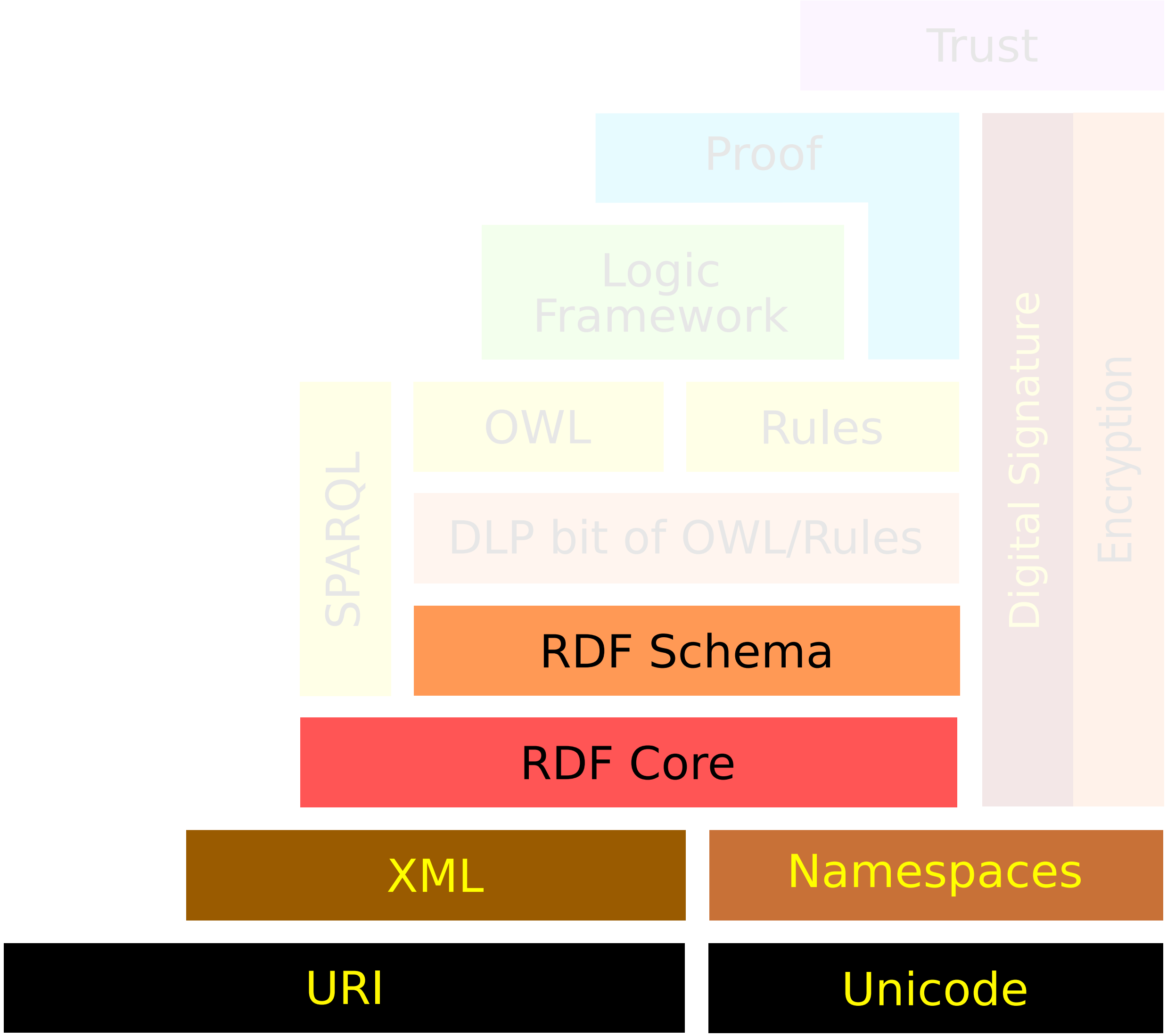
RDF

Pedro Szekely
University of Southern California/ISI

slide by Pedro Szekely

Semantic Web Layer Cake



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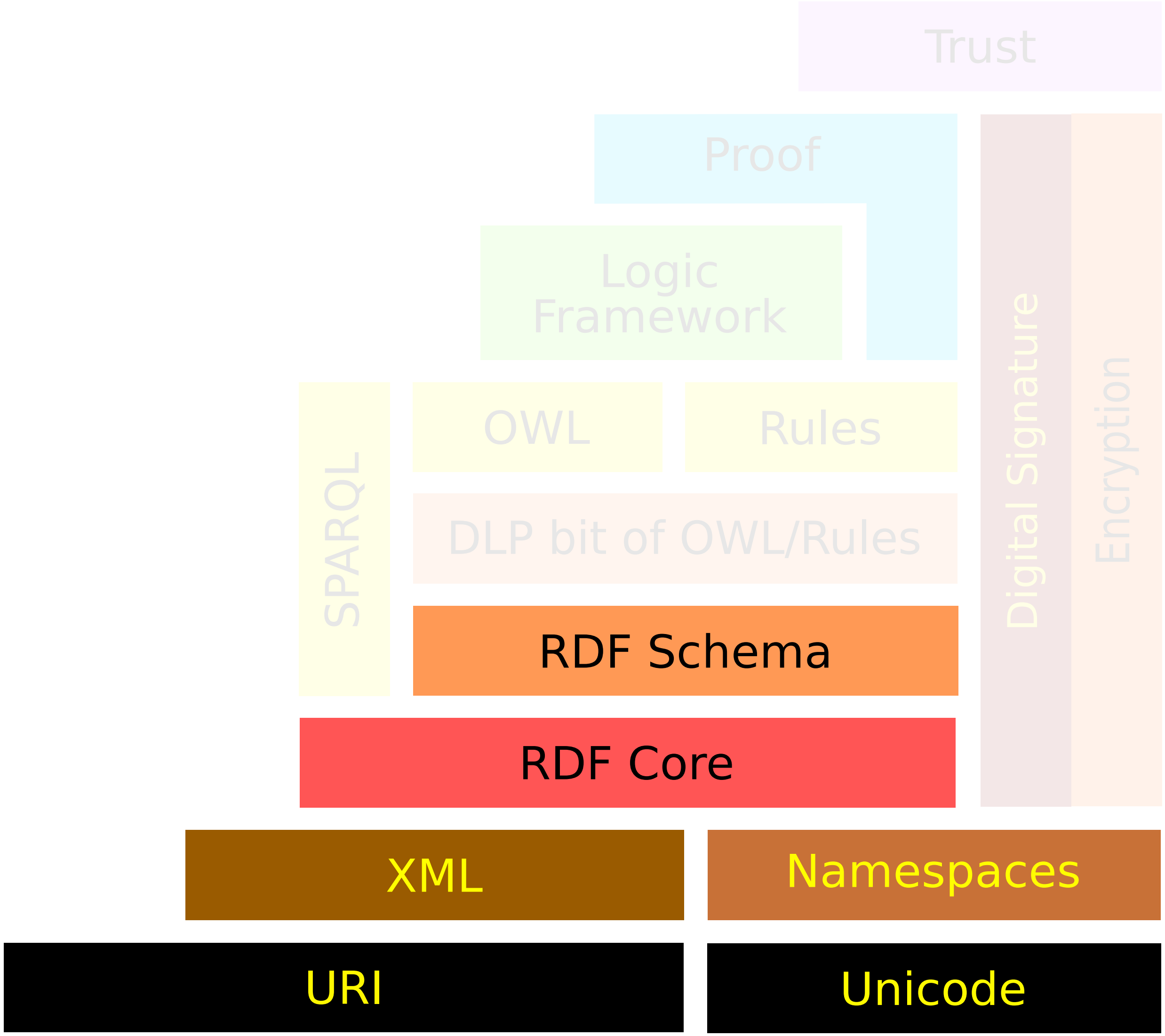
Unicode



slide by Pedro Szekely

Why Unicode?

http://site.com/Македонски.html

http://site.com/Μία_Σελίδα

http://www.中国政府.政务.cn

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Unicode

Unicode is a computing industry standard for the consistent encoding, representation and handling of text expressed in most of the world's writing systems.

… the latest version of Unicode consists of a repertoire of more than 110,000 characters covering over 100 scripts

Wikipedia

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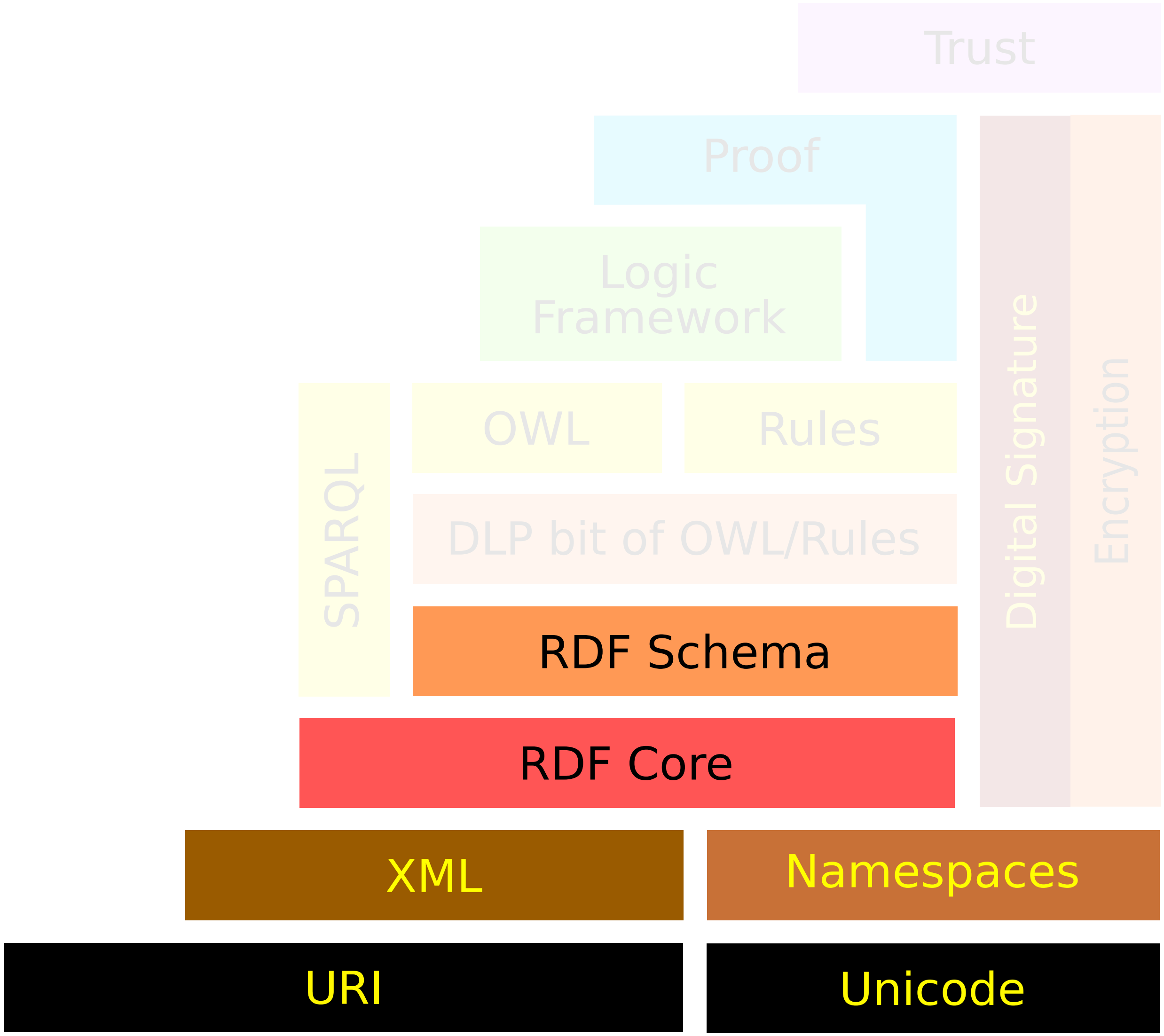
URI



Trust

Proof

Logic Framework

SPARQL

OWL

Rules

DLP bit of OWL/Rules

RDF Schema

RDF Core

Digital Signature

Encryption

XML

Namespaces

URI

Unicode

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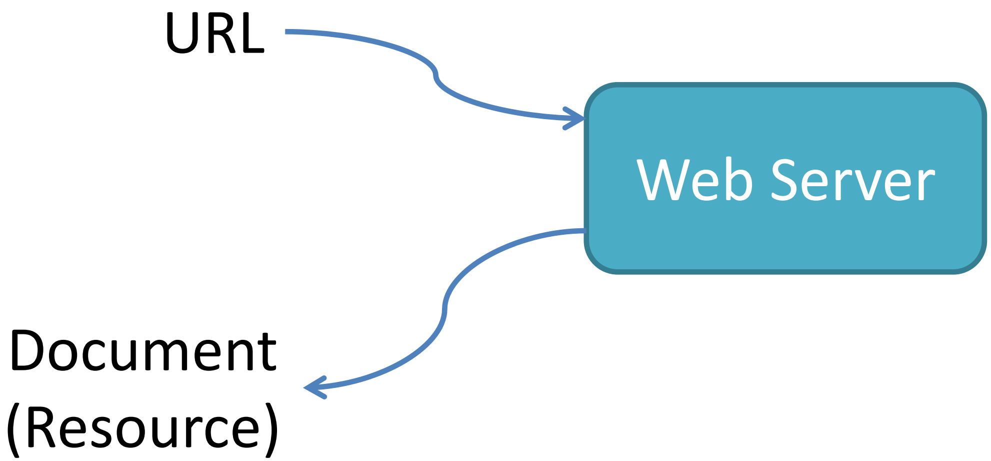
URL: Uniform Resource Locator

A reference to an Internet resource



URL

Web Server

Document (Resource)

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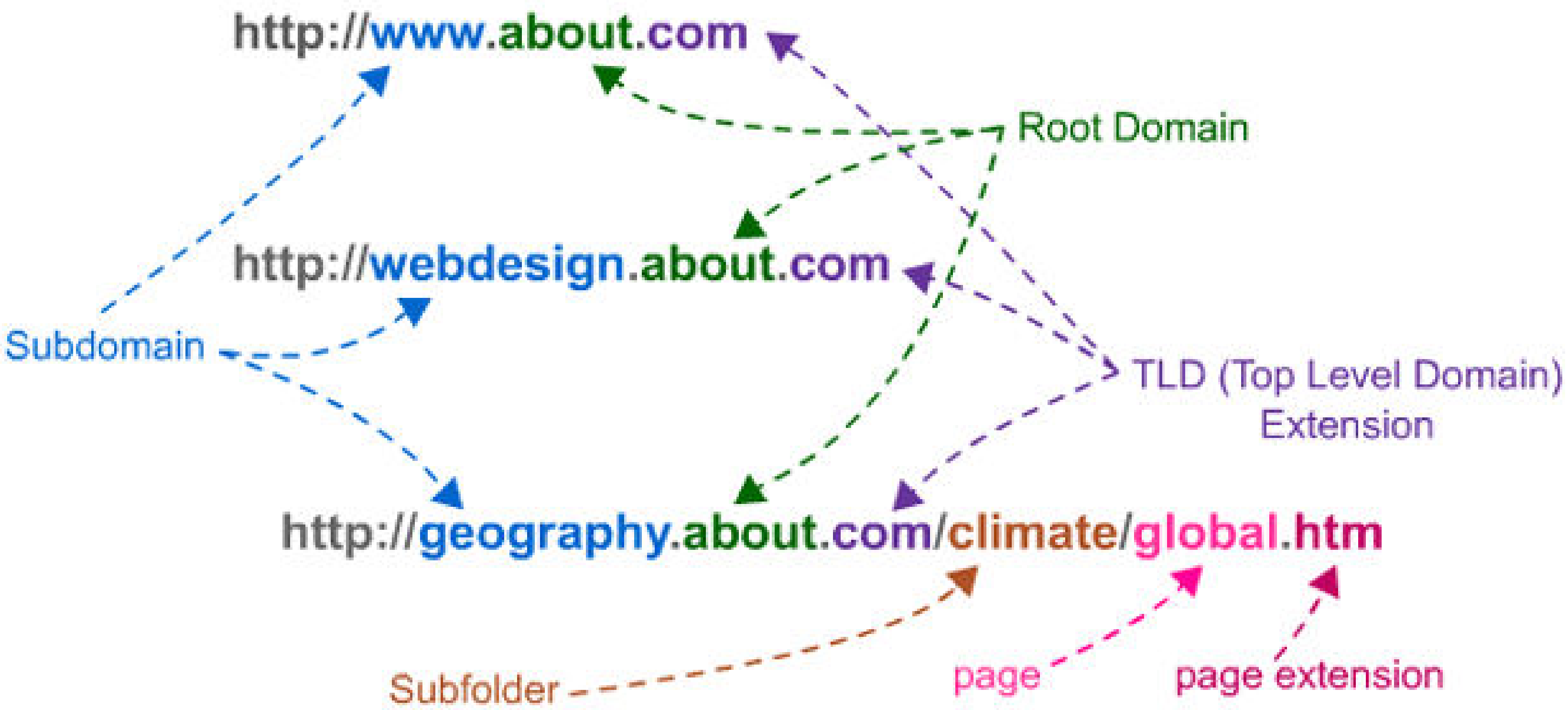
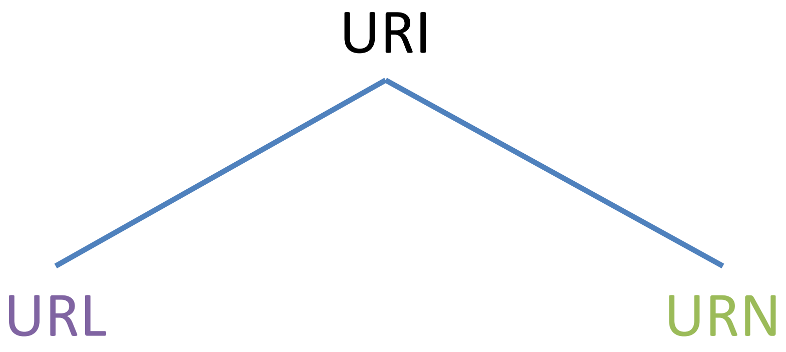
URL: Uniform Resource Locator


http://www.about.com
Root Domain
http://webdesign.about.com
Subdomain
TLD (Top Level Domain) Extension
http://geography.about.com/climate/global.htm
Subfolder
page
page extension

http://www.seomoz.org/blog/subfolders-root-domains-linkscape-update-more

URL vs URI



URI

URL

URN

locators

like person's street address

method for finding it

names

like a person's name

item's identity

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Can USC Have a URI?

slide by Pedro Szekely

Can USC Have a URI?

http://dbpedia.org/page/University_of_Southern_California

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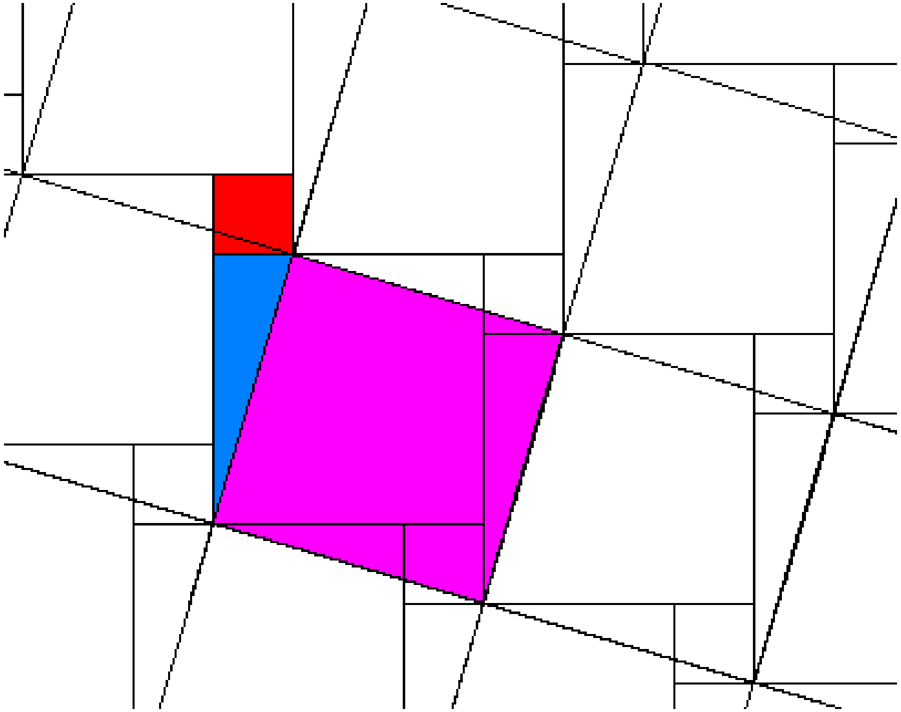
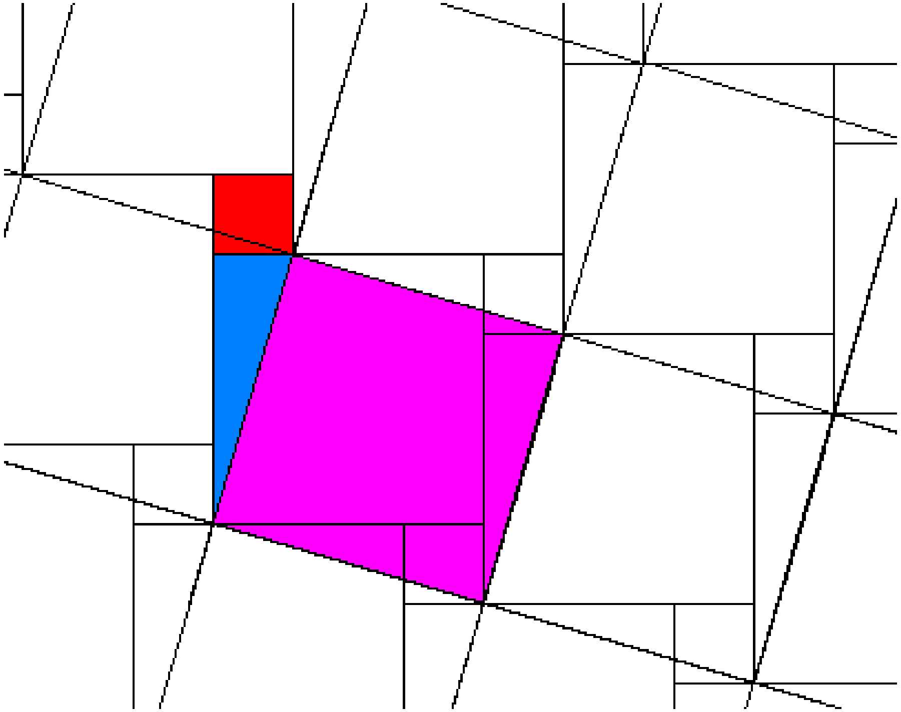
Things can have URIs

Can the Pythagoras Theorem Have a URI?



Can the Pythagoras Theorem Have a URI?



http://www.freebase.com/view/en/pythagorean_theorem

slide by Pedro Szekely

Ideas can have URIs

My Dog: Can He Have a URI?

slide by Pedro Szekely

My Dog: Can He Have a URI?

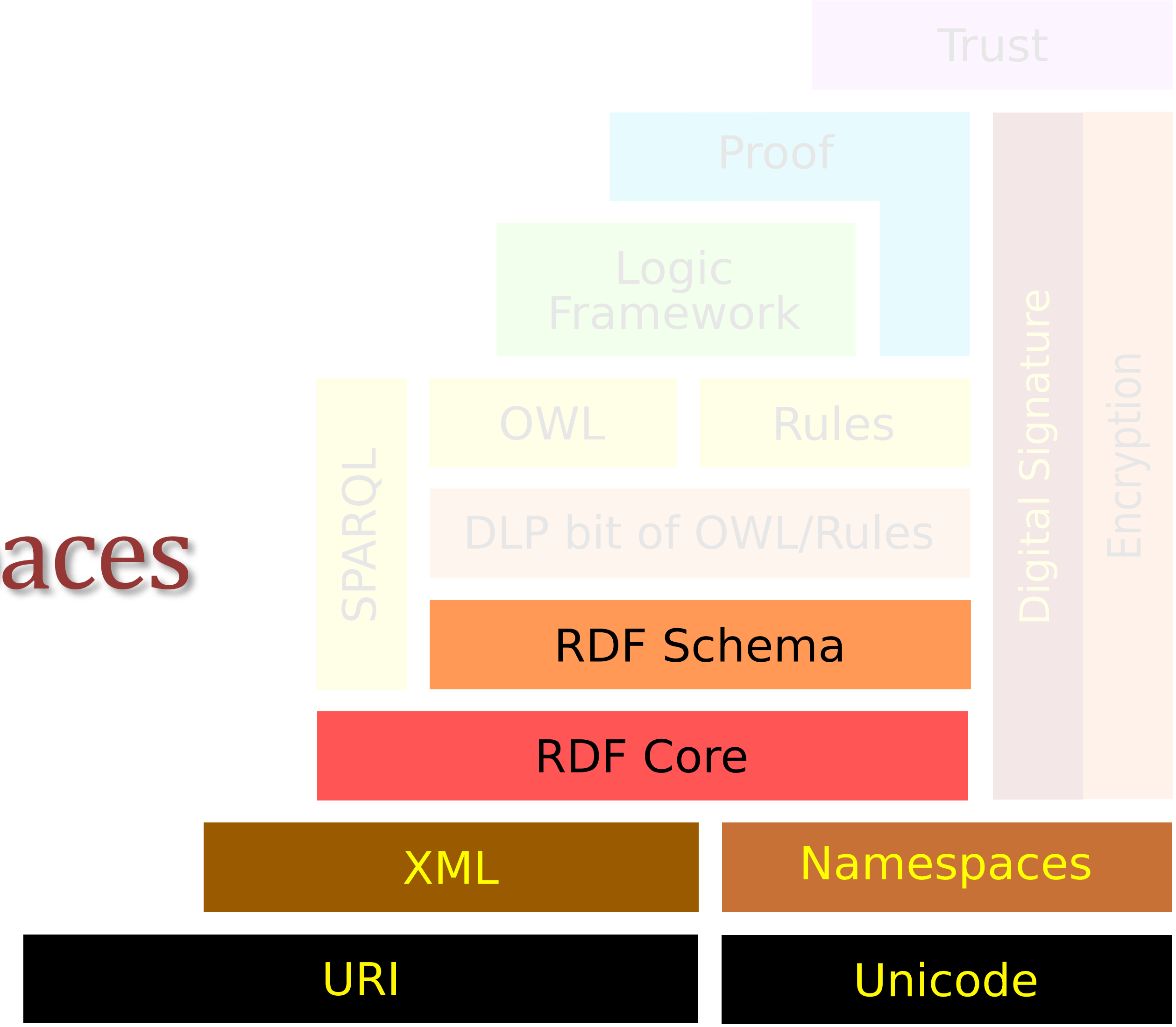
http://szekelys.com/diego

slide by Pedro Szekely

It does not have to be “important” to have a URI

slide by Pedro Szekely

Namespaces



slide by Pedro Szekely

Are These the Same?

```
<Bookstore>
<Book>
   <Author>John Doe</Author>
   <Title>Introduction to XML</Title>
   <Publisher>XYZ</Publisher>
</Book>
</Bookstore>
```

```
<http://amazon.com/store/Bookstore>
<http://amazon.com/store/Book>
   <http://amazon.com/store/Author>John Doe</http://amazon.com/store/Author>
   <http://amazon.com/store/Title>Introduction to XML</http://amazon.com/store/Title>
   <http://amazon.com/store/Publisher>XYZ</http://amazon.com/store/Publisher>
</http://amazon.com/store/Book>
</http://amazon.com/store/Bookstore>
```

```
<http://barnesandnoble.com/store/Bookstore>
<http://barnesandnoble.com/store/Book>
   <http://barnesandnoble.com/store/Author>John Doe</http://barnesandnoble.com/store/Author>
   <http://barnesandnoble.com/store/Title>Introduction to XML</http://barnesandnoble.com/store/Title>
   <http://barnesandnoble.com/store/Publisher>XYZ</http://barnesandnoble.com/store/Publisher>
</http://barnesandnoble.com/store/Book>
</http://barnesandnoble.com/store/Bookstore>
```

slide by Pedro Szekely

Namespaces

XML namespaces are used for providing uniquely named elements and attributes in an XML document

Wikipedia

xmlns="http://amazon.com/store"

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Using a Namespace Declaration

```
<http://amazon.com/store/Bookstore>
<http://amazon.com/store/Book>
  <http://amazon.com/store/Author>John Doe</http://amazon.com/store/Author>
  <http://amazon.com/store/Title>Introduction to XML</http://amazon.com/store/Title>
  <http://amazon.com/store/Publisher>XYZ</http://amazon.com/store/Publisher>
</http://amazon.com/store/Book>
</http://amazon.com/store/Bookstore>
```

=

```
<Bookstore xmlns=“http://amazon.com/store”>
<Book>
  <Author>John Doe</Author>
  <http://amazon.com/store/Title>Introduction to XML</Title>
  <http://amazon.com/store/Publisher>XYZ</Publisher>
</Book>
</Bookstore>
```

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Default and Prefix Namespaces

```
<http://amazon.com/store/Bookstore>
<http://amazon.com/store/Book>
  <http://amazon.com/store/Author>John Doe</http://amazon.com/store/Author>
  <http://amazon.com/store/Title>Introduction to XML</http://amazon.com/store/Title>
  <http://amazon.com/store/Publisher>XYZ</http://amazon.com/store/Publisher>
</http://amazon.com/store/Book>
</http://amazon.com/store/Bookstore>
```

=

```
<Bookstore xmlns=“http://amazon.com/store”>
<Book>
  <Author>John Doe</Author>
  <Title>Introduction to XML</Title>
  <Publisher>XYZ</Publisher>
</Book>
</Bookstore>
```

=

```
<am:Bookstore xmlns:am=“http://amazon.com/store”>
<am:Book>
  <am:Author>John Doe</am:Author>
  <am:Title>Introduction to XML</am:Title>
  <am:Publisher>XYZ</am:Publisher>
</am:Book>
</am:Bookstore>
```

slide by Pedro Szekely

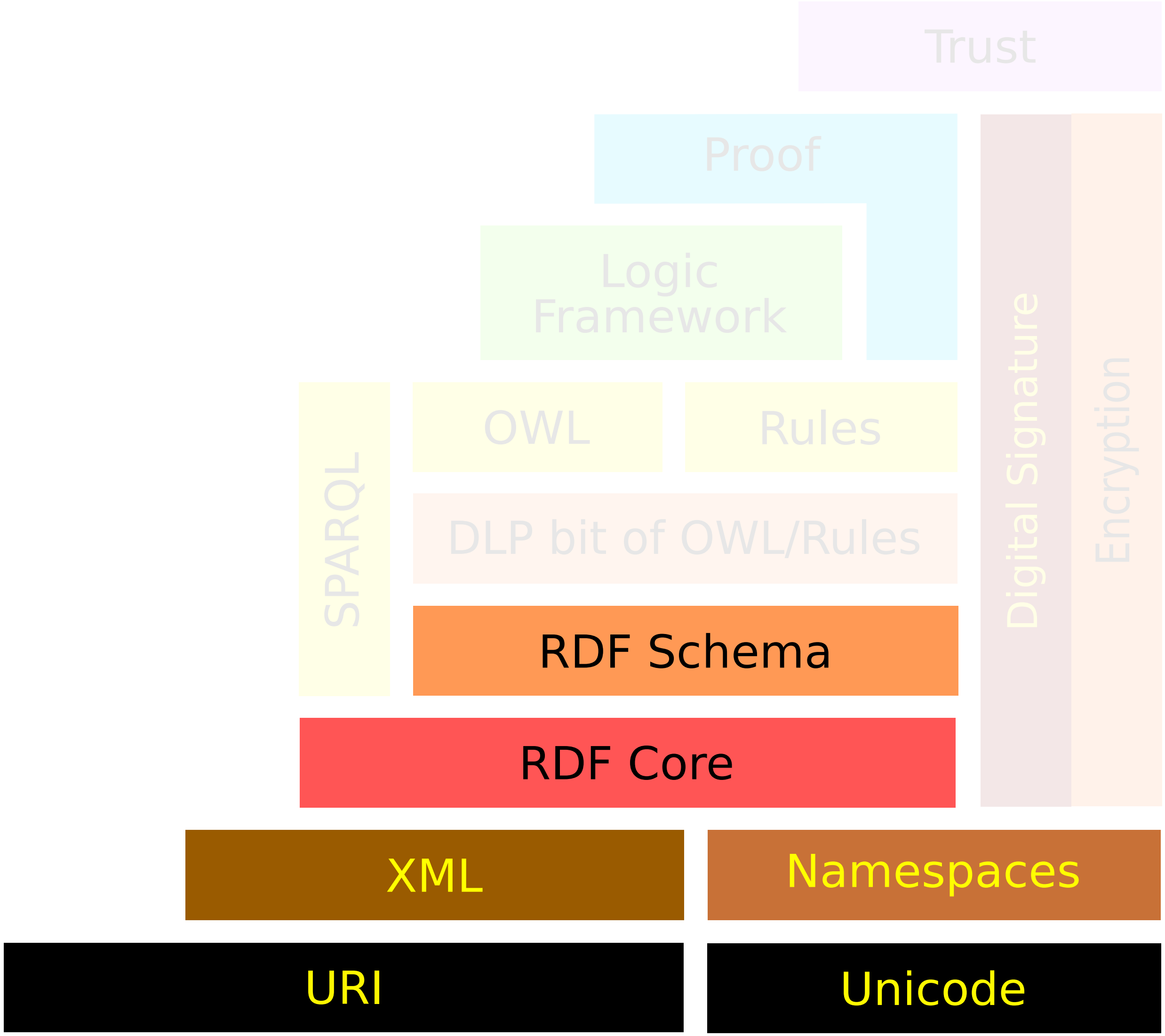
Default and Prefix Namespaces

```
<am:Bookstore
    xmlns:am="http://amazon.com/store"
    xmlns:bn=http://barnesandnoble.com/store>
<am:Book>
  <am:Author>John Doe</am:Author>
  <bn:Author>Jane Doe</bn:Author>
  <am:Title>Introduction to XML</am:Title>
  <am:Publisher>XYZ</am:Publisher>
</am:Book>
</am:Bookstore>
```

If elements were defined within a global scope,
it would be a problem to
combine elements from multiple documents

slide by Pedro Szekely

XML



slide by Pedro Szekely

eXtensible Markup Language

HTML specifies how to display data

fixed
set of tags

```
<h2>Nonmonotonic Reasoning</h2>
<i>by <b>V. Marek</b> and <b>M. Truszczynski</b></i><br>
Springer 1993<br>
ISBN 0387976892
```

XML specifies data

extensible
set of tags

```
<book>
    <title>Nonmonotonic Reasoning</title>
    <author>V. Marek</author>
    <author>M. Truszczynski</author>
    <publisher>Springer</publisher>
    <year>1993</year>
    <ISBN>0387976892</ISBN>
</book>
```

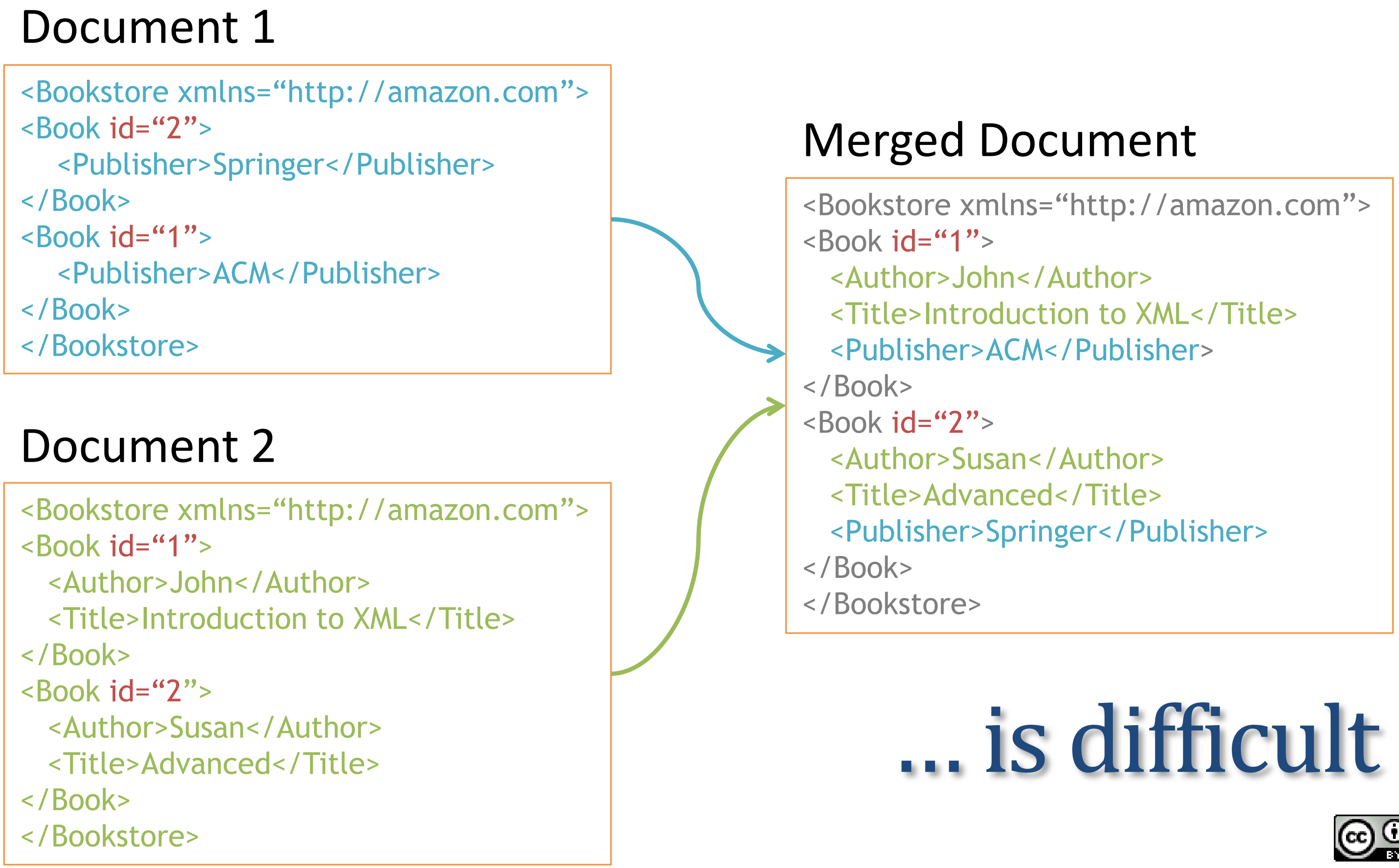
slide by Pedro Szekely

Design of XML

- Tags can be used to indicate the meaning of data
- No fixed set of markup tags: new tags can be defined
- Underlying data model is a tree structure
  - Actually XML can represent graphs through IDs and IDREFs, but it’s a bit cumbersome
- XML provides a common exchange format
- W3C Recommendation:

  http://www.w3.org/TR/REC-xml/

Merging Problem in XML



Document 1

```
<Bookstore xmlns="http://amazon.com">
<Book id="2">
    <Publisher>Springer</Publisher>
</Book>
<Book id="1">
    <Publisher>ACM</Publisher>
</Book>
</Bookstore>
```

Document 2

```
<Bookstore xmlns="http://amazon.com">
<Book id="1">
   <Author>John</Author>
   <Title>Introduction to XML</Title>
</Book>
<Book id="2">
   <Author>Susan</Author>
   <Title>Advanced</Title>
</Book>
</Bookstore>
```

Merged Document

```
<Bookstore xmlns="http://amazon.com">
<Book id="1">
   <Author>John</Author>
   <Title>Introduction to XML</Title>
   <Publisher>ACM</Publisher>
</Book>
<Book id="2">
   <Author>Susan</Author>
   <Title>Advanced</Title>
   <Publisher>Springer</Publisher>
</Book>
</Bookstore>
```

... is difficult

slide by Pedro Szekely

Does XML Represent Meaning?

John is an instructor for CS101

```
<instructor name="John">
  <teaches>CS 101</teaches>
<instructor>
```

```
<course name="CS101">
  <instructor> John </instructor>
<course>
```

Opposite nesting, same information!

based on slide from Jose Luis Ambite slide by Pedro Szekely

Does XML Represent Meaning?

John is an instructor for CS101

```
<instructor name="John">
  <teaches>CS 101</teaches>
<instructor>
```

```
<course name="CS101">
  <instructor> John </instructor>
<course>
```

hasInstructor inverseOf teaches

$\forall C,I\ hasInstructor(C,I) \leftrightarrow teaches(I,C)$

range(hasInstructor) = Person

$\forall C,I\ hasInstructor(C,I) \rightarrow \square\ Person(I)$

based on slide from Jose Luis Ambite slide by Pedro Szekely

Meaning of Data in XML?

```
…
<Book>
   <Author>John</Author>
   <Title>Introduction to XML</Title>
   <Publisher>ACM</Publisher>
   <Country>USA</Country>
</Book>
…
```

What is the meaning of Country?

… where the book is sold?
… where it is published?
… where the author lives?
… ???

slide by Pedro Szekely

XML Schema

The purpose of a schema is to define a class of XML documents, and so the term "instance document" is often used to describe an XML document that conforms to a particular schema

http://www.w3.org/TR/xmlschema-0/

a syntax checker

slide by Pedro Szekely

Example

Defining the USAddress Type

```
<xsd:complexType name="USAddress" >
  <xsd:sequence>
    <xsd:element name="name"   type="xsd:string"/>
    <xsd:element name="street" type="xsd:string"/>
    <xsd:element name="city"   type="xsd:string"/>
    <xsd:element name="state"  type="xsd:string"/>
    <xsd:element name="zip"    type="xsd:decimal"/>
  </xsd:sequence>
  <xsd:attribute name="country" type="xsd:NMTOKEN" fixed="US"/>
</xsd:complexType>
```

… must have specific elements
… in a specific order
… filled with specific types of data

slide by Pedro Szekely

XML Schema by Example

```
<?xml version="1.0"?>
<xsd:schema xmlns:xsd=“http://www.w3.org/2001/XMLSchema”
               targetNamespace="http://www.books.org"
               xmlns=http://www.books.org>
  <xsd:element name="Bookstore">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref="Book" minOccurs="1" maxOccurs="unbounded"/>
      </xsd:sequence>
    </xsd:complexType>
  </xsd:element>
  <xsd:element name="Book">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref="Title" minOccurs="1" maxOccurs="1"/>
        <xsd:element ref="Author" minOccurs="1" maxOccurs=“unbounded”/>
        <xsd:element ref="Date" minOccurs="1" maxOccurs="1"/>
        <xsd:element ref="ISBN" minOccurs="1" maxOccurs="1"/>
        <xsd:element ref="Publisher" minOccurs="1" maxOccurs="1"/>
      </xsd:sequence>
    </xsd:complexType>
  </xsd:element>
  <xsd:element name="Title" type="xsd:string"/>
  <xsd:element name="Author" type="xsd:string"/>
  <xsd:element name="Date" type="xsd:Date"/>
  <xsd:element name="ISBN" type="xsd:integer"/>
  <xsd:element name="Publisher" type="xsd:string"/>
</xsd:schema>
```

“Bookstore” is a complex Type

A sequence of 1 or more “Book” elements

When referring to another Element, use “ref”

Notice the use of more meaningful data types

XML Schema Primitive Types

string
boolean
decimal
float
double

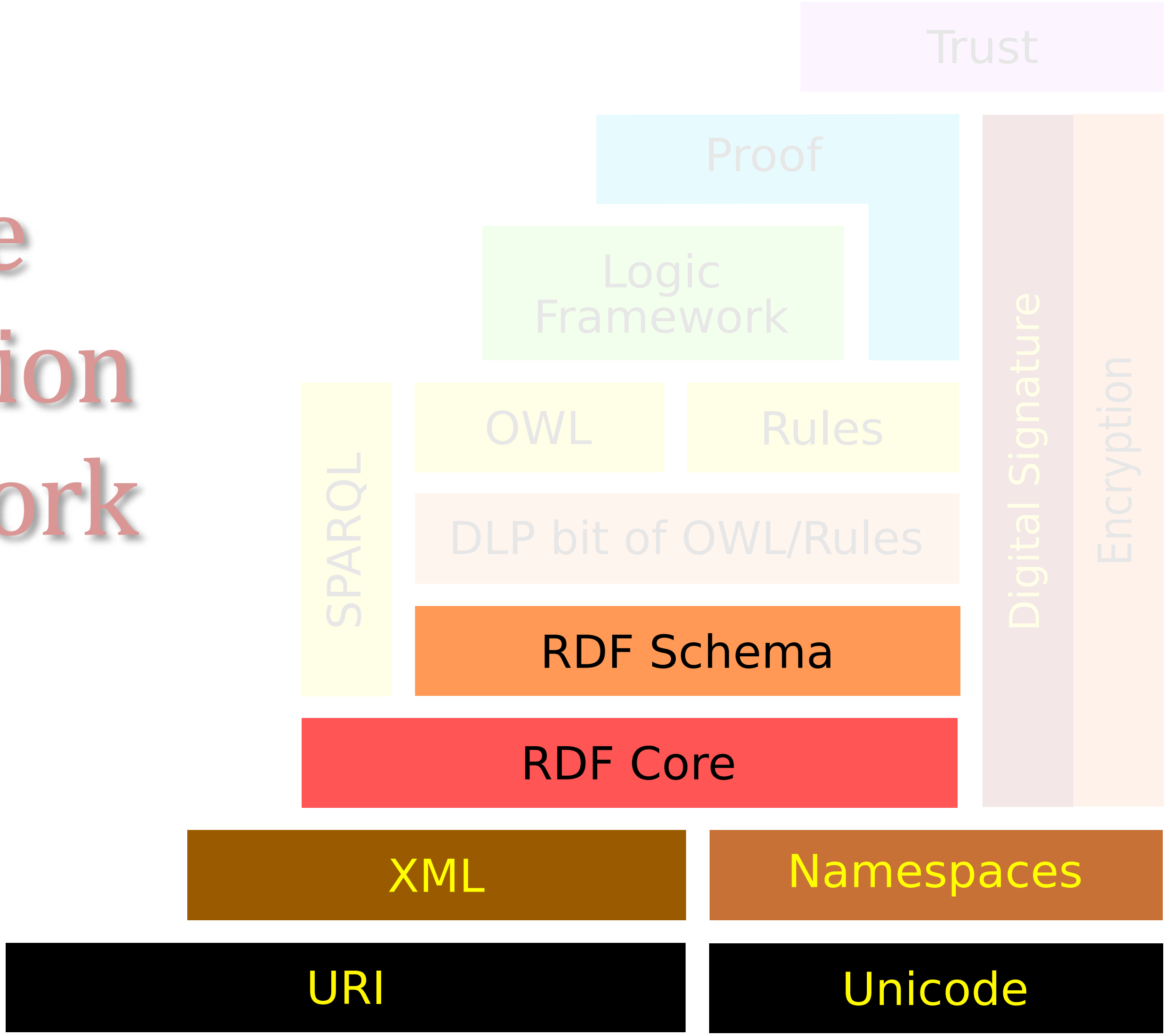
duration
dateTime
time
date
gYearMonth
gYear
gMonthDay
gDay
gMonth

hexBinary
base64Binary
anyURI
Qname
NOTATION

useful in RDF

slide by Pedro Szekely

Resource Description Framework



slide by Pedro Szekely

The Resource Description Framework (RDF)
is a language for
representing information about resources
in the World Wide Web

http://www.w3.org/TR/rdf-primer/

slide by Pedro Szekely

Resource Description Framework

Intended for representing metadata about Web resources,
such as the title, author, and modification date
of a Web document

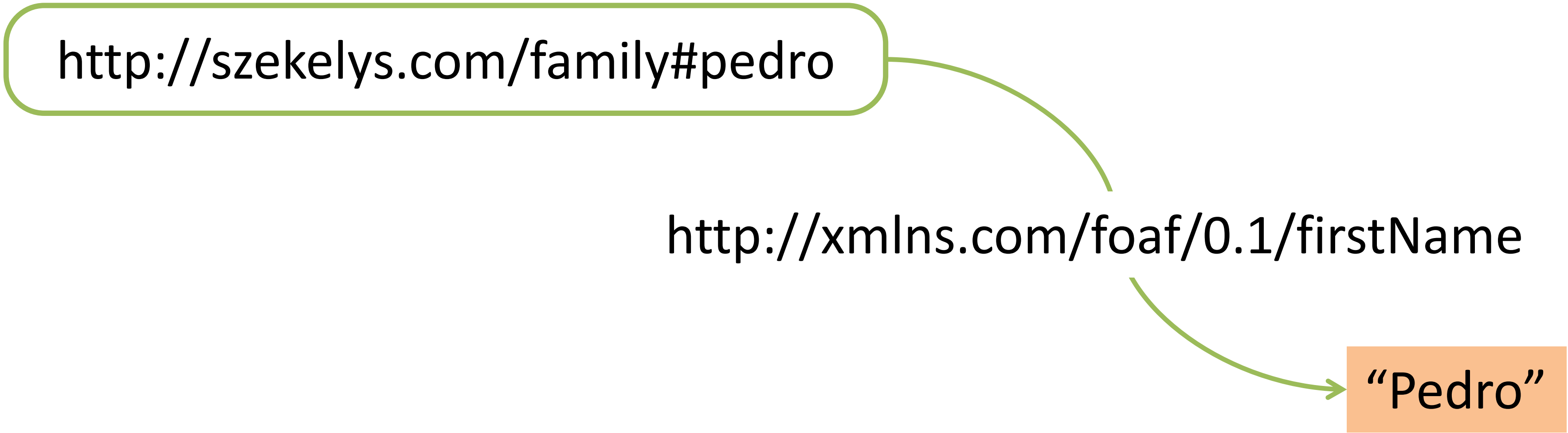
… also be used to represent information about
things that can be *identified* on the Web,
even when they cannot be directly *retrieved* on the Web

examples include information about items available from on-line
shopping facilities (e.g., prices and availability)

slide by Pedro Szekely

Represent Resources Using URIs

That guy has first name “Pedro”



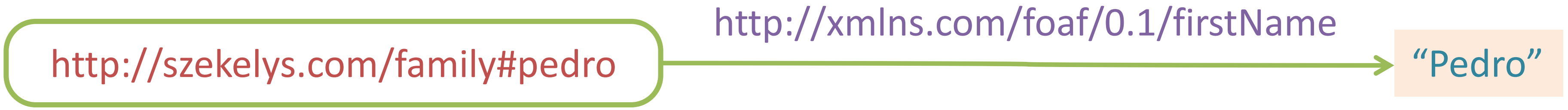
http://szekelys.com/family#pedro

http://xmlns.com/foaf/0.1/firstName

“Pedro”

slide by Pedro Szekely

Represent Information as Triples



http://szekelys.com/family#pedro

http://xmlns.com/foaf/0.1/firstName

“Pedro”

Subject

The resource being described

Predicate

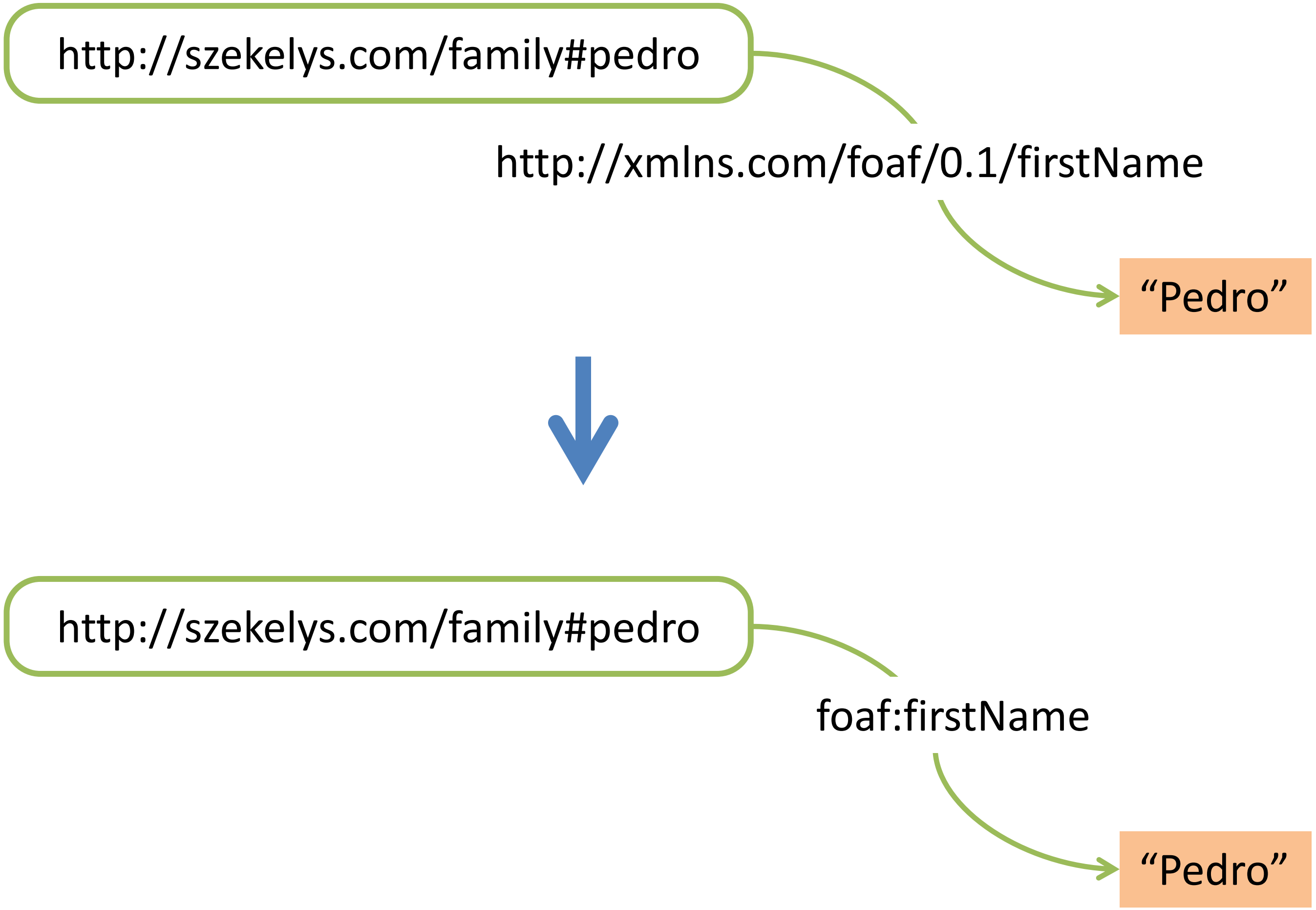
A property of the resource

Object

The value of the property

slide by Pedro Szekely

Use Namespaces



http://szekelys.com/family#pedro

http://xmlns.com/foaf/0.1/firstName

"Pedro"

http://szekelys.com/family#pedro

foaf:firstName

"Pedro"

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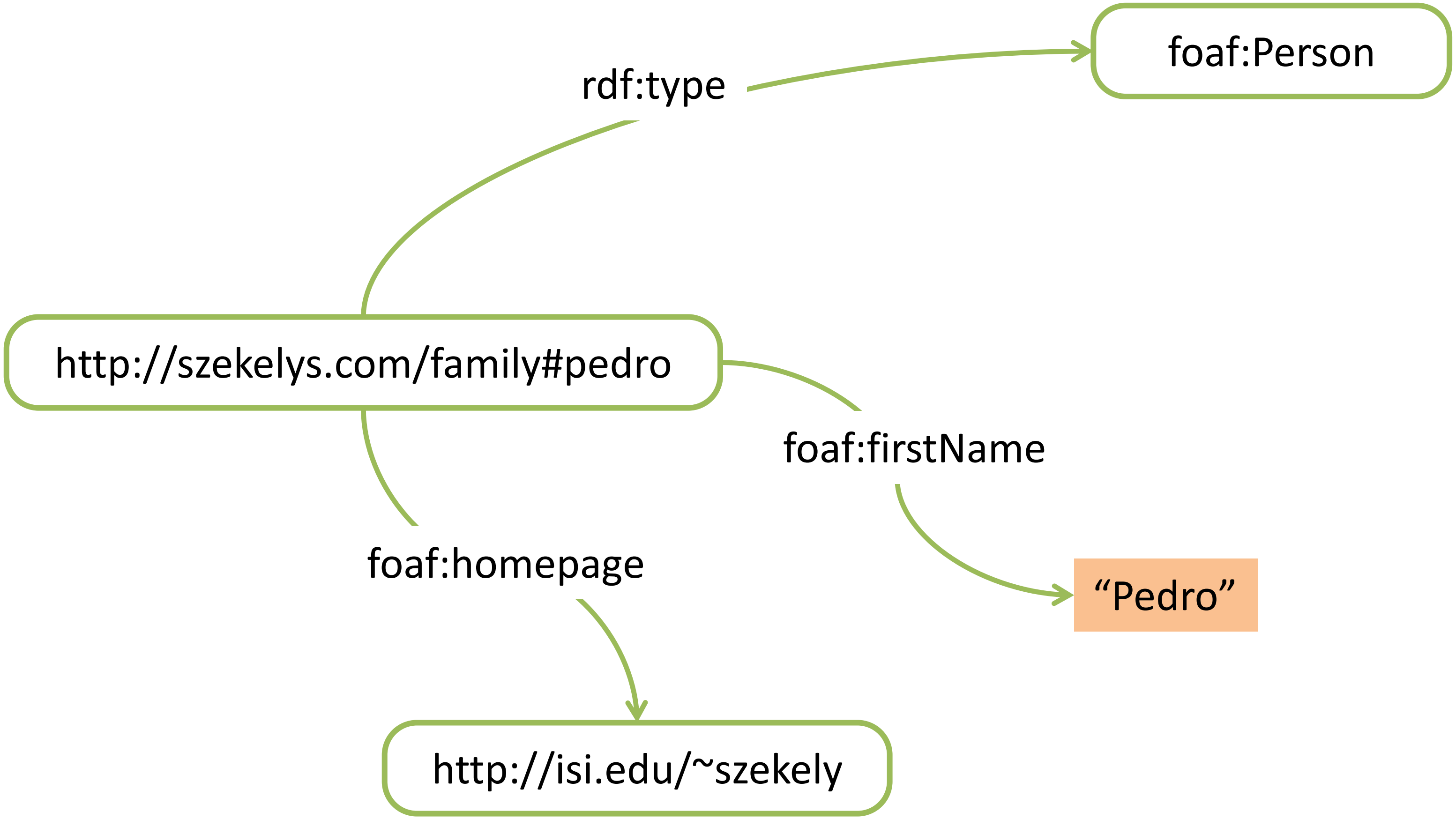
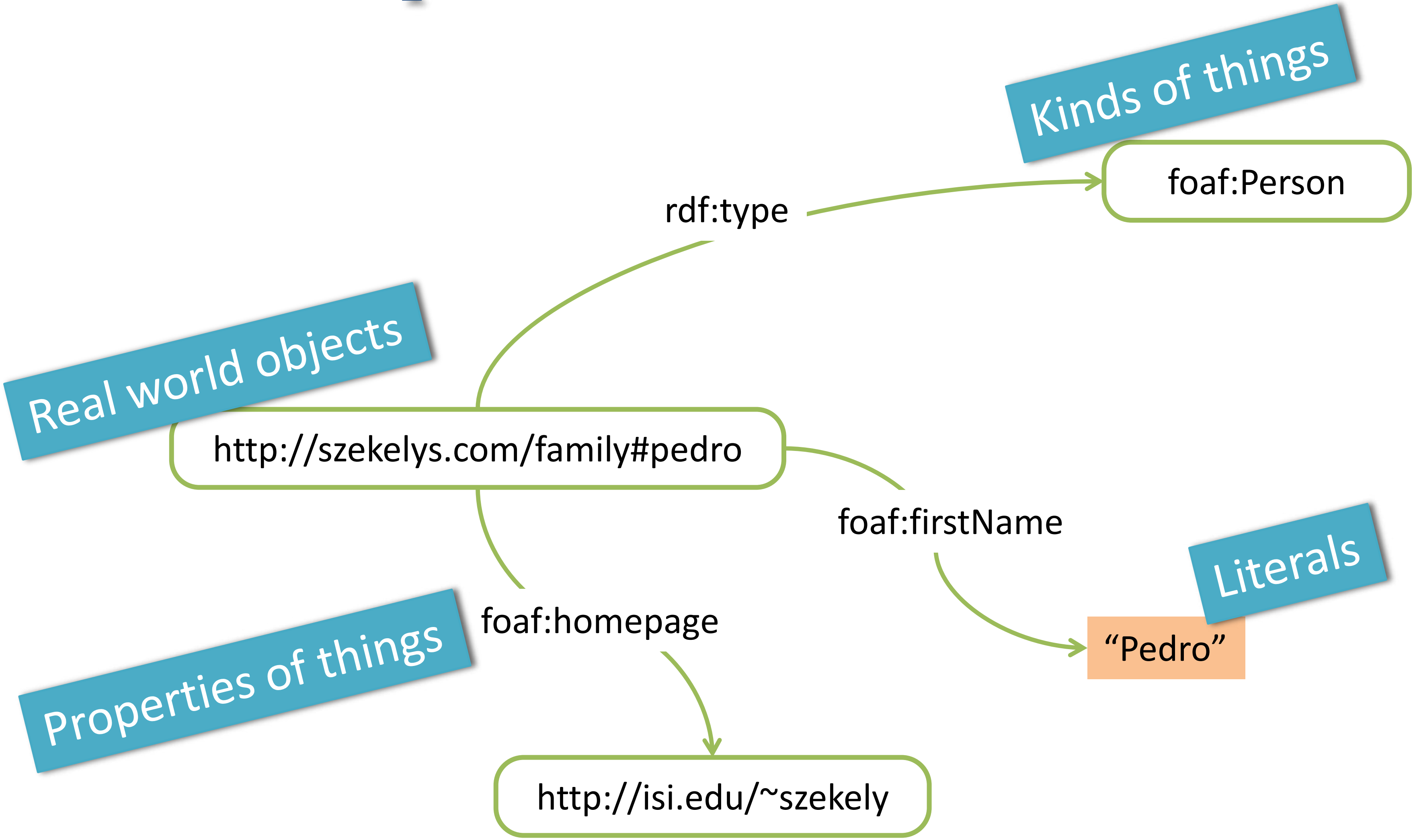
RDF Graphs


rdf:type
foaf:Person
http://szekelys.com/family#pedro
foaf:firstName
foaf:homepage
"Pedro"
http://isi.edu/~szekely

RDF Graphs



Kinds of things

foaf:Person

rdf:type

Real world objects

http://szekelys.com/family#pedro

foaf:firstName

Literals

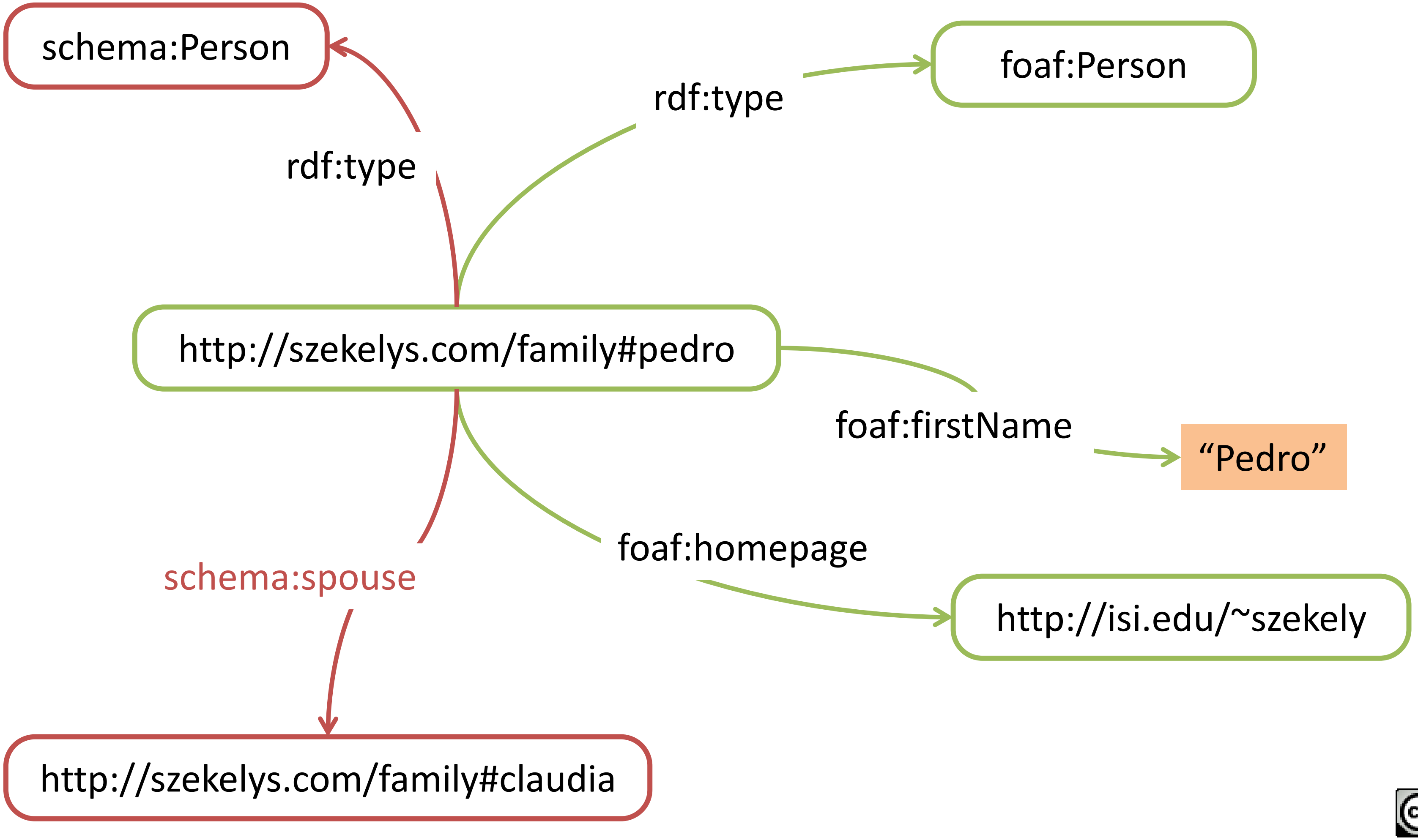
"Pedro"

foaf:homepage

Properties of things

http://isi.edu/~szekely

Mix Vocabularies


schema:Person

rdf:type

foaf:Person

rdf:type

http://szekelys.com/family#pedro

foaf:firstName

“Pedro”

foaf:homepage

http://isi.edu/~szekely

schema:spouse

http://szekelys.com/family#claudia

Why Use URIs?

□ URIs look cool

slide by Pedro Szekely

Why Use URIs?

- URIs look cool
- Precisely identify resources
  - Avoid confusion among different “Jose Lopez”
- Precisely identify properties
  - E.g., name of a company or name of a person
- Provide information about properties
- Look them up on the web

slide by Pedro Szekely

XML vs RDF

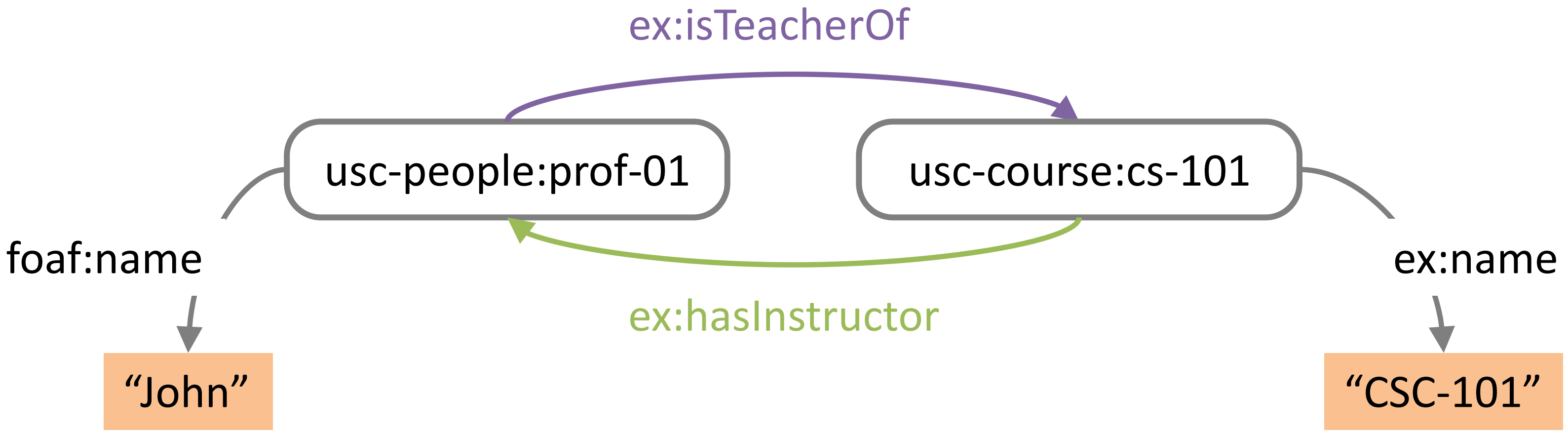
John is an instructor for CS101

XML

```
<instructor name="“John”>
  <teaches>CS 101</teaches>
<instructor>
```

```
<course name=“CS101”>
  <instructor> John </instructor>
<course>
```

RDF



slide by Pedro Szekely

RDF Syntaxes

XML

Leverages XML tools
Hard for humans to read

N3, Turtle

Terse RDF Triple Language
Human readable format
Works with software too

N-Triples

Subset of turtle, supports streaming
Standard for large RDF dumps

RDFa

Allows embedding RDF in HTML pages

slide by Pedro Szekely

XML Syntax

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <rdf:Description rdf:about="http://szekelys.com/family#pedro">
     <foaf:firstName>Pedro</foaf:firstName>
     <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
  </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

slide by Pedro Szekely

XML Syntax

It’s an XML document

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <rdf:Description rdf:about="http://szekelys.com/family#pedro">
     <foaf:firstName>Pedro</foaf:firstName>
     <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
  </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

slide by Pedro Szekely

XML Syntax

Here comes some RDF

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <rdf:Description rdf:about="http://szekelys.com/family#pedro">
     <foaf:firstName>Pedro</foaf:firstName>
     <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
  </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

slide by Pedro Szekely

XML Syntax

Namespace declarations

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/">

   <rdf:Description rdf:about="http://szekelys.com/family#pedro">
       <foaf:firstName>Pedro</foaf:firstName>
       <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
   </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

slide by Pedro Szekely

XML Syntax

Subject

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <rdf:Description rdf:about="http://szekelys.com/family#pedro">
    <foaf:firstName>Pedro</foaf:firstName>
    <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
  </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

slide by Pedro Szekely

XML Syntax

Predicate

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
            xmlns:foaf="http://xmlns.com/foaf/0.1/">

   <rdf:Description rdf:about="http://szekelys.com/family#pedro">
       <foaf:firstName>Pedro</foaf:firstName>
       <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
   </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

slide by Pedro Szekely

XML Syntax

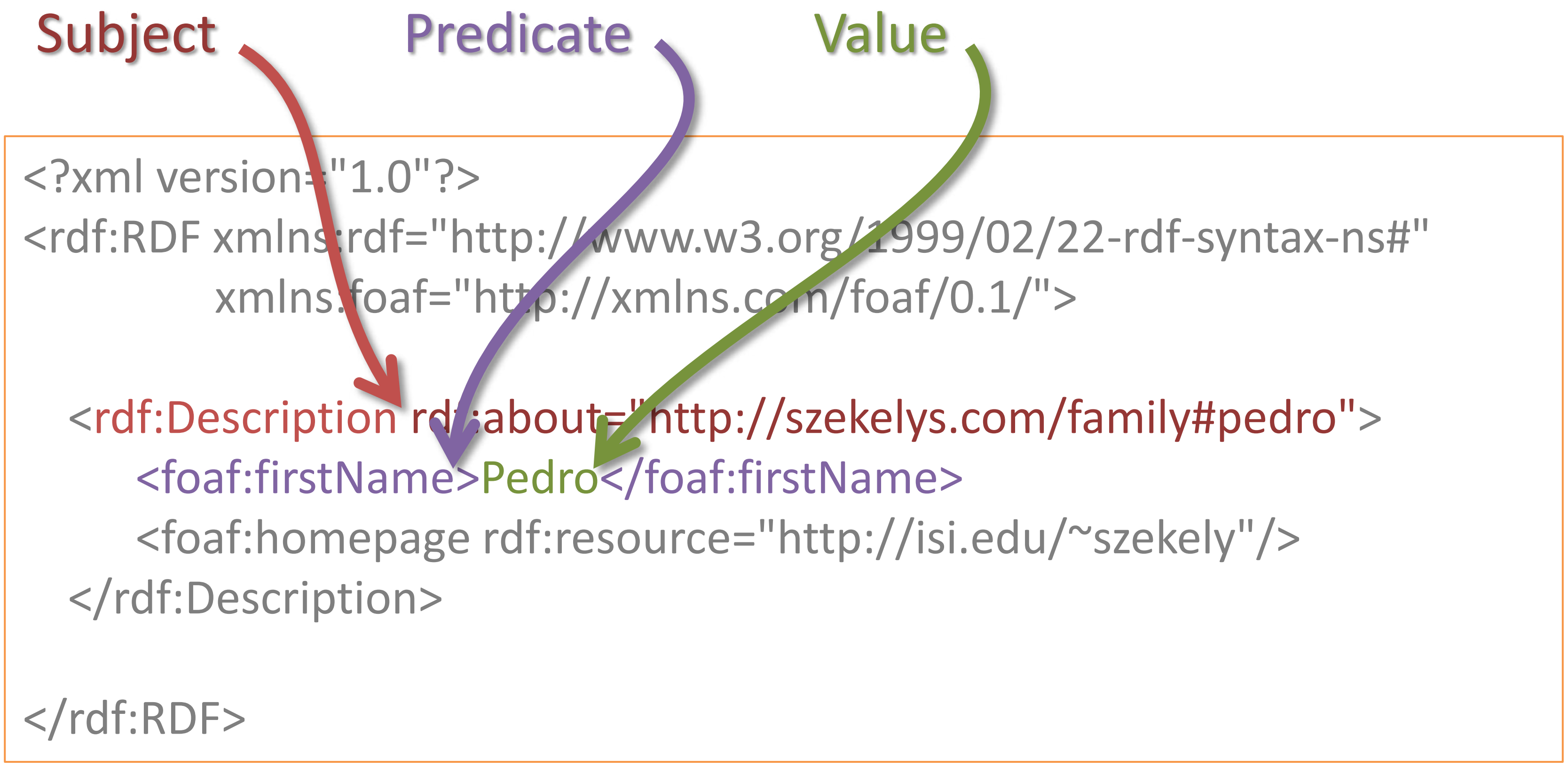
Value

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
            xmlns:foaf="http://xmlns.com/foaf/0.1/">

   <rdf:Description rdf:about="http://szekelys.com/family#pedro">
       <foaf:firstName>Pedro</foaf:firstName>
       <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
   </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

slide by Pedro Szekely

XML Syntax



Subject Predicate Value

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <rdf:Description rdf:about="http://szekelys.com/family#pedro">
     <foaf:firstName>Pedro</foaf:firstName>
     <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
  </rdf:Description>

</rdf:RDF>
```

Pedro’s homepage is "http://isi.edu/~szekely"

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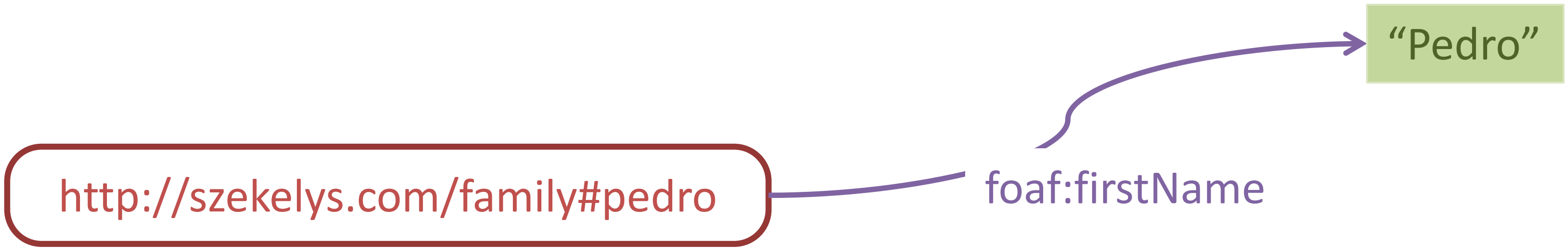
XML Syntax



```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
          xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <rdf:Description rdf:about="http://szekelys.com/family#pedro">
      <foaf:firstName>Pedro</foaf:firstName>
      <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
  </rdf:Description>

</rdf:RDF>
```

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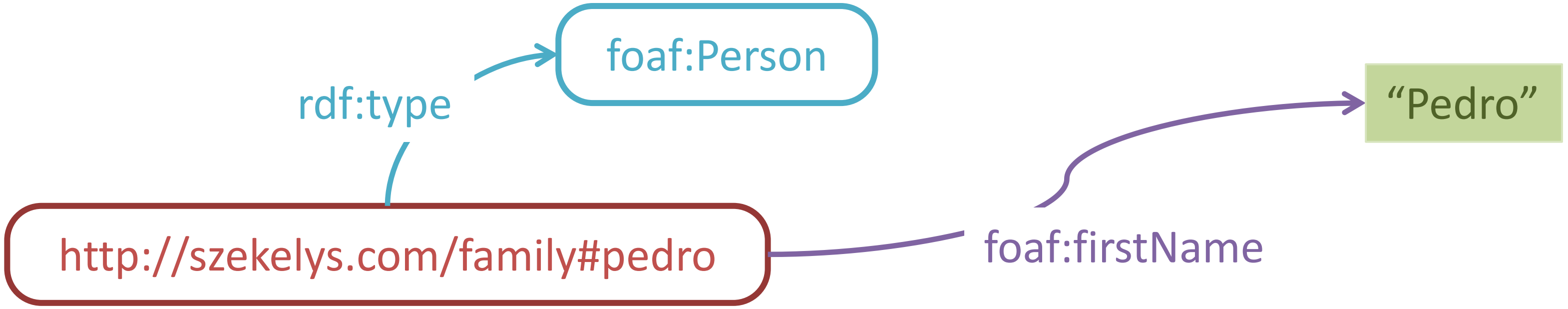
XML Syntax



```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <foaf:Person rdf:about="http://szekelys.com/family#pedro">
    <foaf:firstName>Pedro</foaf:firstName>
    <foaf:homepage rdf:resource="http://isi.edu/~szekely"/>
  </foaf:Person>

</rdf:RDF>
```

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RDF Syntaxes

XML

Leverages XML tools
Hard for humans to read

N3, Turtle

Terse RDF Triple Language
Human readable format
Works with software too

N-Triples

Subset of turtle, supports streaming
Standard for large RDF dumps

RDFa

Allows embedding RDF in HTML pages

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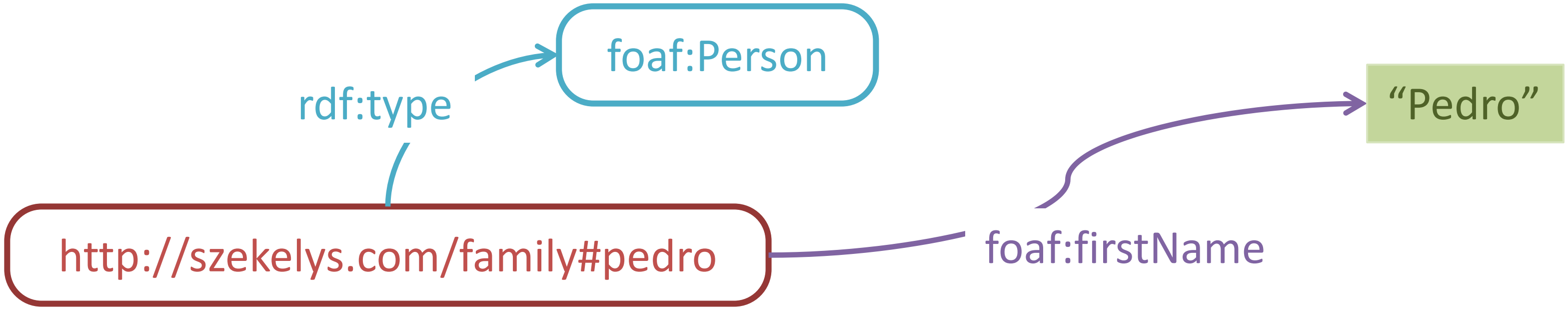
N3 and Turtle Syntaxes



foaf:Person

rdf:type

"Pedro"

http://szekelys.com/family#pedro

foaf:firstName

```
@prefix   rdf:      <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix   foaf:     <http://xmlns.com/foaf/0.1/> .

<http://szekelys.com/family#pedro> foaf:firstName   "Pedro" .
<http://szekelys.com/family#pedro> rdf:type   foafPerson .
```

Each triple ends with a dot

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More Complex Structures

English

“USC/ISI’s address is
4676 Admiralty Way, Marina del Rey, CA 90292”

RDF

```
usc:isi
      schema:address
      “4676 Admiralty Way, Marina del Rey, CA 90292”
      .
```

~~In what city is USC/ISI located?~~

~~Find all universities in California~~

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English

“USC/ISI’s address is
4676 Admiralty Way, Marina del Rey, CA 90292”

RDF

```
usc:isi
    schema:address
    “4676 Admiralty Way, Marina del Rey, CA 90292”
    .
```

How to represent nested structures?

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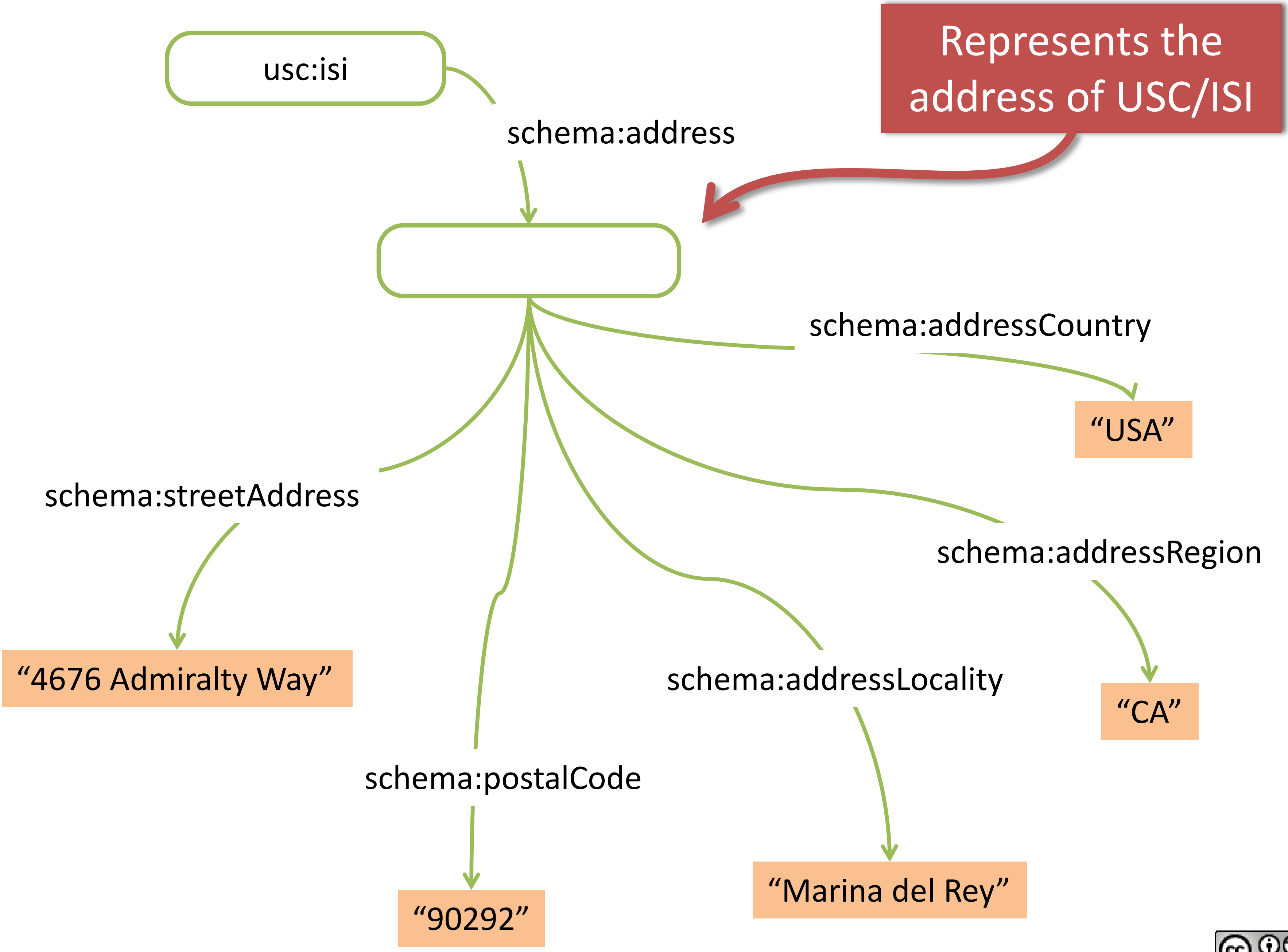

Represents the address of USC/ISI

usc:isi

schema:address

schema:addressCountry

“USA”

schema:streetAddress

“4676 Admiralty Way”

schema:addressRegion

“CA”

schema:addressLocality

“Marina del Rey”

schema:postalCode

“90292”

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English

“USC/ISI’s address is
4676 Admiralty Way, Marina del Rey, CA 90292”

RDF

```
usc:isi      schema:address        usc:isi-address .

usc:isi-address
      schema:addressCountry   “USA” ;
      schema:addressRegion    “CA”
      schema:addressLocality  “Marina del Rey” ;
      schema:postalCode       “90292” ;
      schema:streetAddress    “4676 Admiralty Way” .
```

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We minted a URI for USC/ISI's address

```
usc:isi     schema:address     usc:isi-address .

usc:isi-address
     schema:addressCountry    "USA" ;
     schema:addressRegion     "CA"
     schema:addressLocality   "Marina del Rey" ;
     schema:postalCode        "90292" ;
     schema:streetAddress     "4676 Admiralty Way" .
```

… but sometimes we don't want to mint URIs

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Blank Nodes

Blank node prefix is "_"

```
usc:isi      schema:address          _:isi-address .

_:isi-address
     schema:addressCountry    "USA" ;
     schema:addressRegion     "CA" ;
     schema:addressLocality   "Marina del Rey" ;
     schema:postalCode        "90292" ;
     schema:streetAddress     "4676 Admiralty Way" .
```

... can be improved ...

What If I Don’t Know the URI?

English

“Pedro Szekely lives in Los Angeles”

Blank node

RDF

```
_:pedro
    foaf:firstName              “Pedro” ;
    foaf:lastName               “Szekely” ;
    foaf:mbox                   “szekely1401@gmail.com” ;
    schema:addressLocality      “Los Angeles” .
```

... is this useful? ... maybe

Typed Literals

Compact blank node syntax

```
gn:bogota     weather:event      [
   weather:temperature       “10” ;
   weather:date              ”18 June 2012”
   ] .
```

… what is the meaning of the strings?

… how do I specify numbers?

… how about dates?

… how do I specify 10 degrees centigrade?

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Typed Literals

```
gn:bogota     weather:event  [
     weather:temperature
     “10”^^<http://www.w3.org/2001/XMLSchema#integer> ;
     weather:date                    ”18 June 2012” ;
     ] .
```

URI specifies the type

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Typed Literals

```
gn:bogota     weather:event   [
     weather:temperature
     “10”^^<http://www.w3.org/2001/XMLSchema#integer> ;
     weather:date                    ”18 June 2012” ;
     weather:date                    ”2012-06-18”^^xsd:date ;
] .
```

URI from the XML Schema namespace are popular

… No set of predefined types defined in RDF

… Software that consumes RDF must process types

… XSD types commonly used

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Containers and Collections

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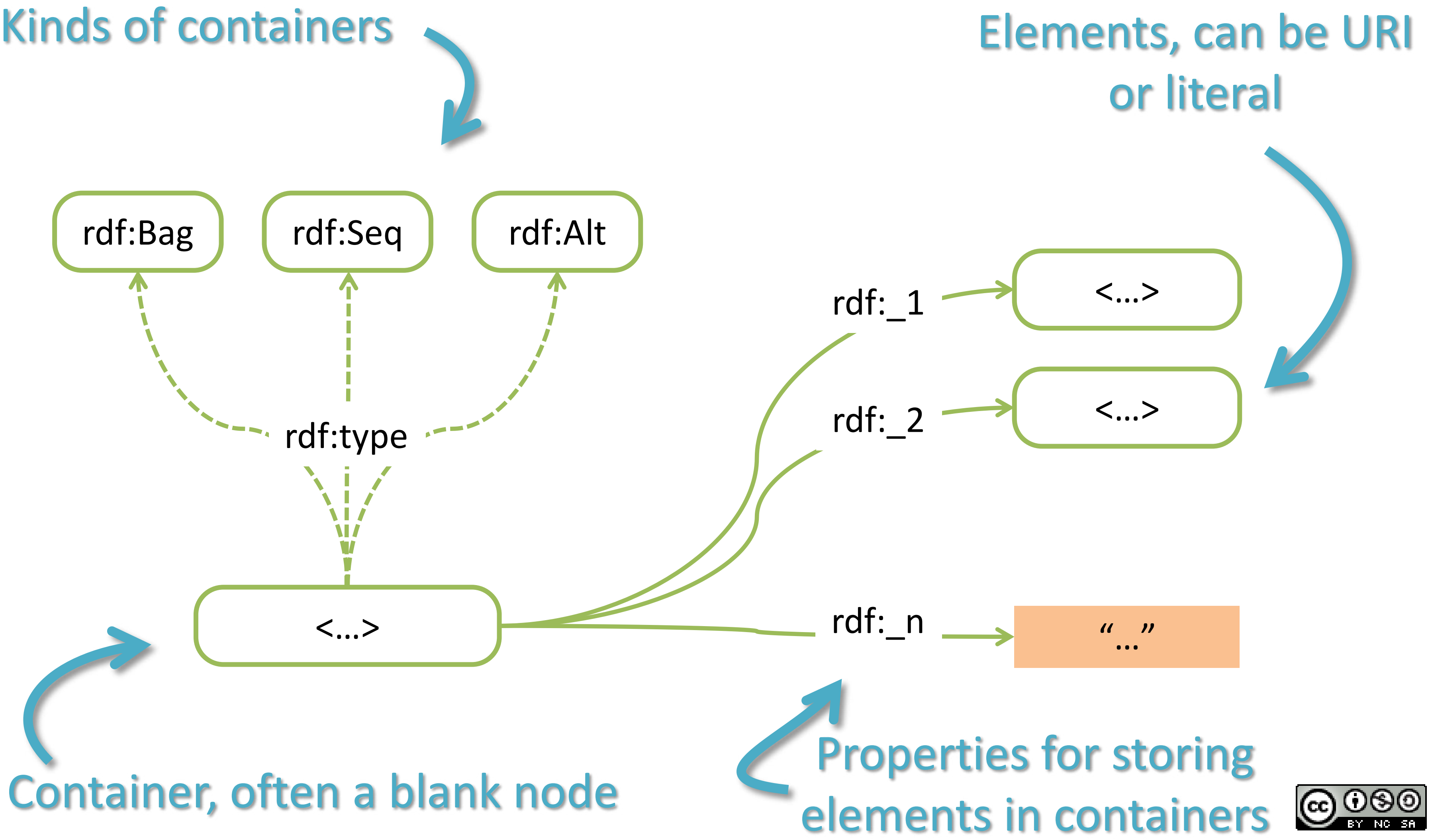
Bag, Sequence, Alternative



Kinds of containers
Elements, can be URI or literal
rdf:Bag
rdf:Seq
rdf:Alt
rdf:type
rdf:_1
rdf:_2
rdf:_n
<…>
<…>
<…>
"…"
Container, often a blank node
Properties for storing elements in containers

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Bag Example

“Three papers that Sue published”

```
exstaff:Sue   exterms:publication   _:z .
_:z           rdf:type              rdf:Bag .
_:z           rdf:_1                ex:AnthologyOfTime .
_:z           rdf:_2                ex:ZoologicalReasoning .
_:z           rdf:_3                ex:GravitationalReflections .
```

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What’s the Difference?

```
exstaff:Sue   exterms:publication   _:z .
_:z         rdf:type          rdf:Bag .
_:z         rdf:_1            ex:AnthologyOfTime .
_:z         rdf:_2            ex:ZoologicalReasoning .
_:z         rdf:_3            ex:GravitationalReflections .
```

```
exstaff:Sue   exterms:publication      ex:AnthologyOfTime .
exstaff:Sue   exterms:publication      ex:ZoologicalReasoning .
exstaff:Sue   exterms:publication      ex:GravitationalReflections .
```

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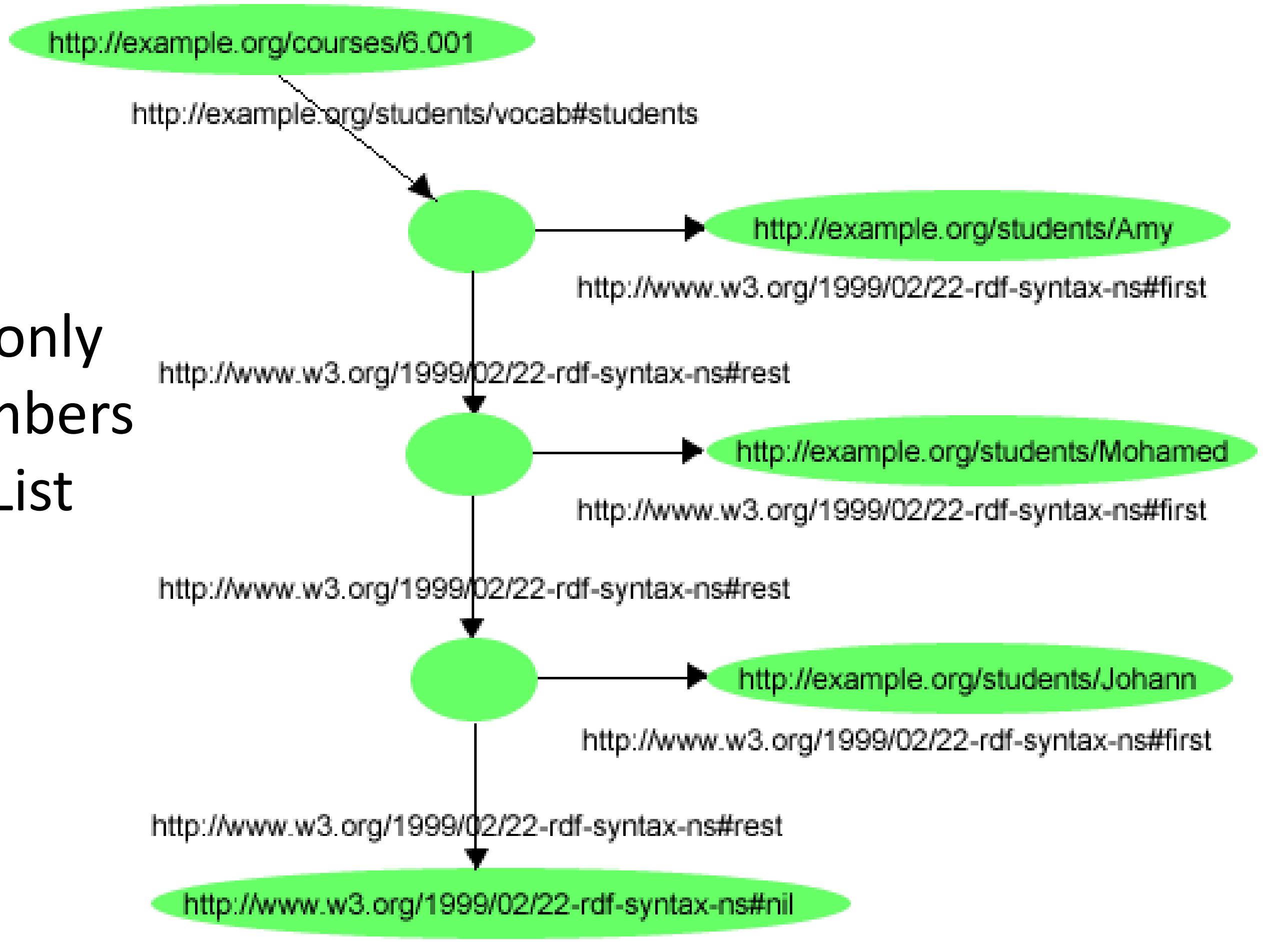
List

RDF Collection:

- group containing only the specified members
- represented as a List structure


http://example.org/courses/6.001
http://example.org/students/vocab#students
http://example.org/students/Amy
http://www.w3.org/1999/02/22-rdf-syntax-ns#first
http://www.w3.org/1999/02/22-rdf-syntax-ns#rest
http://example.org/students/Mohamed
http://www.w3.org/1999/02/22-rdf-syntax-ns#first
http://www.w3.org/1999/02/22-rdf-syntax-ns#rest
http://example.org/students/Johann
http://www.w3.org/1999/02/22-rdf-syntax-ns#first
http://www.w3.org/1999/02/22-rdf-syntax-ns#rest
http://www.w3.org/1999/02/22-rdf-syntax-ns#nil

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
            xmlns:s="http://example.org/students/vocab#">
  <rdf:Description rdf:about="http://example.org/courses/6.001">
    <s:students rdf:parseType="Collection">
        <rdf:Description rdf:about="http://example.org/students/Amy"/>
        <rdf:Description rdf:about="http://example.org/students/Mohamed"/>
        <rdf:Description rdf:about="http://example.org/students/Johann"/>
    </s:students>
  </rdf:Description>
</rdf:RDF>
```

slide by Jose Luis Ambite

Containers vs Collections

RDF philosophy

Open World

Incomplete information

There are things I don't know

Scales to the whole Web

Containers

open world sets

Closed World

Complete Information

If I don't know it, it does not exist

Does not scale

Collections

closed world sets

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Reification

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Why Do We Need Reification?

English

"On June 19 2012, Claudia said that
Pedro's email address is szekely1401@gmail.com"

RDF

<http://szekelys.com/family#pedro>   foaf:mbox   <szekely1401@gmail.com>

Correct?   ……………………… No!

We need to make a statement about a statement

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Reification

English

“On June 19 2012, Claudia said that
Pedro’s email address is szekely1401@gmail.com”

RDF

```
_:s     rdf:type            rdf:Statement .
_:s     rdf:subject         <http://szekelys.com/family#pedro> .
_:s     rdf:predicate       foaf:mbox .
_:s     rdf:object          <szekely1401@gmail.com> .

_:s     dcterms:date        “2012-06-19”^^xsd:date .
_:s     dcterms:creator     <http://uniandes.edu.co/faculty#claudiaj> .
```

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Problems With Reification

RDF 1

```
_:s     rdf:type            rdf:Statement .
_:s     rdf:subject         <http://szekelys.com/family#pedro> .
_:s     rdf:predicate       foaf:mbox .
_:s     rdf:object          <szekely1401@gmail.com> .

_:s     dcterms:date        “2012-06-19”^^xsd:date .
_:s     dcterms:creator     <http://uniandes.edu.co/faculty#claudiaj> .
```

RDF 2

```
<http://szekelys.com/family#pedro>    foaf:mbox    <szekely1401@gmail.com>
```

RDF 1 implies RDF 2?   …….. No!

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Problems With Reification

```
_:s     rdf:subject         <http://szekelys.com/family#pedro> .
_:s     rdf:predicate       foaf:mbox .
_:s     rdf:object          <szekely1401@gmail.com> .

_:s     dcterms:date        “2012-06-19”^^xsd:date .
_:s     dcterms:creator     <http://uniandes.edu.co/faculty#claudiaj> .
```

- Needs 3 times more triples
- Most software cannot reason with it
- Nice idea that does not work well!
- Use sparingly, often there is a better way

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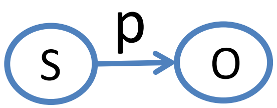
Views of RDF statements and documents

An RDF statement can be viewed as:

- A triple (subject, predicate, object): s p o .
- A piece of a labeled graph:



- A piece of XML code: <s> <p> o </p> <s>
- A binary predicate in logic: p(s, o)

Thus an RDF document can be viewed as:

- A set of triples
- A directed labeled graph (semantic net)
- An XML document
- A set of logical facts

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