

Fundamentals of Semantic Web Development

Oshani Seneviratne and Lalana Kagal
Decentralized Information Group



Organization

- ◆ Instructors: Oshani Seneviratne and Lalana Kagal
- ◆ Coaches: Ian Jacobi, Jim Hollenbach, Matt Cherian, Kenny Luck ...

Agenda

- ◆ Session I: 40 mins
 - SW concepts and serializations
- ◆ Break: 10 mins
- ◆ Session II: 40 mins
 - SW libraries
- ◆ Break: 10 mins
- ◆ Session III: 40 mins
 - ontology development
- ◆ Break: 10 mins
- ◆ Session IV: 40 hour
 - commonly used ontologies
 - RDFa



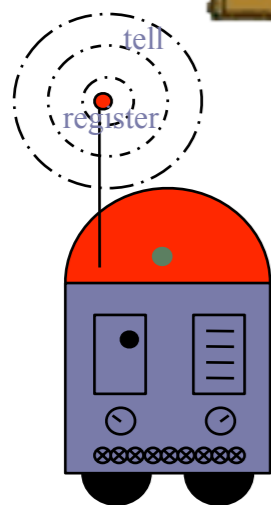
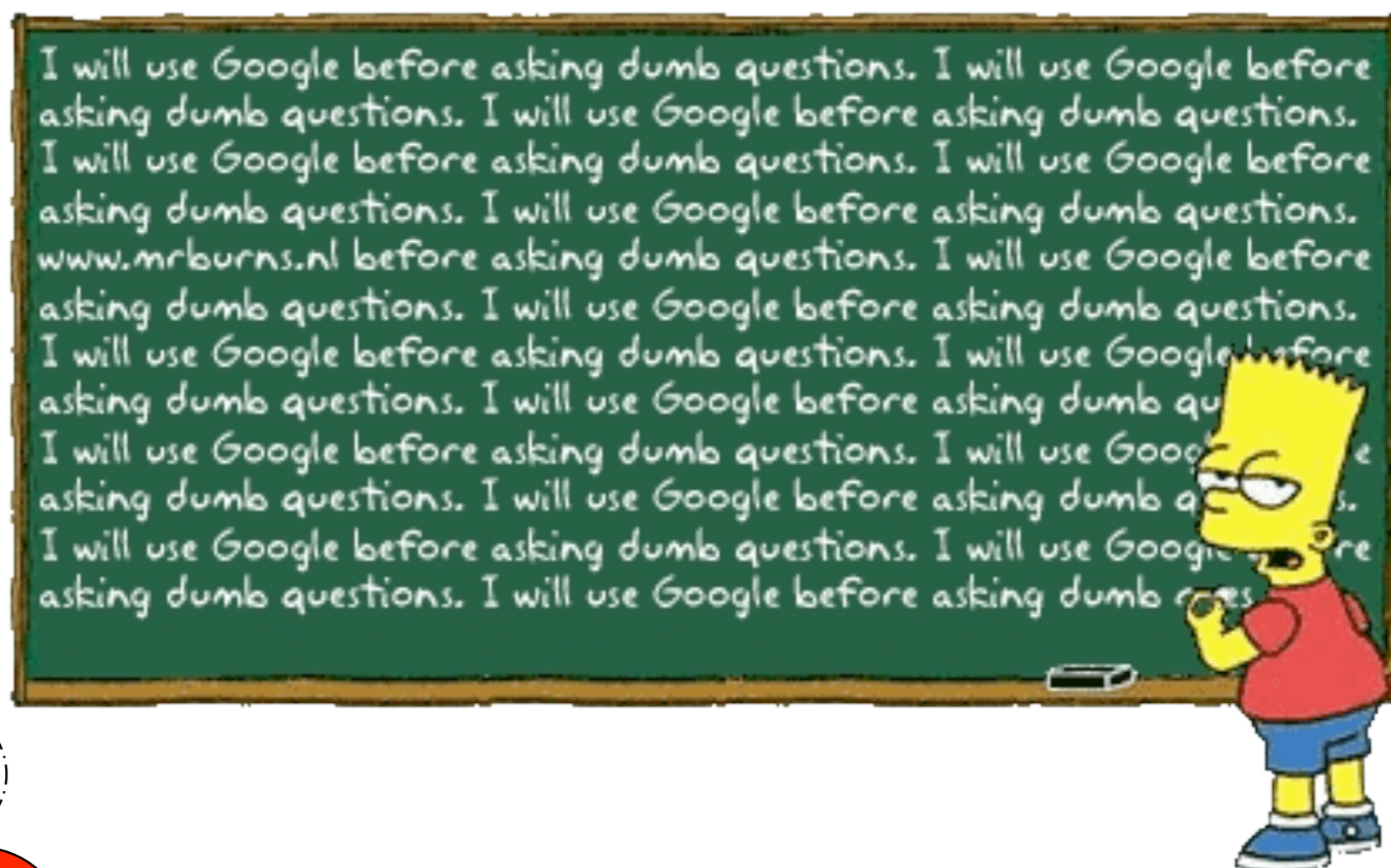
Session I: Semantic Web Concepts & Serializations

The Web has made people smarter



Kodak EasyShare Gallery amazon.com. ebay craigslist
 Blogger™
 CNN.com. Surfing
 CiteSeer
 Autonomous Citation Indexing
 dblp.uni-trier.de
 Search
 bag-of-words tagging
 Epinions.com™
 a Shopping.com company
 flickr™
 GAMMA
 del.icio.us
 Technorati™

But what about machines ?



Machines still have a very minimal understanding of text and images.

Semantic Web: machine-understandable data

◆ Natural Language

Alice is a person

as seen by a person

Alice isa $\nabla \Rightarrow \Updownarrow \Leftrightarrow$

as seen by a machine

◆ XML – represent structures

`<person>Alice</person>`

as seen by a person

`<⇕⇔>☹️⌘⌘■∪⊆</⇕⇔>`

as seen by a machine

◆ Semantic Web - represent more semantics

- represent structures
- enable common vocabulary
- associate symbols with logic interpretation for inference

What the Web looks like

What the Web looks like



<http://www2002.org>
WWW2002
 THE ELEVENTH INTERNATIONAL WORLD WIDE WEB CONFERENCE
 Sheraton Waikiki Hotel
 Honolulu, Hawaii, USA
 7-11 May 2002
HAWAII
 1 LOCATION. 5 DAYS. LEARN. INTERACT.

Registered participants coming from:
 Australia · Canada · Chile · Denmark · France · Germany · Ghana · Hong Kong · India · Italy · Ireland · Japan · Malta · New Zealand · The Netherlands · Norway · Singapore · Switzerland · The United States · Vietnam · Zambia

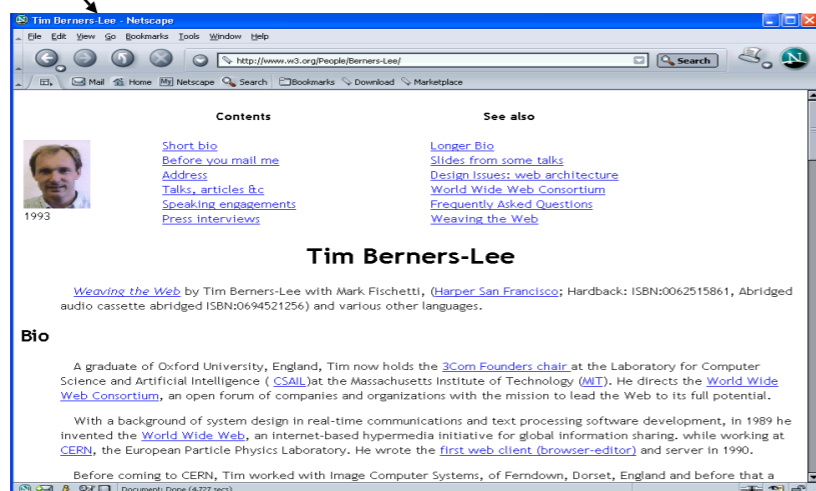
REGISTER NOW

On 7-11 May 2002, Honolulu, Hawaii will provide the backdrop for The Eleventh International World Wide Web Conference. This prestigious series of the International World Wide Web Conference Committee (IW3C2) attracts participants from around the world, and it provides a public forum for the World Wide Web Consortium (W3C) through the annual W3C track.

The conference is being organized by the International World Wide Web Conference Committee (IW3C2), the University of Hawaii and the Pacific Telecommunications Council (PTC).

FEATURED SPEAKERS (CONFIRMED)


- 
 Tim Berners-Lee, inventor of the World Wide Web and Director of the W3C who now holds the 3Com Founders chair at the Laboratory for Computer Science (LCS) at the Massachusetts Institute of Technology (MIT).
- 
 Richard A. DeMillo, vice president and chief technology officer for Hewlett-Packard Company.
- 
 Ian Foster, guru of "Grid Computing", associate
- 
 McArthur Prize Winner



Tim Berners-Lee - Netscape
 http://www.w3.org/People/Berners-Lee/

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[Slides from some talks](#)
[Design Issues: web architecture](#)
[World Wide Web Consortium](#)
[Frequently Asked Questions](#)
[Weaving the Web](#)


 1993

Tim Berners-Lee

[Weaving the Web](#) by Tim Berners-Lee with Mark Fischetti, (Harper San Francisco; Hardback: ISBN:0062515861, Abridged audio cassette abridged ISBN:0694521256) and various other languages.

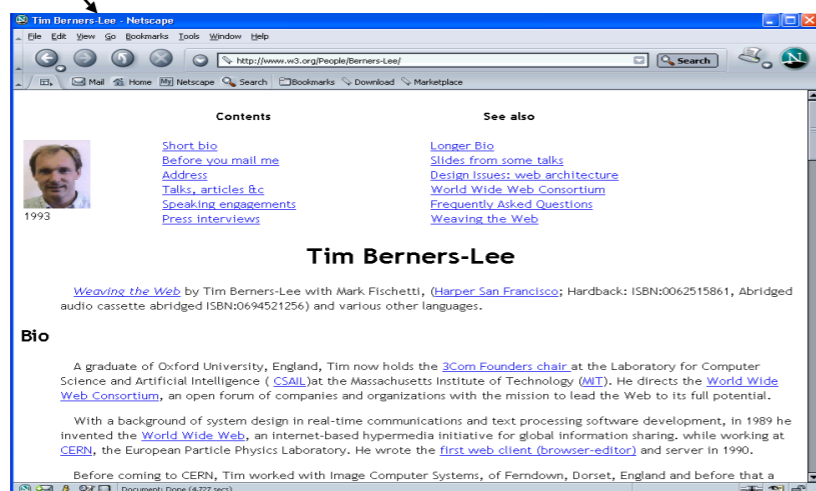
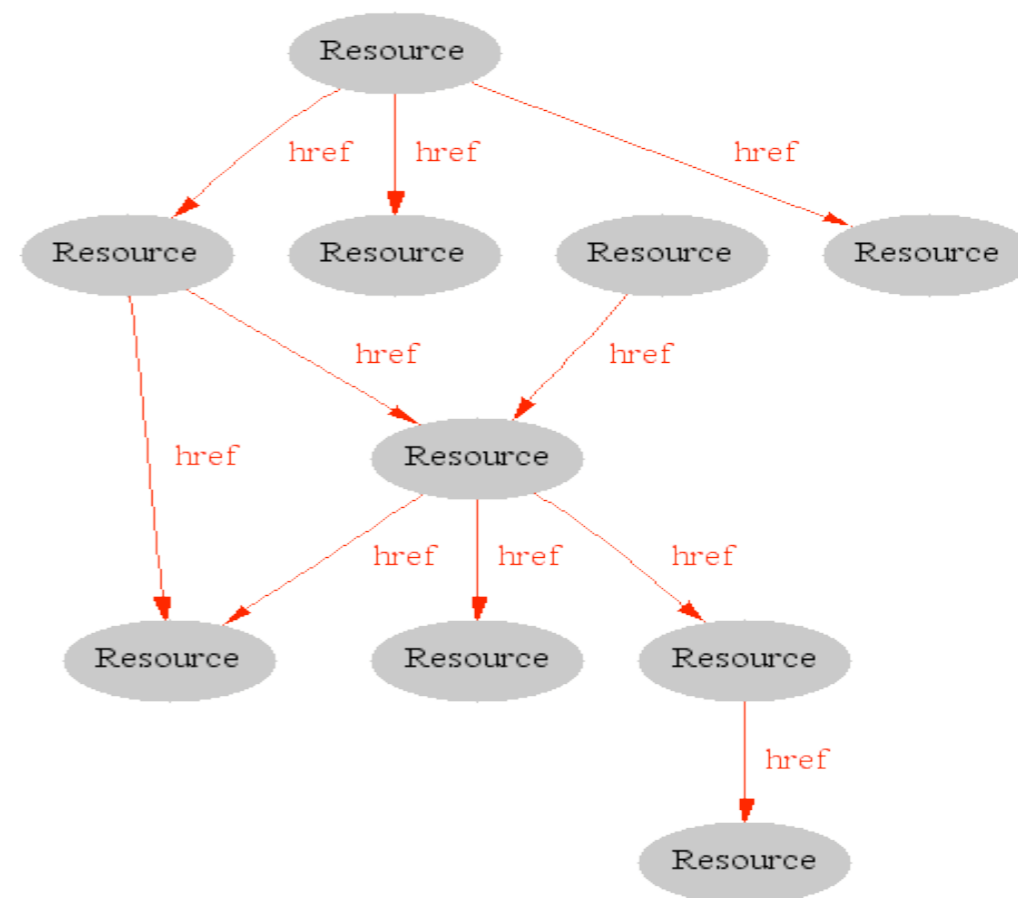
Bio

A graduate of Oxford University, England, Tim now holds the [3Com Founders chair](#) at the Laboratory for Computer Science and Artificial Intelligence (CSAIL) at the Massachusetts Institute of Technology (MIT). He directs the [World Wide Web Consortium](#), an open forum of companies and organizations with the mission to lead the Web to its full potential.

With a background of system design in real-time communications and text processing software development, in 1989 he invented the [World Wide Web](#), an internet-based hypermedia initiative for global information sharing, while working at CERN, the European Particle Physics Laboratory. He wrote the [first web client \(browser-editor\)](#) and server in 1990.

Before coming to CERN, Tim worked with Image Computer Systems, of Ferndown, Dorset, England and before that a

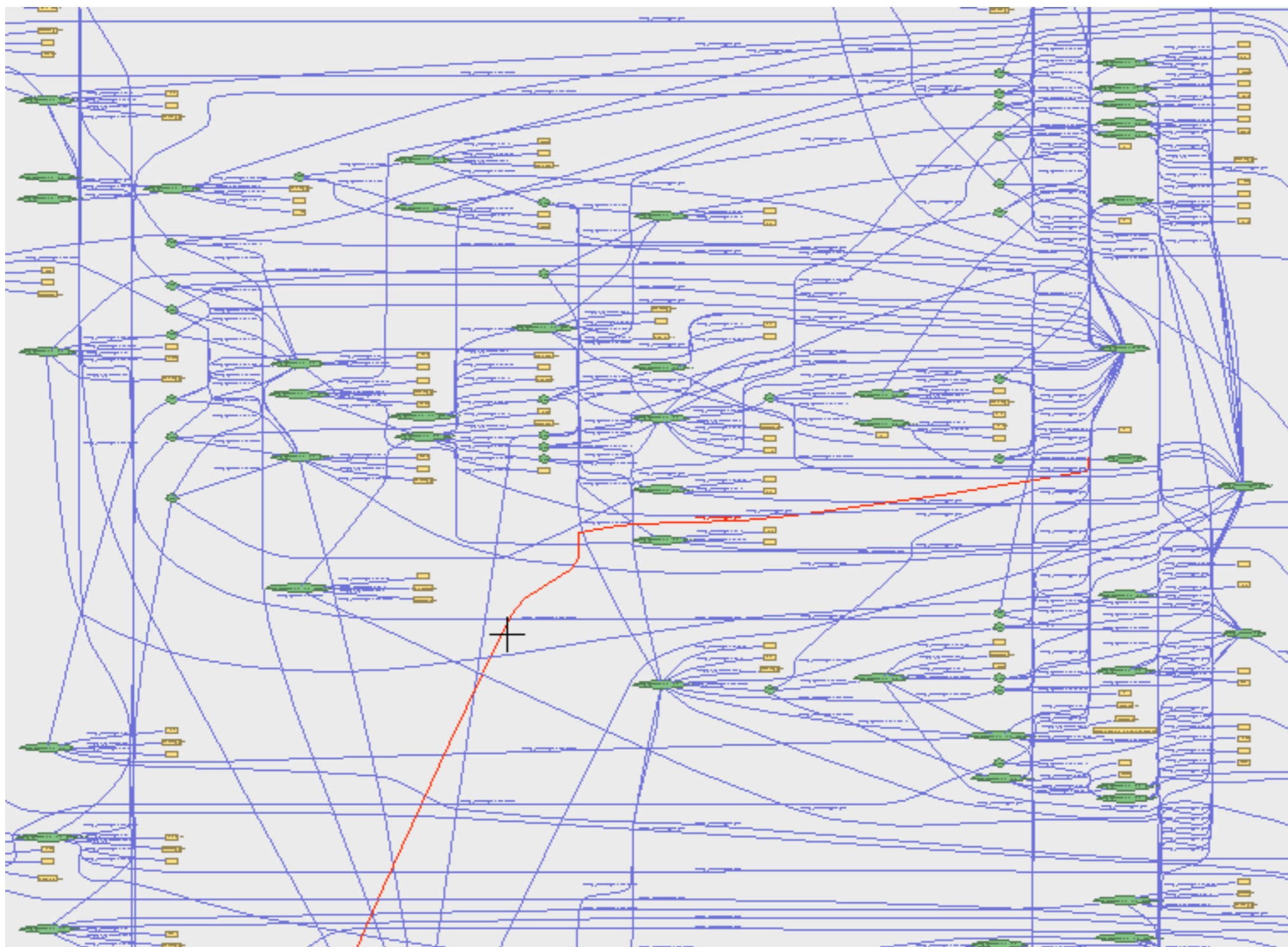
What the Web looks like





What the Semantic Web looks like (birds eye view)

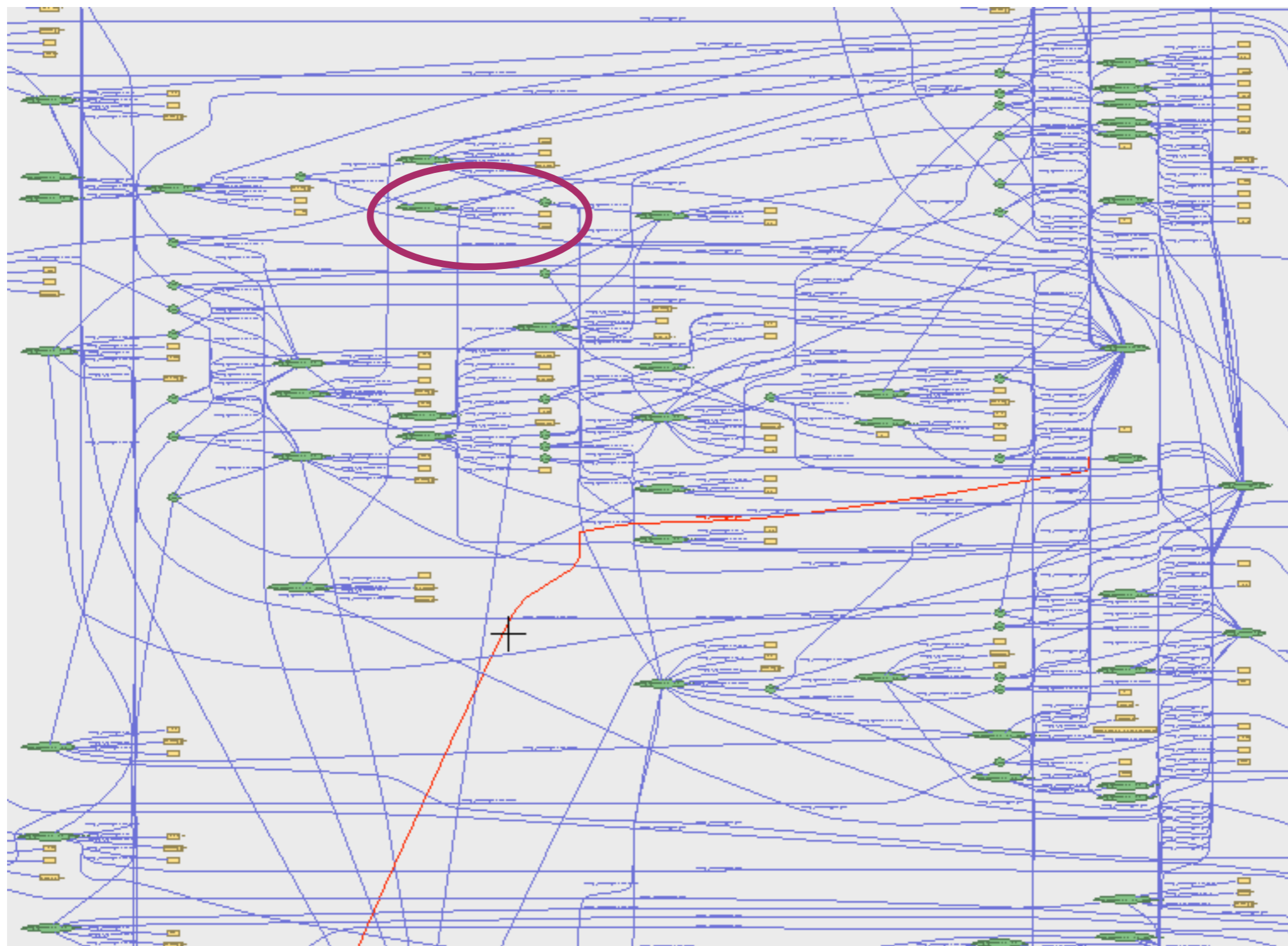
What the Semantic Web looks like (birds eye view)



IsaViz Screenshot

Image courtesy of W3C <http://www.w3.org/2001/11/IsaViz/>

What the Semantic Web looks like (birds eye view)



Inside the Semantic Web (zooming in)

Inside the Semantic Web (zooming in)

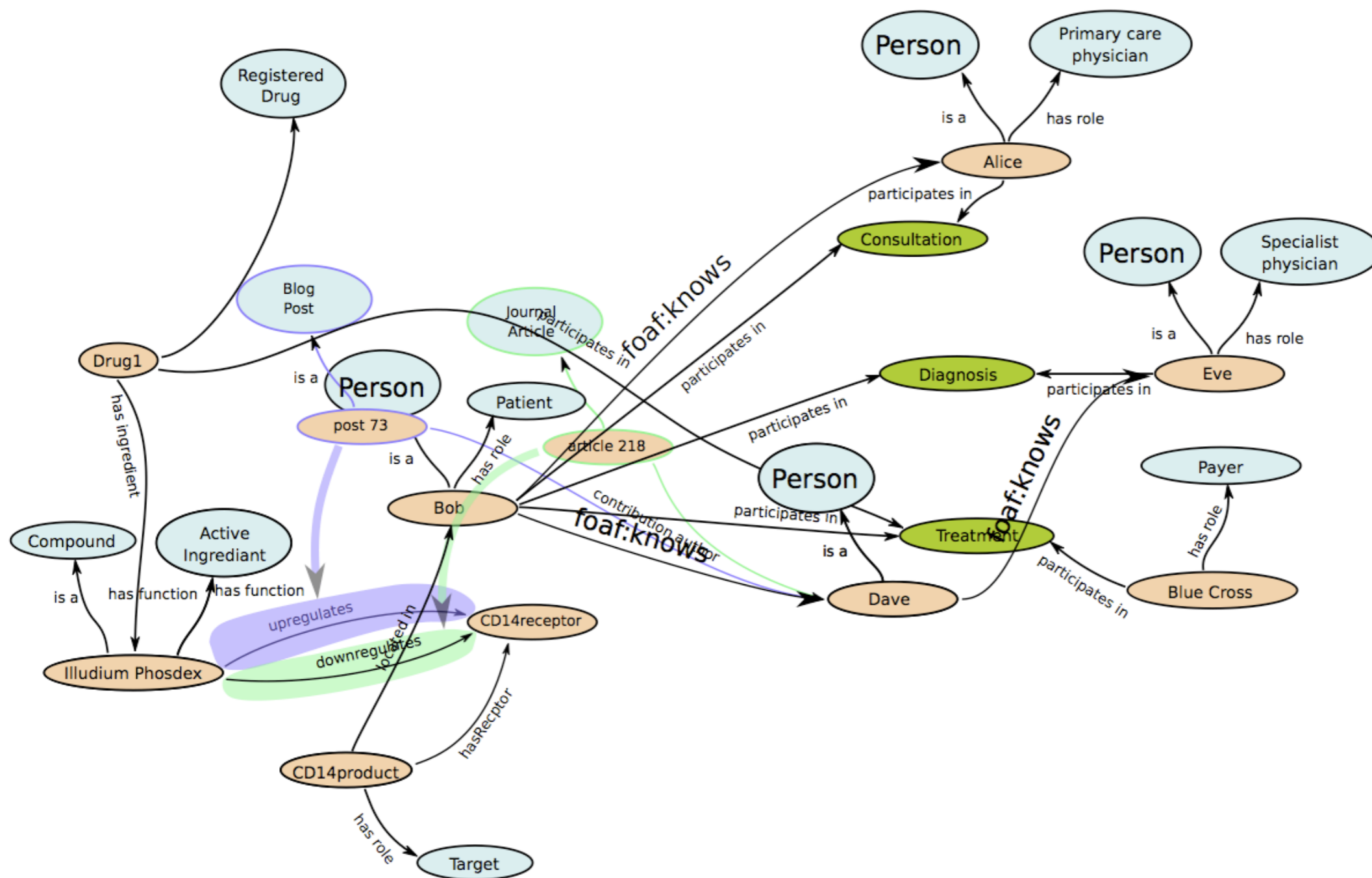


Image courtesy of Eric Prud'hommeaux
<http://www.w3.org/2009/Talks/1005-jaoo-egp/>

Inside the Semantic Web (zooming in)

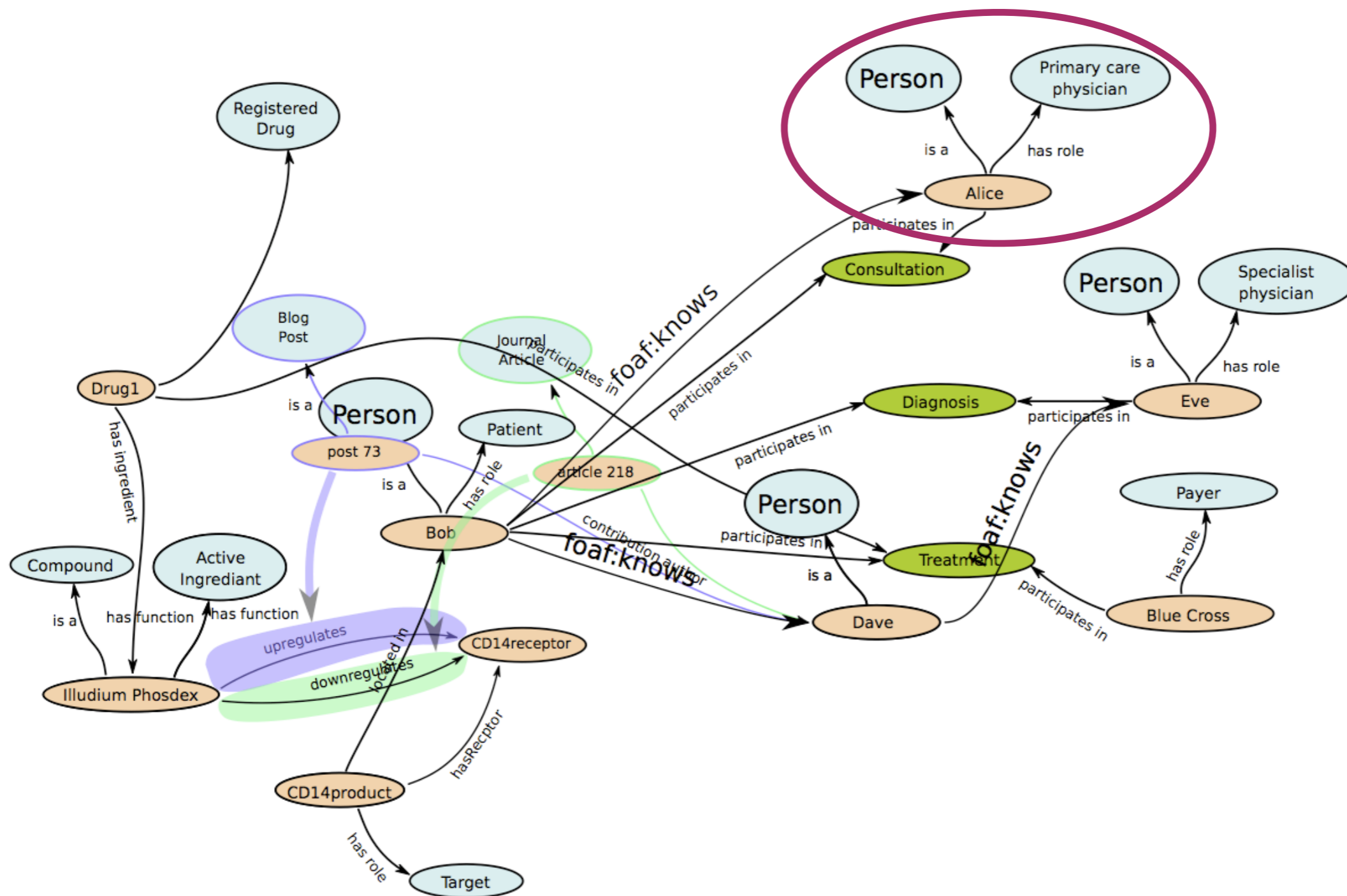
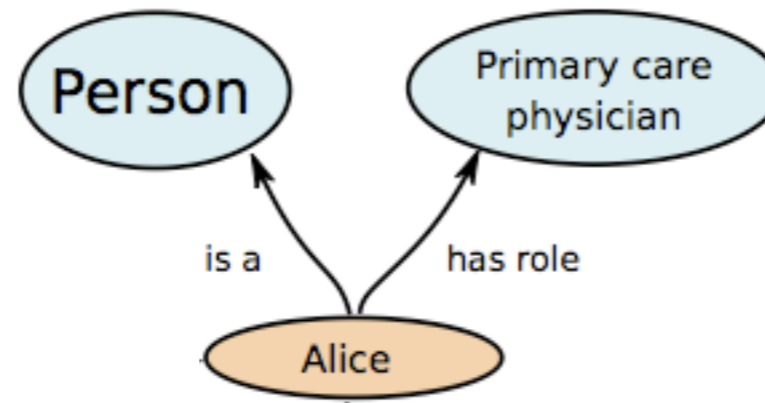


Image courtesy of Eric Prud'hommeaux
<http://www.w3.org/2009/Talks/1005-jaoo-egp/>

Inside the Semantic Web (still closer)

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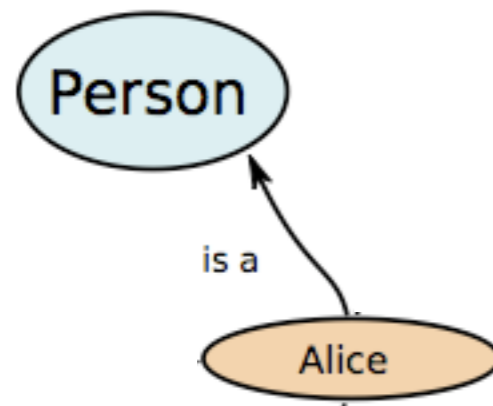
- ◆ What does it mean ?
 - Circles - concepts or instances
 - ▣ Classes: Person & Primary Care Physician
 - ▣ Instances: Alice
 - Arrows - relationships/properties
 - ▣ Properties/Links: is a, has role
- ◆ Diagram is read: **Alice** is a **person** and has role **primary care physician**
- ◆ **Note:** Named links (relationships/properties) is one of the differences between SW and Web

RDF Data Model

- ◆ RDF data is represented as RDF graphs
- ◆ RDF graphs are collections of statements called triples
- ◆ Each triple contains a subject, verb (also called predicate) and object

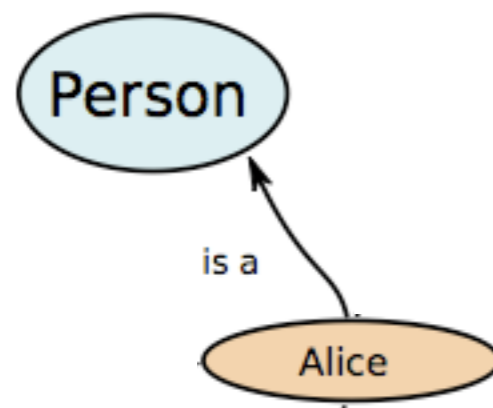
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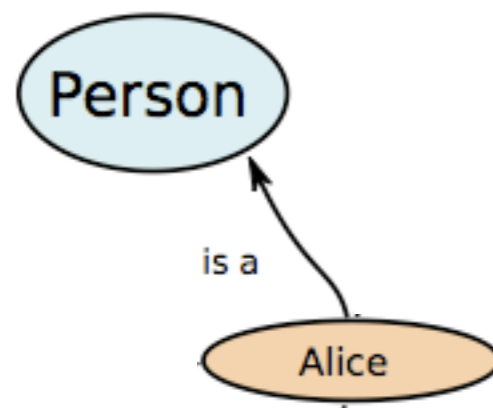
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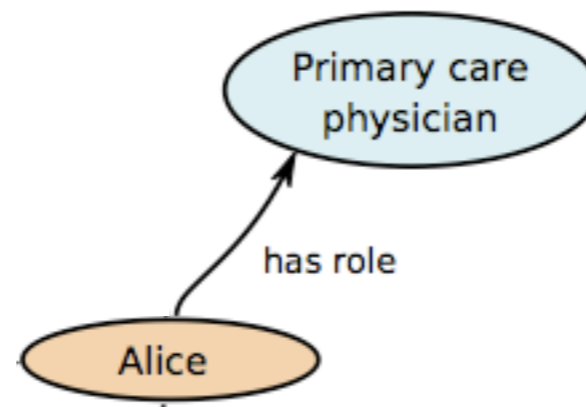
subject - Alice
verb/predicate - is a
object - Person

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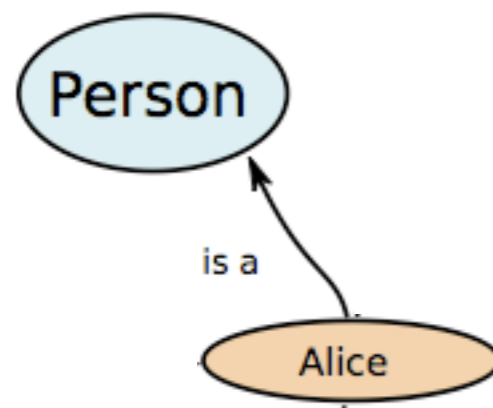


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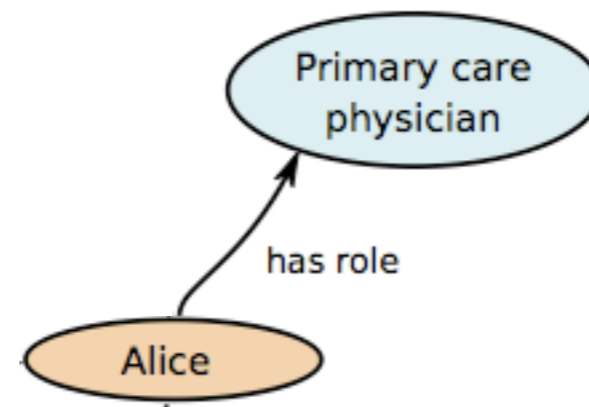


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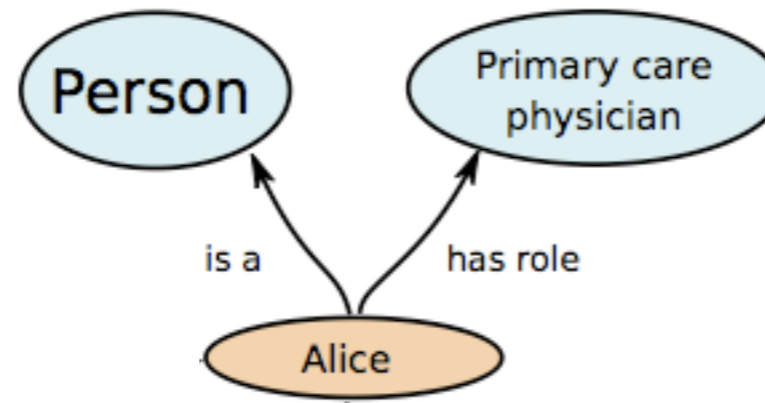


subject - Alice
verb/predicate - is a
object - Person



subject - Alice
verb/predicate - has role
object - PrimaryCarePhysician

RDF Data Model



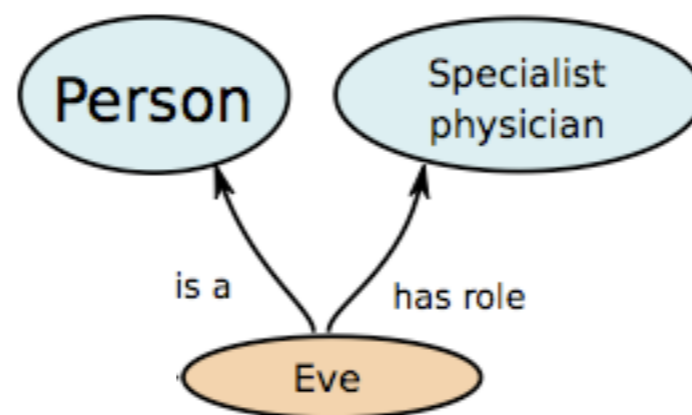
- ◆ Statements/triples describe properties of resources
- ◆ A resource is any object that can be pointed to by a URI:
 - a document, a picture, a paragraph on the Web;
 - a book in the library, a real person
 - isbn://5031-4444-3333
 - Alice, Person, PrimaryCarePhysician
- ◆ Properties themselves are resources and have URIs

Uniform Resource Identifier (URI)

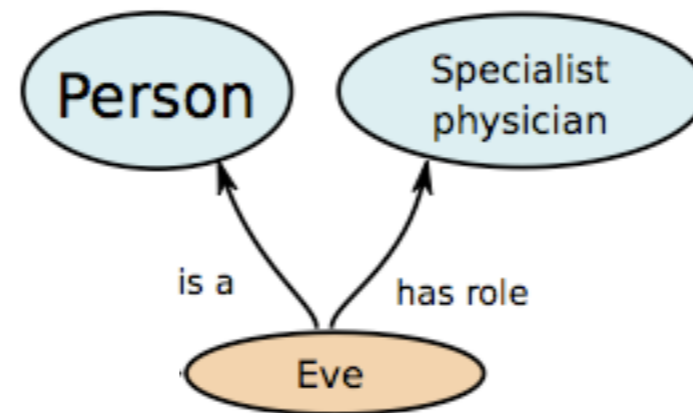
- ◆ "The generic set of all names/addresses that are short strings that refer to resources"
- ◆ URLs (Uniform Resource Locators) are a particular type of URI, used for resources that can be retrieved from the Web (e.g., web pages)
- ◆ In RDF, URIs typically look like “normal” URLs, often with fragment identifiers to point at specific parts of a document:
 - <http://www.somedomain.com/some/path/to/file#fragmentID>
 - <http://example.org/ontology#Person>
 - <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person>

Exercise 1

Exercise 1

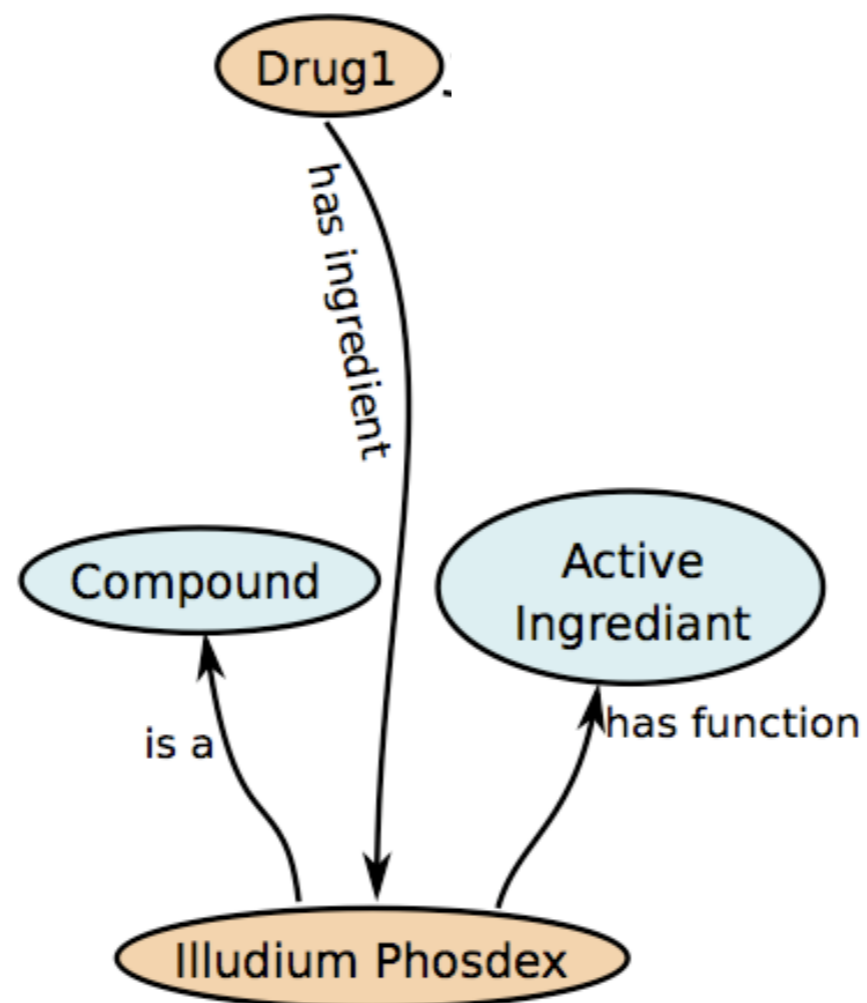


Exercise 1

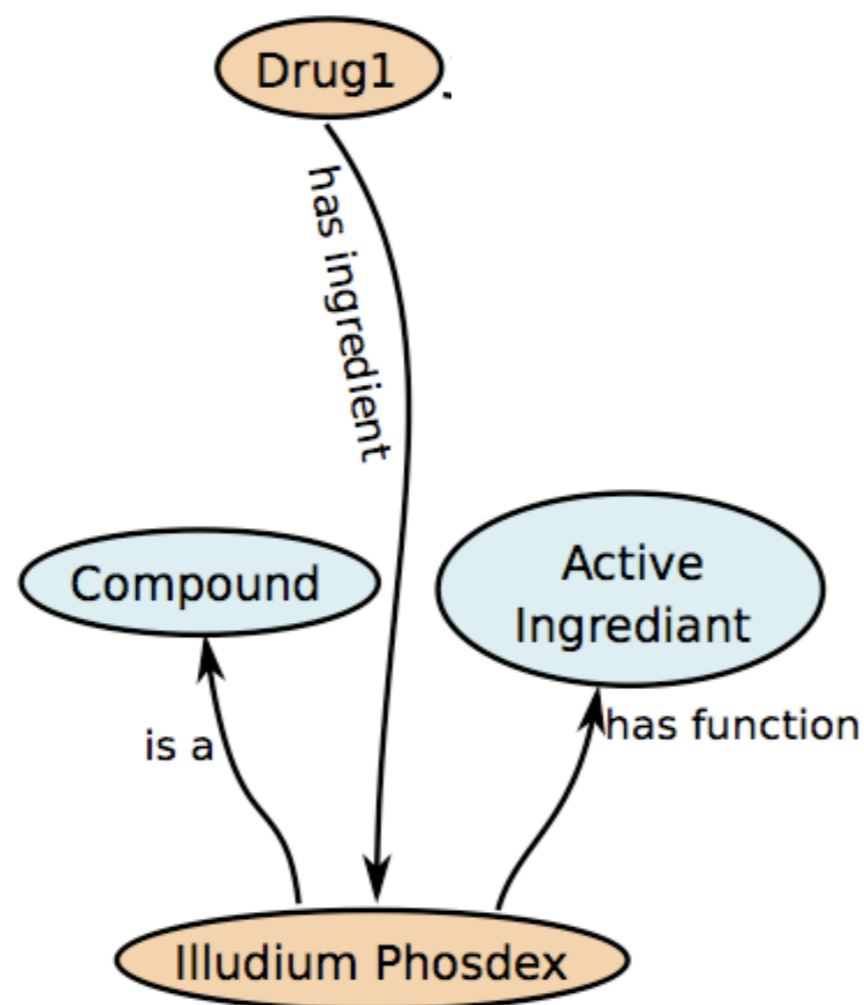


- ◆ Properties: is a and has role
- ◆ Concepts: Eve, Person, Specialist Physician
- ◆ Eve is a person and has role Specialist physician

Exercise 2



Exercise 2



- ◆ Drug1 has ingredient Illudium Phosdex
- ◆ Illudium Phosdex is a Compound and has function Active Ingredient

Exercise 3

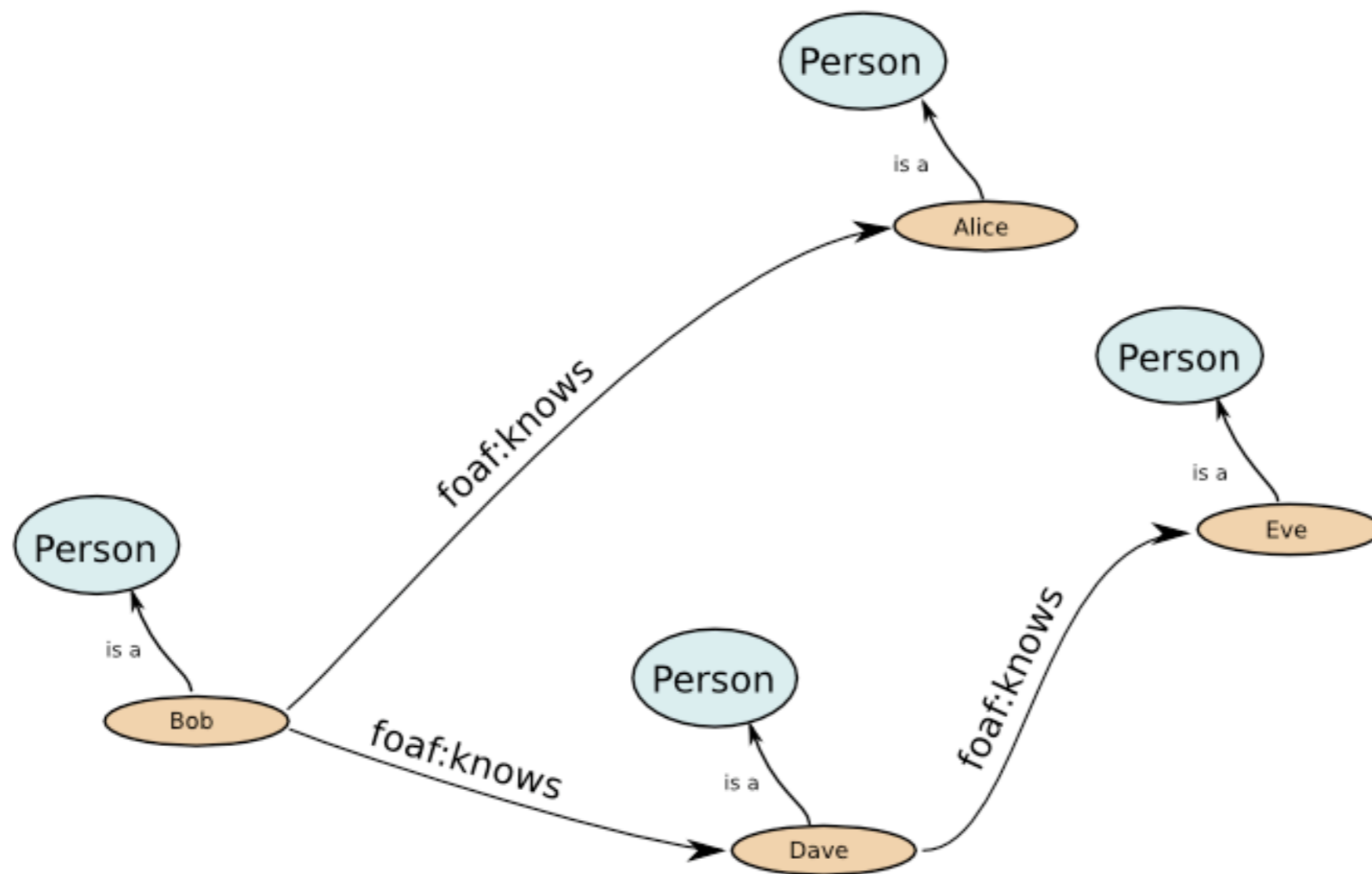
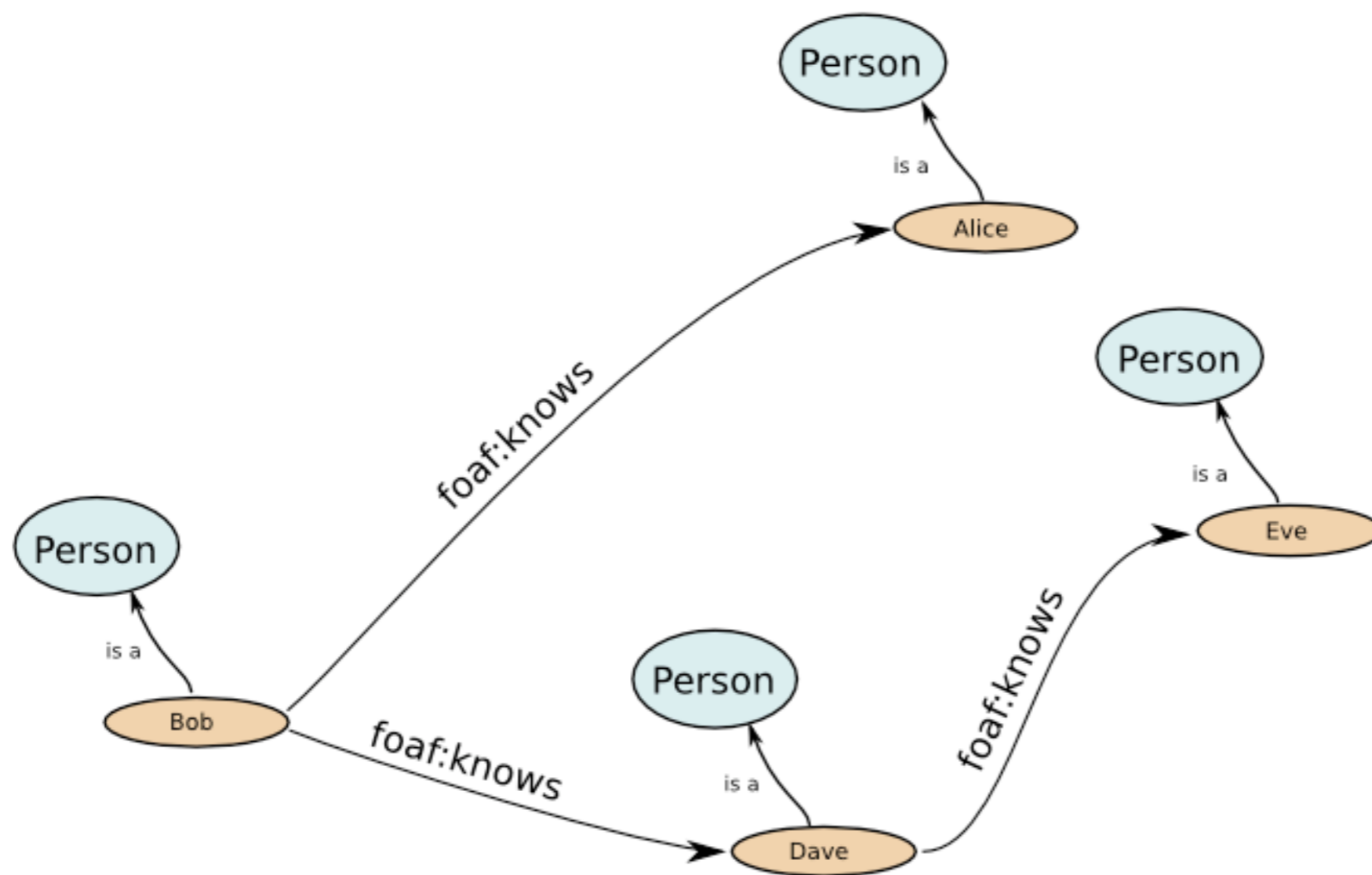


Image courtesy of Eric Prud'hommeaux
<http://www.w3.org/2009/Talks/1005-jaoo-egp/>

Exercise 3



- ◆ Concepts: Bob, Dave, Alice, Eve, Person
Properties: foaf:knows, is a
- ◆ Bob is a person and knows Alice, who is a person, and Dave, who is a person.
- ◆ Dave knows Eve, who is a person

Image courtesy of Eric Prud'hommeaux
<http://www.w3.org/2009/Talks/1005-jaoo-egp/>

Serializations

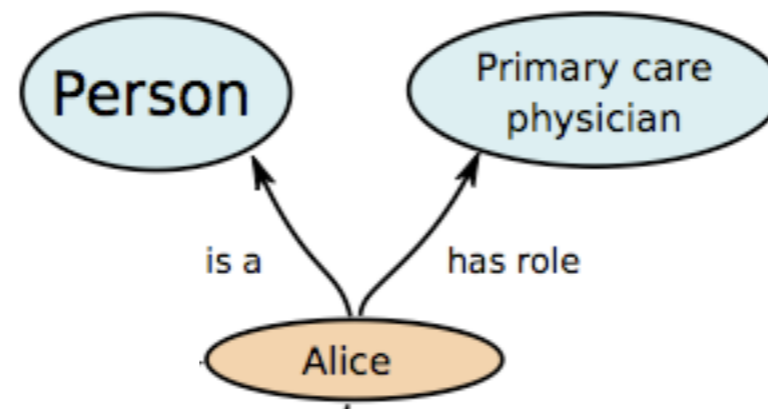
- ◆ Some serializations include
 - RDF/XML and RDFa (W3C standard)
 - NTriples
 - Terse RDF Triple Language (Turtle)
 - Notation3 (N3)

NTriples

- ◆ Plain text format for RDF
- ◆ <http://www.w3.org/2001/sw/RDFCore/ntriples/>

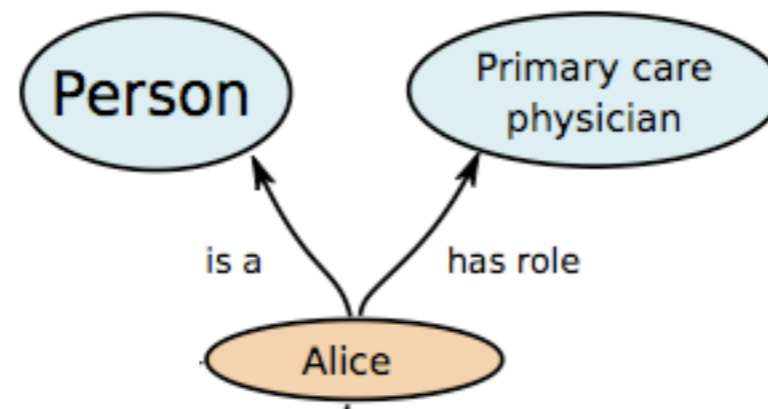
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NTriples

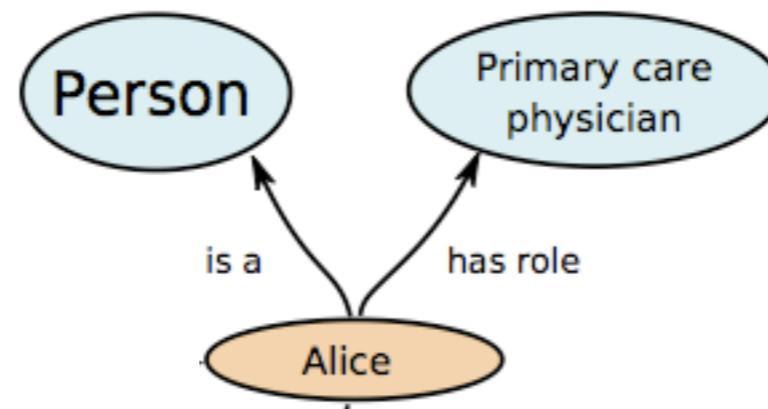
- ◆ Plain text format for RDF
- ◆ <http://www.w3.org/2001/sw/RDFCore/ntriples/>



<http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice> <<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>> <<http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person>>

NTriples

- ◆ Plain text format for RDF
- ◆ <http://www.w3.org/2001/sw/RDFCore/ntriples/>

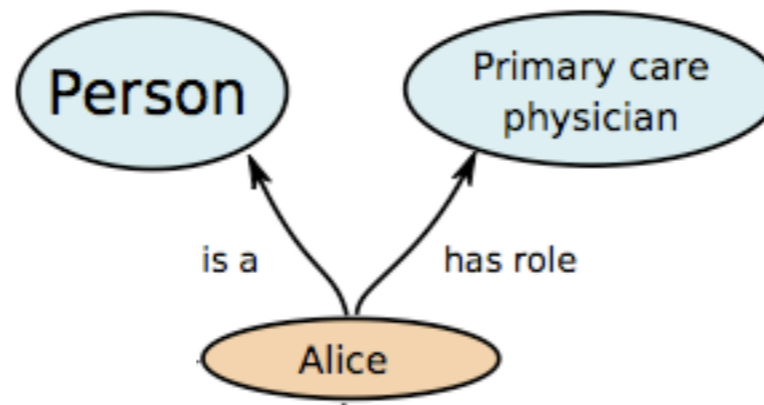


```

<http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice> <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person>
<http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice> <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#role> <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician>
  
```

Terse RDF Triple Language (Turtle)

- ◆ Textual syntax for RDF that allows RDF graphs to be completely written in a compact and natural text form, with abbreviations for common usage patterns and datatypes
- ◆ Blackboard, writable syntax
- ◆ <http://www.w3.org/TeamSubmission/turtle/>



```
@prefix ex: <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix: alice: <http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#> .
```

```
alice:Alice rdf:type ex:Person .
alice:Alice ex:role ex:PrimaryCarePhysician .
```

Turtle

◆ Namespaces

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

@prefix alice: <http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#> .

◆ Prefix

http://www.w3.org/1999/02/22-rdf-syntax-ns#type => rdf:type

<http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice => alice:Alice

◆ Default namespace

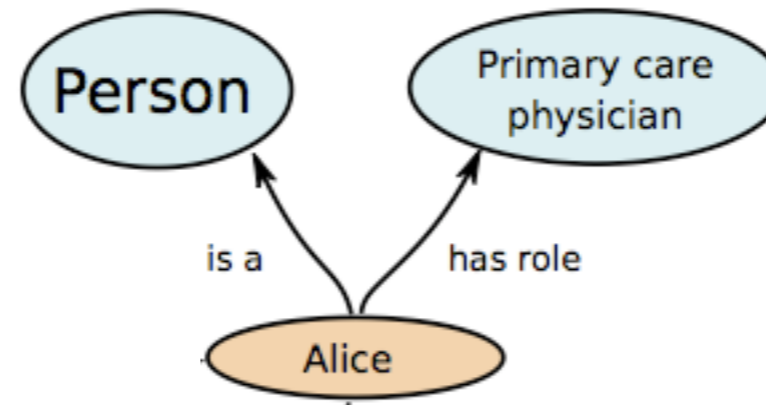
@prefix: <http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#> .

alice:Alice rdf:ex:Person => :Alice rdf:type ex:Person.

◆ Each statement is

<subject> <predicate> <object>.

Turtle



```
@prefix ex: <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#> .
```

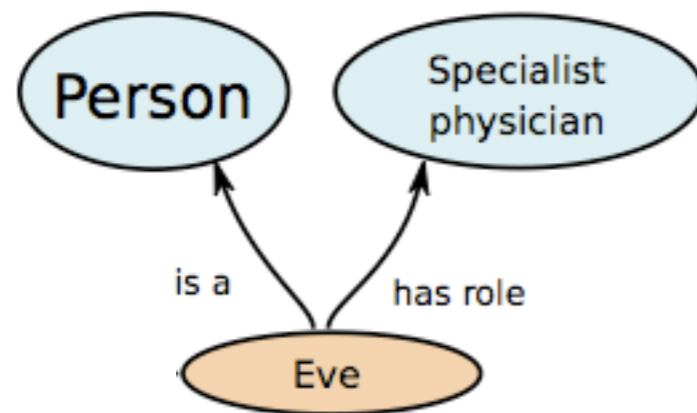
```
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
```

```
@prefix : <http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#> .
```

```
:Alice rdf:type ex:Person.
```

```
:Alice ex:role ex:PrimaryCarePhysician.
```


Exercise 4



Assume the following namespaces

Eve is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#>

SpecialistPhysician and Person are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

ALICE

@prefix ex: <<http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>> .

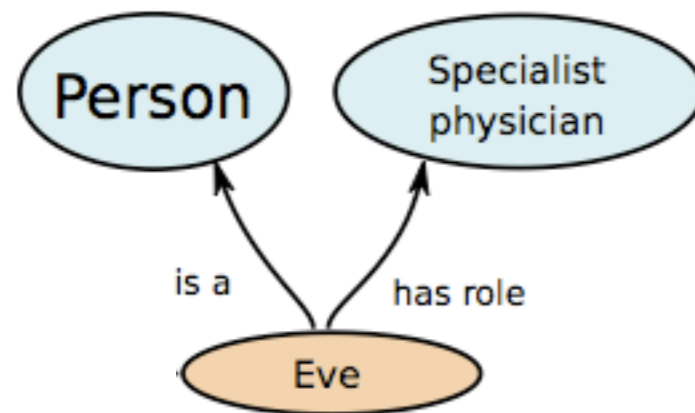
@prefix rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>> .

@prefix : <<http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#>> .

:Alice rdf:type ex:Person.

:Alice ex:role ex:PrimaryCarePhysician.

Exercise 4



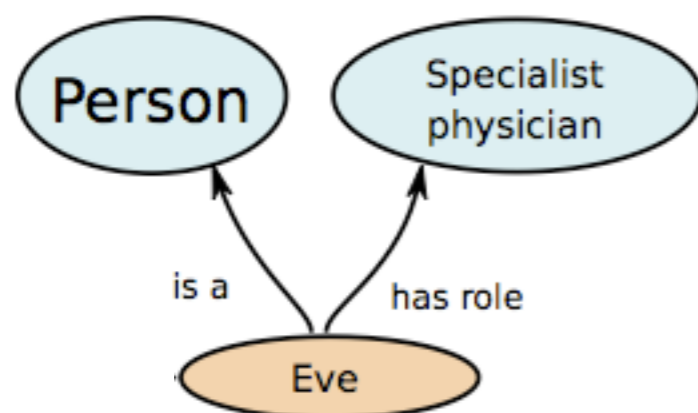
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Eve is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#>

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SpecialistPhysician and Person are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

EVE

@prefix ex: <<http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>> .

@prefix rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>> .

@prefix : <<http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#>> .

:Eve rdf:type ex:Person.

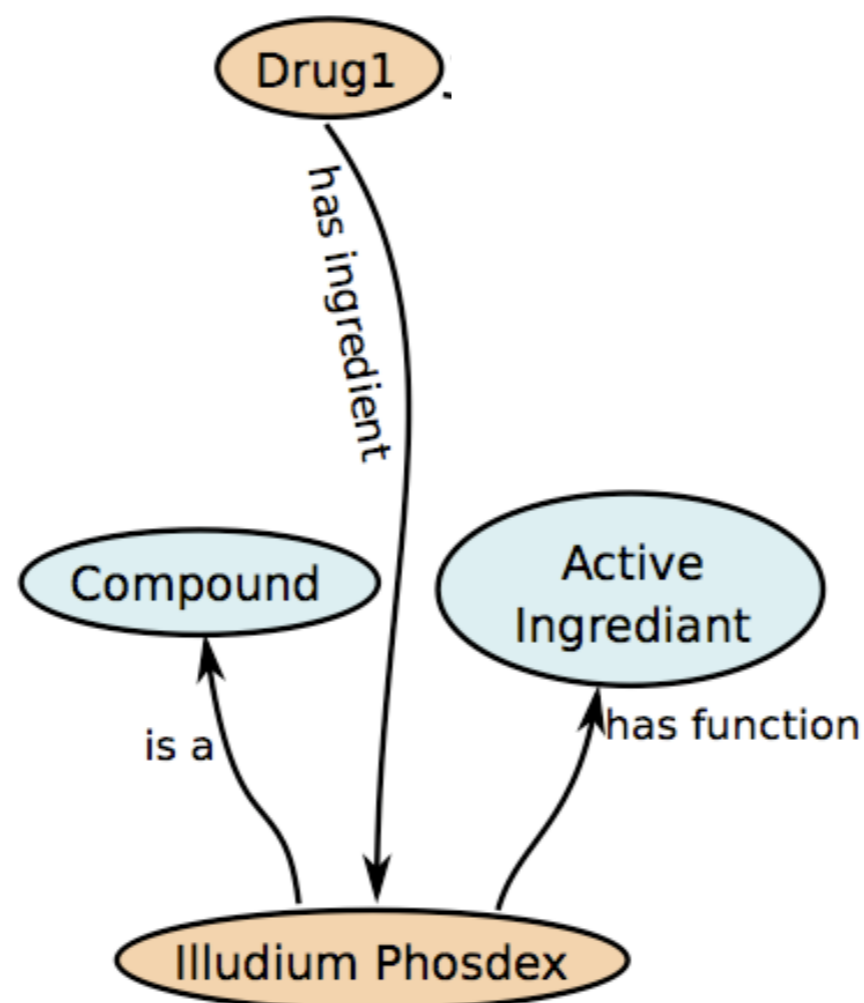
:Eve ex:role ex:SpecialistPhysician.

Turtle

◆ Shorthand notations

- multiple property-value pairs of same instance can be combined
`<subject> <predicate1> <object1>; <predicate2> <object2>; <predicate3> <object3>.`
`:Alice rdf:type ex:Person;`
`ex:role ex:PrimaryCarePhysician .`
- multiple values for same properties
`:Alice rdf:type ex:Person, ex:Female.`
- anonymous node (no identifier)
`[rdf:type ex:Person, ex:Female].`
`:Alice foaf:knows [foaf:name "Carol Nobody"].`

Exercise 5



Assume the following namespaces

IlludiumPhosdex, Drug1 is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#>

Compound, ActiveIngredient, function, and ingredient is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

Exercise 5 Solution

Exercise 5 Solution

@prefix ex: <<http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>> .

@prefix rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>> .

Exercise 5 Solution

@prefix ex: <<http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>> .

@prefix rdf: <<http://www.w3.org/1999/02/22-rdf-syntax-ns#>> .

@prefix : <<http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#>> .

Exercise 5 Solution

@prefix ex: <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#> .

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

@prefix : <http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#> .

:illudiumphosdex rdf:type ex:Compound;

Exercise 5 Solution

@prefix ex: <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#> .

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

@prefix : <http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#> .

:illudiumphosdex rdf:type ex:Compound;
ex:function ex:ActiveIngredient .

Exercise 5 Solution

@prefix ex: <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#> .

@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

@prefix : <http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#> .

:illudiumphosdex rdf:type ex:Compound;
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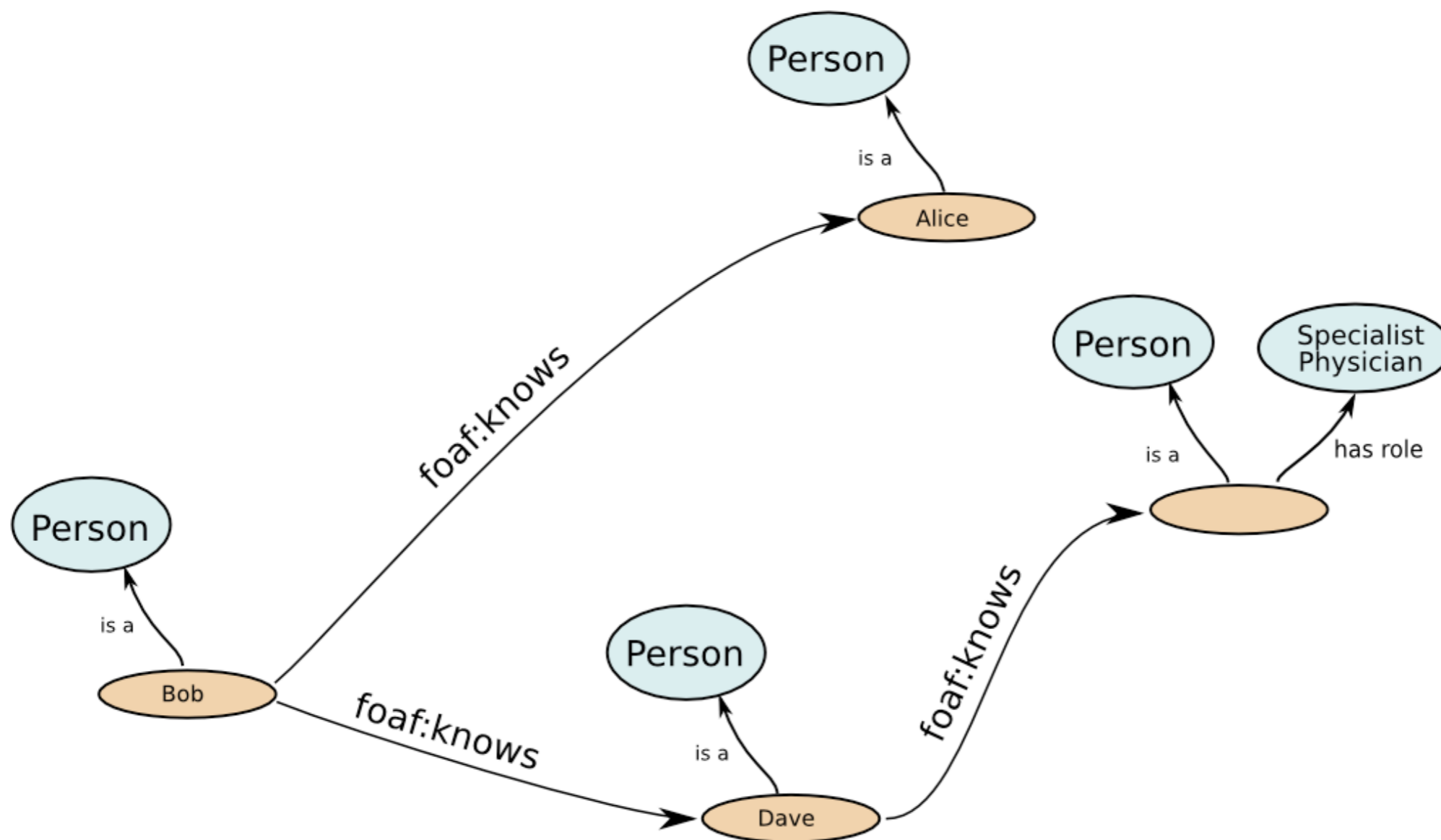
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .

@prefix : <http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#> .

:illudiumphosdex rdf:type ex:Compound;
ex:function ex:ActiveIngredient .

:drug1 ex:ingredient :illudiumphosdec .

Exercise 6



Assume the following namespaces

All beige concepts are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/<name>#>

foaf:knows is defined <http://xmlns.com/foaf/0.1/>

Person is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

Exercise 6 Solution

```
@prefix foaf: <http://xmlns.com/foaf/0.1/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix ex: <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#> .
@prefix alice: <http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#> .
@prefix bob: <http://dig.csail.mit.edu/2010/LinkedData/testdata/bob#> .
@prefix dave: <http://dig.csail.mit.edu/2010/LinkedData/testdata/dave#> .
@prefix : <http://dig.csail.mit.edu/2010/LinkedData/testdata/knows#> .
```

```
bob:Bob rdf:type ex:Person;
  foaf:knows alice:Alice, dave:Dave.
```

```
alice:Alice rdf:type ex:Person.
```

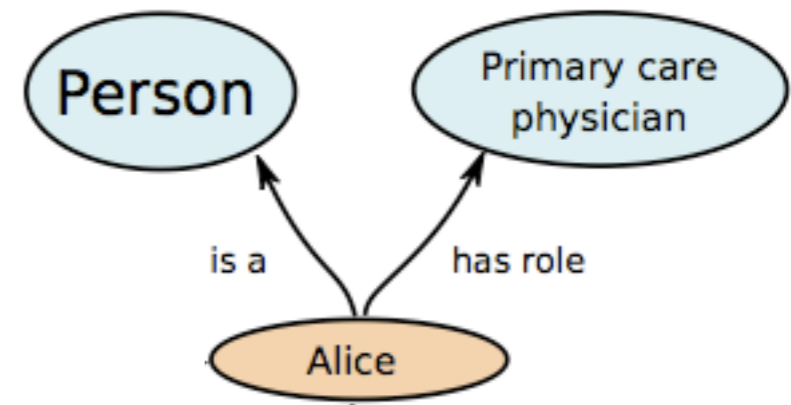
```
dave:Dave rdf:type ex:Person;
  foaf:knows [ rdf:type ex:Person; ex:role ex:SpecialistPhysician ].
```

Notation3

- ◆ language which is a compact and readable alternative to RDF's XML syntax, but also is extended to allow greater expressiveness (such as rules)
 - ◆ <http://www.w3.org/DesignIssues/Notation3>
 - ◆ Turtle + rules + builtins
 - ◆ Some shorthand notations
 - @keywords a. => no default ":" and rdf:type is replaced by "a"
- @prefix : <<http://dig.csail.mit.edu/2010/LinkedData/testdata/family#>> .
JoeLamba a Person.

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



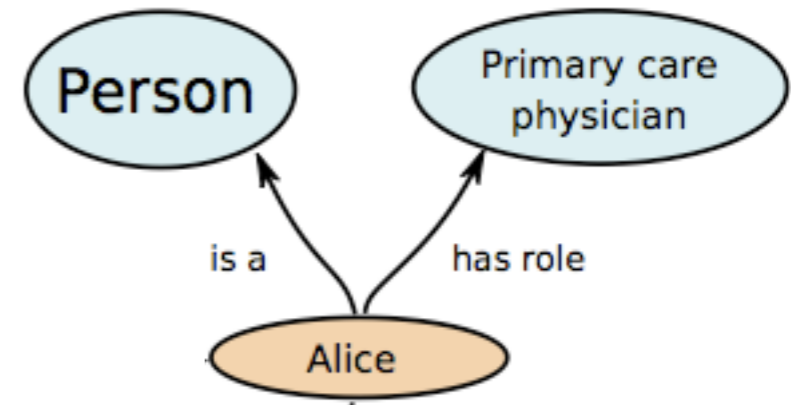
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```


RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



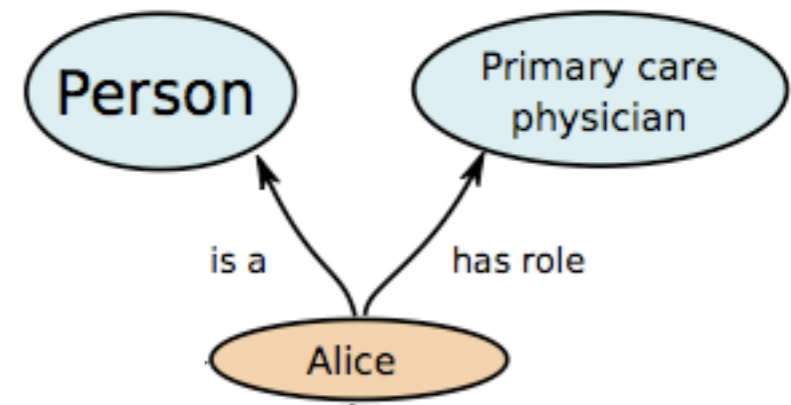
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



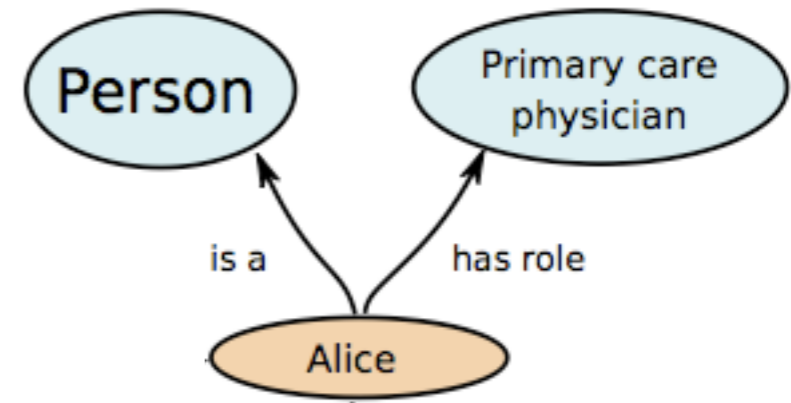
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



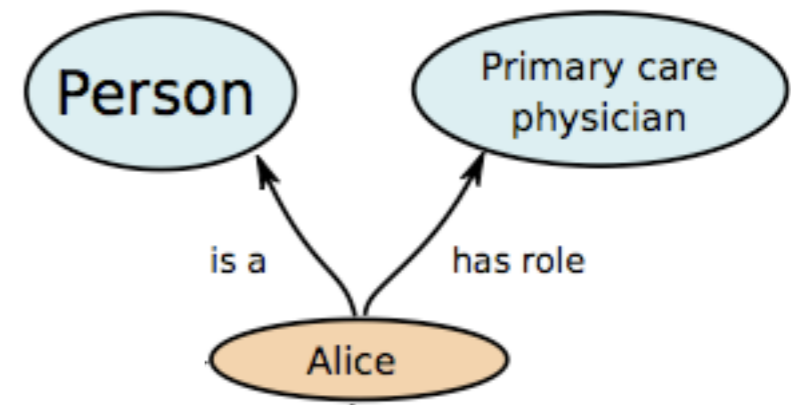
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



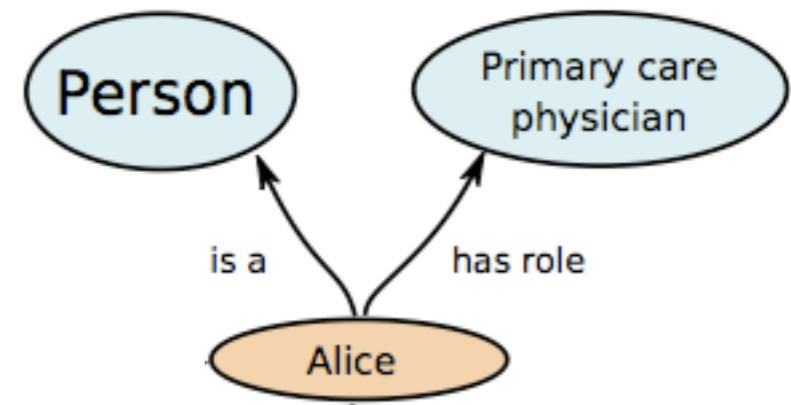
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
```

```
<rdf:type>
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
```

```
</rdf:Description>
```

```
</rdf:type>
```

```
</rdf:Description>
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
```

```
<ex:role>
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
```

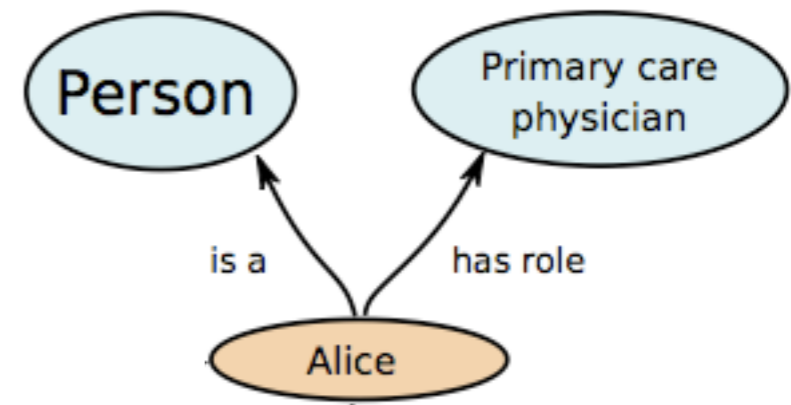
```
</rdf:Description>
```

```
</ex:role>
```

```
</rdf:Description>
```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



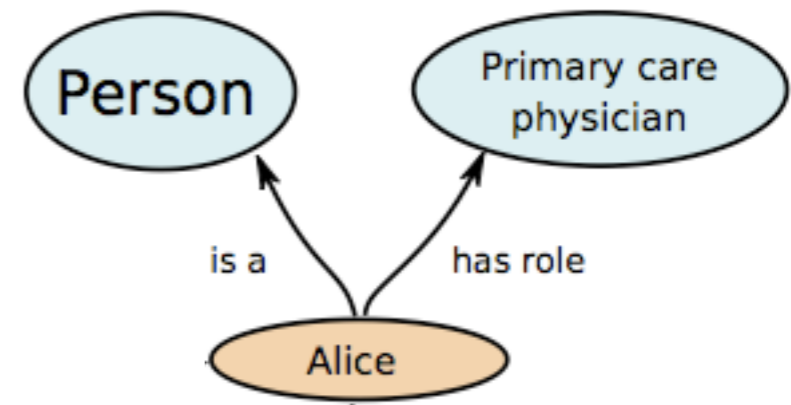
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

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- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



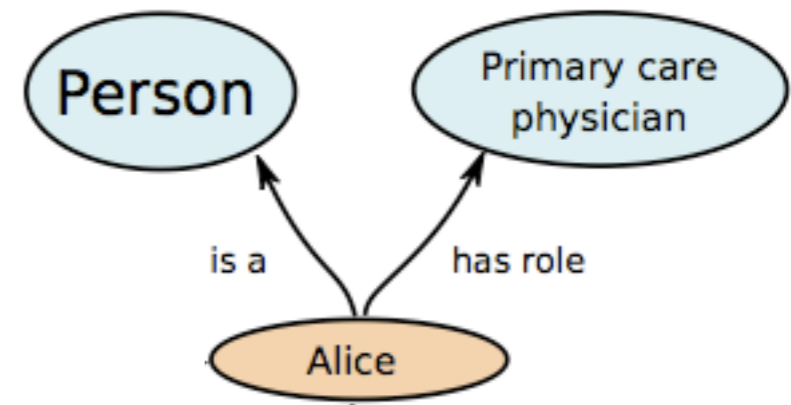
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



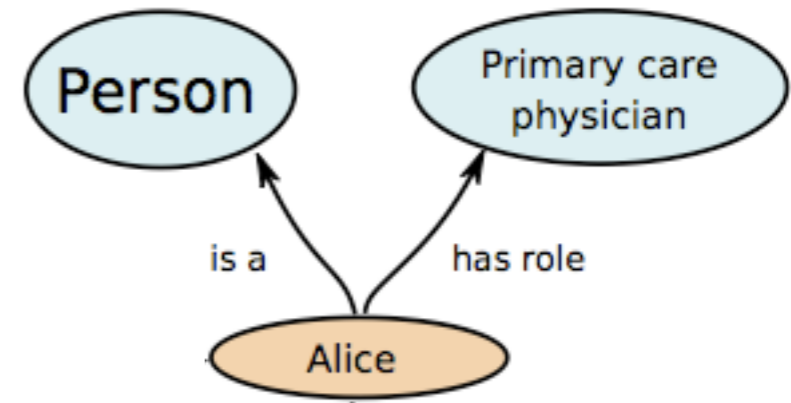
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```


RDF/XML

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- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



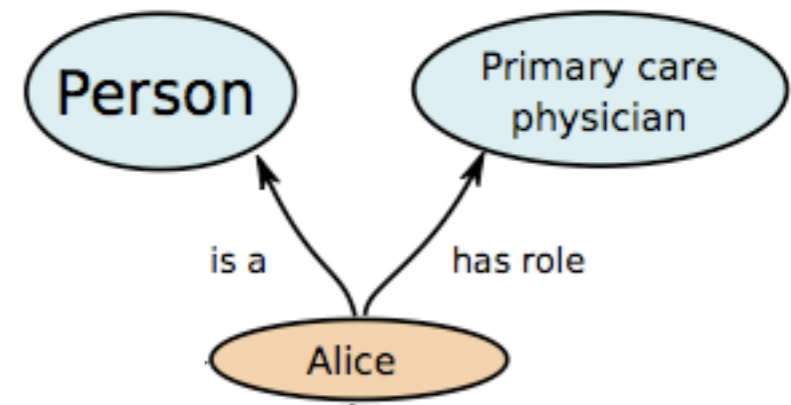
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



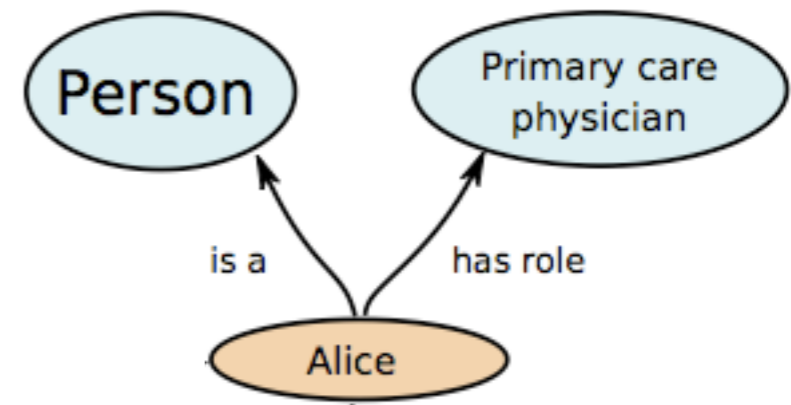
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



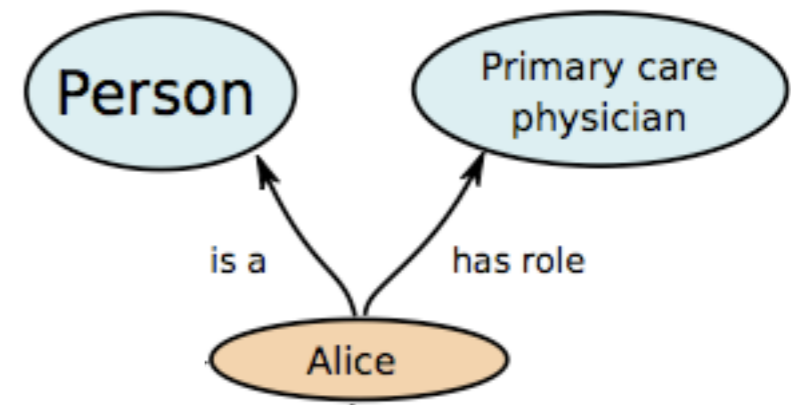
```

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ XML syntax for RDF
- ◆ W3C Recommendation
- ◆ <http://www.w3.org/TR/REC-rdf-syntax/>



```

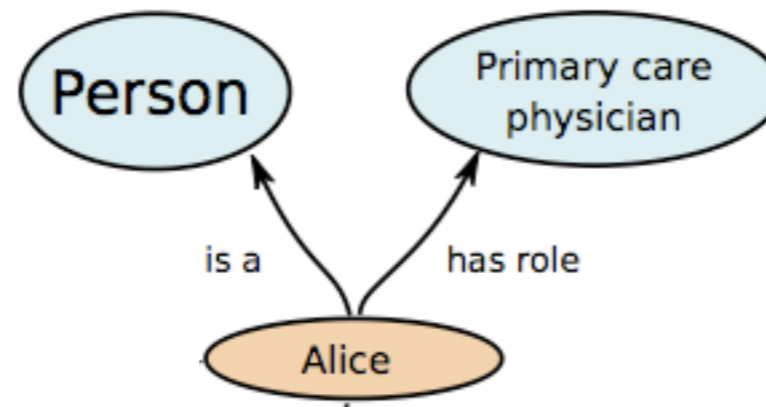
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
  <rdf:type>
    <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
      </rdf:Description>
    </rdf:type>
  </rdf:Description>
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
    <ex:role>
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
        </rdf:Description>
      </ex:role>
    </rdf:Description>
  </rdf:Description>

```

RDF/XML

- ◆ Starting and ending tags
`<rdf:RDF> ... </rdf:RDF>`
- ◆ Namespaces
`xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"`
`xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#"`
- ◆ Prefixes
`http://www.w3.org/1999/02/22-rdf-syntax-ns#type => rdf:type`
- ◆ Subjects defined using
`<rdf:Description rdf:about=uri of subject >`
`</rdf:Description>`
- ◆ Properties of subjects defined inside `rdf:Description` of the subject using start and end tags
`<rdf:type></rdf:type>`
- ◆ Objects defined inside property tags using `rdf:Description`

RDF/XML



```
<rdf:RDF
```

```
  xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
  <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
```

```
    <rdf:type>
```

```
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
```

```
        <rdf:type>
```

```
          <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">
```

```
            </rdf:Description>
```

```
          </rdf:type>
```

```
        </rdf:Description>
```

```
      <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">
```

```
        <ex:role>
```

```
          <rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">
```

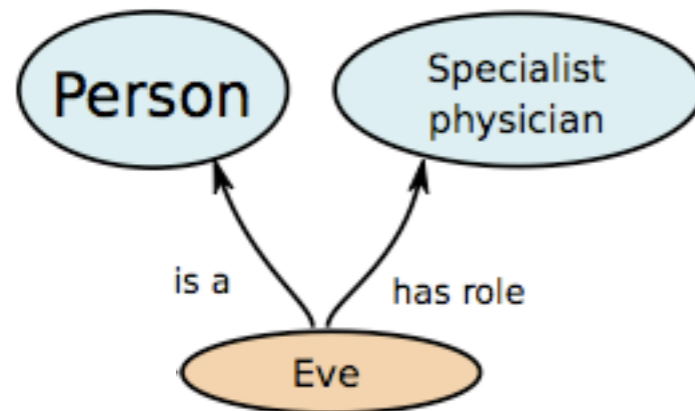
```
            </rdf:Description>
```

```
          </ex:role>
```

```
        </rdf:Description>
```

```
</rdf:RDF>
```

Exercise 7



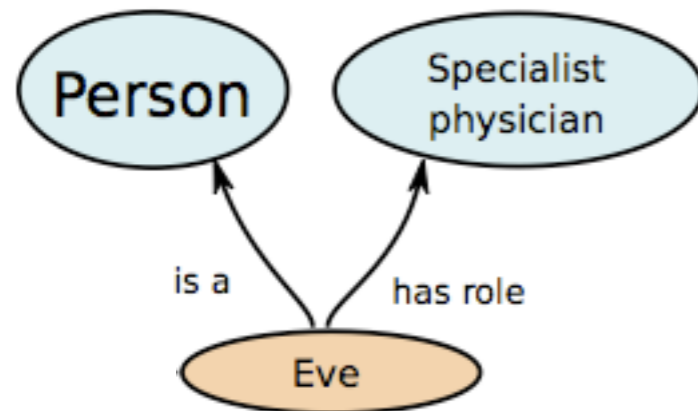
Assume the following namespaces

Eve is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#>

SpecialistPhysician and Person are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

Exercise 7



Assume the following namespaces

Eve is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#>

SpecialistPhysician and Person are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

ALICE

<rdf:RDF

xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#" data-bbox="43 503 561 530"/>

xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#" data-bbox="43 532 615 559"/>

xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" data-bbox="43 561 523 587"/>

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">

<rdf:type>

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">

</rdf:Description>

</rdf:type>

</rdf:Description>

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">

<ex:role>

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician">

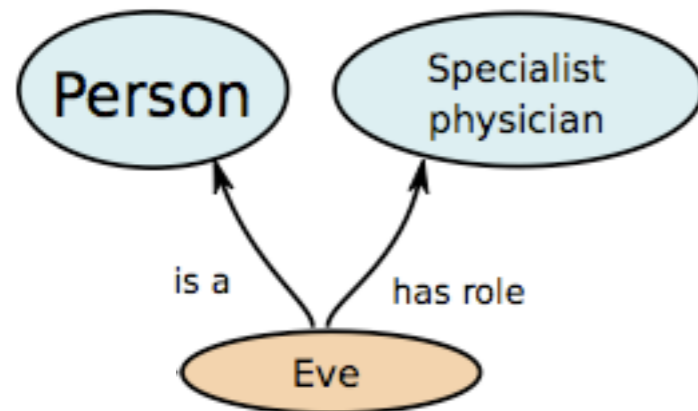
</rdf:Description>

</ex:role>

</rdf:Description>

</rdf:RDF>

Exercise 7



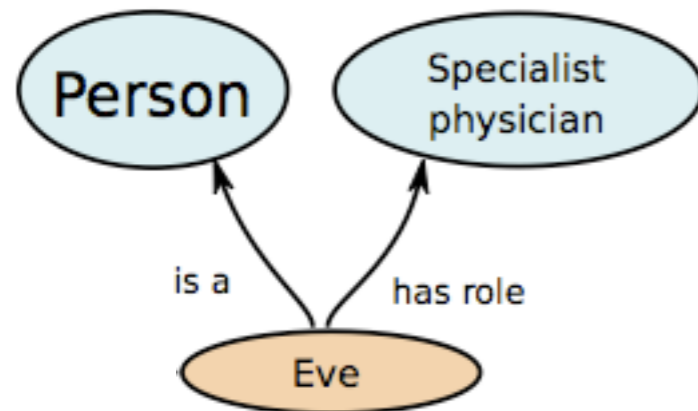
Assume the following namespaces

Eve is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#>

SpecialistPhysician and Person are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

Exercise 7



Assume the following namespaces

Eve is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#>

SpecialistPhysician and Person are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

EVE

<rdf:RDF

xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#"

xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"

xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#Eve">

<rdf:type>

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person">

</rdf:Description>

</rdf:type>

</rdf:Description>

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/eve#Eve">

<ex:role>

<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#SpecialistPhysician">

</rdf:Description>

</ex:role>

</rdf:Description>

</rdf:RDF>

RDF/XML

◆ Shorthand notations

■ dropping rdf:Description for objects

```
<rdf:type>  
  <rdf:Description rdf:about="http://www.ex.org/ontology#Person">  
  </rdf:Description>  
</rdf:type>
```

```
=> <rdf:type rdf:resource="http://www.ex.org/ontology#Person">  
    </rdf:type>
```

■ dropping end tags

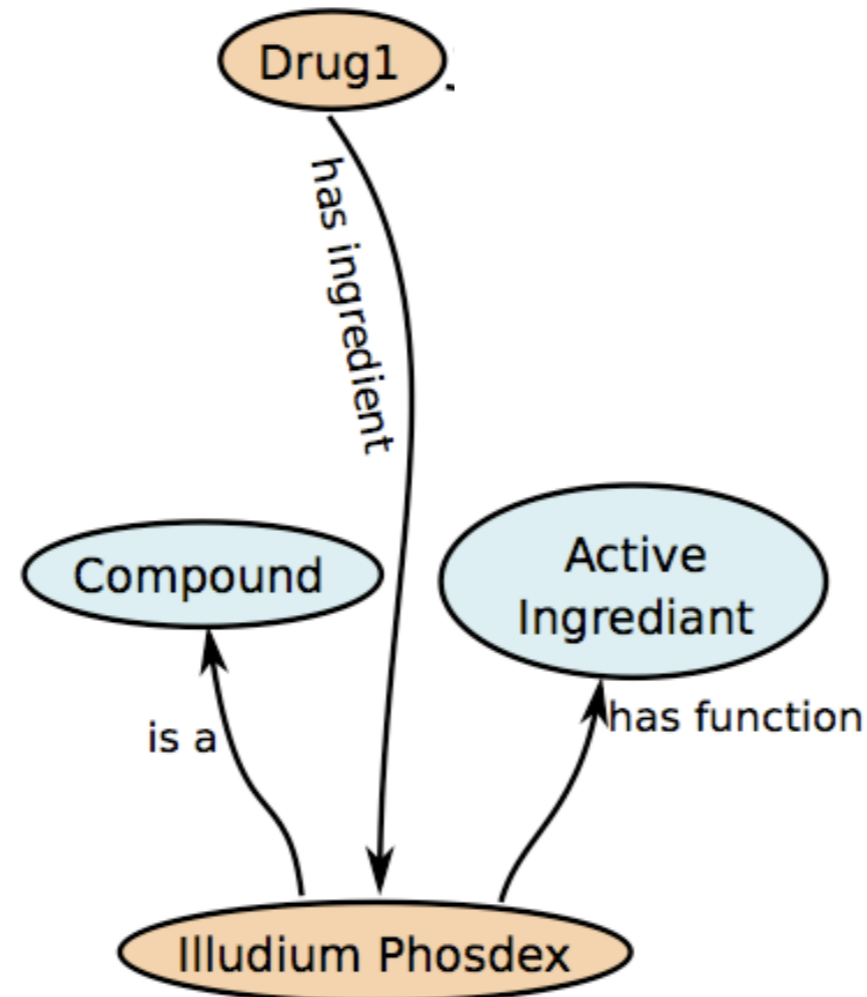
```
<rdf:type rdf:resource="http://www.ex.org/ontology#Person">  
</rdf:type>
```

```
=> <rdf:type rdf:resource="http://www.ex.org/ontology#Person" />
```

■ combining all property-value pairs of the subject into single rdf:Description

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/alice#Alice">  
  <rdf:type rdf:resource="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#Person" />  
  <ex:role rdf:resource="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#PrimaryCarePhysician" />  
</rdf:Description>
```

Exercise 8



Assume the following namespaces

IlludiumPhosdex, Drug1 is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#>

Compound, ActiveIngredient, function, and ingredient is defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>
 rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

Exercise 8 Solution

Exercise 8 Solution

`<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"`

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
```

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```


Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
```

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
  <rdf:type rdf:resource="http://example.org/ontology#Compound" />
```

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
  <rdf:type rdf:resource="http://example.org/ontology#Compound" />
  <ex:function rdf:resource="http://example.org/ontology#ActiveIngredient" />
```

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
  <rdf:type rdf:resource="http://example.org/ontology#Compound" />
  <ex:function rdf:resource="http://example.org/ontology#ActiveIngredient" />
</rdf:Description>
```

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
  <rdf:type rdf:resource="http://example.org/ontology#Compound" />
  <ex:function rdf:resource="http://example.org/ontology#ActiveIngredient" />
</rdf:Description>
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#drug1">
```

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
  <rdf:type rdf:resource="http://example.org/ontology#Compound" />
  <ex:function rdf:resource="http://example.org/ontology#ActiveIngredient" />
</rdf:Description>
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#drug1">
  <ex:ingredient rdf:resource="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec" />
```

Exercise 8 Solution

```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
  <rdf:type rdf:resource="http://example.org/ontology#Compound" />
  <ex:function rdf:resource="http://example.org/ontology#ActiveIngredient" />
</rdf:Description>
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#drug1">
  <ex:ingredient rdf:resource="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec" />
</rdf:Description>
```

Exercise 8 Solution

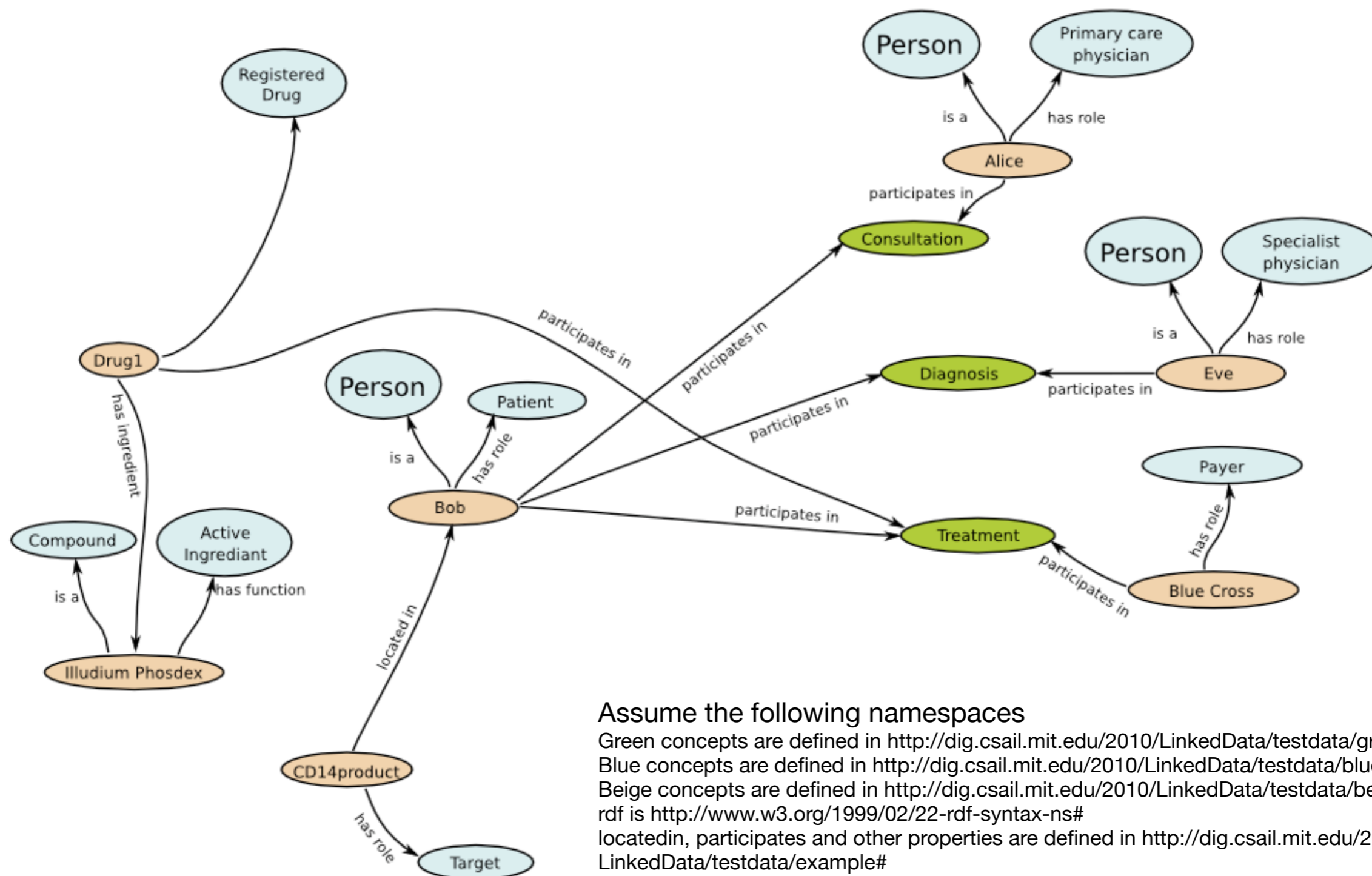
```
<rdf:RDF xmlns="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#"
  xmlns:ex="http://dig.csail.mit.edu/2010/LinkedData/testdata/example#"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec">
  <rdf:type rdf:resource="http://example.org/ontology#Compound" />
  <ex:function rdf:resource="http://example.org/ontology#ActiveIngredient" />
</rdf:Description>
```

```
<rdf:Description rdf:about="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#drug1">
  <ex:ingredient rdf:resource="http://dig.csail.mit.edu/2010/LinkedData/testdata/drug#illudiumphosdec" />
</rdf:Description>
```

```
</rdf:RDF>
```


Exercise 9: Describe following graph in Turtle & RDF/XML



Assume the following namespaces

Green concepts are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/green#>

Blue concepts are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/blue#>

Beige concepts are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/beige#>

rdf is <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

locatedin, participates and other properties are defined in <http://dig.csail.mit.edu/2010/LinkedData/testdata/example#>

Summary

◆ RDF data

- represented by graphs consisting of triples
- triples consist of <subject> <predicate> <object>
- can be represented pictorially using circles and arrows diagrams
- can be represented in text via serializations
 - RDF/XML & RDFa
 - NTriples
 - Turtle
 - N3

References

- ◆ Primer: Getting into RDF & Semantic Web using N3, <http://www.w3.org/2000/10/swap/Primer>
- ◆ RDF Primer, <http://www.w3.org/TR/2004/REC-rdf-primer-20040210/>
- ◆ N3, <http://www.w3.org/DesignIssues/Notation3>
- ◆ RDF/XML, <http://www.w3.org/TR/REC-rdf-syntax/>