Introduction to Ontological Engineering

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- NeOn Methodology
  - Scenarios in Ontology Building
  - Guidelines for Ontology Specification
  - Quick Search of Existing Knowledge Resources
  - Ontology development project Planning
  - Non-Ontological Resource Reuse and Re-engineering
  - Ontology Reuse
  - Creating the Ontology Model
  - Localizing the Ontology
- Conclusions
Motivation

Ontological Resource Re-engineering

Non-Ontological Resource Re-engineering

Merging Ontological Resources

Ontological Resource Reuse

Localizing Ontological Resources

Non-Ontological Resource Reuse

Reusing Ontology Design Patterns

Restructuring Ontological Resources

Non-Ontological Re-engineering

Ontological Re-engineering

Classical
Motivation

In our team, we want to build an OWL ontology in the pharmaceutical domain, but we want to use several pharmaceutical standards in XML and classification schemes in our own format.
Motivation

In our team, we want to build an ontology about human resources management domain. The ontology should include information about occupations and activity sectors, data must be kept in the original DBs, and we want to have the ontology in several natural languages.
Building ontologies in the 90s

Methodologies for building single ontologies

- Uschold and King’s method
- Grüninger and Fox’s methodology
- KACTUS approach
- METHONTOLOGY
- SENSUS method
- On-To-Knowledge
- DILIGENT

Ontology learning approaches for building ontologies from structured, semi-structured and non-structured data

- Are not integrated with current methodologies
- Mainly from non-structured data using NLP techniques
Current situation

• Reuse of knowledge-aware resources
• Ontologies are built collaboratively
• Ontologies are connected in ontology networks
• Multilingual features
Ontology Support Activities: Knowledge Acquisition (Elicitation); Documentation; Configuration Management; Evaluation (V&V); Assessment
NeOn Methodology

Process and activities covered:
- Ontology Specification
- Scheduling
- Non-Ontological Resource Reuse
- Non-Ontological Resource Re-engineering
- Reuse General Ontologies
- Reuse Domain Ontologies
- Reuse Ontology Statements
- Reuse Ontology Design Patterns

All processes and activities are described with:
- A filling card
- A workflow
- Examples

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E. Montiel
G. Aguado
M. Espinoza
Looking for an European Employment
Helping Job Seekers on their way

LEGENDA
- Requester ES
- Responding ES
- ES not involved
- Job Seeker’s Candidacy
- Employer Job Vacancy
Key issues

• Reuse of proprietary knowledge-aware resources

• Heterogeneity
  – Terms are in different languages
  – Different conceptualization (different ways of organizing job categories)
  – Different DB schemas

• Data must be kept in the original sources and in their own language.
Key aspects of Ontological Engineering

- **Ontologies**
  - Single versus network of ontologies?
  - Are ontologies built from scratch or reusing knowledge-aware resources?
  - Are mappings used for solving conceptual mismatches?

- **Instances**
  - Where are the data/instances?
    - Instances are in the ontology
    - Instances are in RDF files independently of the ontology
    - Data are kept in the original sources
  - Are instances distributed or centralized?
  - Have instances a very high rate of changes?
  - Heterogeneous provenance of instances
  - Degrees of data quality
  - Permissions
Centralized network of ontologies where data are distributed

1. Build a reference ontology
2. Build mappings between the reference ontology and the data sources

Federated network of ontologies where data are distributed

1. Build a reference ontology for the domain
2. Build local ontologies
3. Build mappings between the core and local ontologies
4. Build mappings between the local ontologies and the data sources
Ontological Engineering

Knowledge Resources

Non Ontological Resources
- Glossaries
- Dictionaries
- Lexicons
- Classification Schemas
- Taxonomies
- Thesauri

Ontological Resources
- O. Design Patterns
- O. Repositories and Registries
  - Flogic
  - RDF(S)
  - OWL

Ontological Resource Reuse
- O. Aligning
- O. Merging

Ontological Resource Reengineering

Ontology Design Pattern Reuse

Ontology Restructuring (Pruning, Extension, Specialization, Modularization)

Ontology Support Activities: Knowledge Acquisition (Elicitation); Documentation; Configuration Management; Evaluation (V&V); Assessment

NeOn Methodology

RDF(S)
Flogic
OWL
## Ontology Requirement Specification Document Template

| 1 | Purpose | “Software developers and ontology practitioners should include in this slot the purpose of the ontology” |
| 2 | Scope | “Software developers and ontology practitioners should include in this slot the scope of the ontology” |
| 3 | Level of Formality | “Software developers and ontology practitioners should include in this slot the level of formality of the ontology” |
| 4 | Intended Users | “Software developers and ontology practitioners should include in this slot the intended users of the ontology” |
| 5 | Intended Uses | “Software developers and ontology practitioners should include in this slot the intended uses of the ontology” |
| 6 | Groups of Competency Questions | “Software developers and ontology practitioners should include in this slot the groups of competency questions and their answers, including priorities for each group” |
| 7 | Pre-Glossary of Terms | “Software developers and ontology practitioners should include in this slot the list of terms included in the CQs and their frequencies” |
|      | Objects | “Software developers and ontology practitioners should include in this slot a list of objects and their frequencies” |
## Ontology Specification

### Purpose

The purpose of building the Reference Ontology is to provide a consensual knowledge model of the employment domain that could be used by public e-Employment services (PES).

### Scope

The ontology has to focus just on the ICT (Information and Communication Technology) domain. The level of granularity is directly related to the competency questions and terms identified.

### Intended Users

1. Candidate who is unemployed and searching for a job or searching another occupation for immediate or future purposes
2. Employer who needs more human resources.
3. Public or private employment search service which offers services to gather CVs or job postings and to prepare some data and statistics.
4. National and Local Governments which want to analyze the situation on the employment market in their countries and prepare documents on employment, social and educational policy.
5. European Commission and the governments of EU countries which want to analyze the statistics and prepare international agreements and documents on the employment, social and educational policy.

### Intended Uses

1. Publish CV. Job seeker places his/her CV on the PES Portal.
5. Provide Job Statistics. The PES Portal provides employment statistics to the Job Seeker and Employer.
## Ontology Specification:

Identify requirements using competency questions

<table>
<thead>
<tr>
<th>N</th>
<th>Competency Questions</th>
<th>Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>CQ1 What is the Job Seeker Name?</td>
<td>Lewis Hamilton</td>
</tr>
<tr>
<td>3</td>
<td>CQ2 What is the Job Seeker nationality?</td>
<td>British; Spanish; Italian; French; German</td>
</tr>
<tr>
<td>4</td>
<td>CQ3 When is the Job Seeker birthday?</td>
<td>13/09/1984, 30/03/1970, 15/04/1978</td>
</tr>
<tr>
<td>5</td>
<td>CQ4 What is the Job Seeker contact information?</td>
<td>Programme, Computer Engineer, Computer Assistant</td>
</tr>
<tr>
<td>6</td>
<td>CQ5 What is the Job Seeker current job?</td>
<td>Radio engineer; Hardware designer; Software Engineer</td>
</tr>
<tr>
<td>7</td>
<td>CQ6 What is the Job Seeker desired job?</td>
<td>Autonomous, Seasonal Job, Traineeship, Consultant</td>
</tr>
<tr>
<td>8</td>
<td>CQ7 What are the Job Seeker desired working conditions?</td>
<td>Basic education; Higher education/University</td>
</tr>
<tr>
<td>9</td>
<td>CQ8 What kind of contract does the Job Seeker want?</td>
<td>3 months, 6 months, 1 year, 2 years, 3 years</td>
</tr>
<tr>
<td>10</td>
<td>CQ9 How much salary does the Job Seeker want to earn?</td>
<td>SQL programming, network administration</td>
</tr>
<tr>
<td>11</td>
<td>CQ10 What is the Job Seeker education level?</td>
<td>CEFRIEL Research Company, Milano, Italy</td>
</tr>
<tr>
<td>12</td>
<td>CQ11 What is the Job Seeker work experience?</td>
<td>Java Programmer, C Programmer, Database administration</td>
</tr>
<tr>
<td>13</td>
<td>CQ12 What is the Job Seeker knowledge?</td>
<td>3,600 euros, 3,000 USD, 2,000 euros</td>
</tr>
<tr>
<td>14</td>
<td>CQ13 What is the Job Seeker expertise?</td>
<td>Research, Financial, Education; Industrial</td>
</tr>
<tr>
<td>15</td>
<td>CQ14 What are the Job Seeker skills?</td>
<td>Sun Certified Java Programmer</td>
</tr>
<tr>
<td>16</td>
<td>CQ15 What publications does the Job Seeker have?</td>
<td>Full time; Part time; Autonomous; Seasonal Job;</td>
</tr>
<tr>
<td>17</td>
<td>CQ16 What hobbies does the Job Seeker have?</td>
<td>Basic education; Higher education/University</td>
</tr>
<tr>
<td>18</td>
<td>CQ17 What is the employer information?</td>
<td>1 year, 2 years, 3 years, 4 years, 5 or more years</td>
</tr>
<tr>
<td>19</td>
<td>CQ18 What kind of job does the employer offer?</td>
<td>Java, Object oriented design, Haskell, Windows</td>
</tr>
<tr>
<td>20</td>
<td>CQ19 What kind of contract does the employer offer?</td>
<td>ASP Programmer, Data warehouse, Hardware programming</td>
</tr>
<tr>
<td>22</td>
<td>CQ21 What is the economic activity of the employer?</td>
<td>4 years, 6 years, 7 years and 6 months</td>
</tr>
<tr>
<td>23</td>
<td>CQ22 What is the description of the job offer?</td>
<td>1 month, 6 months, 1 year, 2 years, 3 years</td>
</tr>
<tr>
<td>24</td>
<td>CQ23 What is the work condition of the job offer?</td>
<td>2001; March 1999, 23/10/1970</td>
</tr>
<tr>
<td>25</td>
<td>CQ24 What is the required education level for the job offer?</td>
<td>Basic education; Higher education/University</td>
</tr>
<tr>
<td>26</td>
<td>CQ25 What is the required work experience for the job offer?</td>
<td>1 year, 2 years, 3 years, 4 years, 5 or more years</td>
</tr>
<tr>
<td>27</td>
<td>CQ26 What is the required knowledge for the job offer?</td>
<td>Java, Object oriented design, Haskell, Windows</td>
</tr>
<tr>
<td>28</td>
<td>CQ27 What are the required skills for the job offer?</td>
<td>ASP Programmer, Data warehouse, Hardware programming</td>
</tr>
<tr>
<td>29</td>
<td>CQ28 When the Job Seeker completed his/her first degree?</td>
<td>2001; March 1999, 23/10/1970</td>
</tr>
<tr>
<td>30</td>
<td>CQ29 Is the Job Seeker older than 30 years?</td>
<td>4 years, 6 years, 7 years and 6 months</td>
</tr>
<tr>
<td>31</td>
<td>CQ30 How much time did the Job Seeker spend completing his/her first degree?</td>
<td>1 month, 6 months, 1 year, 2 years, 3 years</td>
</tr>
</tbody>
</table>
Ontology Specification: Group requirements.

Job Offer (10 CQ)
- General (24 CQ)
- SEEMP ReferenceOntology
- Competency Questions
- Job Seeker (16 CQ)
- Time and date (6 CQ)
- Currencies (4 CQ)

CQ17. What is the employer information?
CQ18. What kind of job does the employer offer?
CQ19. What kind of contract does the employer offer?
CQ20. How much salary does the employer offer?
CQ21. What is the economic activity of the employer?
CQ22. What is the description of the job offer?
CQ23. What is the work condition of the job offer?
CQ24. What is the required education level for the job offer?
CQ25. What is the required work experience for the job offer?
CQ26. What is the required knowledge for the job offer?
CQ27. What are the required skills for the job offer?

CQ28. Given the personal information (name, nationality, birth date, contact information) and the objectives (desired contract type, desired job, desired working conditions, desired salary) of the job seeker, what job offers are the most appropriate?
CQ29. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ30. Given the objectives (desired contract type, desired job, desired working conditions, desired salary) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ31. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ32. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ33. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ34. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ35. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ36. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ37. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
CQ38. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skills) of the job seeker, what job offers are the most appropriate?
Ontology Specification.
The Ontology Requirement Specification Document

| Purpose | The purpose of building the Reference Ontology is to provide a consensual knowledge model of the employment domain that could be used by public employment services (PES). |
| Scope | The ontology has to focus just on the ICT (Information and Communication Technology) domain. The level of granularity is directly related to the competency questions and terms identified. |
| Level of Formality | The ontology has to be implemented in WSMO language. |
| Intended Users | User 1: Candidate who is unemployed and searching for a job or searching another occupation for immediate or future purposes. User 2, User 3, User 4, User 5. |

### Pre-Glossary of Terms

<table>
<thead>
<tr>
<th>Terms</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Seeker</td>
<td>27</td>
</tr>
<tr>
<td>CV</td>
<td>2</td>
</tr>
<tr>
<td>Personal Information</td>
<td>3</td>
</tr>
<tr>
<td>Name</td>
<td>5</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
</tr>
<tr>
<td>Birth date</td>
<td>1</td>
</tr>
<tr>
<td>Address</td>
<td>2</td>
</tr>
<tr>
<td>Nationality</td>
<td>1</td>
</tr>
<tr>
<td>Contact (phone, fax, mail)</td>
<td>4</td>
</tr>
<tr>
<td>Objective</td>
<td>3</td>
</tr>
<tr>
<td>Job Category</td>
<td>6</td>
</tr>
<tr>
<td>Job Offer</td>
<td>27</td>
</tr>
<tr>
<td>Employer Information</td>
<td>1</td>
</tr>
<tr>
<td>Vacancy</td>
<td>1</td>
</tr>
<tr>
<td>Activity Sector</td>
<td>1</td>
</tr>
<tr>
<td>Location</td>
<td>3</td>
</tr>
<tr>
<td>Work Condition</td>
<td>3</td>
</tr>
<tr>
<td>Contract Type</td>
<td>3</td>
</tr>
<tr>
<td>Salary</td>
<td>3</td>
</tr>
<tr>
<td>Education</td>
<td>3</td>
</tr>
<tr>
<td>Work Experience</td>
<td>3</td>
</tr>
</tbody>
</table>

### Objects in the Universe of Discourse, Which are Instances of:

- **Job Category**
  - 01 Computer System Designer
  - 02 Computer System Analyst
  - 03 Programmer
  - 04 Computer Engineer
  - 05 Computer Assistant
  - 06 Computer Equipment Operator
  - 07 Industrial Robot Controller
  - 08 Telecommunication Equipment Operator
  - 09 Medical Equipment Operator
  - 10 Electronic Equipment Operator
  - 11 Image Equipment Operator

- **Nationality**
  - 012 Austrian
  - 013 Belgian
  - 014 Danish
  - 015 Estonian
  - 016 Finnish
  - 017 French
  - 018 German
  - 019 Greek
  - 020 Italian

- **Activity Sector**
  - 021 Telecommunication
  - 022 Justice and Judicial
  - 023 Public Security and Law
  - 024 Manufacturing of machine tools
  - 025 Research and Development
  - 026 Hardware Consultancy
  - 027 Software Consultancy and Supply
  - 028 Data processing

- **Education**
  - 029 Life Science
  - 030 Mathematics
  - 031 Computer Science
  - 032 Computer Use
  - 033 Statistics
  - 034 Physics
  - 035 Network Administration

- **Languages**
  - 036 Swedish
  - 037 Spanish
  - 038 Slovenian
  - 039 Portuguese
  - 040 English
  - 041 French
  - 042 German

- **Currency**
  - 043 Euro
  - 044 Krones
  - 045 Great British Pound
  - 046 Zloty
  - 047 US Dollar
  - 048 Franc

- **Location**
  - 049 Austria
  - 050 Belgium
  - 051 Denmark
  - 052 Estonia
  - 053 Finland
  - 054 France
  - 055 Germany
  - 056 Greece

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Ontology Support Activities: Knowledge Acquisition (Elicitation); Documentation; Configuration Management; Evaluation (V&V); Assessment

Non Ontological Resources:
- Glossaries
- Dictionaries
- Lexicons
- Classification
- Taxonomies
- Thesauri

Ontological Resources:
- O. Design Patterns
- O. Repositories and Registries
- Flogic
- RDF(S)
- OWL

Ontological Resource Reuse
- O. Aligning
- O. Merging

Ontological Resource Reengineering
- Alignments

Ontology Design Pattern Reuse

Ontology Restructuring (Pruning, Extension, Specialization, Modularization)

O. Specification Scheduling
- O. Conceptualization
- O. Formalization
- O. Implementation

O. Localization
Searching Resources

- Use the terminology from the ORSD
- Find resources covering the terminology

Where:
- Internet
- Standardization bodies (ISO, …)
- Intranet of the organization
- Ontology Registries
<table>
<thead>
<tr>
<th>Term</th>
<th>BT</th>
<th>NT</th>
<th>RT</th>
<th>UF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Cereals</td>
<td>Broken rice</td>
<td>Rice straw</td>
<td>Paddy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Basmati rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oryza</td>
<td>Poaceae</td>
<td>Oryza sativa</td>
<td>Rice fields</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oryza perennis</td>
<td>Cereal crops</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oryza rufipogon</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oryza longistaminata</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wetland rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oryza glaberrima</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upland rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oryza punctata</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Thesaurus**

**Implicit knowledge coded in numbers**

XX-YY-ZZ
02-01-02
02: transportation
01: road
02: 3-lines highway
## Ontological Engineering

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**ISO 4217 (currencies)**

<table>
<thead>
<tr>
<th>Entity</th>
<th>Currency</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFGHANISTAN</td>
<td>Afghani</td>
<td>AFG</td>
</tr>
<tr>
<td>ALBANIA</td>
<td>Lek</td>
<td>ALL</td>
</tr>
<tr>
<td>ALGERIA</td>
<td>Algerian Dinar</td>
<td>DZD</td>
</tr>
<tr>
<td>AMERICAN SAMOA</td>
<td>US Dollar</td>
<td>USD</td>
</tr>
<tr>
<td>ANDORRA</td>
<td>Euro</td>
<td>EUR</td>
</tr>
<tr>
<td>ANGOLA</td>
<td>Kwanzá</td>
<td>AOA</td>
</tr>
<tr>
<td>ANGUILLA</td>
<td>East Caribbean Dollar</td>
<td>XCD</td>
</tr>
<tr>
<td>ANTARCTICA</td>
<td>No universal currency</td>
<td></td>
</tr>
<tr>
<td>ANTIGUA AND BARBUDA</td>
<td>East Caribbean Dollar</td>
<td>XCD</td>
</tr>
<tr>
<td>ARGENTINA</td>
<td>Argentine Peso</td>
<td>ARS</td>
</tr>
<tr>
<td>ARMENIA</td>
<td>Armenian Dram</td>
<td>AMD</td>
</tr>
<tr>
<td>ARUBA</td>
<td>Arabian Dinar</td>
<td>AWG</td>
</tr>
<tr>
<td>AUSTRALIA</td>
<td>Australian Dollar</td>
<td>AUD</td>
</tr>
<tr>
<td>AUSTRIA</td>
<td>Euro</td>
<td>EUR</td>
</tr>
<tr>
<td>AZERBAIJAN</td>
<td>Azerbaijani Manat</td>
<td>AZN</td>
</tr>
<tr>
<td>BAHAMAS</td>
<td>Bahamian Dollar</td>
<td>BSD</td>
</tr>
<tr>
<td>BAHRAIN</td>
<td>Bahraini Dinar</td>
<td>BBD</td>
</tr>
<tr>
<td>BANGLADESH</td>
<td>Taka</td>
<td>BDT</td>
</tr>
<tr>
<td>BARBADOS</td>
<td>Barbados Dollar</td>
<td>BB$</td>
</tr>
<tr>
<td>BELARUS</td>
<td>Belarusian Ruble</td>
<td>BYR</td>
</tr>
</tbody>
</table>

---

**ISO 3166 (countries)**

```xml
<?xml version="1.0" encoding="ISO 8859-1" standalone="yes"?>
<ISO_3166_1_list xml:lang="en">
  <ISO_3166_1 Entry>
    <ISO_3166_1 Country_name>AFGHANISTAN</ISO_3166_1 Country_name>
    <ISO_3166_1 Alpha_2_Code_element>Af</ISO_3166_1 Alpha_2_Code_element>
  </ISO_3166_1 Entry>
  ...
</ISO_3166_1_list>
```

---

© A Method for Reusing and Re-engineering Non-Ontological Resources for Building Ontologies
Ontology Support Activities: Knowledge Acquisition (Elicitation); Documentation; Configuration Management; Evaluation (V&V); Assessment
Selection of Ontologies

• Search ontologies
• Compare ontologies in the same domain using a set of criteria
• Assess if the ontologies cover the set of competency questions
• Select the best ontology based on
  – Coverage of the domain
  – Expressivity of the Implementation language
The NeOn methodology includes guidelines for reusing statements
Gantt chart for your project. Waterfall model
Reuse and Re-engineering + Incremental
Motivation

I want to transform my adjacency list-based classification into an ontology.
Non-Ontological Resources are knowledge-aware resources whose semantics have not been formalized yet by means of an ontology.

- Glossary
- Dictionary
- Lexicon
- Classification Scheme
- Thesaurus
- Folksonomy
- Type of non-ontological resource
- Path Enumeration
- Adjacency List
- Data model
- Snowflake
- Flattened
- Database
- XML File
- Implementation
- Classification scheme modeled using a Path Enumeration model and stored in a database.
- Resource 1
- Resource 2
- Classification scheme modeled using a Path Enumeration model and stored in an XML file.
Types of non-ontological resources

<table>
<thead>
<tr>
<th>Id</th>
<th>Category Name</th>
<th>Parent</th>
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<td>20000</td>
<td>Water area</td>
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<tr>
<td>20000.21000</td>
<td>Environmental area</td>
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</tr>
<tr>
<td>20000.22000</td>
<td>Fishing Statistical area</td>
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<td>20000.24020</td>
<td>Jurisdiction area</td>
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<tr>
<td>21000.21001</td>
<td>Inland/marine</td>
<td>21000</td>
</tr>
<tr>
<td>21000.21002</td>
<td>Ocean</td>
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</tr>
<tr>
<td>21000.21003</td>
<td>North/South/Equatorial</td>
<td>21000</td>
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<tr>
<td>21000.21004</td>
<td>Sub Ocean</td>
<td>21000</td>
</tr>
<tr>
<td>21000.21005</td>
<td>Large Marine ecosystem</td>
<td>21000</td>
</tr>
</tbody>
</table>
Approaches to transform resources into ontologies

ABox

Transforming resource schema into an ontology schema, and resource content into ontology instances

TBox

Transforming resource content into an ontology schema

Population

Transforming resource content into instances of an existing ontology
Approach for Re-engineering Non-Ontological Resources

Patterns for Reengineering Non Ontological Resources (PR-NOR)

Reverse Engineering
- Conceptual
- Requirements
- Design
- Implementation

Transformation

Forward Engineering
- Specification
- Conceptualization
- Formalization
- Implementation

Non Ontological Resource

Ontology
PR-NOR library at the ODP Portal

Submissions: Re-engineering ODPs

Below you find the currently proposed Re-engineering ODPs (RP). New proposals of RPs are very welcome. Please post a new proposal if you want to contribute.

Proposed Re-engineering ODPs

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Intent</th>
<th>Submitted by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-engineering a classification scheme, which follows the adjacency list data model, into an ontology schema.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
<tr>
<td>Re-engineering a classification scheme, which follows the flattened model, into an ontology schema.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
<tr>
<td>Re-engineering a classification scheme which follows the path enumeration data model to design an ontology schema.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
<tr>
<td>Re-engineering a classification scheme, which follows the snowflake model, to design an ontology schema.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
<tr>
<td>Re-engineering a term-based thesaurus which follows the record-based data model into an ontology schema.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
<tr>
<td>Re-engineering a term-based thesaurus, which follows the relations-based model, to design an ontology schema.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
<tr>
<td>Re-engineering a term-based thesaurus which follows the record-based model to design a lightweight ontology.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
<tr>
<td>The semantics of the relation between narrower and broader terms are subclassOf.</td>
<td></td>
<td>Bori Vilazón-Terrazas</td>
</tr>
</tbody>
</table>

NOR2O: a Library for Transforming Non-Ontological Resources to Ontologies

http://mccarthy.dia.fi.upm.es/nor2o/

Ontological Engineering

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Pattern based approach for re-engineering non ontological resources

ISCO-88 (COM)
International Standard Classification of Occupations
(for European Union purposes)

FOET
Classification of fields of education and training

NACE
Statistical Classification of Economic Activities in the European Community

ISO 3166
English country names and code elements

ISTAT
Italian Geography Standard
Knowledge Resource Re-engineering and Aggregation

ISO 3166-1 (XML)

```xml
<ISO_3166-1_Entry>
  <ISO_3166-1_Country_name>SPAIN</ISO_3166-1_Country_name>
  <ISO_3166-1_Alpha-2_Code_element>ES</ISO_3166-1_Alpha-2_Code_element>
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Regions Table (Eures Oracle DB)

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<tbody>
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<td>109</td>
<td>ES</td>
<td>Cataluña</td>
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<tr>
<td>101</td>
<td>ES</td>
<td>Canarias</td>
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<tr>
<td>102</td>
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<td>Galicia</td>
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<td>103</td>
<td>ES</td>
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<td>105</td>
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<td>106</td>
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<tr>
<td>108</td>
<td>ES</td>
<td>Aragon</td>
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</tbody>
</table>

Ontology model

```
<rdf Description rdf:about="webode:mccarthy:dia.fi.upm.es/Geography_Ontology#Country_SPAIN"> 
  <Geo:Ont:Name rdf:datatype="http://www.w3.org/2001/XMLSchema#string">SPAIN</Geo:Ont:Name>
  <Geo:Ont:isLocatedIn:Continent rdf:resource="webode:mccarthy:dia.fi.upm.es/Geography_Ontology#EU_Europe"/>
  <Geo:Ont:hasRegion РФ rdf:resource="webode:mccarthy:dia.fi.upm.es/Geography_Ontology#Galicia"/>
  <Geo:Ont:hasRegion РФ rdf:resource="webode:mccarthy:dia.fi.upm.es/Geography_Ontology#Canarias"/>
  <Geo:Ont:hasRegion РФ rdf:resource="webode:mccarthy:dia.fi.upm.es/Geography_Ontology#Cataluna"/>
</rdf Description>
```

Excerpt of the Geography Ontology

Ontology instances

- Spain
- Cataluña
- Canarias
- Galicia
- Andalucía

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Ontological Engineering

Ontology Support Activities: Knowledge Acquisition (Elicitation); Documentation; Configuration Management; Evaluation (V&V); Assessment

Ontology Restructuring (Pruning, Extension, Specialization, Modularization)

NeOn Scenarios

Ontological Resource Reengineering

Ontological Resource Reuse

O. Specification

O. Conceptualization

O. Formalization

O. Implementation

O. Localization

Non Ontological Resources

Glossaries

Dictionaries

Lexicons

Classification Schemas

Taxonomies

Thesauri

Ontological Resources

O. Design Patterns

O. Repositories and Registries

Flogic

RDF(S)

OWL

Ontology Restructuring (Pruning, Extension, Specialization, Modularization)

Ontology Design Pattern Reuse

Non Ontological Resource Reuse

Non Ontological Resource Reengineering

Ontology Restructuring (Pruning, Extension, Specialization, Modularization)

Ontology Design Pattern Reuse

Ontology Design Pattern Reuse

Ontology Design Pattern Reuse
Ontological Resource Reuse Process

Identify type of terms from ORSD

Which type?
- General or Common terms
- Domain terms

Reuse general or common ontologies

Reuse domain ontologies

Whole Ontology

Which level of granularity?
- Ontology Statements
- Ontology Modules
- Ontology Statements

Reuse ontologies

Reuse ontology modules

Reuse ontology statements

Set of ontologies

Set of ontology modules

Set of ontology statements
Ontology Support Activities: Knowledge Acquisition (Elicitation); Documentation; Configuration Management; Evaluation (V&V); Assessment
Conceptualization:
Modular approach for ontology construction

- Reusability
  - Application
    - Domain O.: Job Seeker, Job Offer
  - Domain O.: Economic Activity, Occupation, Education, Skill, Driving License, Compensation, Labour Regulatory, Competence
  - General/Common Ontologies: Time, Geography, Language
  - Representation Ontology: WSML

- Usability
  - Representation Ontology: WSML
  - General/Common Ontologies: Time, Geography, Language
  - Domain O.: Economic Activity, Occupation, Education, Skill, Driving License, Compensation, Labour Regulatory, Competence
  - Application
    - Domain O.: Job Seeker, Job Offer
  - Reusability
Ontology Support Activities: Knowledge Acquisition (Elicitation); Documentation; Configuration Management; Evaluation (V&V); Assessment

Non Ontological Resources
- Glossaries
- Dictionaries
- Lexicons
- Classification Schemas
- Taxonomies
- Thesauri

Non Ontological Resource Reuse

Non Ontological Resource Reengineering

Knowledge Resources
- Ontological Resources
- Ontological Resource Reengineering
- Ontological Resource Reuse
- Ontological Resource

Ontological Resources
- O. Design Patterns
- O. Repositories and Registries
- O. Aligning
- O. Merging

Ontology Design Pattern Reuse

Ontology Design

Ontology Restructuring
- (Pruning, Extension, Specialization, Modularization)

Ontology Restructuring

Ontology Localization

Ontology Specification Scheduling

Ontology Conceptualization

Ontology Formalization

Ontology Implementation

Alignments

RDF(S)

OWL

Flogic

NeOn Methodology

1, 2, 3, 4, 5, 6, 7, 8, 9
Ontology Localization

**Definition**
Ontology localization refers to the adaptation of an ontology to particular language and culture.

**Goal**
To translate an ontology expressed in a source natural language into a target natural language.

**Input**
An ontology whose ontology terms are expressed in one or several natural languages, from which one is selected as source natural language.

**Output**
An ontology whose ontology terms have been translated to the target natural language. The resulting translations are added to available labels of the original ontology already in one or several languages.

**Who**
Software developers and ontology practitioners, who form part of the ontology development team, in collaboration with domain and linguistic experts.

**When**
Once the conceptual model of the ontology is stable, with the aim of avoiding spending time and resources in a model that is not definitive.
LabelTranslator NeOn plugin
Conclusions

1. The NeOn methodology gives
   1. detailed guidelines for building ontologies
   2. facilitates the reuse and reengineering of non-ontological resources into ontologies

2. The reuse of non-ontological resources that have been reached some degree of consensus in a community allows the development of ontologies easier and quicker
NeOn Book

NeOn Methodology in a Nutshell

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
</tr>
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<tbody>
<tr>
<td>Introduction</td>
<td>Asunción Gómez-Pérez, Enrico Motta, Mari Carmen Suárez-Figueroa</td>
</tr>
<tr>
<td>Definition of Ontology Networks</td>
<td>Mathieu d'Aquin, Aldo Gangemi, Peter Haase</td>
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<tr>
<td>NeOn Methodology Frameworks:</td>
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<tr>
<td>Samarium for Building Ontology Networks and</td>
<td>Mari Carmen Suárez-Figueroa, Asunción Gómez-Pérez</td>
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<tr>
<td>Glossary of Processes and Activities</td>
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<tr>
<td>Collection of Ontology Life Cycle Models</td>
<td>Asunción Gómez-Pérez, Mari Carmen Suárez-Figueroa, Mariano Fernández-López</td>
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<td>Methodology guidelines</td>
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<td>Ontology Requirements Specification</td>
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http://www.neon-project.org/nw/NeOn_Book
22 Executive Chapter Summaries are available at the NeOn Web Site