RDF
Graph Data Model

Mustafa Jarrar

Birzeit University

Watch this lecture and download the slides

Course Page: http://www.jarrar.info/courses/AI/

More Online Courses at: http://www.jarrar.info

Reading

1. **RDF Primer (**http://www.w3.org/TR/rdf-syntax-grammar/ **)**

Please have a look only to:

Chapter 2 Making Statements About Resources
Chapter 3 An XML Syntax for RDF: RDF/XML
Chapter 3 Defining RDF Vocabularies: RDF Schema

2. **Charlie Abela: Lecture notes on Artificial Intelligence**
http://staff.um.edu.mt/cabe2/supervising/csa3003/presentations/RDF%20Tutorial.ppt

RDF
Graph Data Model

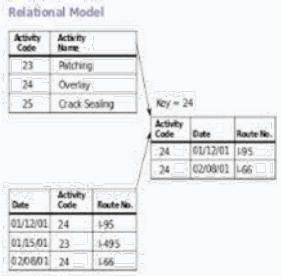
In this lecture:

- Part 1: **Relational/Tree/Graph Data Models**
- Part 2: **Why XML is not enough**
- Part 3: **RDF Syntax**
- Part 4: **Mapping Database/XML to RDF**
- Part 5: **Practical Session**

Relational vs Tree vs Graph Data model

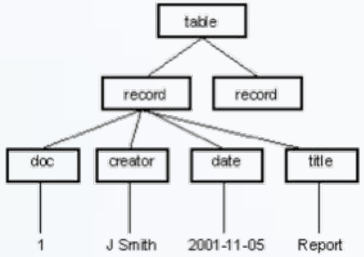
Relational Data models

- Data is represented in tuples, groups into relations
- Relational databases



Tree data models

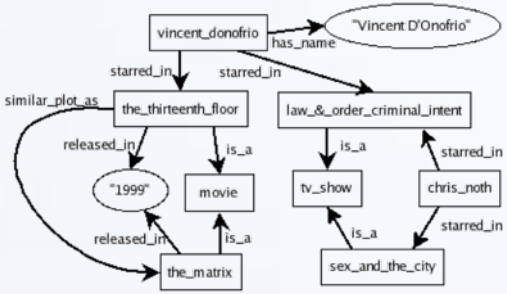
- Parent / child relationships
- Directed Acyclic Graphs
- XML is a tree data model



Graph Data Models

- A node is a data element and links are relations between these elements.
- Directed Labeled Graphs
- RDF is a graph data model

➔ Tree are special case of graphs



RDF
Graph Data Model

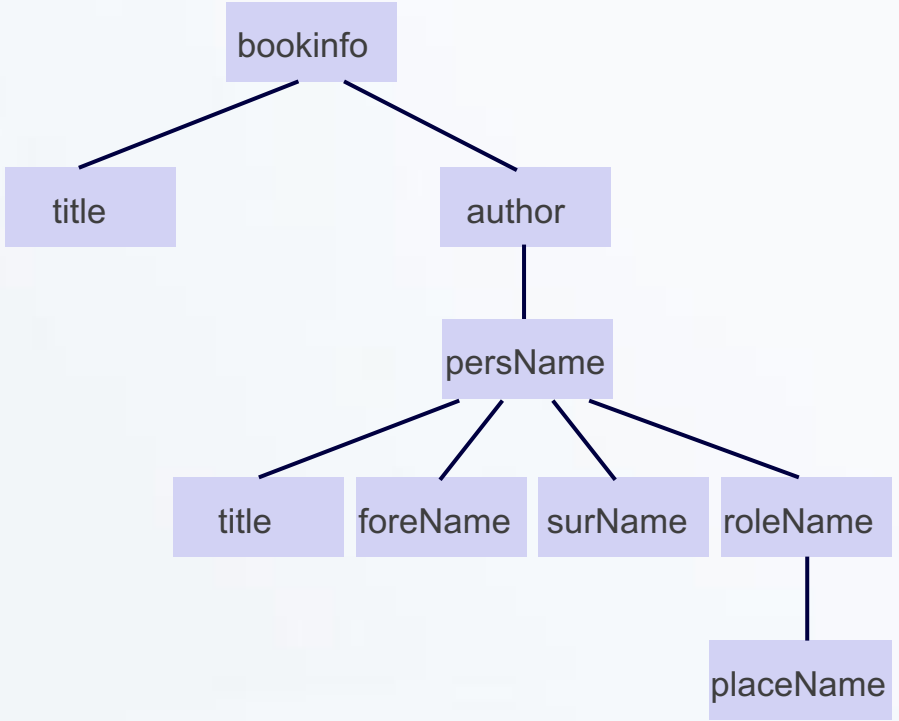
In this lecture:

- Part 1: **Relational/Tree/Graph Data Models**
- Part 2: **Why XML is not enough**
- Part 3: **RDF Syntax**
- Part 4: **Mapping Database/XML to RDF**
- Part 5: **RDF Practical Session**

What is XML

- Provides a common *syntax* for marking up documents.
- Easy to exchange between computers (web)
- Data model: XML Document is an ordered labeled tree (collection of trees).
- W3C standard since 1997.

```
<bookInfo>
  <title>Orientalism</title>
  <author>
    <persName>
      <title>Prof.</title>
      <foreName>Edward</foreName>
      <surName>Said</surName>
      <roleName>University Professor
        <placeName>Columbia University
        </placeName>
      </roleName>
    </persName>
  </author>
</bookInfo>
```



XML Example

```
<address>
    <name>Universsity of Birzeit</name>
    <street>Almarj 435</street>
    <town>Birzeit</town>
</address>
```

Address Example: XML to XML

XML Markup 1:

```
<address>
  <name>University of Birzeit</name>
  <street>Almarj 435</street>
  <town>Birzeit</town>
</address>
```

XML Markup 2:

```
<address>
  <name>University of Birzeit</name>
  <place>
    <street>Almarj 435</street>
    <town>Birzeit</town>
  </place>
</address>
```

XML stylesheets to transform between XML representations

Why XML is Not Enough?

- It provides syntax, but not semantics, which is important when exchanging/representing data over the Web.

```
<aaaa>
    <bbbb>Universsity of Birzeit</bbbb>
    <cccc>Almarj 435</cccc>
    <dddd>Birzeit</dddd>
</aaaa>
```

- Not primitive. Same data can be represented in many ways, which is a problem when exchanging/representing data over the Web.

```
<address>
  <name>University of Birzeit</name>
  <street>Almarj 435</street>
  <town>Birzeit</town>
</address>
```

```
<address name="University of Birzeit">
 <street>Almarj 435</street>
  <town>Birzeit</town>
</address>
```

RDF
Graph Data Model

In this lecture:

- Part 1: **Relational/Tree/Graph Data Models**
- Part 2: **Why XML is not enough**
- Part 3: **RDF Syntax**
- Part 4: **Mapping Database/XML to RDF**
- Part 5: **RDF Practical Session**

What is RDF?

- W3C standard since 1999
- RDF stands for **Resource Description Framework**.
- For describing resources on the web.
- Written in XML. It is not a language but a framework
  - You see it as a way of writing XML ➔ making it meaningful and more primitive.
  - You may see it independent, RDF data might never occur in XML form.

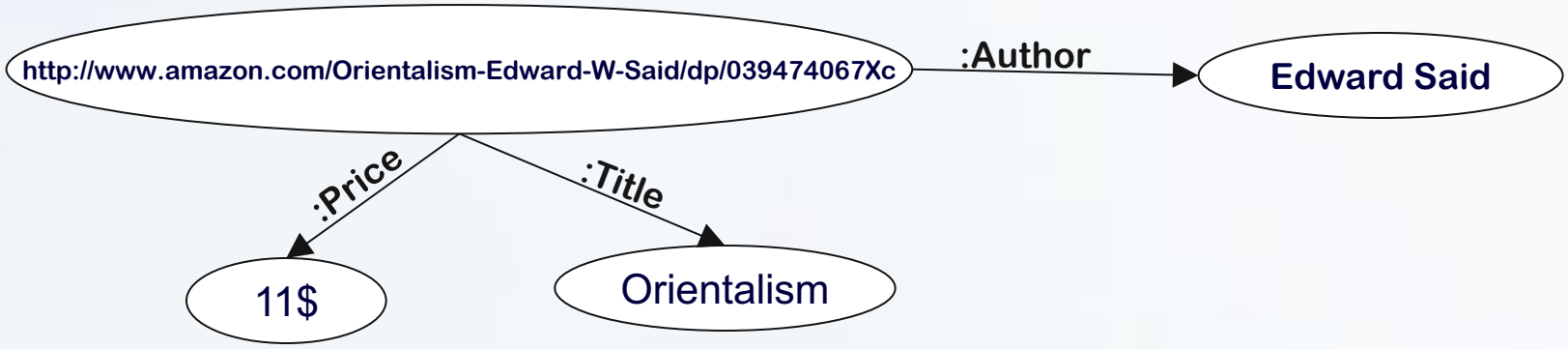
Makes use of URIs

- In order to refer to and identify things on the web (i.e., web resource) RDF uses a **URI** (Uniform Resource Identifier).
- ➔ URIs are like Global Primary Key.
- Unlike URLs, URIs are not limited to identifying things that have a network location.
- A URI reference (*URIref*) is a URI, together with an optional *fragment identifier* at the end.

  http://www.example.org/index.html#section2

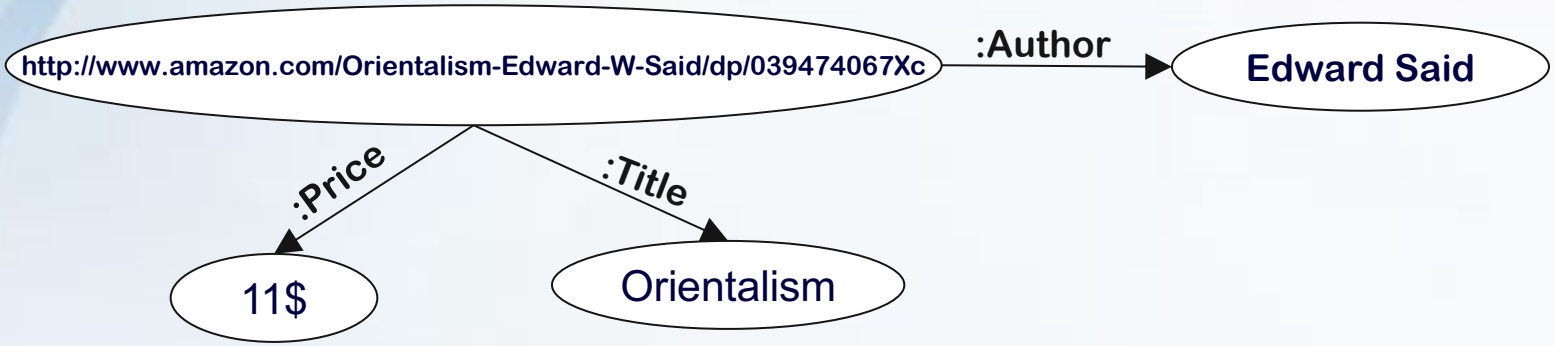
RDF Important Concepts

- Data is represented in RDF as a directed labeled graph.
- An RDF graph is **a set of triples**, of the form <Subject, Predicate, Object>



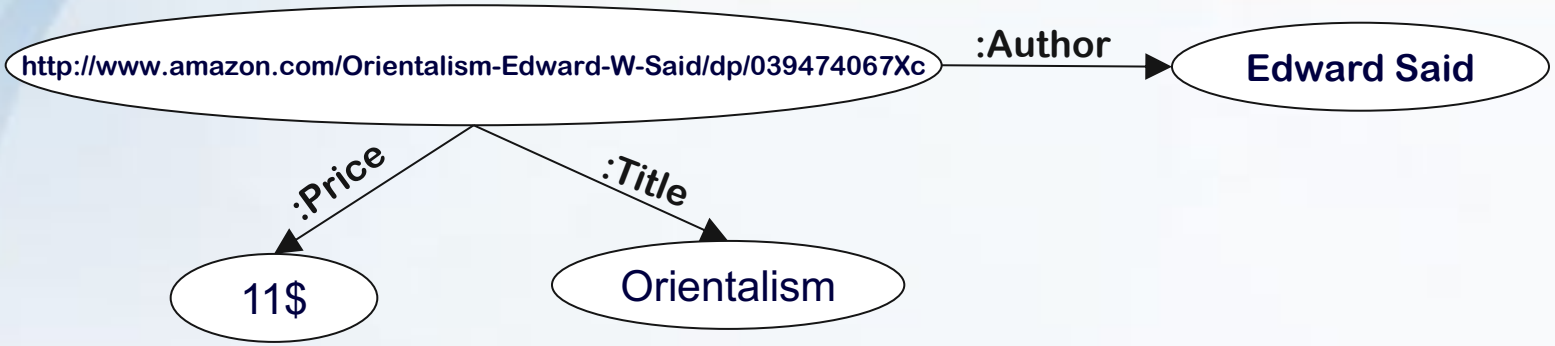
Each **Subject** and each **Predicate** must be a URI; that is, it has to be a unique identifier, not a literal. An **Object** can be either a URI or a literal.

Example 1



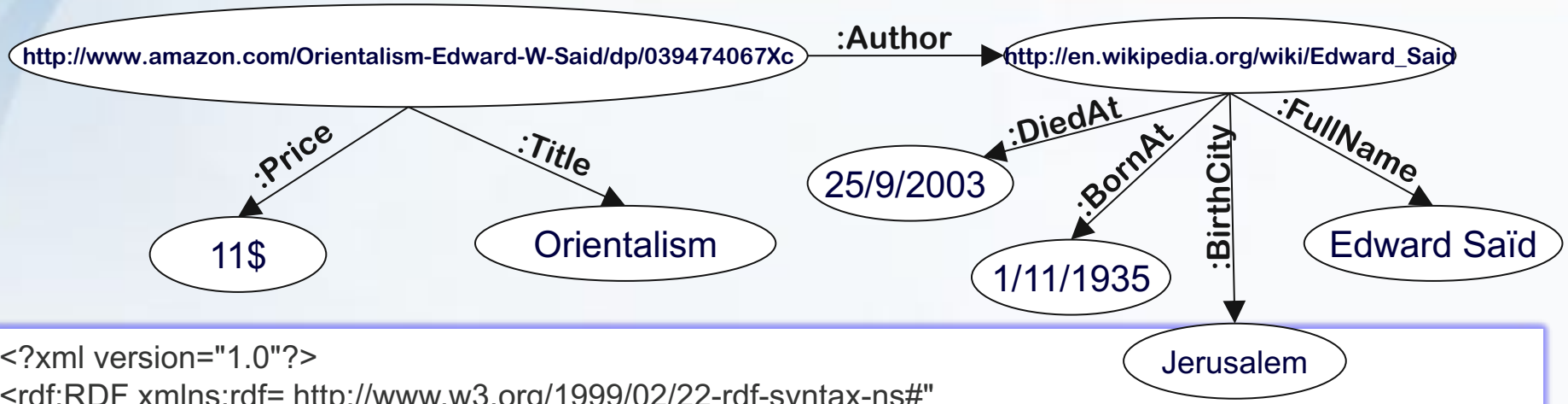
- The URI "http://www.amazon.com/Orientalism-Edward-W-Said/dp/039474067Xc" is used to identify something (a resource on the web).
- the property ”Author" describes the author of this thing
- the property value is ”Edward Said".
- The resource "http://www.amazon.com/Orientalism-Edward-W-Said/dp/039474067Xc" is the subject, “, :Author” is the property, and “Edward Said” is the Object.

Example 1 (Serialization)



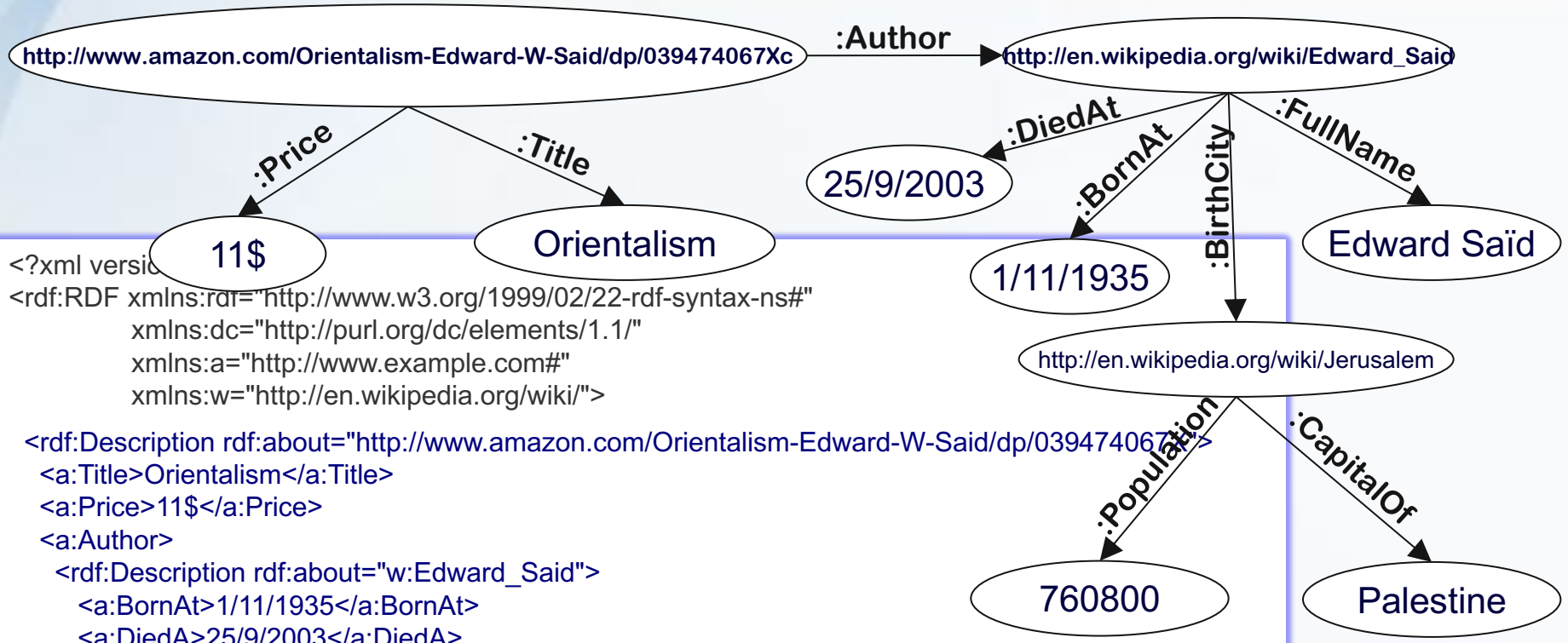

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-ns#
         xmlns:a="http://www.example.com"
         xmlns:w="http://en.wikipedia.org/wiki/">
  <rdf:Description rdf:about="http://www.amazon.com/Orientalism-Edward-W-Said/dp/039474067X">
    <a:Title>Orientalism</a:Title>
    <a:Price>11$</a:Price>
    <a:Author>Edward_Said</a:Author>
  </rdf:Description>
</rdf:RDF>
```

Example 1 (Serialization)



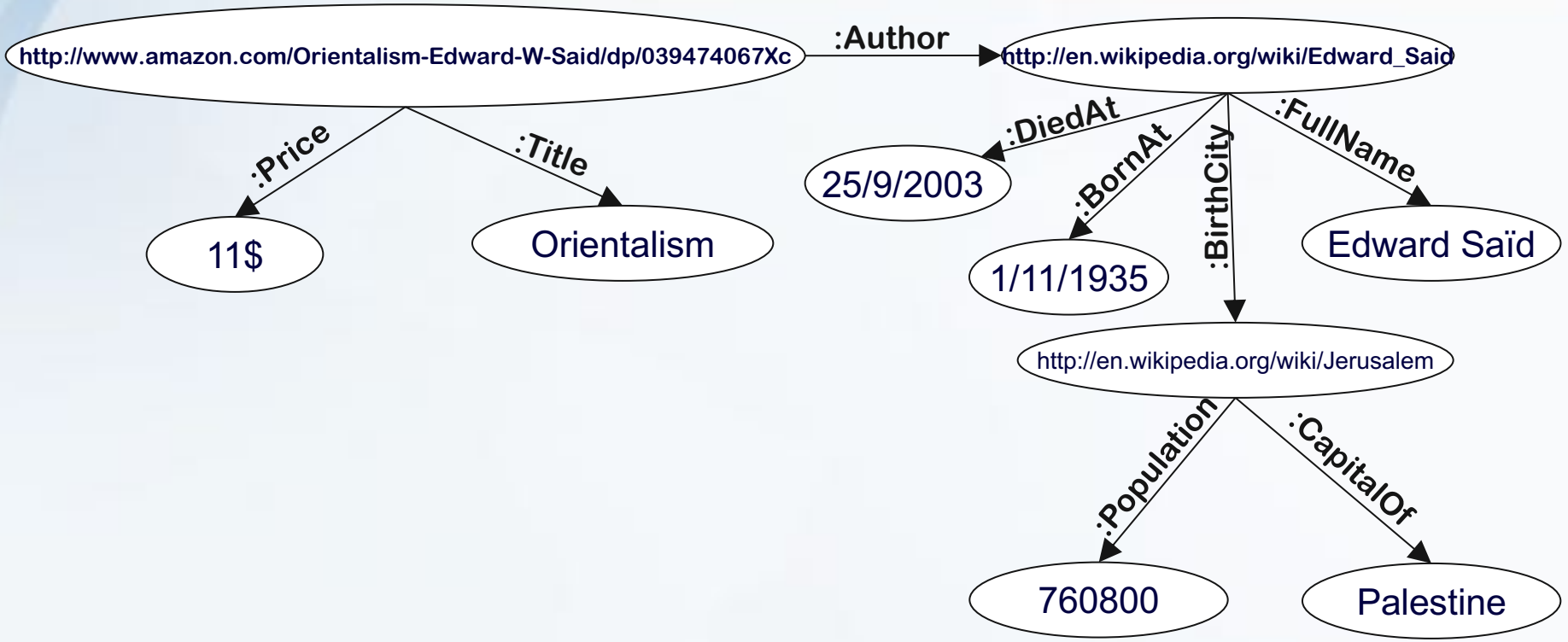

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf= http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:a  ="http://www.example.com/"
         xmlns:w ="http://en.wikipedia.org/wiki/">
 <rdf:Description rdf:about="http://www.amazon.com/Orientalism-Edward-W-Said/dp/039474067X">
  <a:Title>Orientalism</a:Title>
   <a:Price>11$</a:Price>
   <a:Author>
    <rdf:Description rdf:about="w:Edward_Said">
      <a:BirthCity>Jerusalem</a:BirthCity>
      <a:BornAt>1/11/1935</a:BornAt>
      <a:DiedA>25/9/2003</a:DiedA>
    </rdf:Description>
  </a:Author>
 </rdf:Description>
</rdf:RDF>
```

Example 1 (Serialization)




```
<?xml versio
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
         xmlns:dc="http://purl.org/dc/elements/1.1/"
         xmlns:a="http://www.example.com#"
         xmlns:w="http://en.wikipedia.org/wiki/">
 <rdf:Description rdf:about="http://www.amazon.com/Orientalism-Edward-W-Said/dp/039474067X">
  <a:Title>Orientalism</a:Title>
  <a:Price>11$</a:Price>
  <a:Author>
   <rdf:Description rdf:about="w:Edward_Said">
     <a:BornAt>1/11/1935</a:BornAt>
     <a:DiedA>25/9/2003</a:DiedA>
     <a:BirthCity>
      <rdf:Description rdf:about="http://en.wikipedia.org/wiki/Jerusalem">
         <a:Population>760800</a:Population>
         <a:CapitalOf>Palestine</a:CapitalOf>
      </rdf:Description>
     </a:BirthCity>
   </rdf:Description>
  </a:Author>
 </rdf:Description>
</rdf:RDF>
```

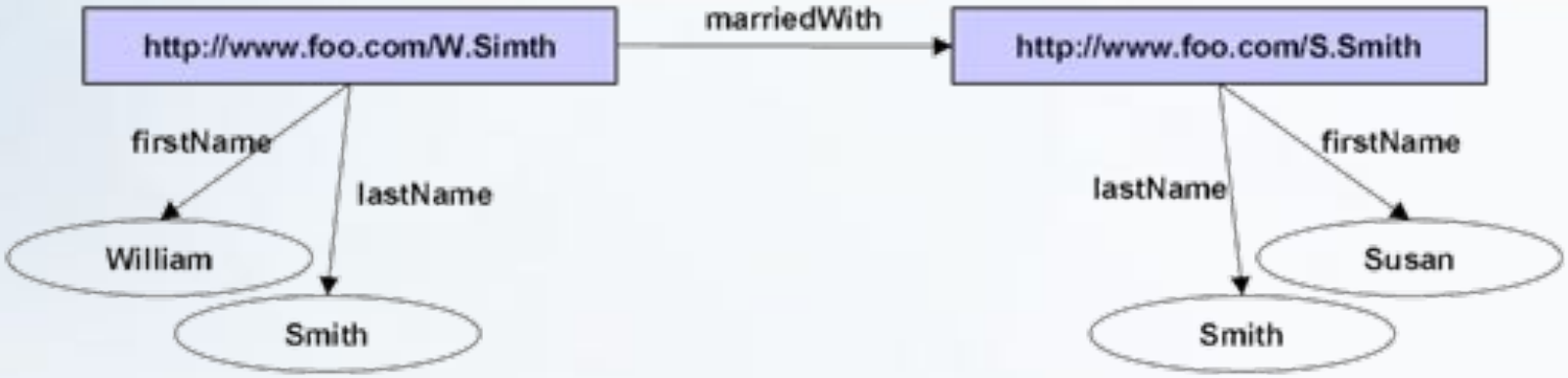
Example 1 (Directed Labeled Graph)



RDF is a **directed Labeled** Graph:

- **Directed**: each property/relation has a direction.
- **Labeled:** each property/relation has a name.

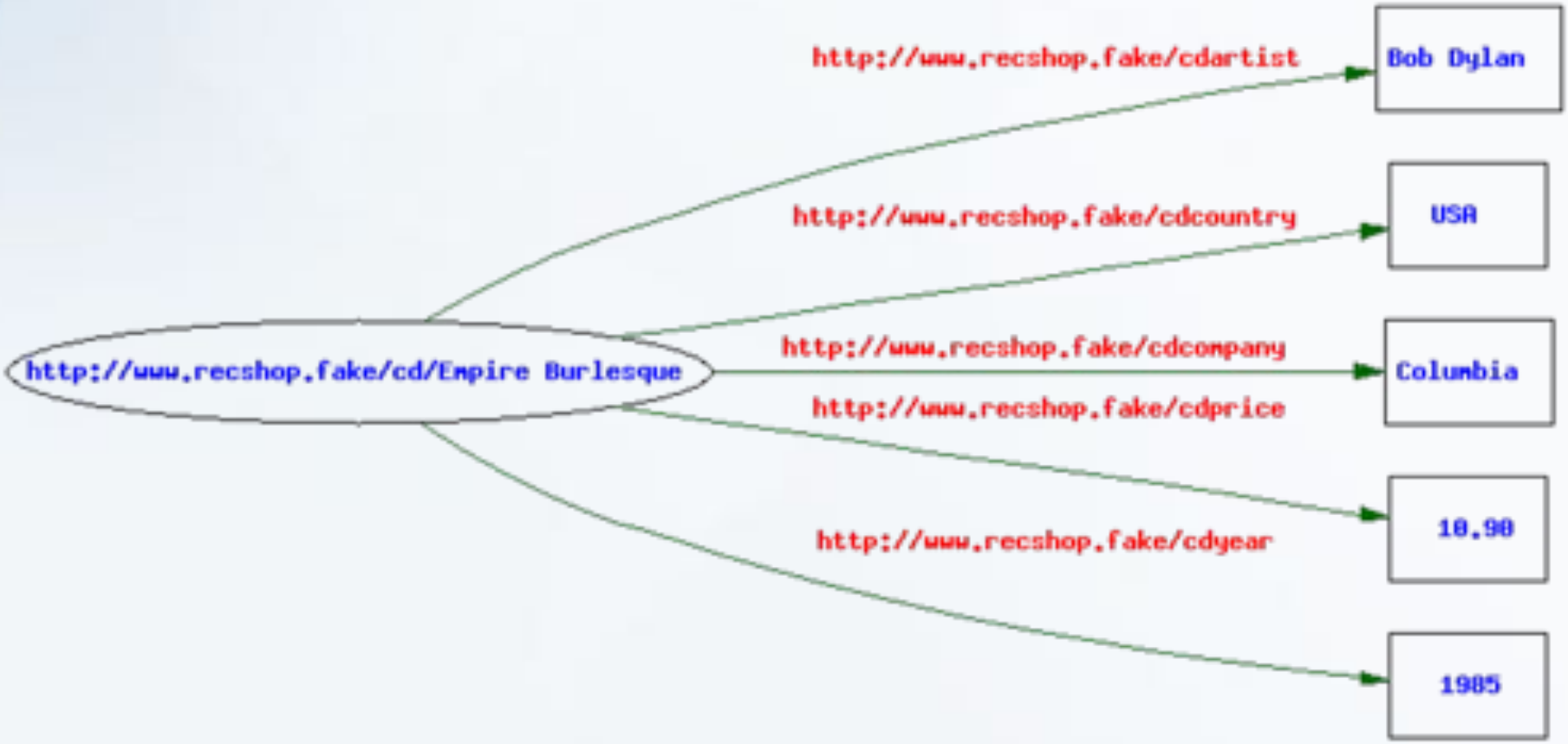
Example 2




```
<?xml version="1.0" encoding="ISO-8859-1"?>
<rdf:RDF xmlns:rdf = "http://www.w3.org/1999/02/22/rdf-syntax-ns">
    <rdf:description about="http://www.foo.com/W.Smith">
        <firstName>William</firstName>
        <lastName>Smith</lastName>
        <marriedWith>
            <rdf:description about ="http://www.foo.com/S.Smith">
                <firstName>Susan</firstName>
                <lastName>Smith</lastName>
            <rdf:description>
        </marriedWith>
    </rdf:description>
</rdf:RDF>
```

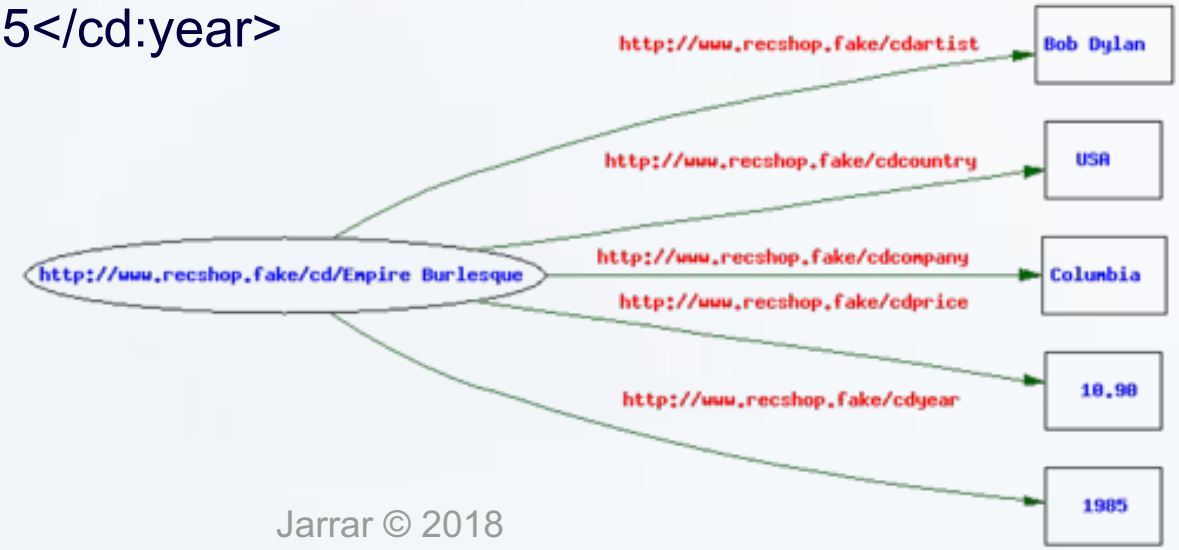
Example 3

Based on [2]



Example 3

```
<rdf:RDF>
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax ns#"
    xmlns:cd="http://www.recshop.fake/cd">
    <rdf:Description
          rdf:about="http://www.recshop.fake/cd/Empire Burlesque">
          <cd:artist>Bob Dylan</cd:artist>
          <cd:country>USA</cd:country>
          <cd:company>Columbia</cd:company> <cd:price>10.90</cd:price>
          <cd:year>1985</cd:year>
    </rdf:Description>
. . . . . .
```



Example 3

Table Representation (List of Triples)

Subject	Predicate	Object
http://www.recshop.fake/cd/Empire Burlesque	http://www.recshop.fake/cdartist	"Bob Dylan"
http://www.recshop.fake/cd/Empire Burlesque	http://www.recshop.fake/cdcountry	"USA"
http://www.recshop.fake/cd/Empire Burlesque	http://www.recshop.fake/cdcompany	"Columbia"
http://www.recshop.fake/cd/Empire Burlesque	http://www.recshop.fake/cdprice	"10.90"
http://www.recshop.fake/cd/Empire Burlesque	http://www.recshop.fake/cdyear	"1985"

Main RDF Properties and Attributes

Main RDF Properties

- **rdf:subject** The subject of the resource in an RDF Statement
- **rdf:predicate** The predicate of the resource in an RDF Statement
- **rdf:object** The object of the resource in an RDF Statement
- **rdf:type** The resource is an instance of a class

Main RDF Attributes

- **rdf:RDF** The root of an RDF document
- **rdf:about** Defines the resource being described
- **rdf:Description** Container for the description of a resource
- **rdf:resource** Defines a resource to identify a property
- **rdf:datatype** Defines the data type of an element

RDF Validator

- Check the correctness of an RDF document:

  http://www.w3.org/RDF/Validator/

- Result shows the subject, predicate and object of each element of the document and a graph of the model.

RDF
Graph Data Model

In this lecture:

- Part 1: **Relational/Tree/Graph Data Models**
- Part 2: **Why XML is not enough**
- Part 3: **RDF Syntax**
- Part 4: **Mapping Database/XML to RDF**
- Part 5: **RDF Practical Session**

Mapping XML into RDF (Example)

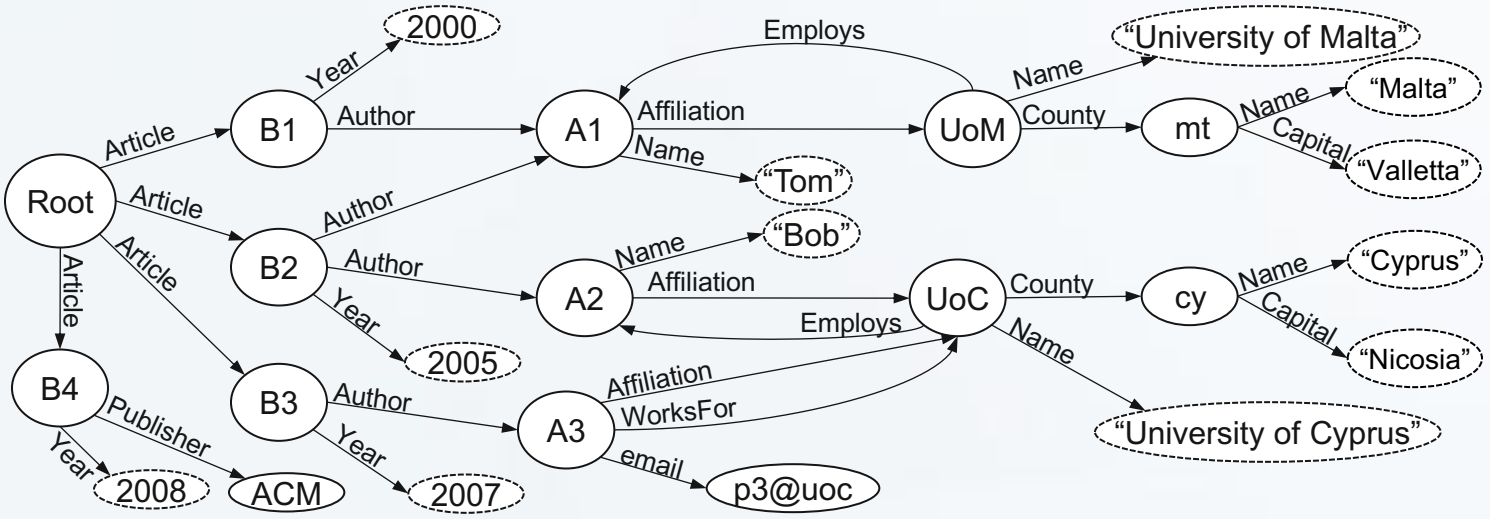
XML

```
<XML>
 <Article ID=B1 Year="2000">
  <Author ID=A1>
   <Name>Tom</Name>
   <Affiliation ID=UoM>
    <Name>University of Malta</Name>
    <Country ID=mt>
     <Name> Malta</Name>
     <Capital>Valletta</Capital>
    </Country>
   </Affiliation>
  <Author>
 </Article>
```

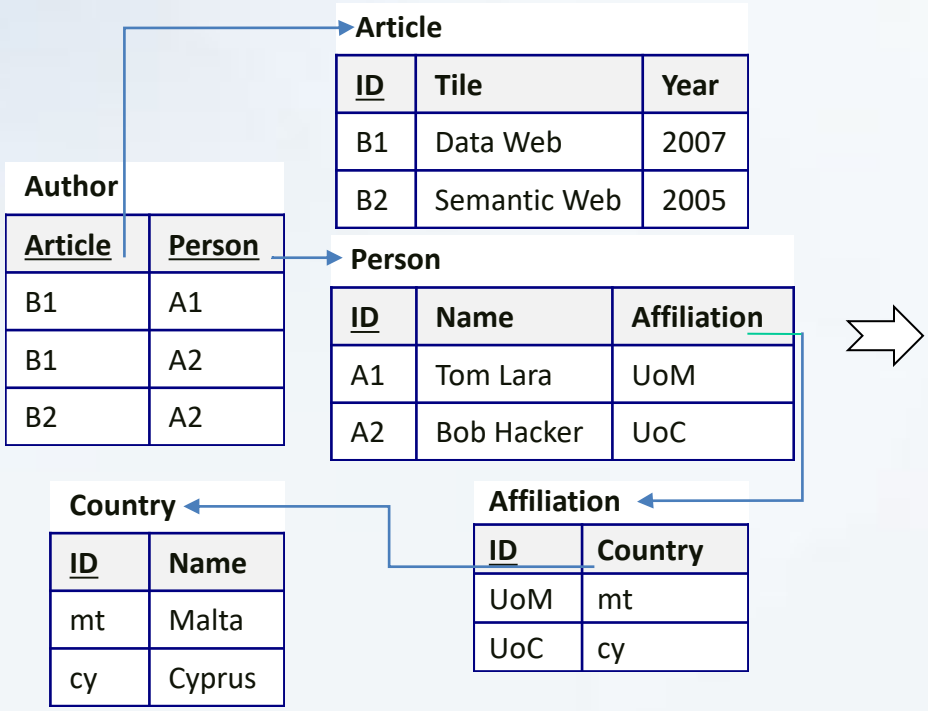
```
<Article ID=B2 Year="2005">
 <Author href="#A1"/>
 <Author ID=A2>
  <Name>Bob</Name>
  <Affiliation ID=UoC>
   <Name>University of Cyprus</Name>
   <Country ID=cy>
    <Name> Cyprus</Name>
    <Capital>Nicosia</Capital>
   </Country>
  </Affiliation>
 <Author>
</Article>
```

```
<Article ID=B3 Year="2007">
 <Author ID=A3>
  <email>ps@uoc</email>
  <Affiliation href="#UoC"/>
<Author>
 </Article>
<Article ID=B4 Year="2008">
 <Publisher ID=ACM/>
</Article>
</XML>
```

RDF



Mapping Database into RDF (Example)



RDF

S	P	O
:B1	rdf:Type	:Article
:B1	:Title	"Data Web"
:B1	:Year	2007
:B2	rdf:Type	:Article
:B2	:Title	"Semantic Web"
:B2	:Year	2005
:B1	:Author	:A1
:B1	:Author	:A2
:B2	:Author	:A1
:A1	rdf:Type	:Person
:A1	:Name	"Tom Lara"
:A1	:Affiliation	:UoM
:A2	:Type	:Person
:A2	:Name	"Bob Hacker"
:A2	:Affiliation	:UoC
:UoM	:Type	:University
:UoM	:Country	:mt
:mt	:Type	:Country
:mt	:Name	"Malta"
:UoC	:Type	:University
:UoC	:Country	:cy
:cy	:Type	:Country
:cy	:Name	"Cyprus"

RDF
Graph Data Model

In this lecture:

- Part 1: **Relational/Tree/Graph Data Models**
- Part 2: **Why XML is not enough**
- Part 3: **RDF Syntax**
- Part 4: **Mapping Database/XML to RDF**
- Part 5: **RDF Practical Session**

Practice Session

Write the information in your Passport using:

1. RDF/XML format,
2. as SPO table.

* You may use this validator https://www.w3.org/RDF/Validator/

Practice Session (Solution Example)

```
<?xml version="1.0"?>
<rdf:RDF
      xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
      xmlns:mz="http://www.example.com/"
      xmlns:xsd="http://www.w3.org/2001/XMLSchema-datatypes">

 <rdf:Description rdf:about="http://mohammad.example.com/">
  <mz:id rdf:datatype="xsd:integer">111111111</mz:id>
  <mz:firstname>Mohammad</mz:firstname>
  <mz:firstname xml:lang="ar"> محمد </mz:firstname>
  <mz:familyname>ZeinEddin</mz:familyname>
  <mz:wife rdf:resource="http://tamara.example.com/" />
 </rdf:Description>

 <rdf:Description rdf:about="http://tamara.example.com/">
  <mz:id rdf:datatype="xsd:integer">2222222222</mz:id>
  <mz:firstname>Tamara</mz:firstname>
  <mz:familyname>Adam</mz:familyname>
 </rdf:Description>
</rdf:RDF>
```

Practice Session (Solution Example)

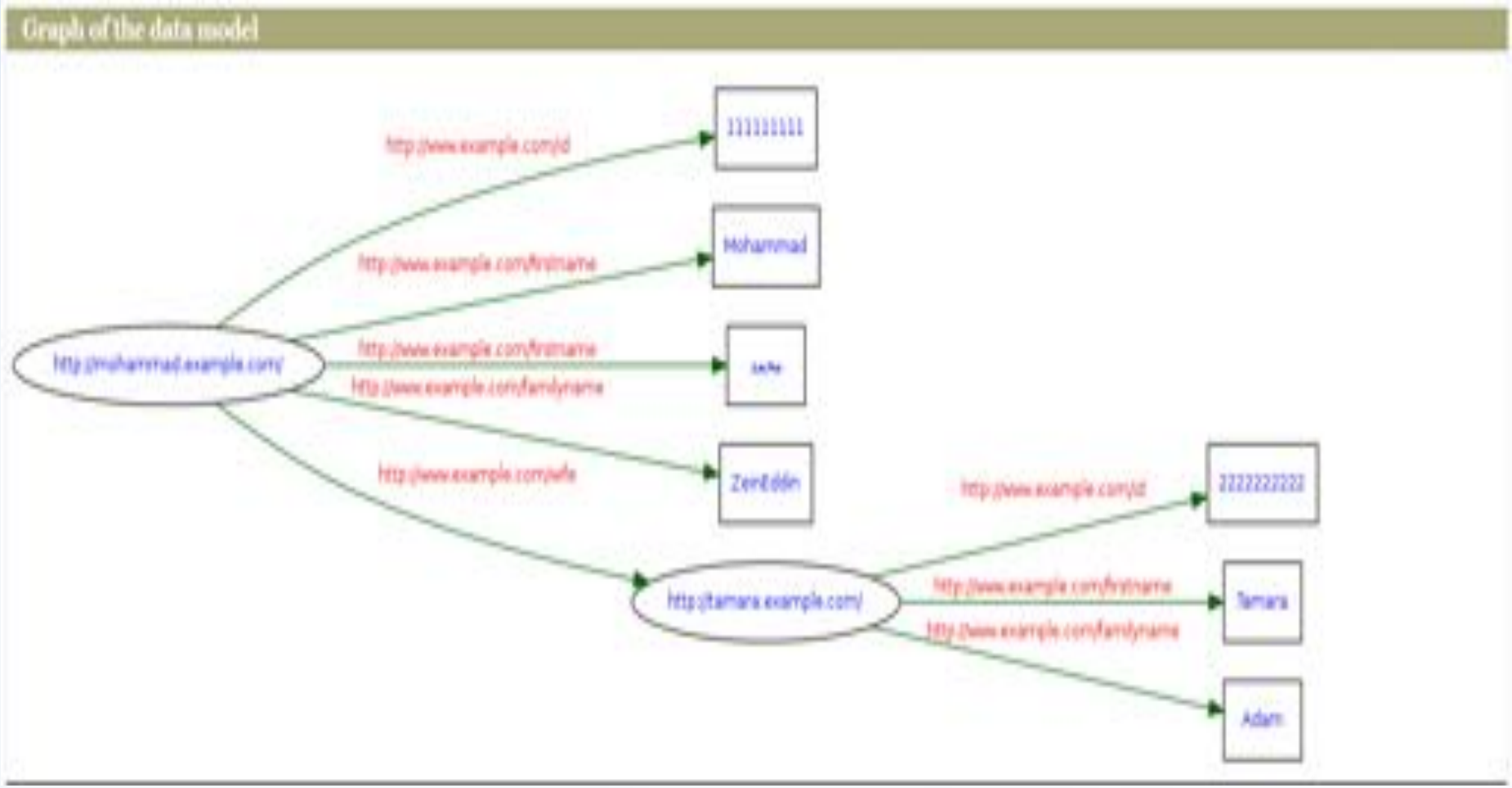
Triples of the Data Model

Number	Subject	Predicate	Object
1	http://mohammad.example.com/	http://www.example.com/id	"111111111"^^xsd:integer
2	http://mohammad.example.com/	http://www.example.com/firstname	"Mohammad"
3	http://mohammad.example.com/	http://www.example.com/firstname	"محمد"@ar
4	http://mohammad.example.com/	http://www.example.com/familyname	"ZeinEddin"
5	http://mohammad.example.com/	http://www.example.com/wife	http://tamara.example.com/
6	http://tamara.example.com/	http://www.example.com/id	"2222222222"^^xsd:integer
7	http://tamara.example.com/	http://www.example.com/firstname	"Tamara"
8	http://tamara.example.com/	http://www.example.com/familyname	"Adam"

The original RDF/XML document

```
1: <?xml version="1.0"?>
2: <rdf:RDF
3:       xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
4:       xmlns:mz="http://www.example.com/"
5:       xmlns:xsd="http://www.w3.org/2001/XMLSchema-datatypes">
6:    <rdf:Description rdf:about="http://mohammad.example.com/">
7:      <mz:id rdf:datatype="xsd:integer">111111111</mz:id>
8:      <mz:firstname>Mohammad</mz:firstname>
9:      <mz:firstname xml:lang="ar">محمد</mz:firstname>
10:      <mz:familyname>ZeinEddin</mz:familyname>
11:      <mz:wife rdf:resource="http://tamara.example.com/" />
12:    </rdf:Description>
13:    <rdf:Description rdf:about="http://tamara.example.com/">
14:      <mz:id rdf:datatype="xsd:integer">2222222222</mz:id>
15:      <mz:firstname>Tamara</mz:firstname>
16:      <mz:familyname>Adam</mz:familyname>
17:    </rdf:Description>
18: </rdf:RDF>
```

Practice Session (Solution Example)



References

[1] Mustafa Jarrar: Lecture Notes on RDF Data Model, Birzeit University, 2018

[2] Mustafa Jarrar: Lecture Notes on RDF Schema, Birzeit University, 2018

[3] Mustafa Jarrar: Lecture Notes on Ontology Web Language (OWL) Birzeit University, 2018

[4] Mustafa Jarrar: Lecture Notes on Data Web and Linked Data, Birzeit University, 2018

[5] Mustafa Jarrar, Anton Deik: The Graph Signature: A Scalable Query Optimization Index For RDF Graph Databases Using Bisimulation And Trace Equivalence Summarization. International Journal on Semantic Web and Information Systems, 11(2), 36-65, 2015

[6] Mustafa Jarrar, Anton Deik, Bilal Faraj: Ontology-Based Data And Process Governance Framework -The Case Of E-Government Interoperability In Palestine . In pre-proceedings of the IFIP International Symposium on Data-Driven Process Discovery and Analysis (SIMPDA'11). Pages(83-98). 2011.

[7] Anton Deik, Bilal Faraj, Ala Hawash, Mustafa Jarrar: Towards Query Optimization For The Data Web - Two Disk-Based Algorithms: Trace Equivalence And Bisimilarity . In proceedings of the International Conference on Intelligent Semantic Web – Applications and Services. Pages 131-137. ACM. 2010.

[8] Rami Hodrob, Mustafa Jarrar: ORM To OWL 2 DL Mapping.. In proceedings of the International Conference on Intelligent Semantic Web – Applications and Services. Pages 131-137. ACM, 2010.

[9] Mustafa Jarrar: Towards Automated Reasoning On ORM Schemes. -Mapping ORM Into The DLR_idf Description Logic. In proceedings of the 26th International Conference on Conceptual Modeling (ER 2007). Pages (181-197). LNCS 4801, Springer. Auckland, New Zealand. 2007

[10] Mustafa Jarrar: Towards Methodological Principles For Ontology Engineering . PhD Thesis. Vrije Universiteit Brussel. (May 2005)