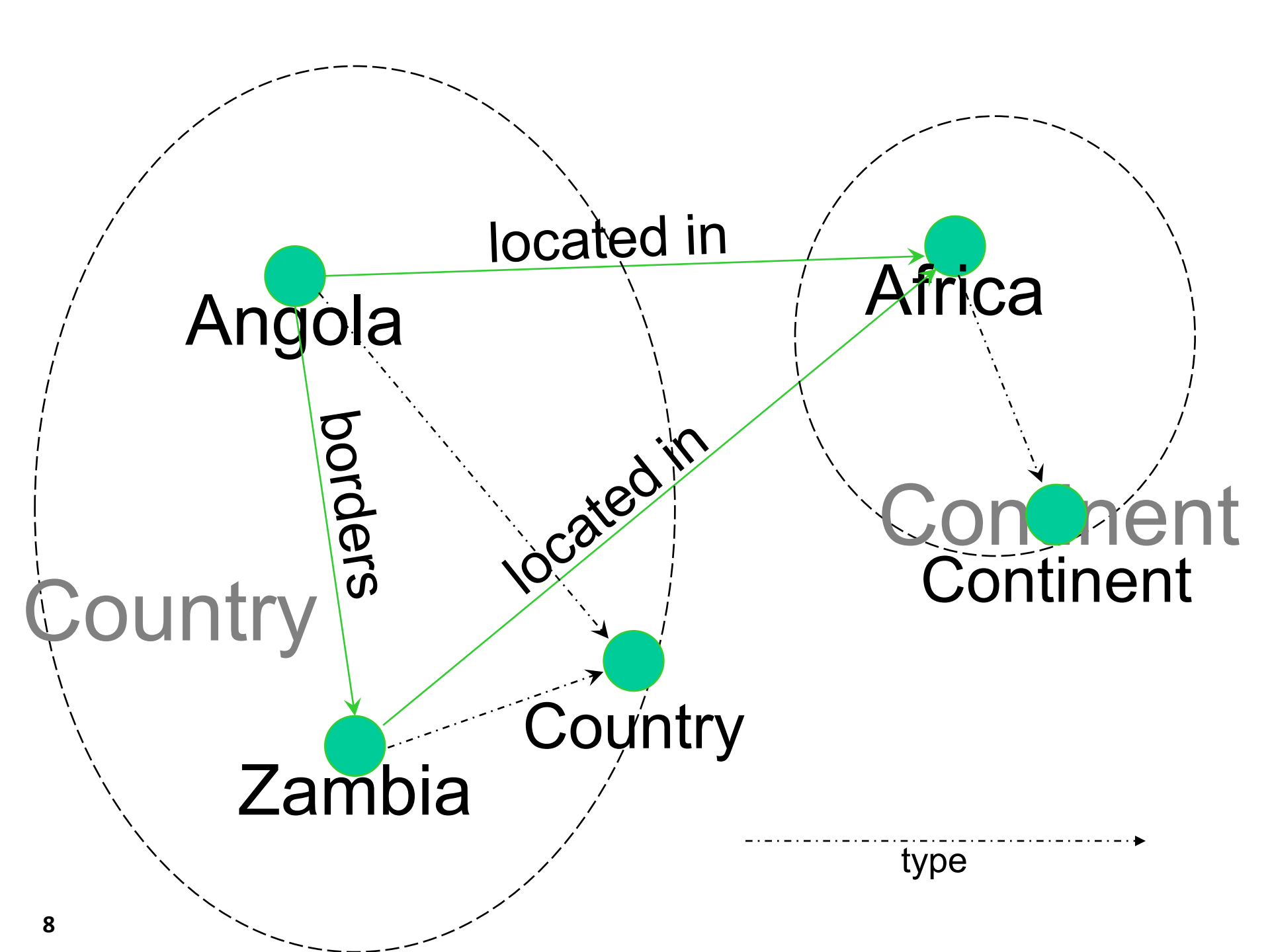
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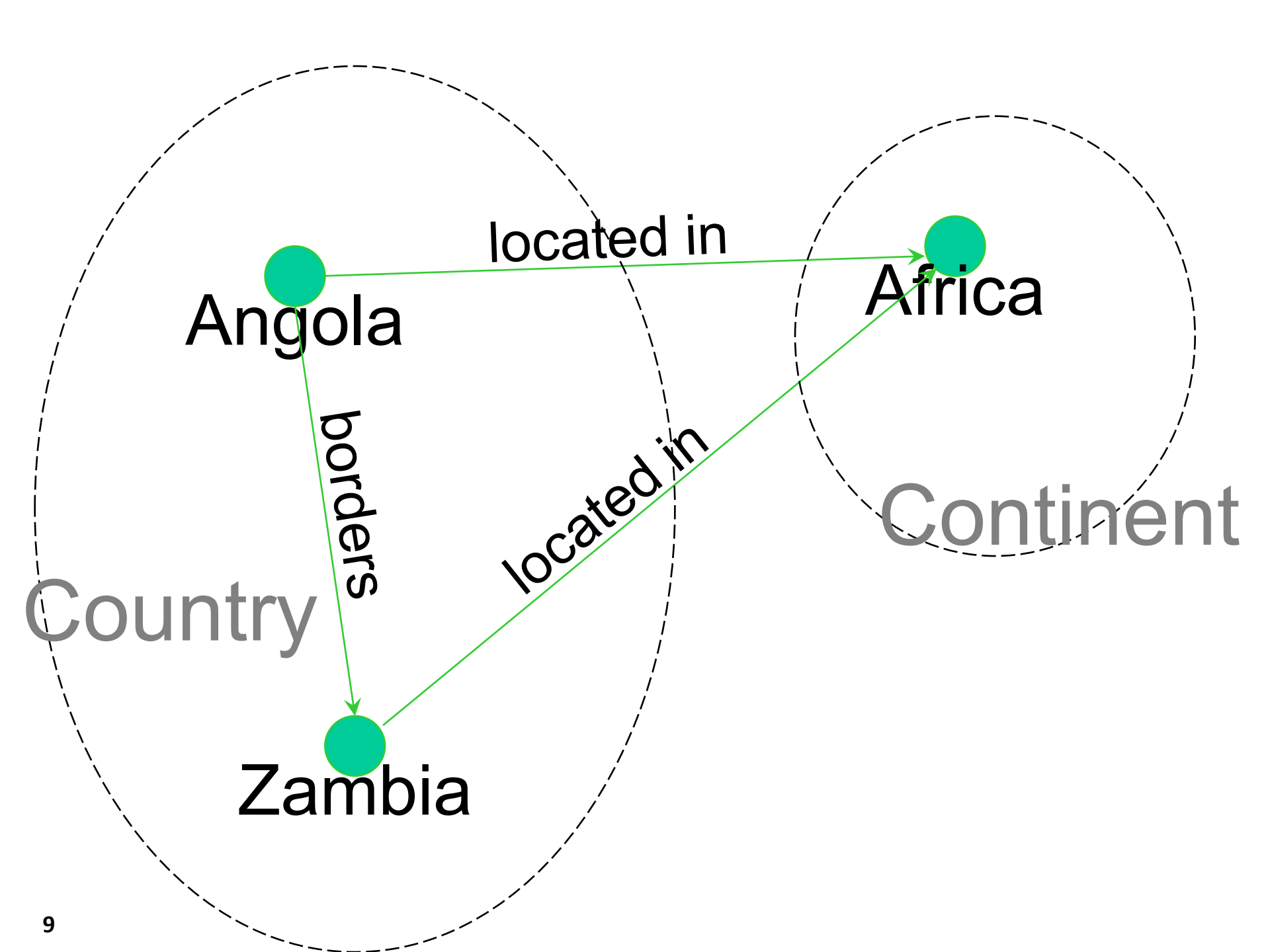
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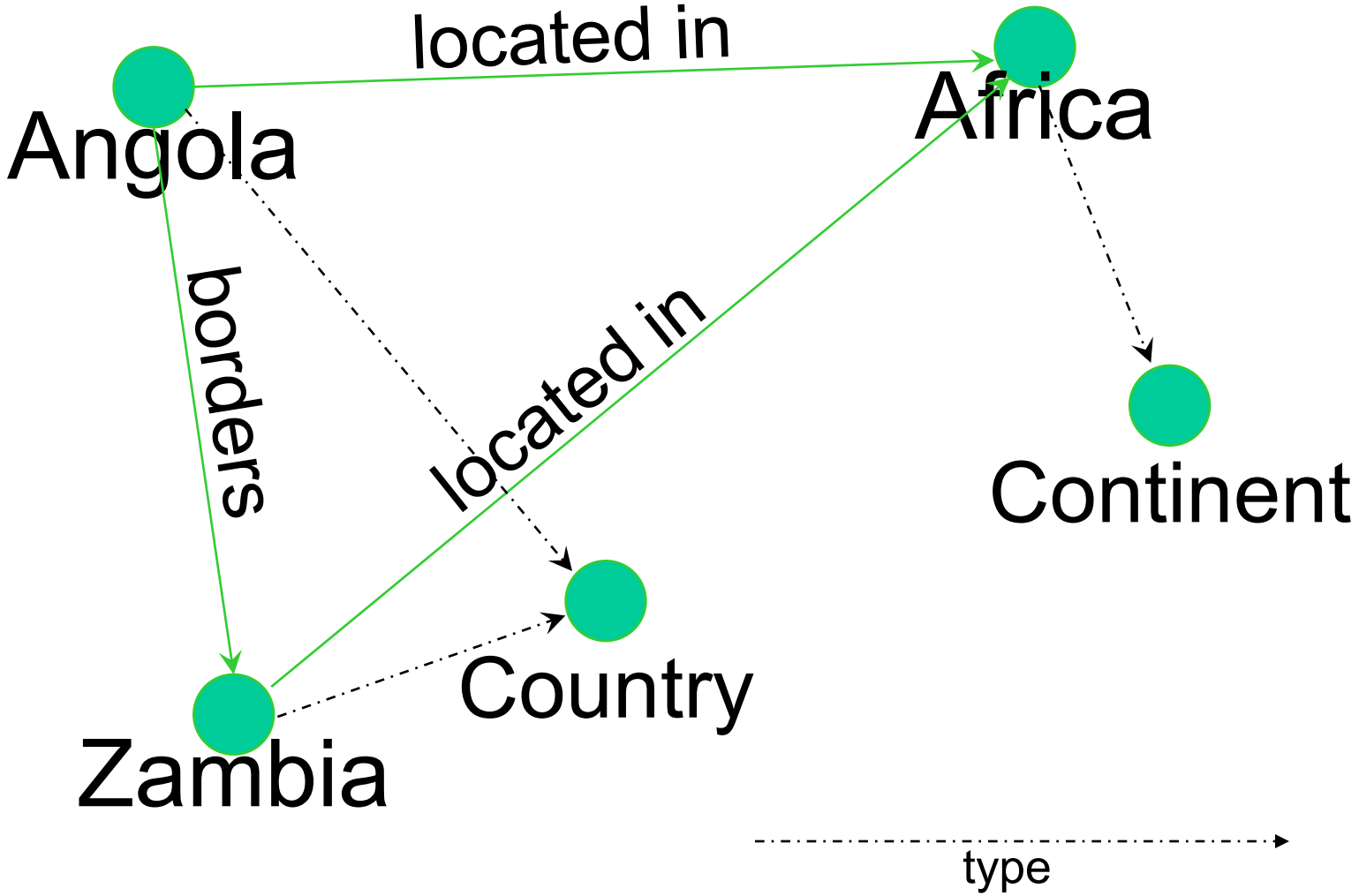
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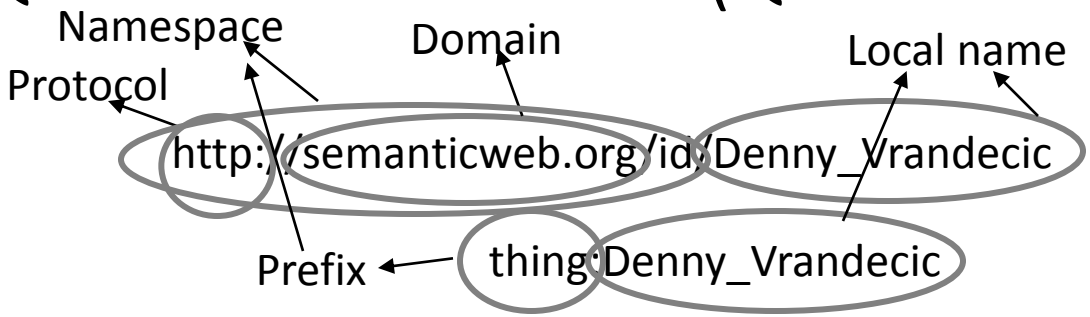
RDF

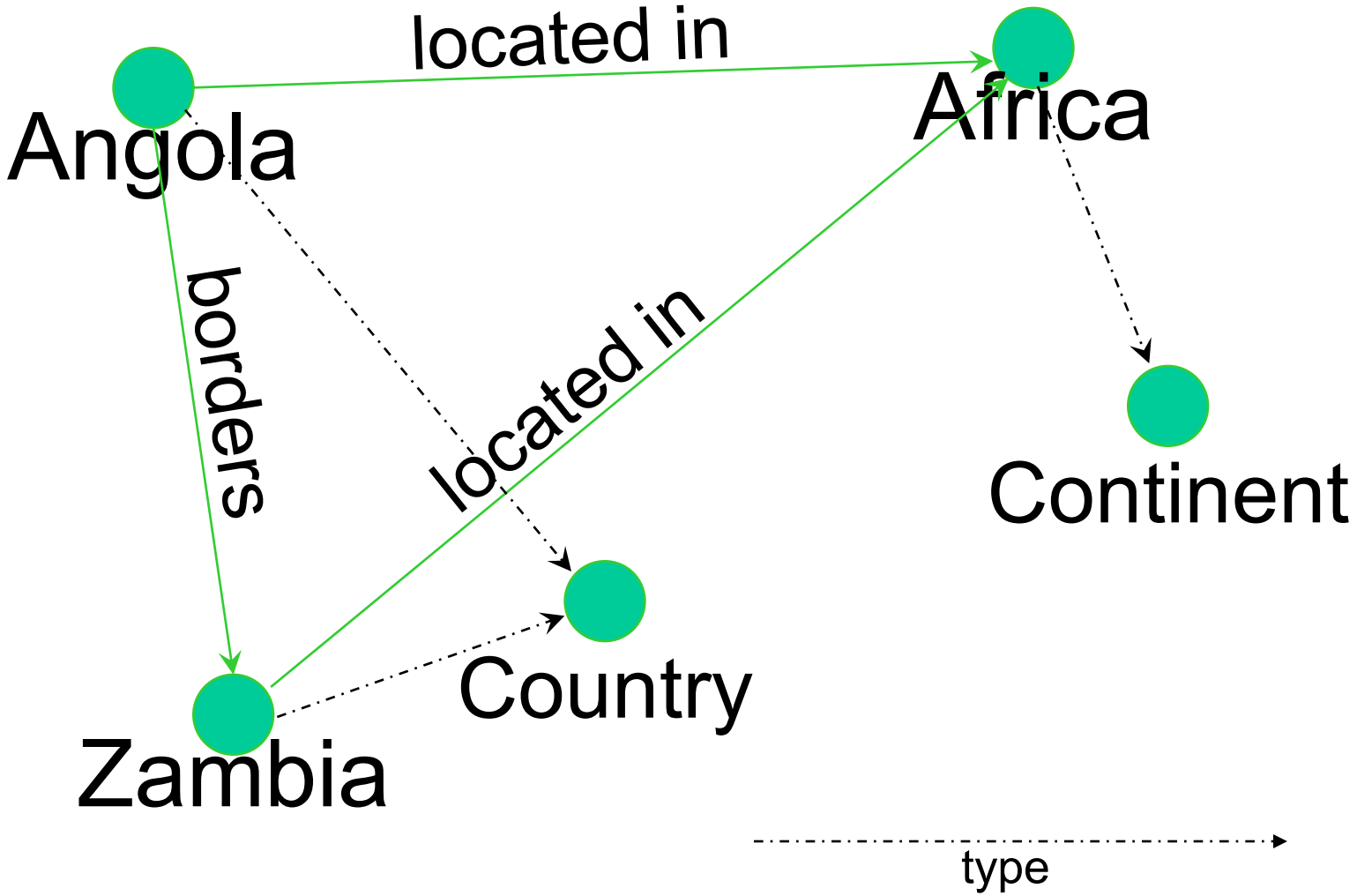
- A set of triples
- Triples are Subject, Predicate, Object

Data interchange:
RDF

URIs / IRIs

- URIs are “Uniform Resource Identifiers”
  - IRI: Unicode-based “Internationalized Resource Identifiers”
- Every URI identifies one entity
- Semantic Web URIs usually use HTTP
  - HyperText Transfer Protocol
  - Can be resolved to get more data (ideally)
  - Linked data
- QName as abbreviation (Qualified Name)

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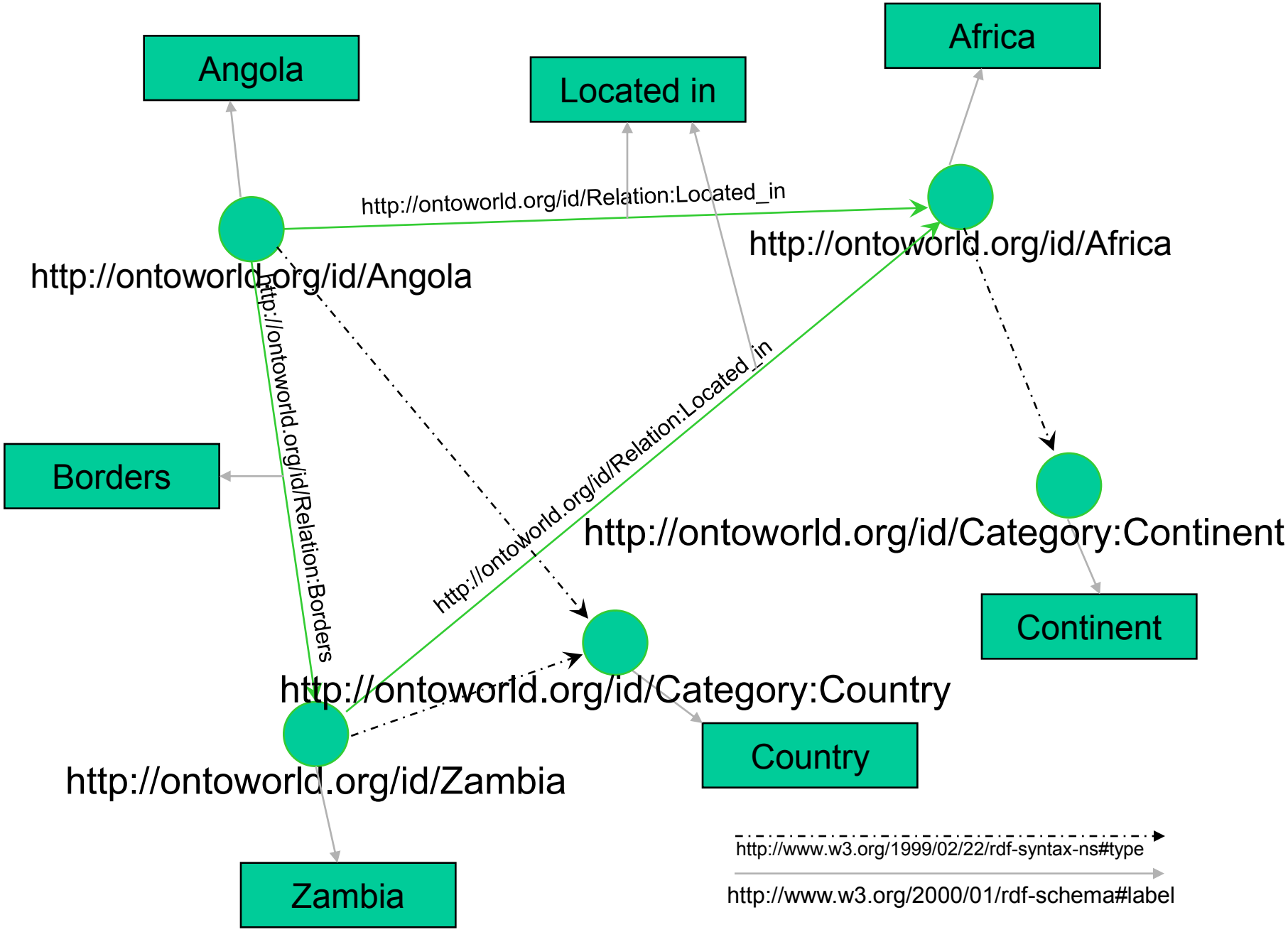
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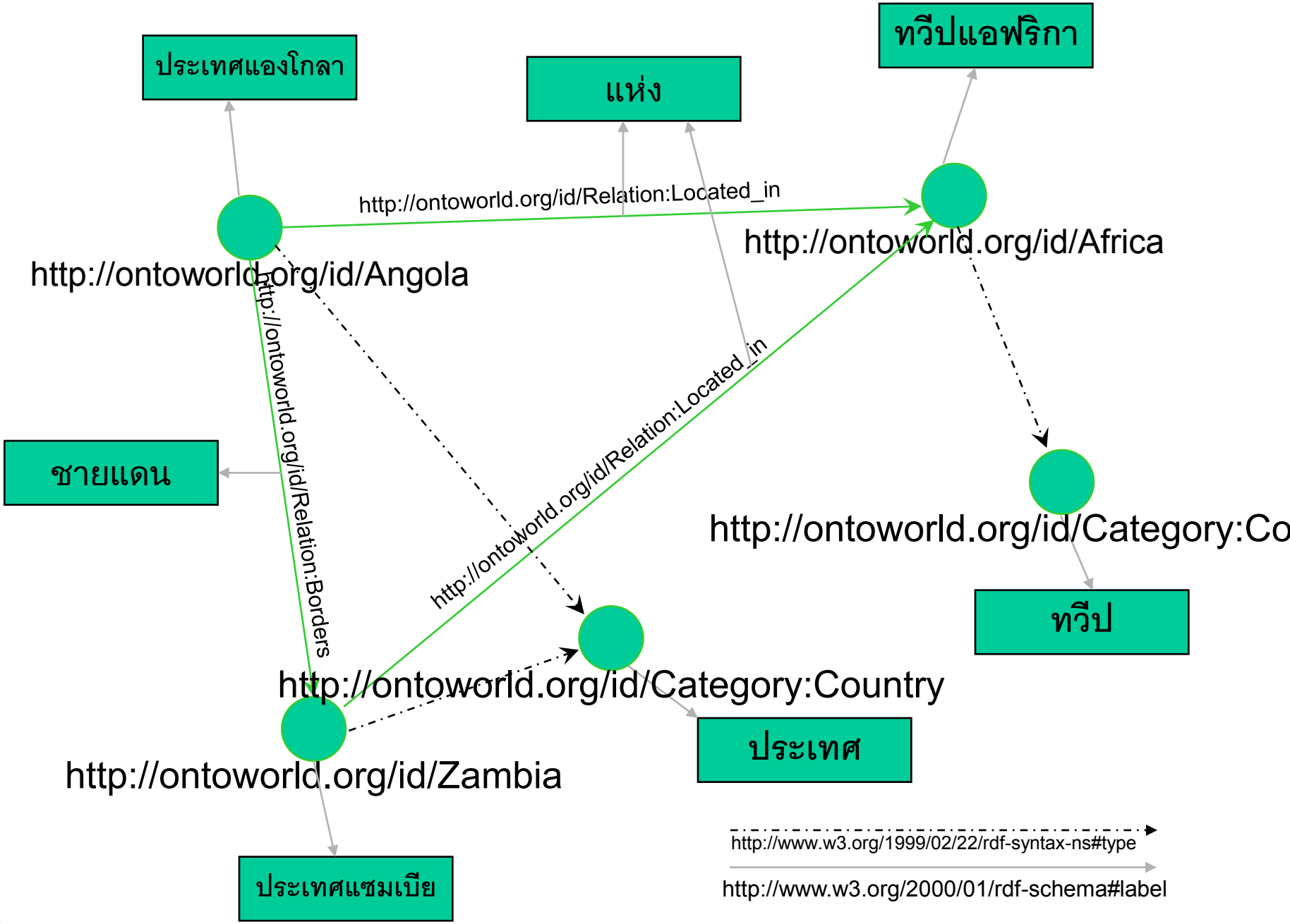
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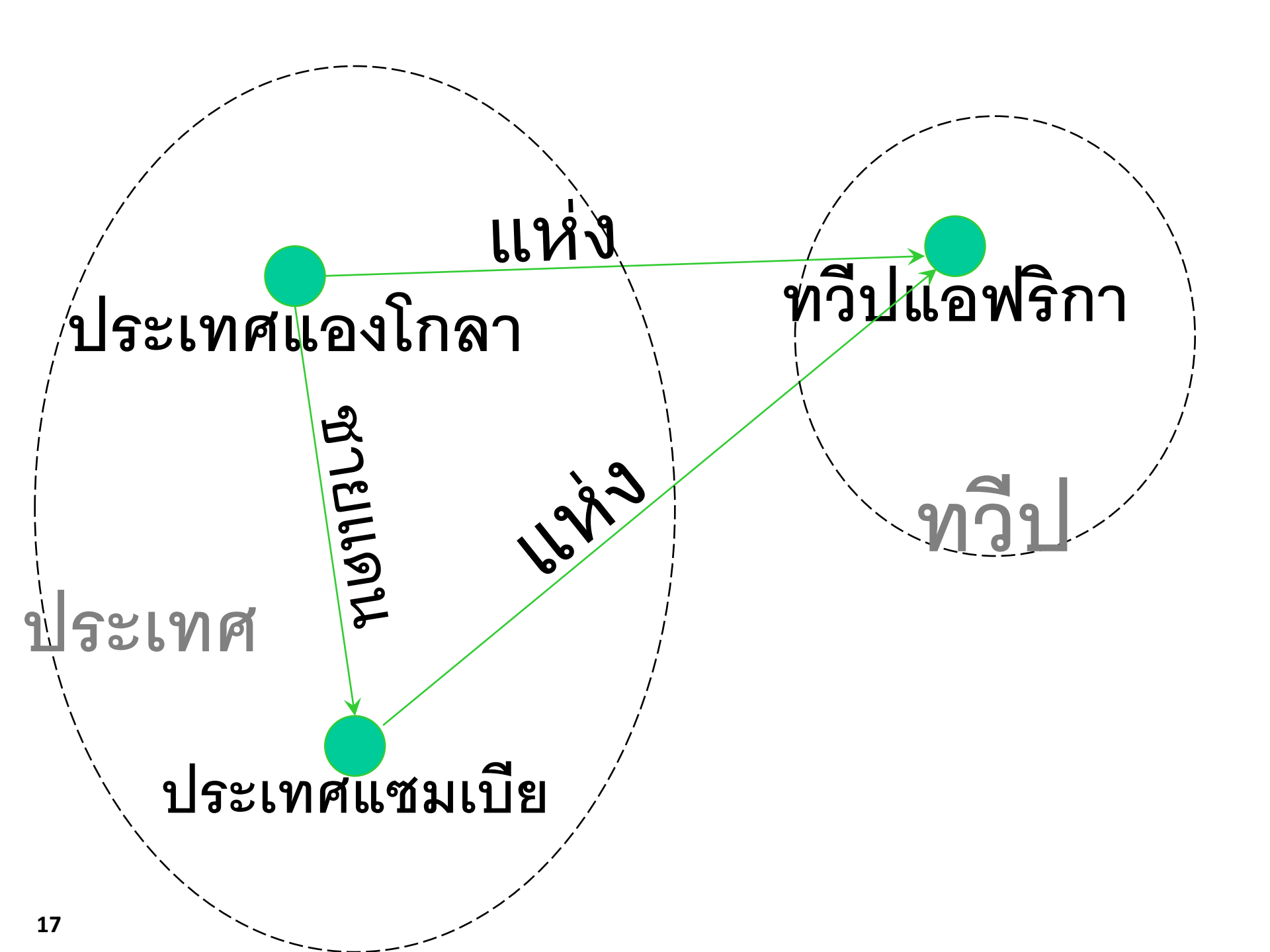
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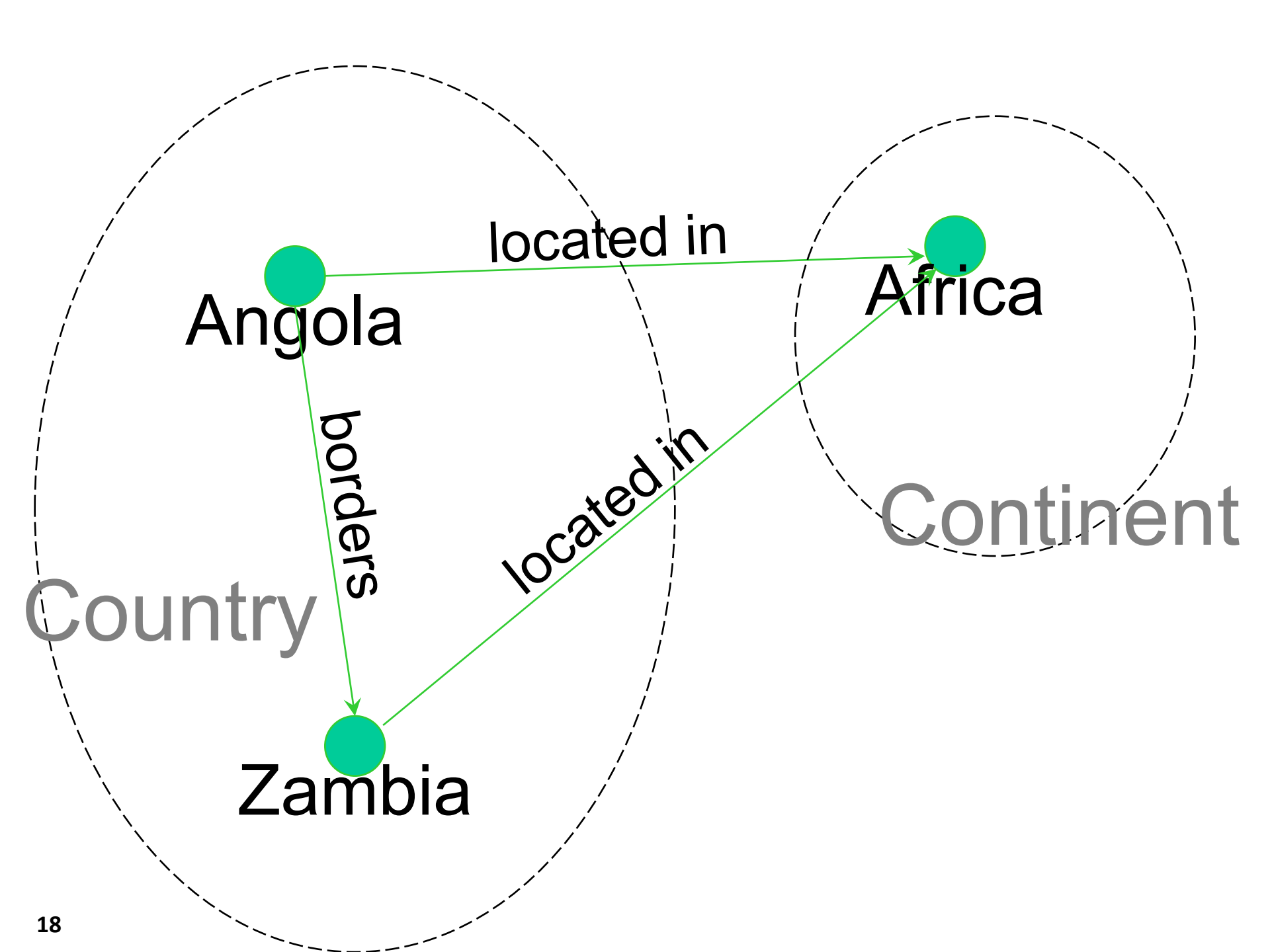
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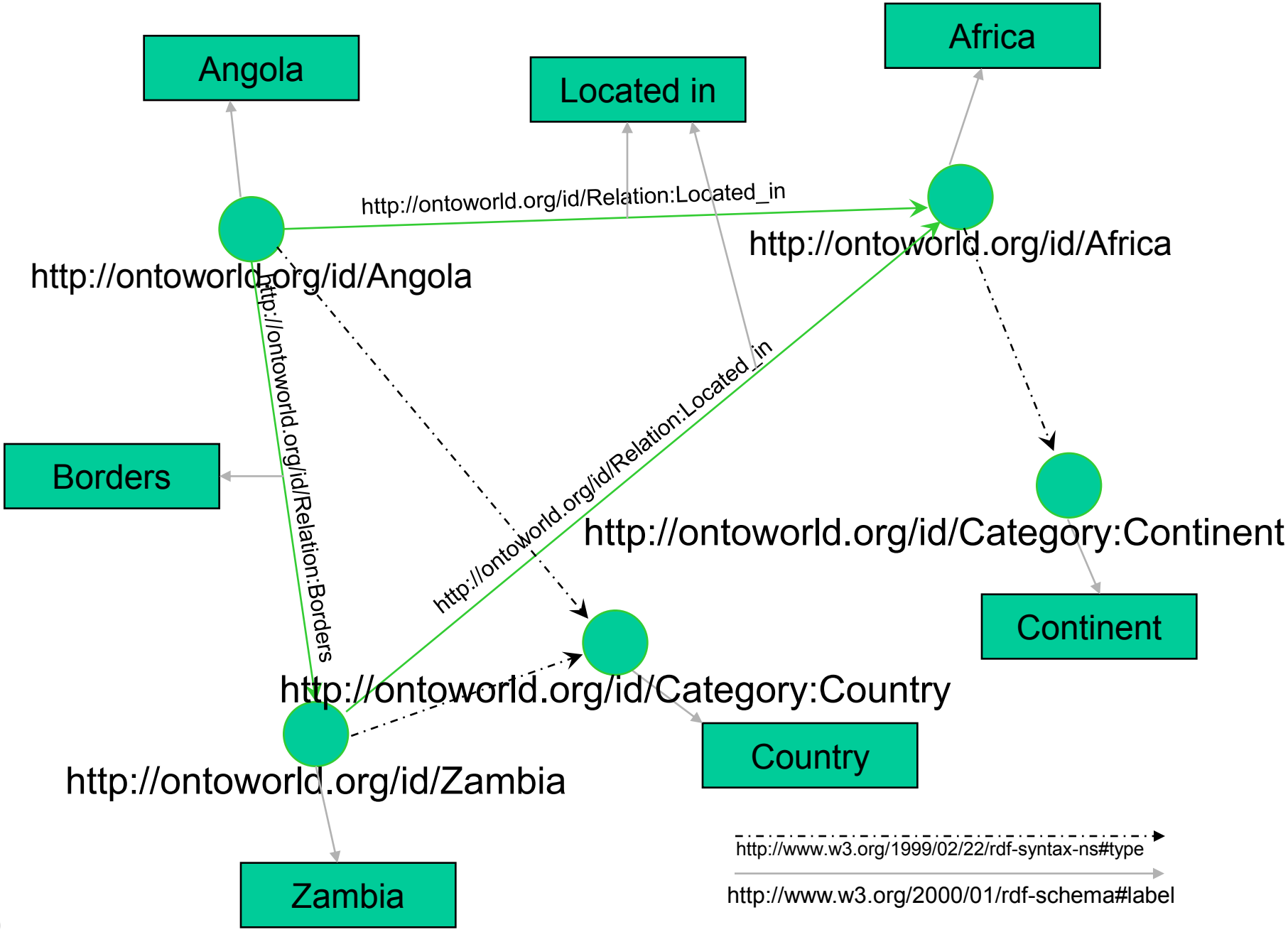
RDF

- A set of triples
- Triples are Subject, Predicate, Object
- Subjects and Predicates are URIs
- Objects are URIs or Literals
  - Literals are concrete data values
  - e.g. the integer 27 or the date July 20, 2009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http://www.w3.org/2000/01/rdf-schema#label

```
xmlns:attribute="&attribute;">
<!-- reference to the Semantic MediaWiki schema -->
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</owl:AnnotationProperty>
<owl:AnnotationProperty rdf:about="&smw;hastype">
        <rdfs:isDefinedBy rdf:resource="http://smw.ontoware.org/2005/smw"/>
</owl:AnnotationProperty>
<owl:Class rdf:about="&smw;Thing">
        <rdfs:isDefinedBy rdf:resource="http://smw.ontoware.org/2005/smw"/>
</owl:Class>
<!-- exported page data -->
<smw:Thing rdf:about="&thing;Angola">
        <rdfs:label>Angola</rdfs:label>
        <smw:hasArticle rdf:resource="&wikiurl;Angola"/>
        <rdfs:isDefinedBy rdf:resource="&wikiurl;Special:ExportRDF/Angola"/>
        <rdf:type rdf:resource="&thing;Category-3ACountry"/>
        <relation:Borders rdf:resource="&thing;Atlantic_Ocean"/>
        <relation:Borders rdf:resource="&thing;Zambia"/>
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        <relation:Borders rdf:resource="&thing;Namibia"/>
        <relation:Located_in rdf:resource="&thing;Africa"/>
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        <attribute:Population rdf:datatype="http://www.w3.org/2001/XMLSchema#integer"
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```
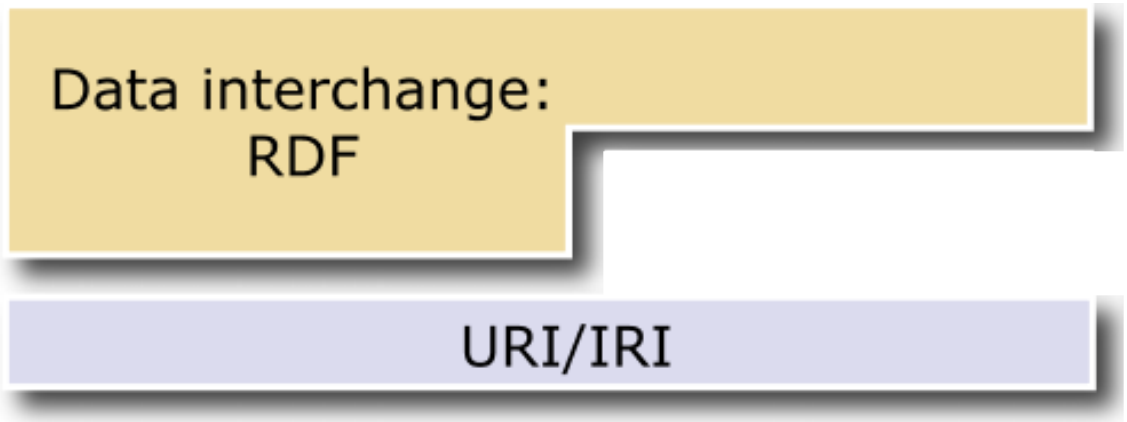
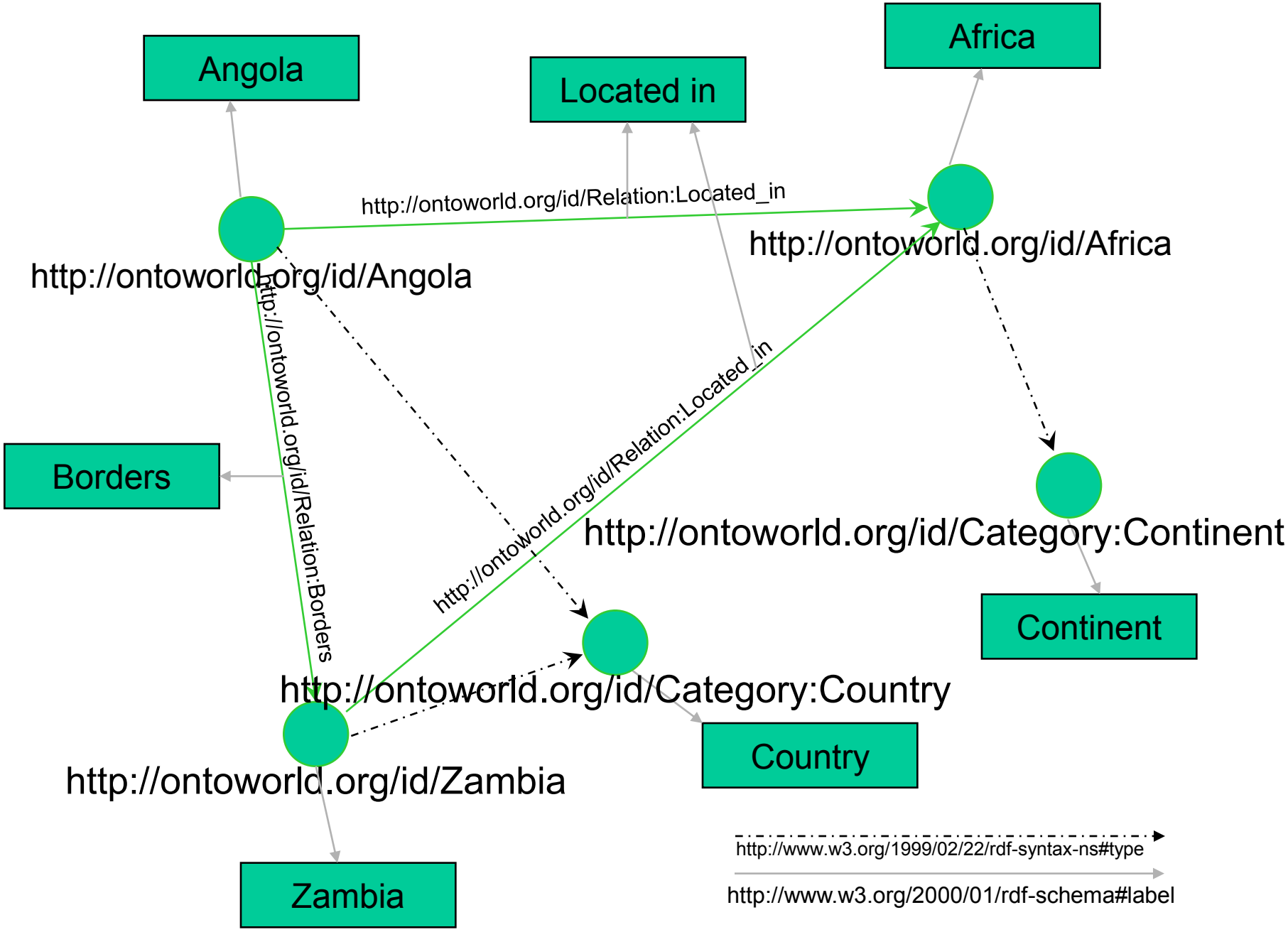

RDF

- A set of triples
- Triples are Subject, Predicate, Object
- Subjects and Predicates are URIs
- Objects are URIs or Literals
  - Literals are concrete data values
  - e.g. the integer 27 or the date Dec 1, 2008
- Several serialization formats like RDF/XML, N3, etc.


Data interchange:
RDF
URI/IRI

SPARQL : RDF Query Language

```
PREFIX rdfs:
  <http://www.w3.org/2000/01/rdf-schema#>
PREFIX thing:
  <http://ontoworld.org/id/>
PREFIX relation:
  <http://ontoworld.org/id/Relation:>

SELECT ?label
WHERE {
 ?c rdfs:label ?label.
 thing:Angola relation:Located_in ?c.
}
```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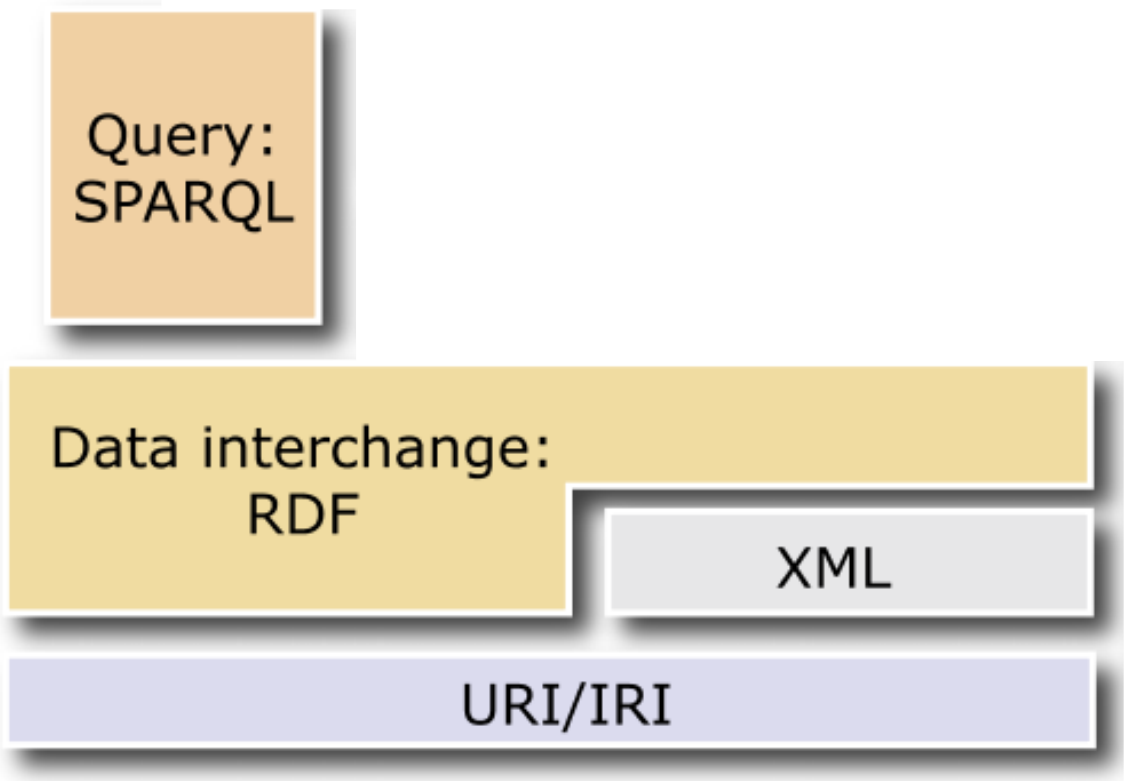

Query:
SPARQL
Data interchange:
RDF
XML
URI/IRI

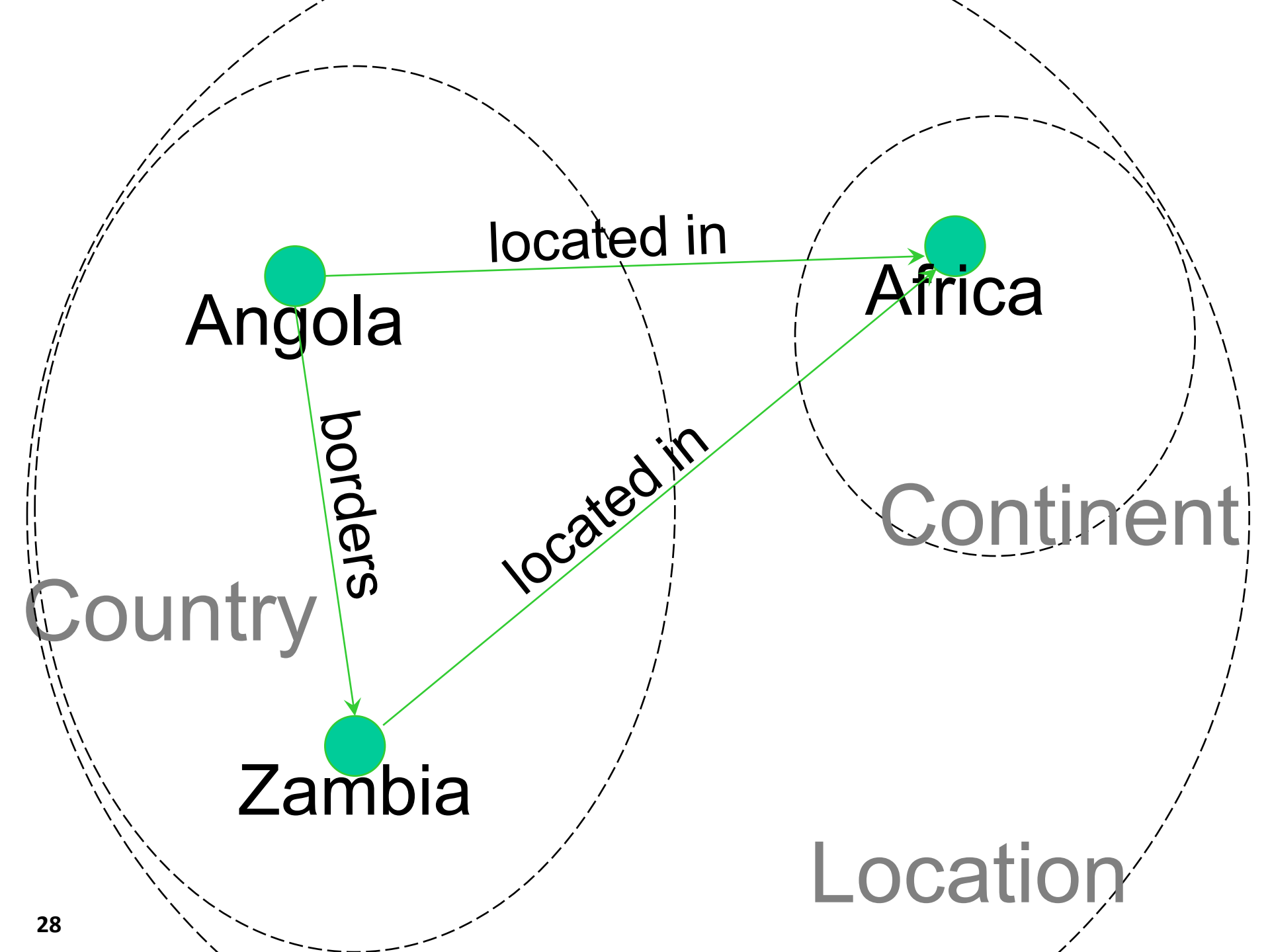
RDF Schema

- A number of terms with a formal semantics to express simple hierarchies and relations

- In RDFS:
  - subClassOf
  - subPropertyOf
  - and others (domain, range, etc.)

- Example:
  - Country subClassOf Location
  - Continent subClassOf Location

- Allows inferences
  - Angola type Country
  - Country subClassOf Location
  - -> Angola type Location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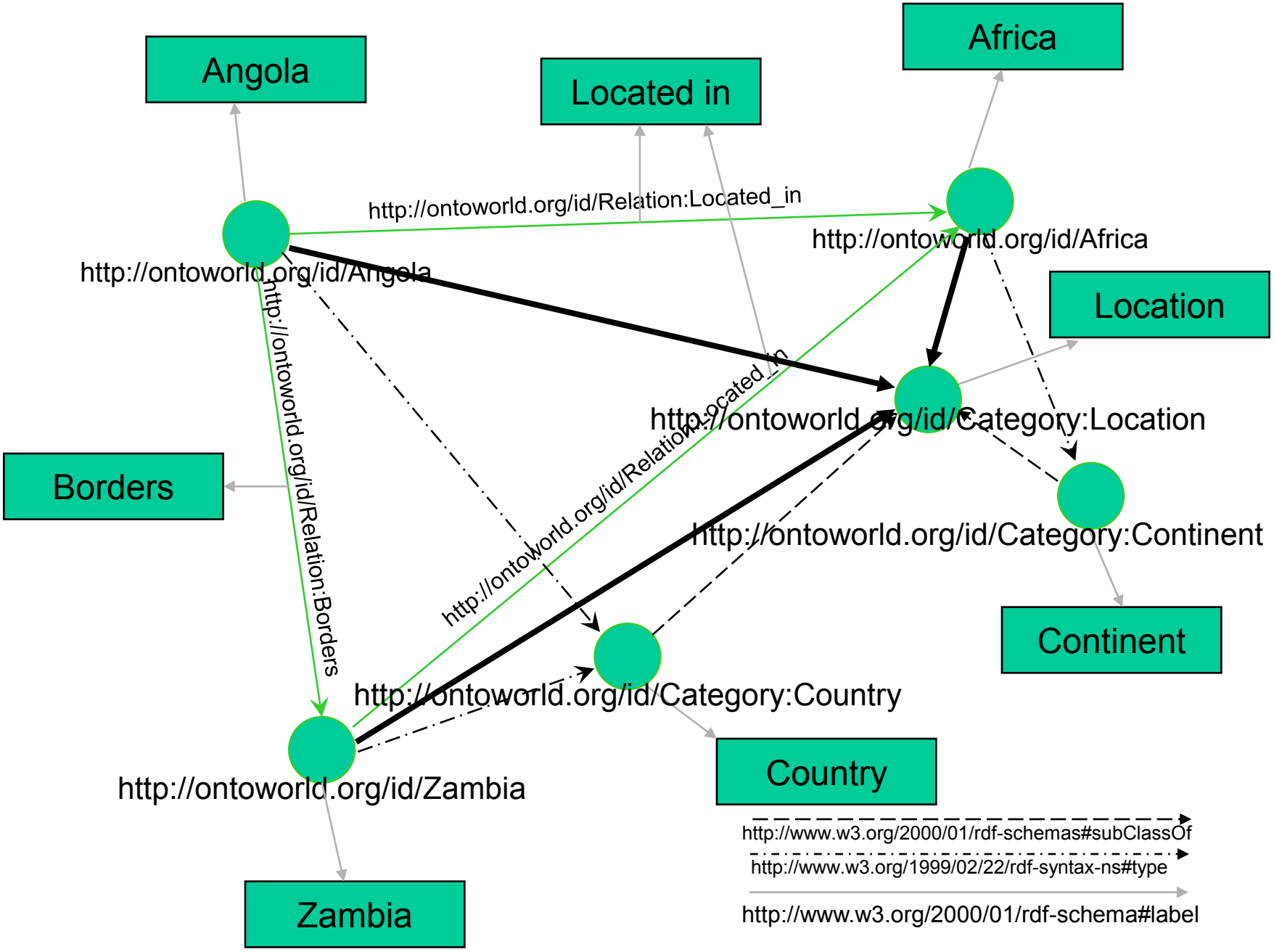
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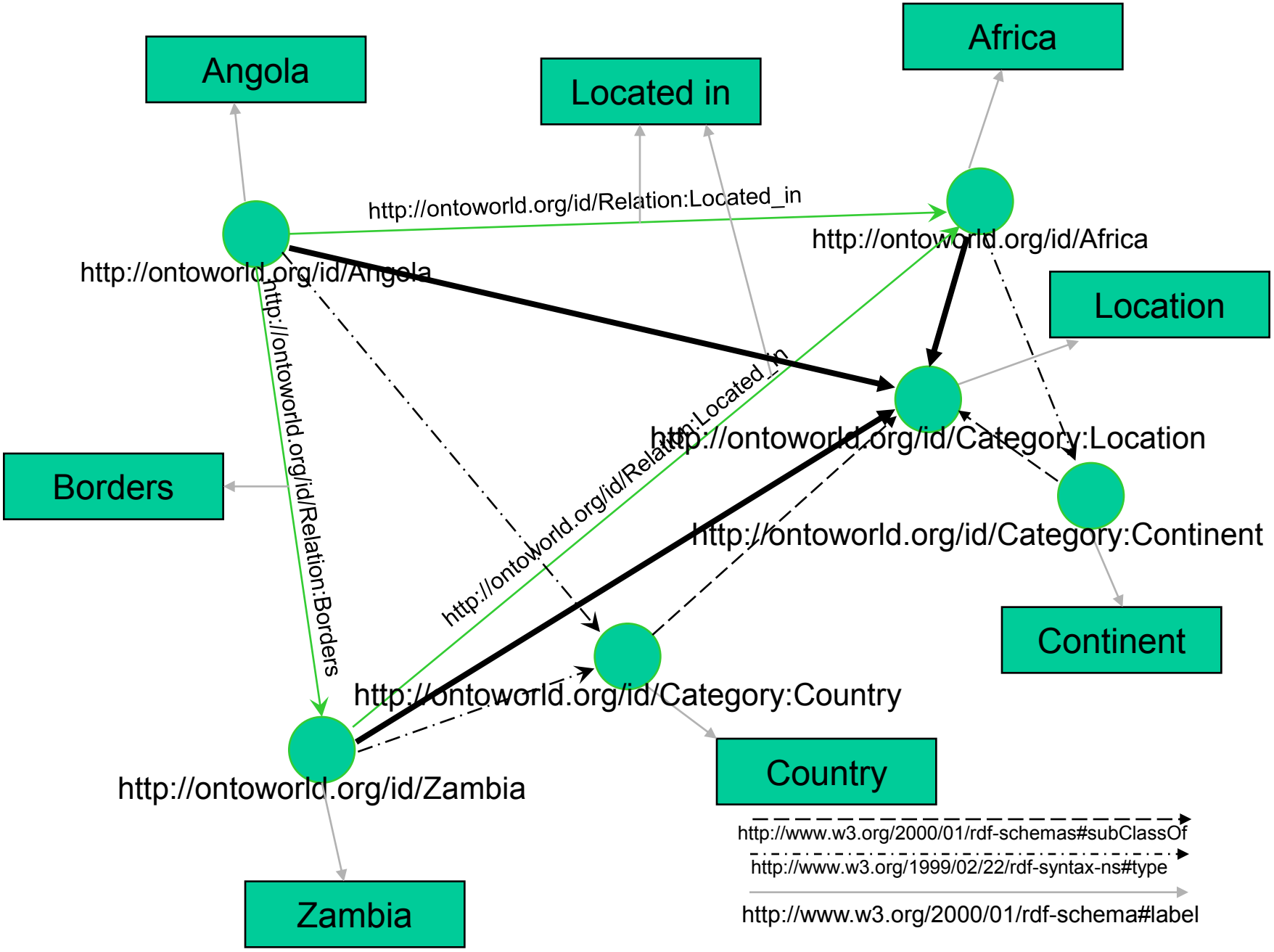
http://www.w3.org/1999/02/22/rdf-syntax-ns#type
http://www.w3.org/2000/01/rdf-schema#label

RDF Schema

- Define relations between terms to give formal semantics
- In RDF(S):
  - subClassOf
  - subPropertyOf
  - And others (domain, range, list, collection, etc.)
- Example:
  - Country subClassOf Location
  - Continent subClassOf Location
- Allows inferences
  - Angola type Country
  - Country subClassOf Location
  - -> Angola type Location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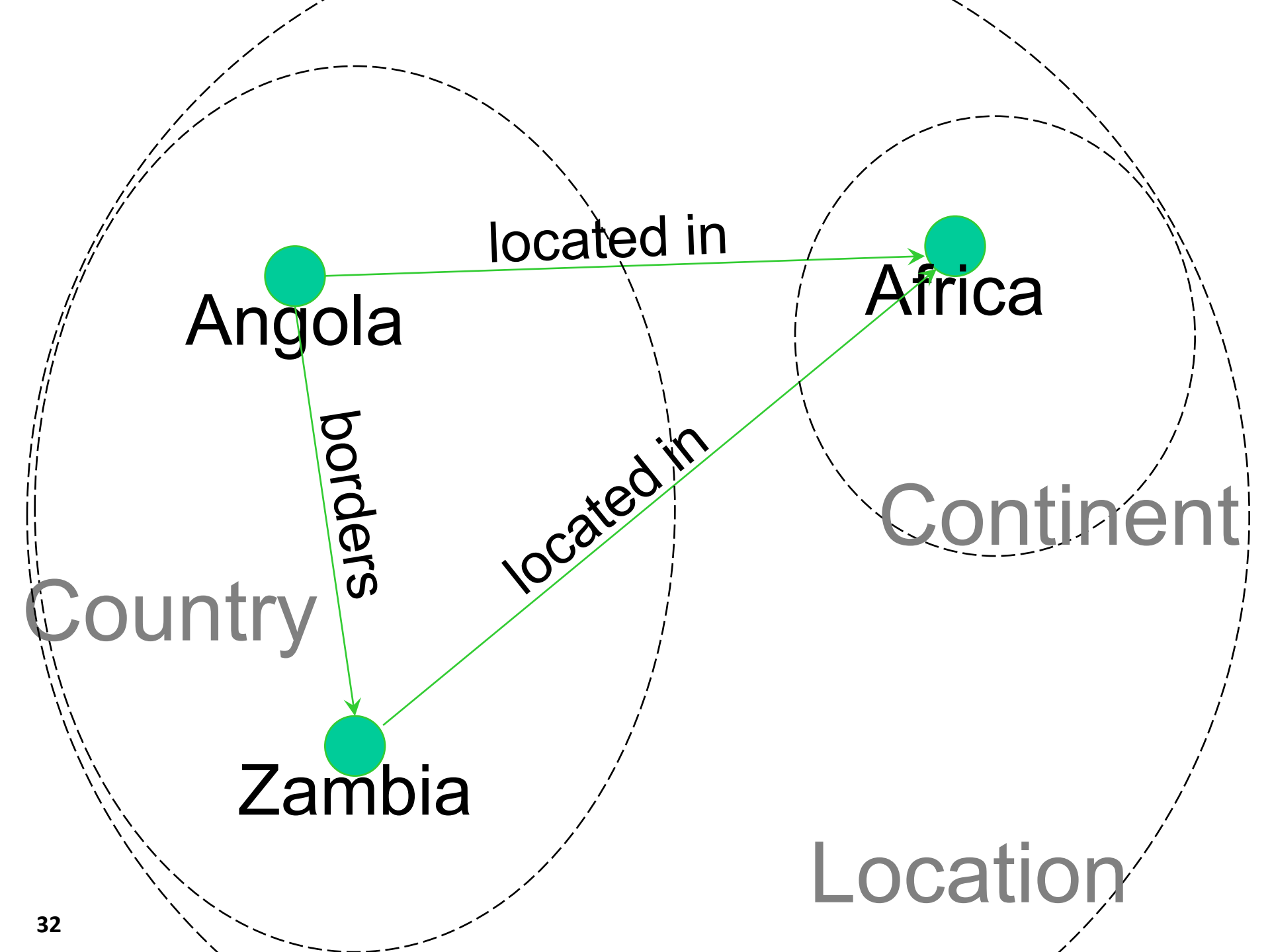
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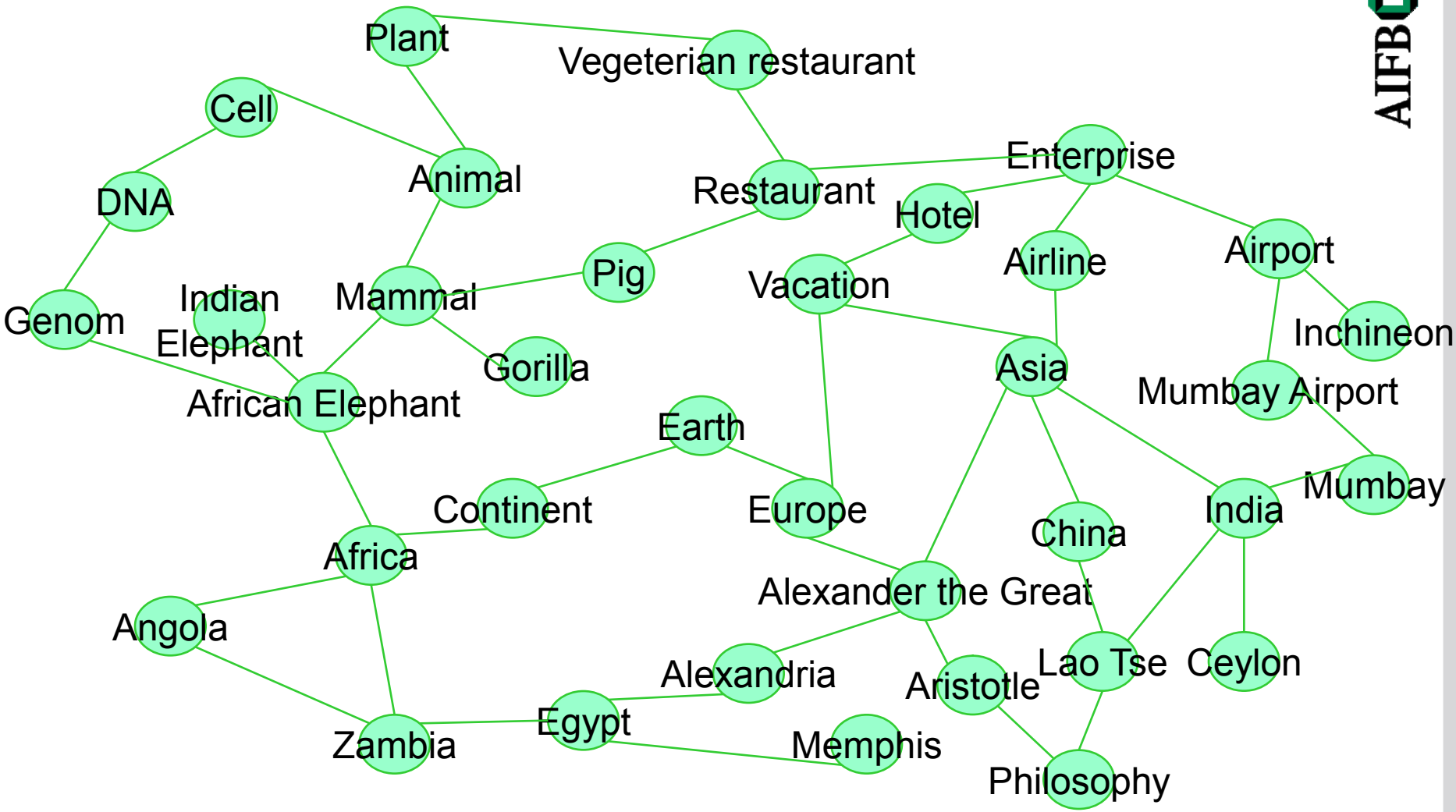
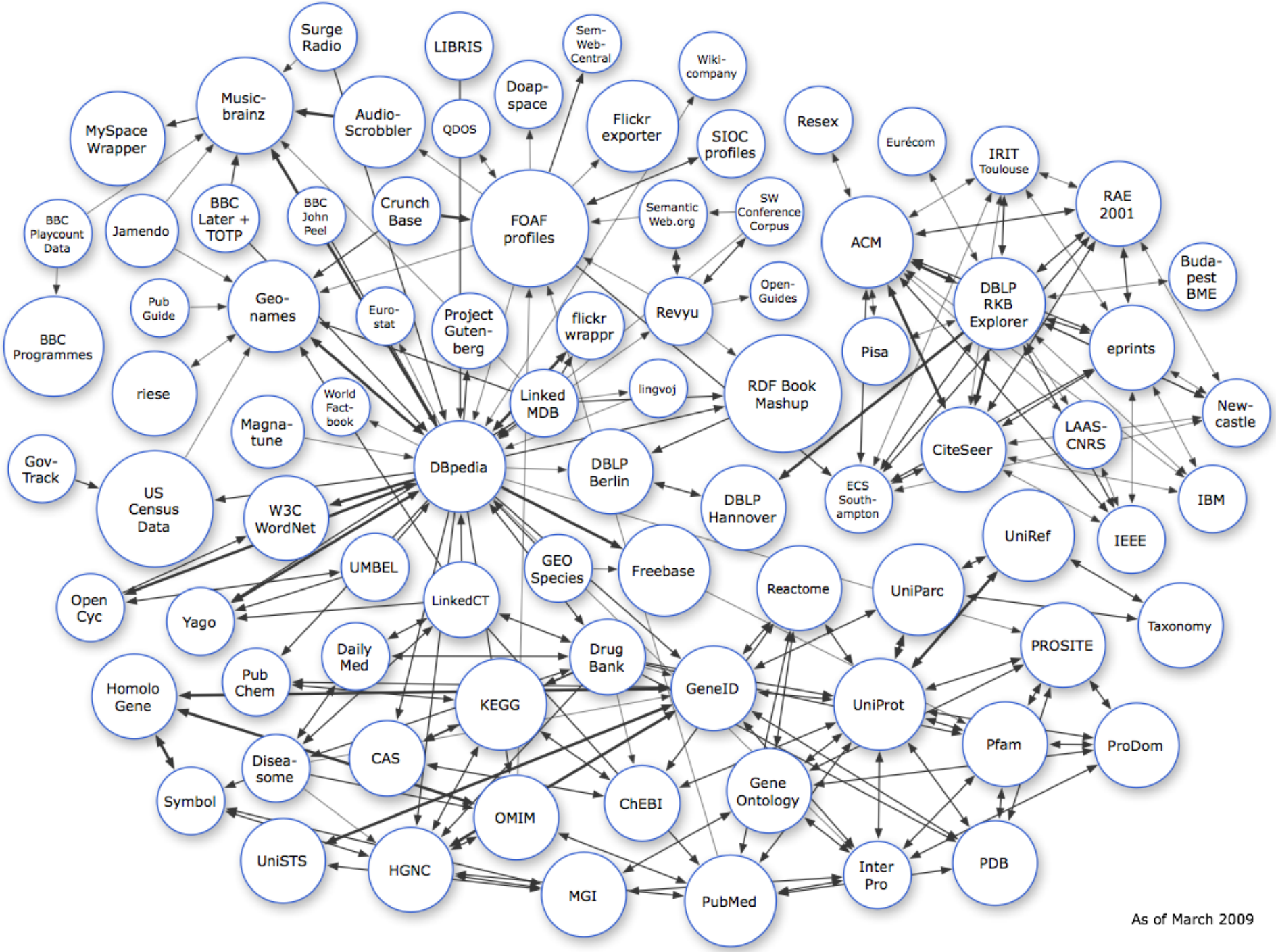
Semantic Web

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IRIT Toulouse
MySpace Wrapper
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BBC John Peel
Crunch Base
FOAF profiles
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ECS South-ampton
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Taxonomy
Daily Med
Drug Bank
PROSITE
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Pub Chem
KEGG
GeneID
UniProt
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ProDom
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UniSTS
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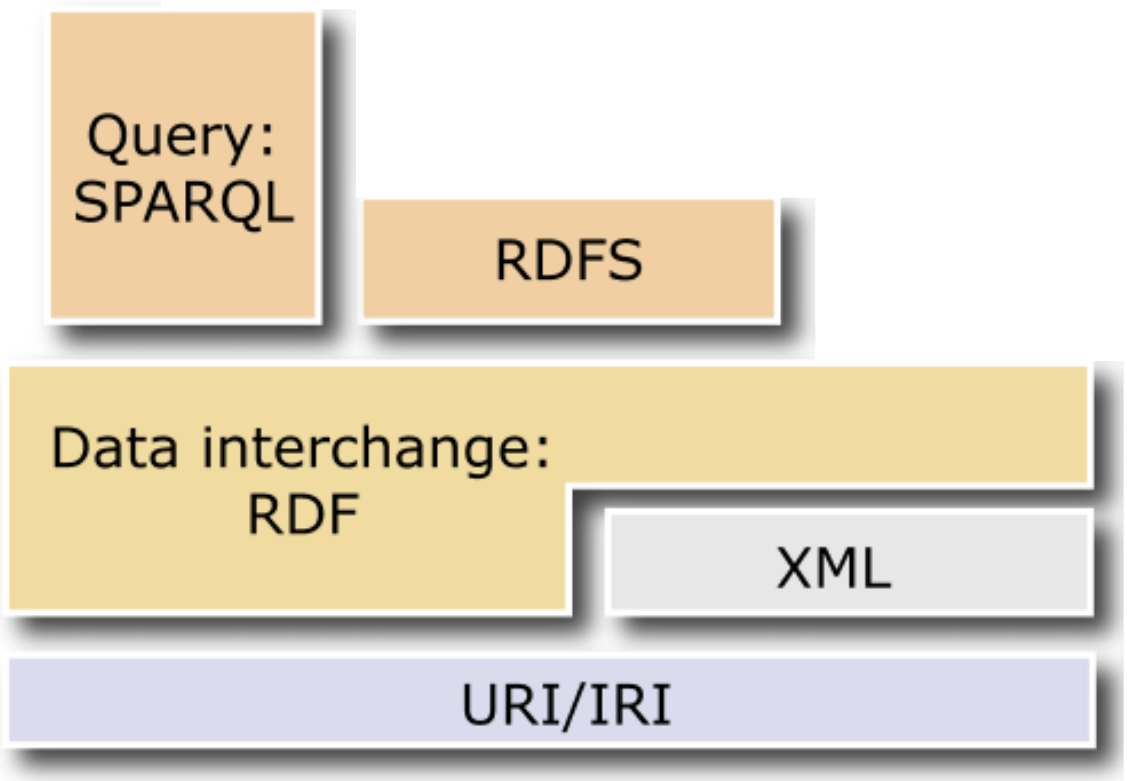
PubMed
Inter Pro
PDB
As of March 2009

Universal Access to All Knowledge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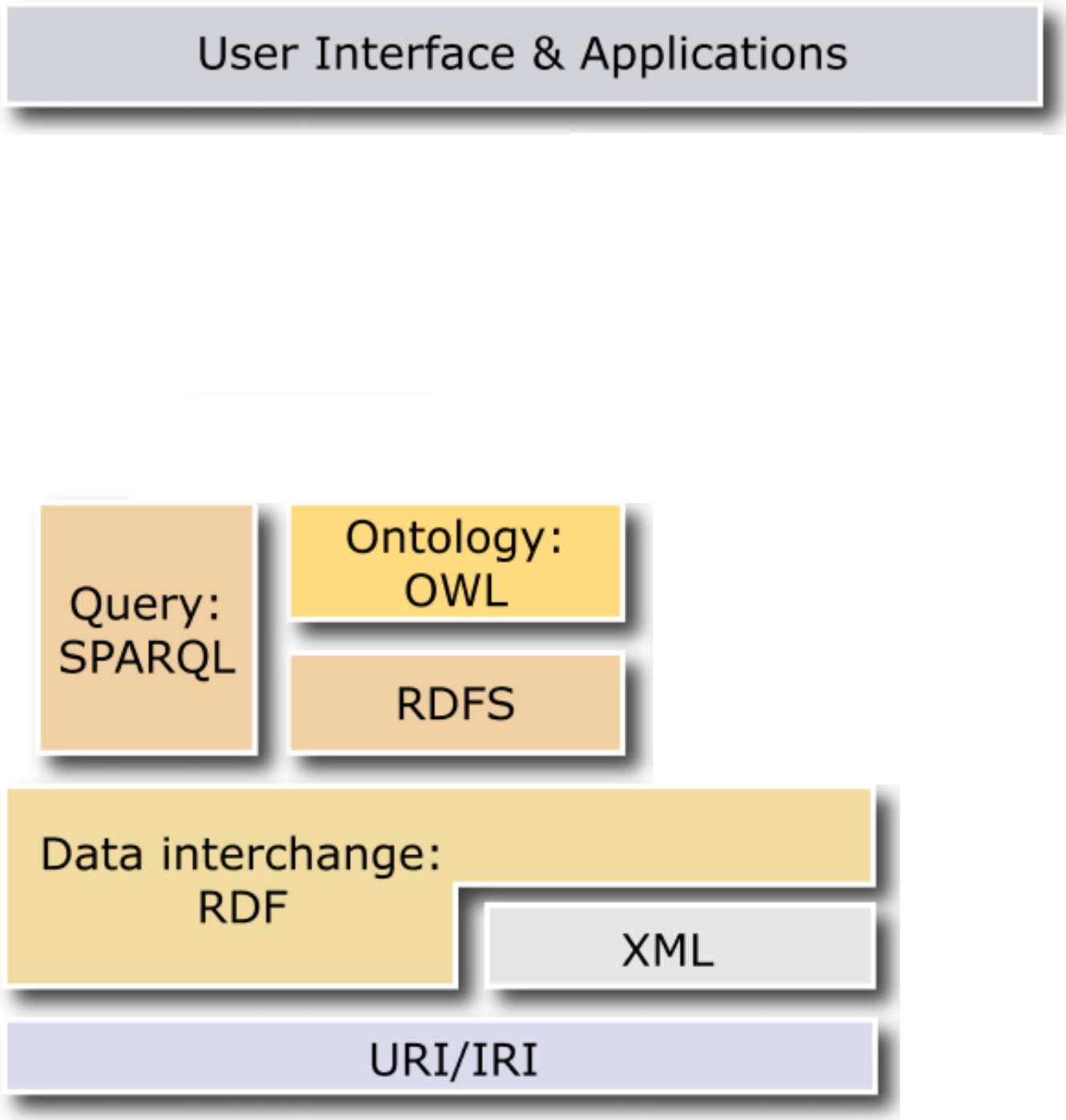
User Interface & Applications
Query:
SPARQL
Ontology:
OWL
RDFS
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Ontology:
OWL

Web Ontology Language OWL

- Ontologies
- Classes
- Properties
- Individuals

Ontologies

- An ontology is a formal specification of a shared conceptualization
- An ontology defines terms and their formal relations to each other
- An ontology is defined using an ontology language

OWL Variants

- Different variants of OWL
  - OWL Lite
  - OWL DL
  - OWL Full

- OWL2: Even more variants
  - OWL2
  - OWL2 EL
  - OWL2 QL
  - OWL2 RL

OWL Classes

- OWL Class
  - Set of things (as in RDFS)
- OWL classes can be described
  - Thus „description logics“
  - What does this class mean? (intensional)
  - Using other terms in the ontology
- Relation between two class descriptions
  - subClassOf $\sqsubseteq$
  - equivalentClass $=$
  - disjointWith

OWL Classes

- Class descriptions using boolean operators
  - intersectionOf
  - unionOf
  - complementOf

Sister = intersectionOf(Woman, Sibling)

Parent = unionOf(Mother, Father)

Man ⊑ complementOf(Woman)

OWL Classes

- Class descriptions using properties
  - allValuesFrom, someValuesFrom
  - minCardinality, maxCardinality, cardinality
  - oneOf
  - hasValue

SoleDaughter ⊑ allValuesFrom(sibling, Man)

Child = someValuesFrom(parent, Woman)

Child = cardinality(parent, 2)

Person = oneOf(gender, (Male, Female))

Woman = hasValue(gender, Female)

OWL Properties

- Properties can also be described
  - subPropertyOf
  - disjointProperty
  - domain
  - range

fatherOf subPropertyOf parentOf.

childOf disjointProperty parentOf.

fatherOf domain Man.

fatherOf range Child.

OWL Properties

- Symmetric / Asymmetric

Symmetric(siblingOf).

Asymmetric(parentOf).

- Reflexive / Irreflexive

Reflexive(commonGenes).

Irreflexive(childOf).

- Transitive

Transitive(ancestorOf).

OWL Properties

- Functional

Functional(hasMother).

- Inverse

Inverse(parentOf, childOf).

- Inverse functional

InverseFunctional(fatherOf).

- Keys

Key(childOf, birthOrder).

OWL Individuals

- sameAs

sameAs (John, Jack).

- differentFrom

differentFrom(John, Sue).

- Positive and negative property assertions

John fatherOf Mary.

not(Mary motherOf John).

Remember: It‘s about semantics

- Actual syntax and tools should not matter
- Standardized semantics

- Number of syntaxes
  - RDF/XML
  - Functional Syntax
  - Manchester Syntax
- Number of tools
  - Protégé
  - NeOn

Karlsruhe Institute of Technology

AIFB

Questions?