



Overview of Semantic Web Technologies

Cristina Vertan, Walther v. Hahn

University of Hamburg • Informatics Department

Natural Language Systems Group

WWW: <http://nats-www.informatik.uni-hamburg.de/>

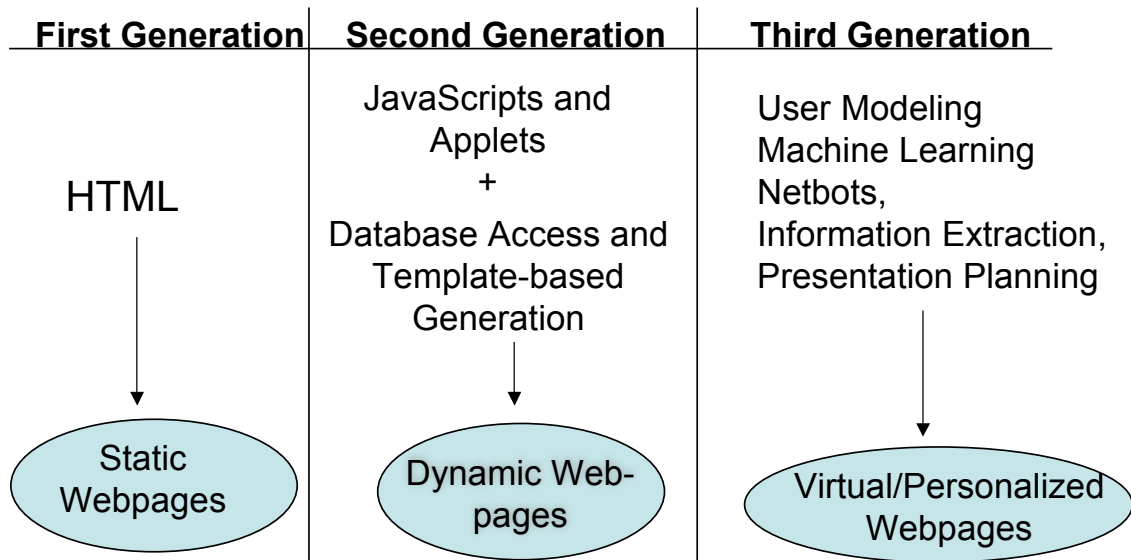
E-Mail: {vertan, vhahn}@informatik.uni-hamburg.de

Contents

- Principles of Semantic Web
- Basic models and languages for Semantic Web
 - XML
 - RDF
 - RDFS, OWL
- Examples



Three Generations of Web pages

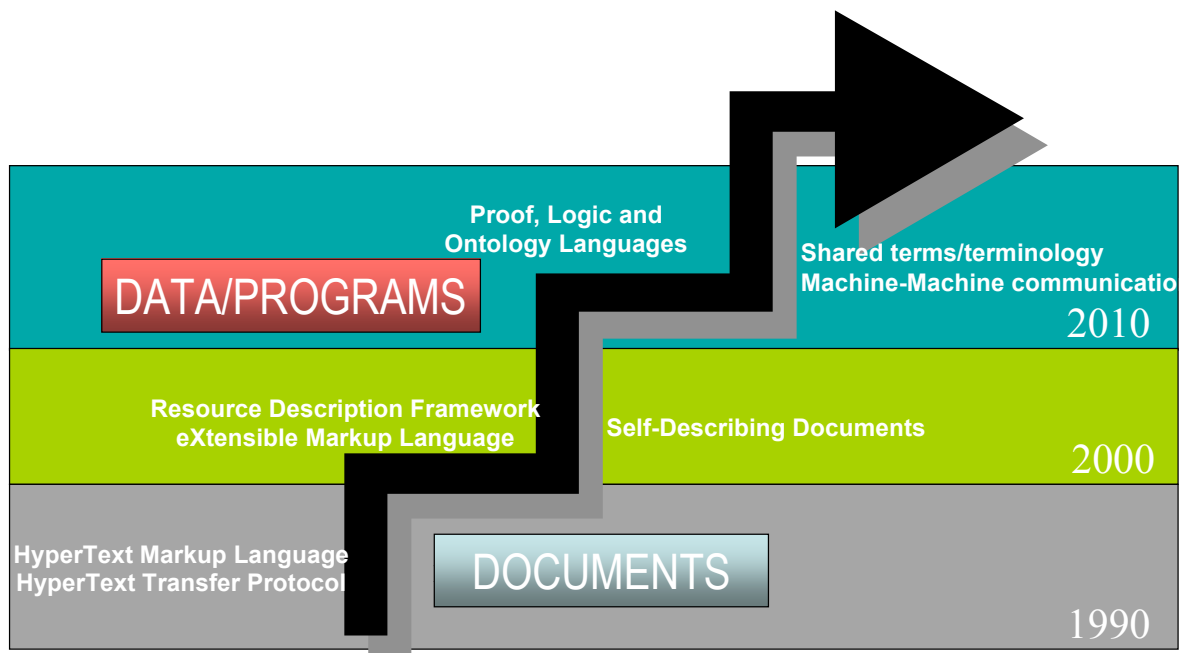


12.09.2005

SW Workshop - MT-Summit 05

3

The Vision of Semantic Web



12.09.2005

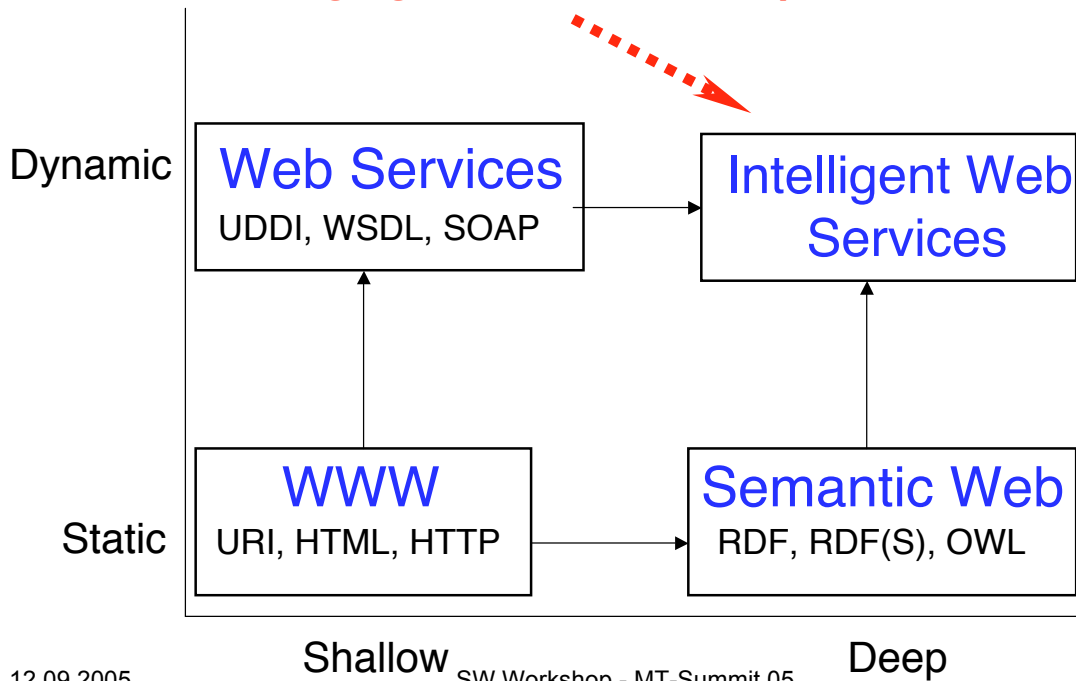
© Berners-Lee, Hendler; *Nature*, 2001
SW Workshop - MT-Summit 05

4

Integration of Semantic Web and Web Services

© D. Fensel

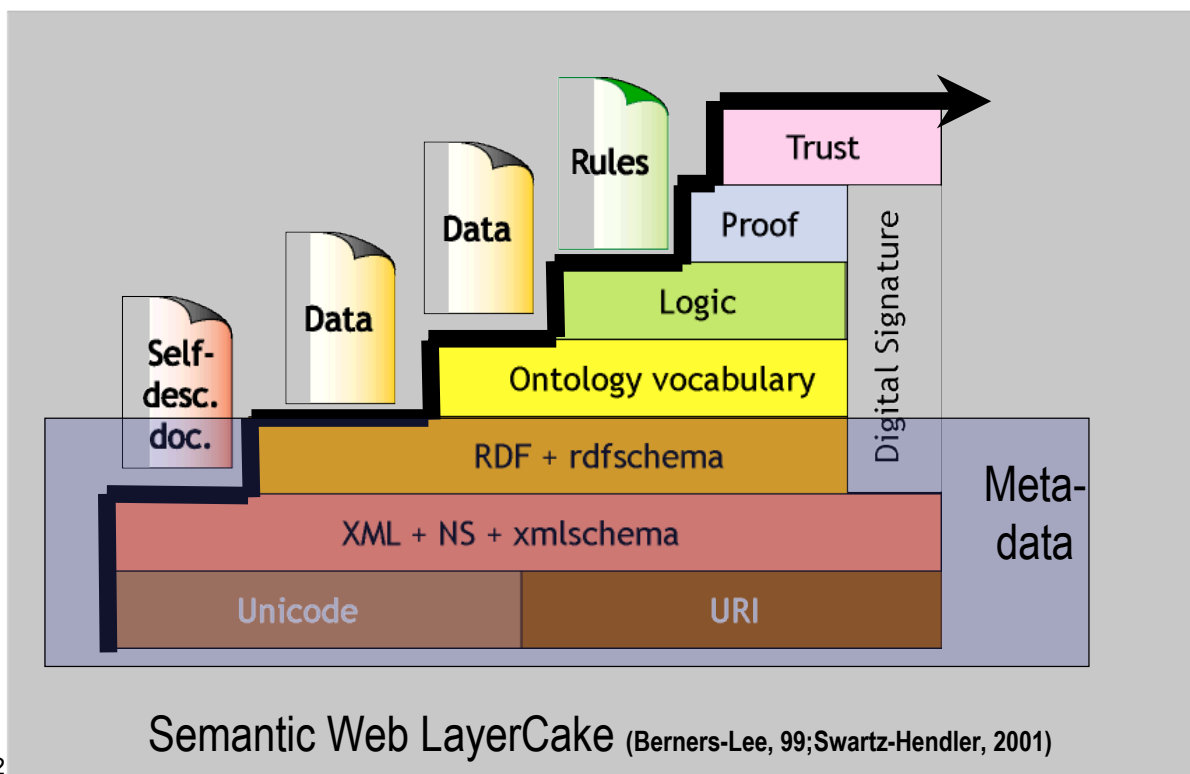
Bringing the web to its full potential



12.09.2005

5

Semantic Web Architecture



12

6

Contents

- Principles of Semantic Web
- Basic models and languages for Semantic Web
- XML
- RDF
- RDFS, OWL
- Examples



How is built the Semantic Web ?

- Semantic Web is built „on top“ of the current Web
- There exist already partial solutions to all layers of Semantic Web.
- Current challenges:
 - Integration
 - Standardisation
 - Tool development
 - Acceptance of the users
- Following technologies are of great importance in the Semantic Web development:
 - Explicit metadata
 - Ontologies
 - Logics (inference rules)
 - Agents

How will work the Semantic Web

- Metadata will be used for identification and extraction of information from web sources
- Ontologies will support the search mechanism through the interpretation of the retrieved information and the communication with other agents.
- Logics will serve to the processing of the retrieved information.

Languages for the Semantic Web

- XML - shallow Syntax für structured documents. The language cannot offer information about the semantics of the documents
- XML Schema - describes syntactic rules for the XML tags.
- RDF - is a data model for objects and relations between objects
- RDFS - describes properties of RDF objects and relations between RDF-objects zwischen RDF-Objekte
- OWL is a full developed language for ontologies

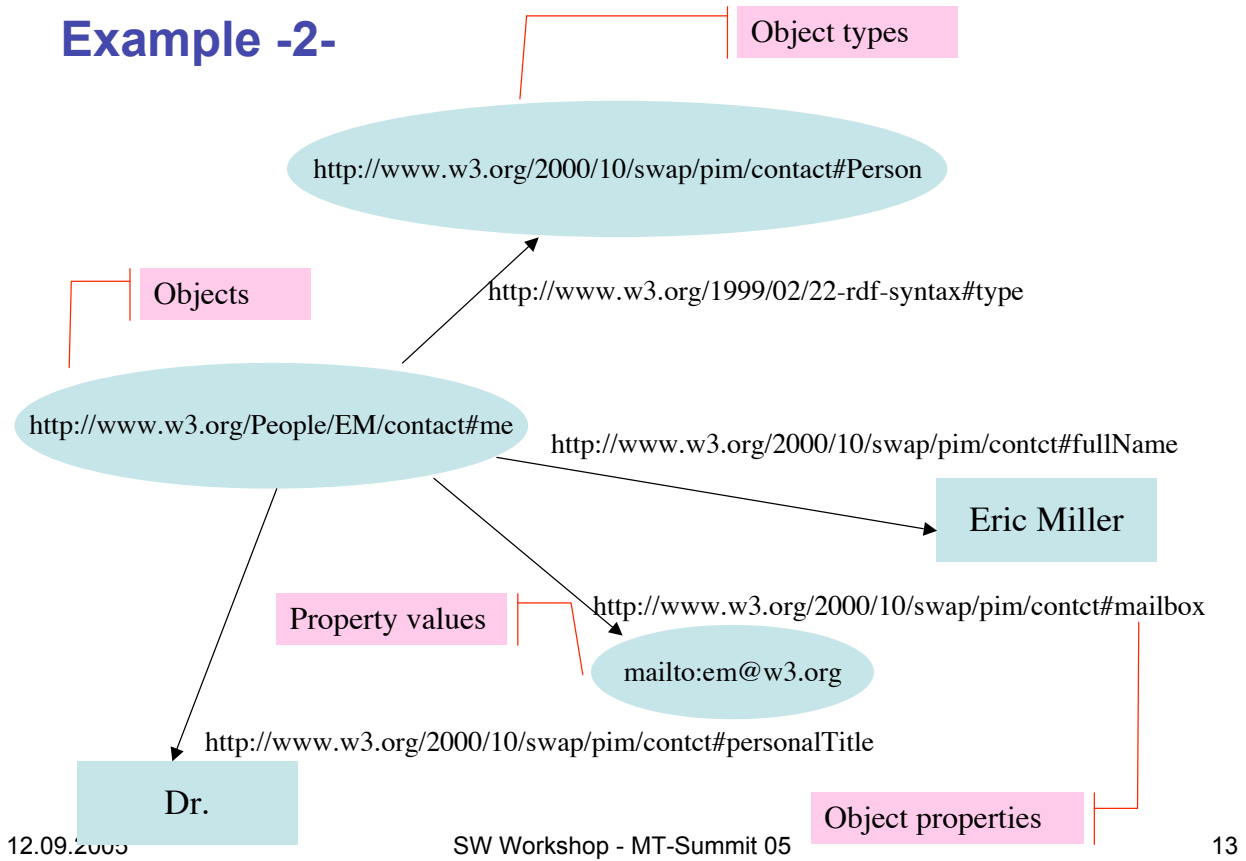
What is RDF ?

- RDF is a modelling language for the representation of information about web resources
- RDF describes web resources for a variety of machine processes.
- Ressources :
 - Have an unique identificator: the URI (Uniforme Resource Identifier)
 - Are described through properties and their values

Example -1-

- How can we represent the following expression:
„ there is a person which :
 - is identified by <http://www.w3.org/People/EM/contact#me>
 - has a name: Eric Miller
 - has an e-mail: em@w3.org
 - has a title: Dr.

Example -2-



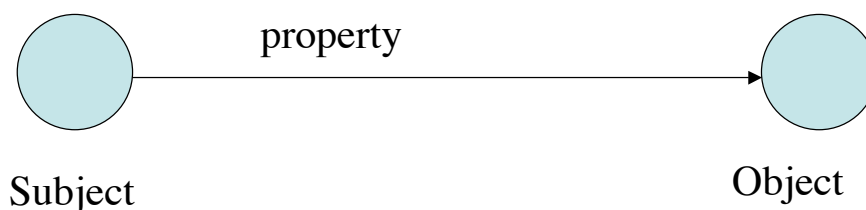
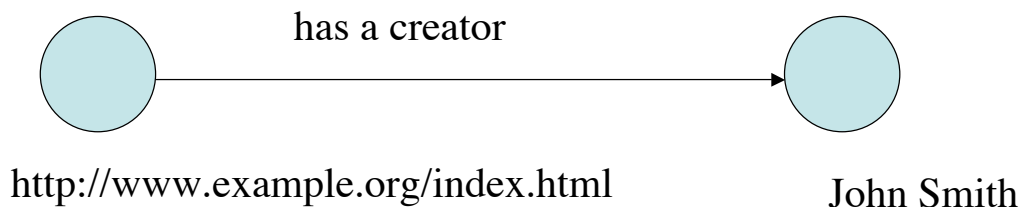
RDF/XML Syntax - Example

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-
  ns#
  xmlns:contact="http://www.w3.org/2000/10/swap/pim/contact#">
  <contact:Person
    rdf:about="http://www..w3.org/People/EM/contact#me"
    <contact:fullName>Eric Miller </contact:fullName>
    <contact:mailbox rdf:resource="mailto:em@w3.org"/>
    <contact:personalTitle>Dr.</contact:personalTitle>
  </contact:Person>
</rdf:RDF>
```

RDF: Statement about resources

- <http://www.example.org/index.html> has a creator whose value is John Smith
- Always an RDF-Triple contains
 - Something about the statement (<http://www.example.org/index.html>)- **Subject**
 - A property, (has a creator)- **Property / Predicate**
 - Value of the property (John Smith) - **Object**

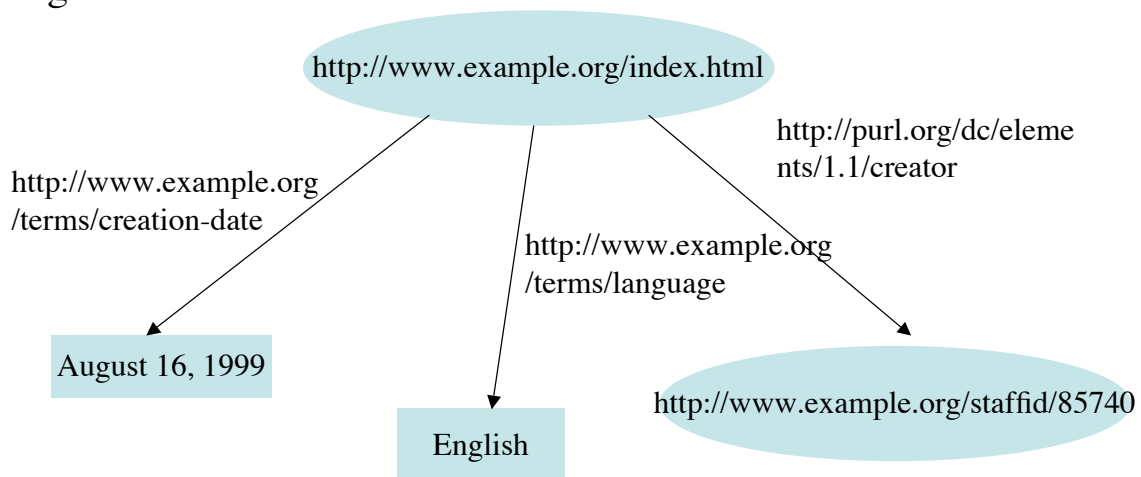
RDF Representation as a graph



Complex Examples

<http://www.example.org/index.html> has a creation-date whose value is August 16, 1999

<http://www.example.org/index.html> has a language whose value is English



12.09.2005

SW Workshop - MT-Summit 05

17

Why OWL ?

- XML DTD & XML Schema
 - Data exchange with predefined vocabulary
 - When dealing with a new XML-Vocabulary changes are required also when sometimes differences are trivial (e.g. synonyms))
- RDF und RDF Schema
 - Connection of terms through a simple semantics
 - Basic ontology language
 - The semantic of RDF- data is not transparent
 - RDFS cannot model real-world complex ontologies

12.09.2005

SW Workshop - MT-Summit 05

18

OWL-1-

- Development and exchange of ontologies
- Description language
- Exchange Syntax RDF/XML
- Elements
 - Taxonomical relations between classes
 - Properties and data types
 - Object properties (properties of individuals)
 - Instances of classes and properties

OWL -2-

- Collection of OWL-Statements and inference rules = Knowledge base (KB)
- Types of OWL:
 - OWL Lite
 - OWL DL
 - OWL Full

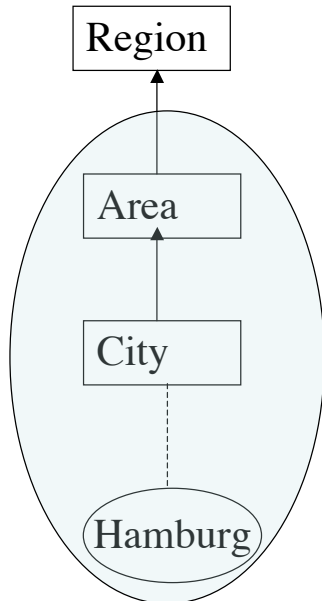
Header

- Header
 - Namespaces (rdf, rdfs, owl, dc, ...)
 - Comments
 - Version
 - Connection with other ontologies

Basic-Definitions -1-

- Labelling with rdf:ID
- Hierarchical classes
 - Class, subclassOf (rdfs)
 - `<owl:Class rdf:ID="Region"> ...`
- Individuals (elements)
 - Implicite Elements of owl:Thing
 - `<Region rdf:ID=...`
 - Thing (ordering to a class with `<owl:Thing rdf:about=...`)

Example



```
<owl:Class rdf:Id="Area"/>
```

```
<owl:Class rdf:ID="City">
```

```
  <rdfs:subclassOf rdf:resource="#Area"/>
```

```
</owl:class>
```

```
<City rdf:ID="Hamburg"/>
```

12.09.2005

SW Workshop - MT-Summit 05

23

Basis - Definitionen

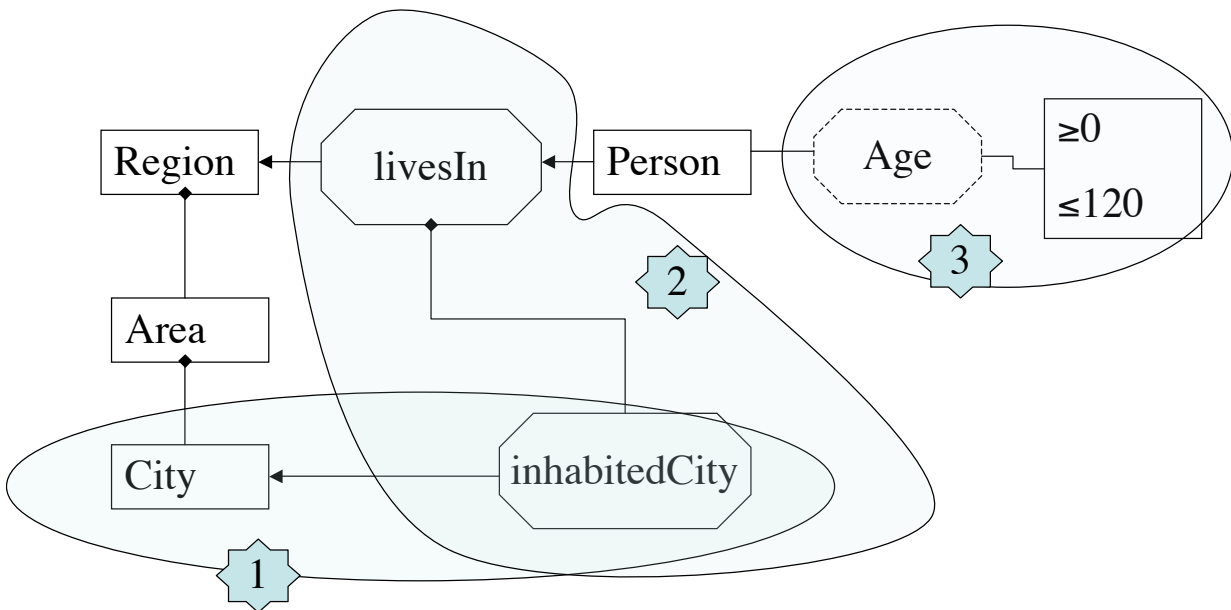
- Definition of properties
 - Object properties
 - ObjectProperty (hierarchical)
 - Domain (domain of definition)
 - Range (domain of values)
 - subPropertyOf (rdfs)
 - Rdf.resource (restriction of property)
 - Range
 - Datatype properties
 - DataTypeProperty
 - Domain
 - Range(domain of values, Strings or XML-Datatypes)

12.09.2005

SW Workshop - MT-Summit 05

24

Graph Example



12.09.2005

SW Workshop - MT-Summit 05

25

OWL Code Example

```
<owl:ObjectProperty rdf="lives In">  
  <rdfs:domain rdf:resource="#Person"/>  
  <rdfs:range rdf:resource="#Region"/>  
</owl:ObjectProperty>
```

1

```
<owl:ObjectProperty rdf:ID="inhabitedCity">  
  <rdfs:subPropertyOf rdf:resource="#livesIn"/>  
  <rdfs:range rdf:resource="City"/>  
</owl:ObjectProperty>
```

2

```
<owl:DatatypeProperty rdf:ID="age">  
  <rdfs:domain rdf:resource="#Person"/>  
  <rdfs:range rdf:resource="&dt;Age"/>  
</owl:DatatypeProperty>
```

3

12.09.2005

SW Workshop - MT-Summit 05

26

Basic Definitions -2

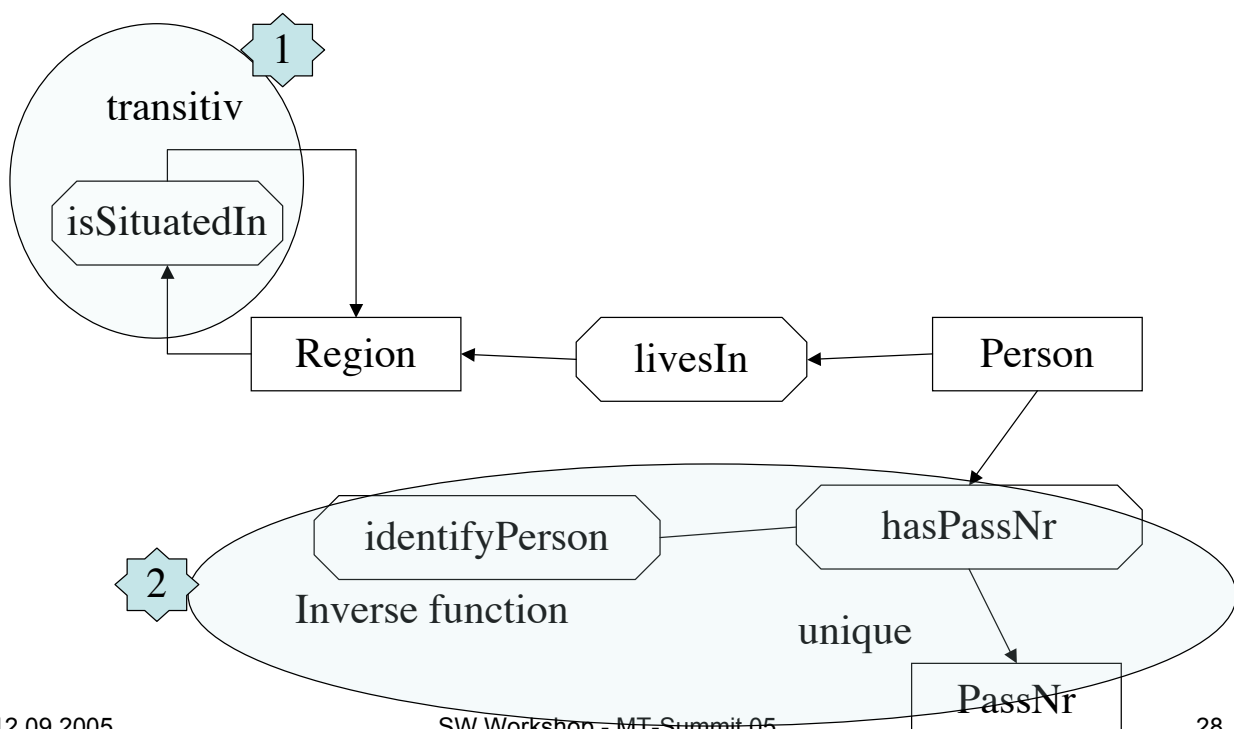
- For properties we can specify
 - <owl:TransitiveProperty rdf:ID=...
 - TransitiveProperty e.g. isSituatEdin
 - SymmetricProperty e.g. NeighbourOf
 - FunctionalProperty z.B. hasBirthday
 - inverseOf
 - <owl:inverseOf rdf:resource=“Object-Propertyt”/>....
 - e.g. producerOf and hasProducer
 - InverseFunctionalProperty
 - <owl:inverseFunctionalProperty rdf:ID=...”>
 - <owl:inverseOf rdf:resource=“Objectproperty”>...

12.09.2005

SW Workshop - MT-Summit 05

27

Beispiel-Graph



12.09.2005

SW Workshop - MT-Summit 05

28

OWL-Code example

```
<owl:TransitiveProperty rdf:ID="issituatedIn">
  <rdfs:domain rdf:resource="#Region"/>
  <rdfs:range rdf:resource="#Region"/>
</owl:TransitiveProperty>
```



```
<owl:FunctionalProperty rdf:ID="hasPassNr">
  <rdfs:domain rdf:resource="#Person"/>
  <rdfs:range rdf:resource="#PassNr"/>
</owl:FunctionalProperty>
```



```
<owl:inverseOf rdf:ID="identifyPerson">
  <owl:inverseOf rdf:resource="hasPassNr"/>
</owl:inverseOf>
```

Basic -Definitions-3-

- Restrictions of properties
 - <rdfs:subClassOf>
 - <owl:Restriction>
 - <owl:onProperty rdf:resource=""/>...
 - allValuesFrom, someValuesFrom <...rdf:resource="Property">...
 - Previous mechanisms are global
 - With owl we can make local restrictions
 - Correspond to All and Existence Quantor
 - Cardinality
 - minCardinality
 - maxCardinality
 - Cardinality
 - hasValue
 - Makes a constant from this property

Graph example



1

Exactly one



2

Values are only wine companies

OWL-Code example


```
<owl:ObjectProperty rdf:ID="producedBy">  
  <rdfs:domain rdf:resource="&owl:Thing"/>  
  <rdfs:range rdf:resource="&owl:Thing"/>  
</owl:ObjectProperty>
```

1

```
<owl:Class rdf:ID="Wine">  
  <rdfs:subclassOf>  
    <owl:Restriction>  
      <owl:onProperty rdf:resource="producedBy"/>  
      <owl:allValuesFrom rdf:resource="WineCompany"/>  
      <owl:cardinality>1</owl:cardinality>  
    </owl:Restriction>  
  </rdfs:subclassOf>  
</owl:Class>
```

2

Contents

- Principles of Semantic Web
- Basic models and languages for Semantic Web
 - XML
 - RDF
 - RDFS, OWL
- Examples 

Example : Description of historical and art Objects in museums

- The Documents (Text and Media) are annotated using the CIDOC-CRM Ontology
- Developed at ICS-FORTH- Heraklion- Crete (http://cidoc.ics.forth.gr/comprehensive_intro.html)
- Goal: Improved Information Retrieval across museums, both for Intranet and Internet activities

Protocol of Proceedings of Crimea Conference



Allied Leaders at Yalta

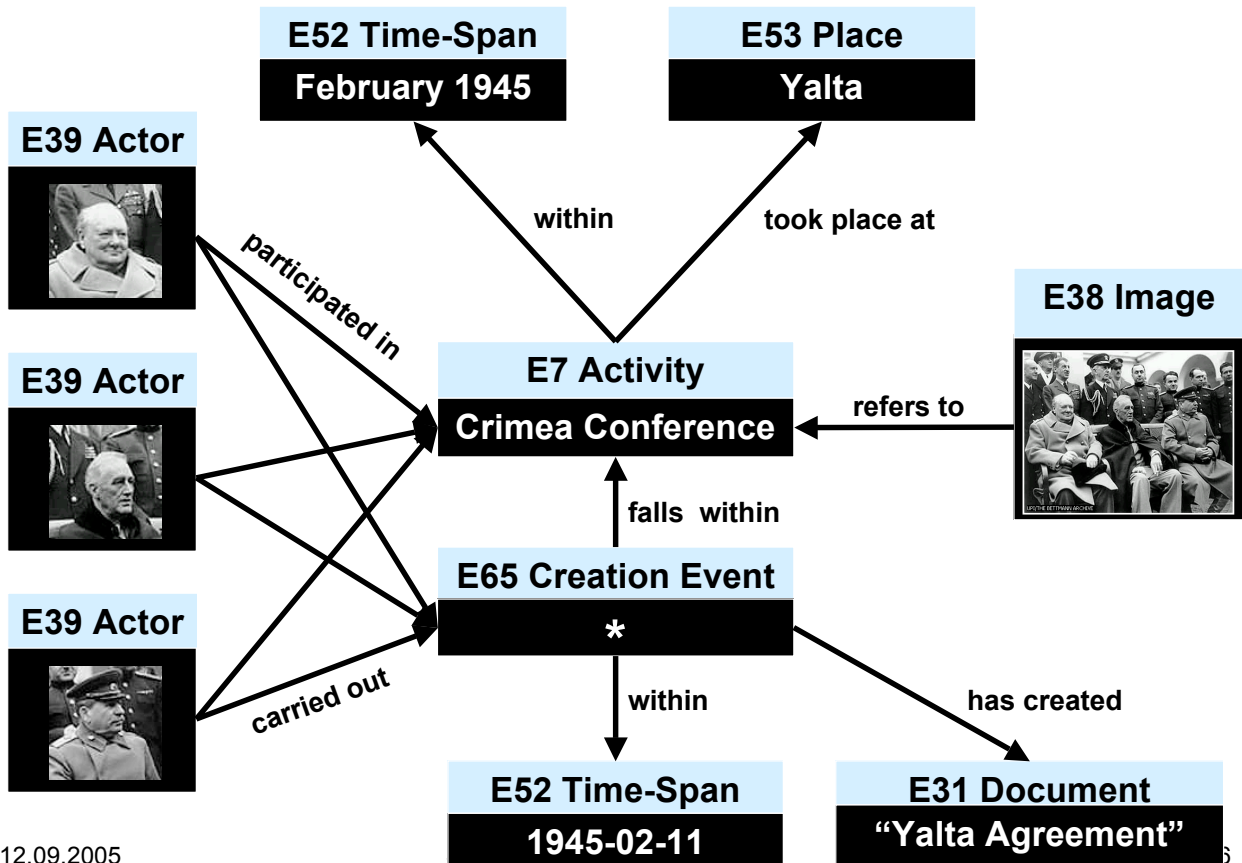
“The following declaration has been approved:

The Premier of the Union of Soviet Socialist Republics, the Prime Minister of the United Kingdom and the President of the United States of America have consulted with each other in the common interests of the people of their countries and those of liberated Europe. They jointly declare their mutual agreement to concert... and to ensure ...”

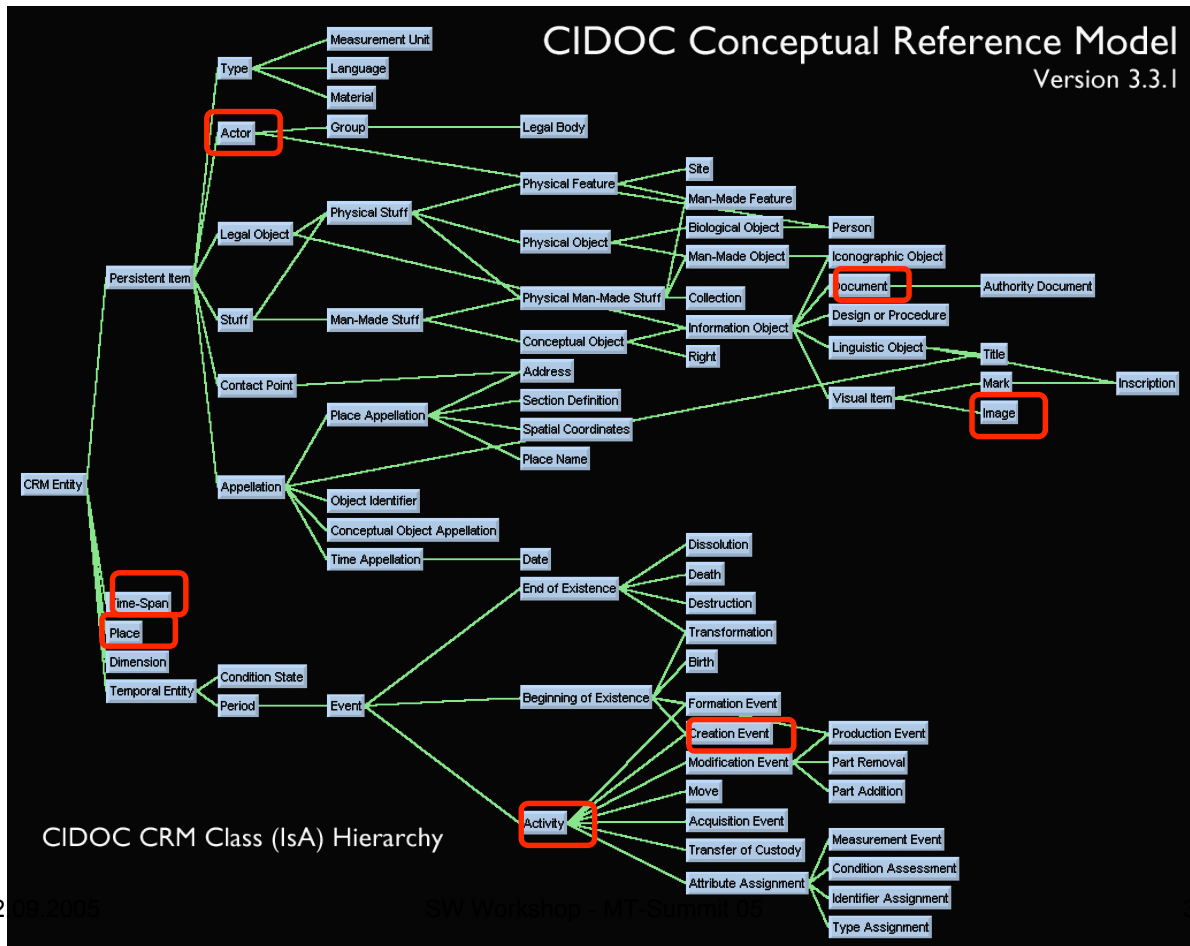
12.09.2005

SW Workshop - MT-Summit 05

35



12.09.2005



Class encoding in OWL -1-

```

<?xml version="1.0" ?>
<!--
CIDOC CRM v3.4.9 Encoded in OWL>
<rdf:RDF xml:lang="en"
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:owl="http://www.w3.org/2002/07/owl#">

  <owl:Class rdf:ID="E7.Activity">
    <rdfs:subClassOf rdf:resource="#E5.Event"/>
  </owl:Class>
  <owl:Class rdf:ID="E31.Document">
    <rdfs:subClassOf rdf:resource="#E73.InformationObject"/>
  </owl:Class>
  <owl:Class rdf:ID="E38.Image">
    <rdfs:subClassOf rdf:resource="#E36.VisualItem"/>
  </owl:Class>

```

Class encoding in OWL -2-

```
<owl:class rdf:ID=„E39.Actor“>
  <rdfs:subClassOf rdf:resource=#E77.Persistent_Item“/>
</owl:Class>
<owl:class rdf:ID=„E52.Time-Span“>
  <rdfs:subClassOf rdf:resource=#E1.CRM_Entity“/>
</owl:Class>
<owl:class rdf:ID=„E53.Place“>
  <rdfs:subClassOf rdf:resource=#E1.CRM_Entity“/>
</owl:Class>
<owl:class rdf:ID=„E65.Creation_Event“>
  <rdfs:subClassOf rdf:resource=#E7.Activity“/>
  <rdfs:subClassOf rdf:resource=#E63.Beginning_of_Existence“/>
</owl:Class>
```

Multiple inheritance

Properties encoding in OWL -1-

```
<owl:ObjectProperty rdf:ID=„P7F.took_place_at“>
  <rdfs:domain rdf:resource=#E4.Period“/>
  <rdfs:range rdf:resource=„E53.Place“/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID=„P10.falls_within“>
  <rdfs:domain rdf:resource=#E4.Period“/>
  <rdfs:range rdf:resource=„E4.Period“/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID=„P11B.participated_in“>
  <rdfs:domain rdf:resource=#E39.Actor“/>
  <rdfs:range rdf:resource=„E5.Event“/>
  <rdfs:subPropertyOf rdf:resource=„#P12B.was_present_at“/>
</owl:ObjectProperty>
```

Properties encoding in OWL -2-

```
<owl:ObjectProperty rdf:ID=„P67F.refers_to“>
  <rdfs:domain rdf:resource=#E73.Information_Object“/>
  <rdfs:range rdf:resource=„E1.CRM_Entity“/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID=„P86F.within“>
  <rdfs:domain rdf:resource=#E52.Time-Span“/>
  <rdfs:range rdf:resource=„E52.Time-Span“/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID=„P49F.has_created“>
  <rdfs:domain rdf:resource=#E65.Creation_event“/>
  <rdfs:range rdf:resource=„E38.Conceptual_Object“/>
  <rdfs:subPropertyOf rdf:resource=„P92F.brought_into_existence“/>
</owl:ObjectProperty>
```

Description of the document in RDF - Example

```
<?xml version=„1.0“?>
<rdf:RDF xml:lang=„en“
  xmlns:rdf=„http://www.w3.org/1999/02/22-rdf-syntax-ns#“
  xmlns:cidoc=„http://cidoc.ics.forth.gr/rdfs/cidoc_crm_v3.4.9.rdfs“
  <rdf:Description rdf:ID=„Winston Churchill“>
    <rdfs:type rdf:resource=„#E39.Actor“>
      <cidoc:P11B.participated_in>
        <rdf:Seq>
          <cidoc:E7.Activity rdf:ID=„Crimea Conference“>
            <cidoc:E65.Creation_event rdf:ID=„*“>
          </rdf:Seq>
        </cidoc: P11.Bparticipated_in>
      </rdf:Description>
```

E39 Actor



participated in

E7 Activity
Crimea Conference

