NeOn Methodology for Building Ontologies

http://www.neon-project.org/nw/NeOn_Book

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- **NeOn Methodology**
  - Scenarios in Ontology Building
  - Methodological Guidelines for Ontology Specification
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  - Guidelines for Ontology development project Planning
  - Methodological Guidelines for Non-Ontological Resource Reuse and Re-engineering
  - Methodological Guideliness for Ontology Reuse
  - Creating the final Ontology Model
  - Localizing the Ontology
- Conclusions

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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

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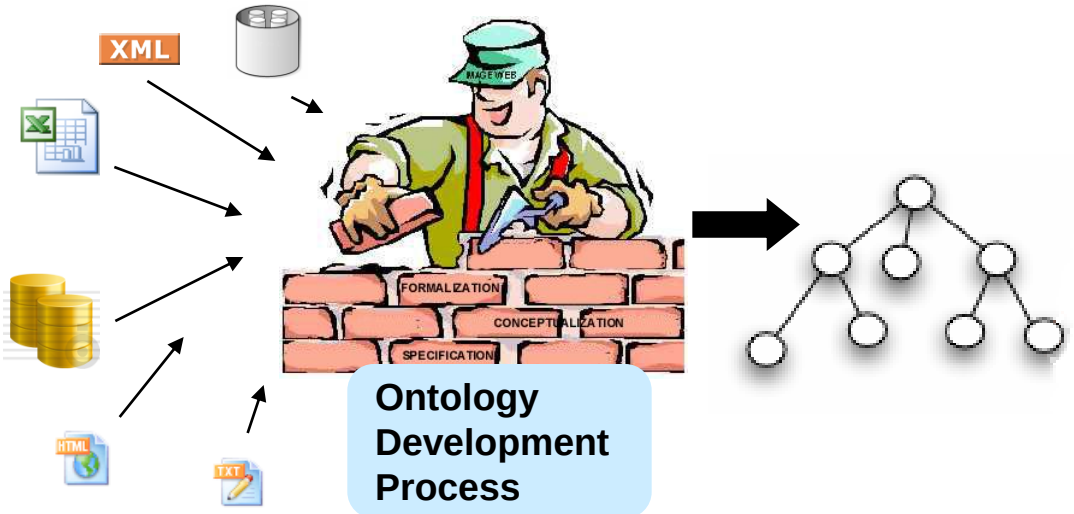
Current situation

- Reuse of knowledge-aware resources
- Ontologies are built collaboratively
- Ontologies are connected in ontology networks
- Multilingual features



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Looking for an European Employment

EURES ES (Int)

Lombard ES (It)

Catalonia ES (Es)

Private ES (Int)

Wallonia ES (Be)

p ES, q ES, r ES, a ES, b ES, c ES, d ES, f ES, h ES, i ES, m ES, n ES

Cand. Vacan.

LEGENDA

- ES — Employment Service
- Cand. — Job Seeker's Candidacy
- Vacan. — Employer Job Vacancy

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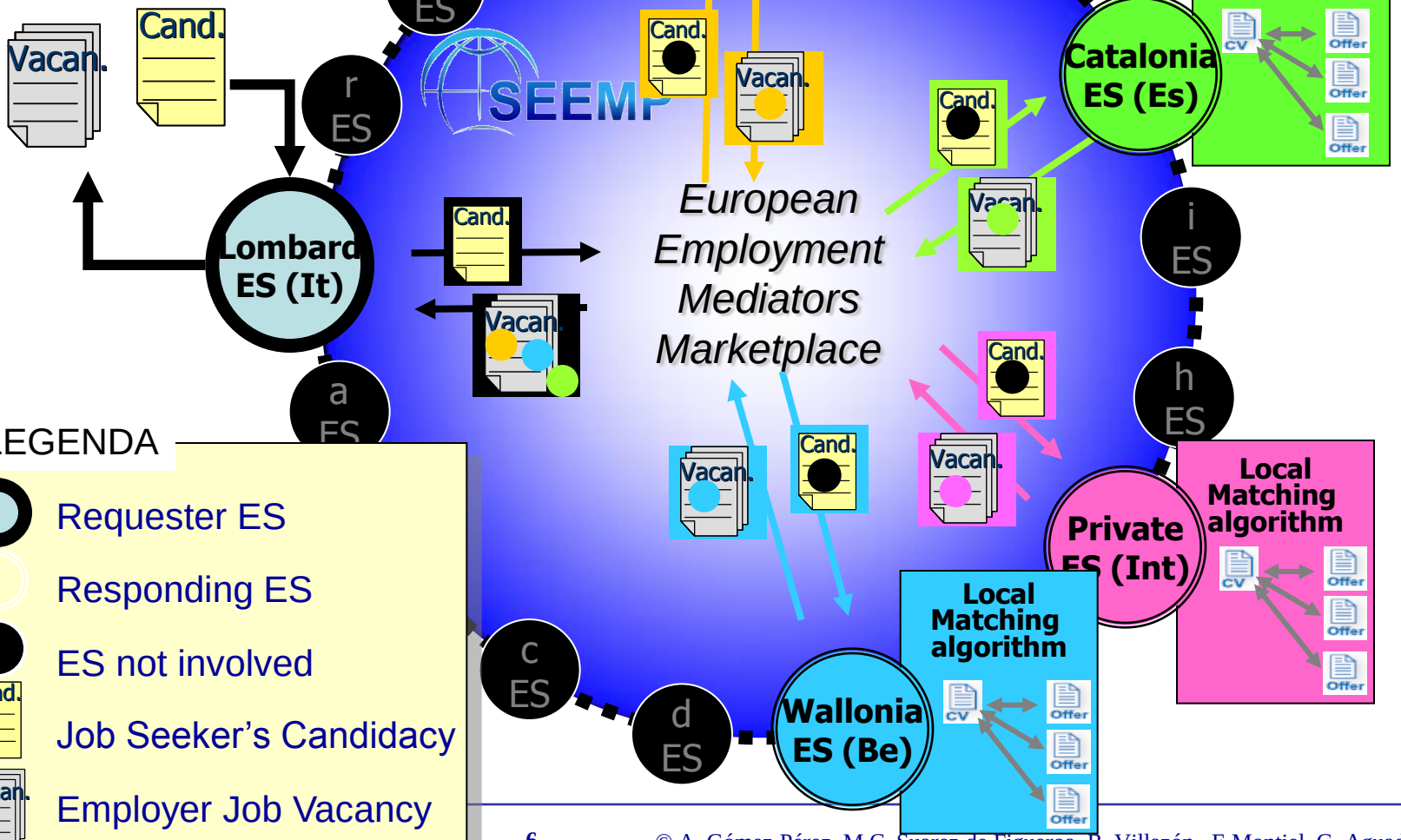
Helping Job Seekers on their way



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Planning and scheduling the ontology development

In our team, we want to build an ontology human resources management domain. ontology should include information ab occupations and activity sectors, data must be k in the original DBs, and we want to have tology in seve atural languages.

Classical

Ontology

Mappings

Ontology-DB mapping

Ontological Resource Reuse

Re-engineering Non-ontological resources

Localizing Ontological Resources

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.

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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 mistmaches?
- 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

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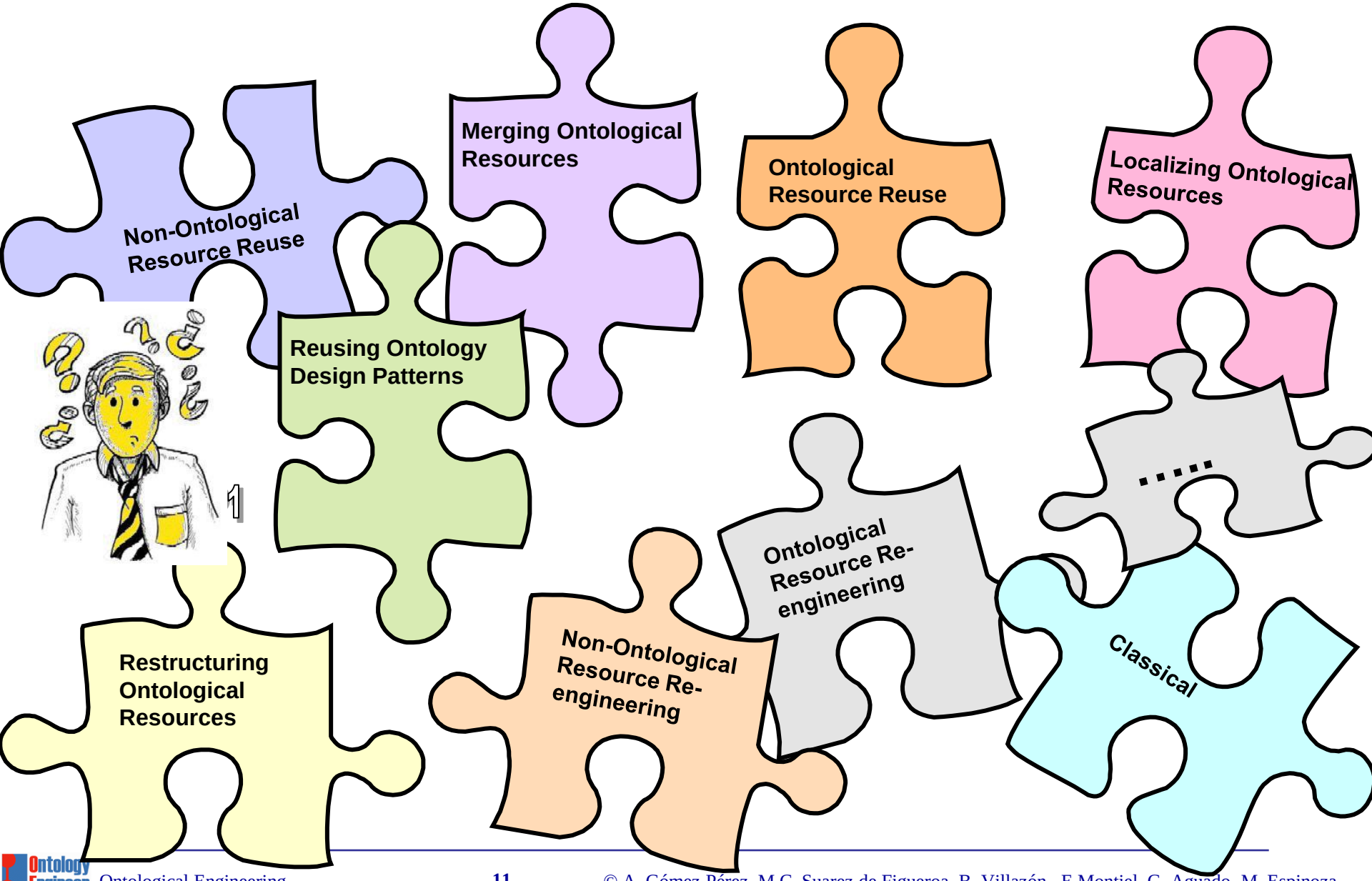
Which are the Processes and Activities needed?



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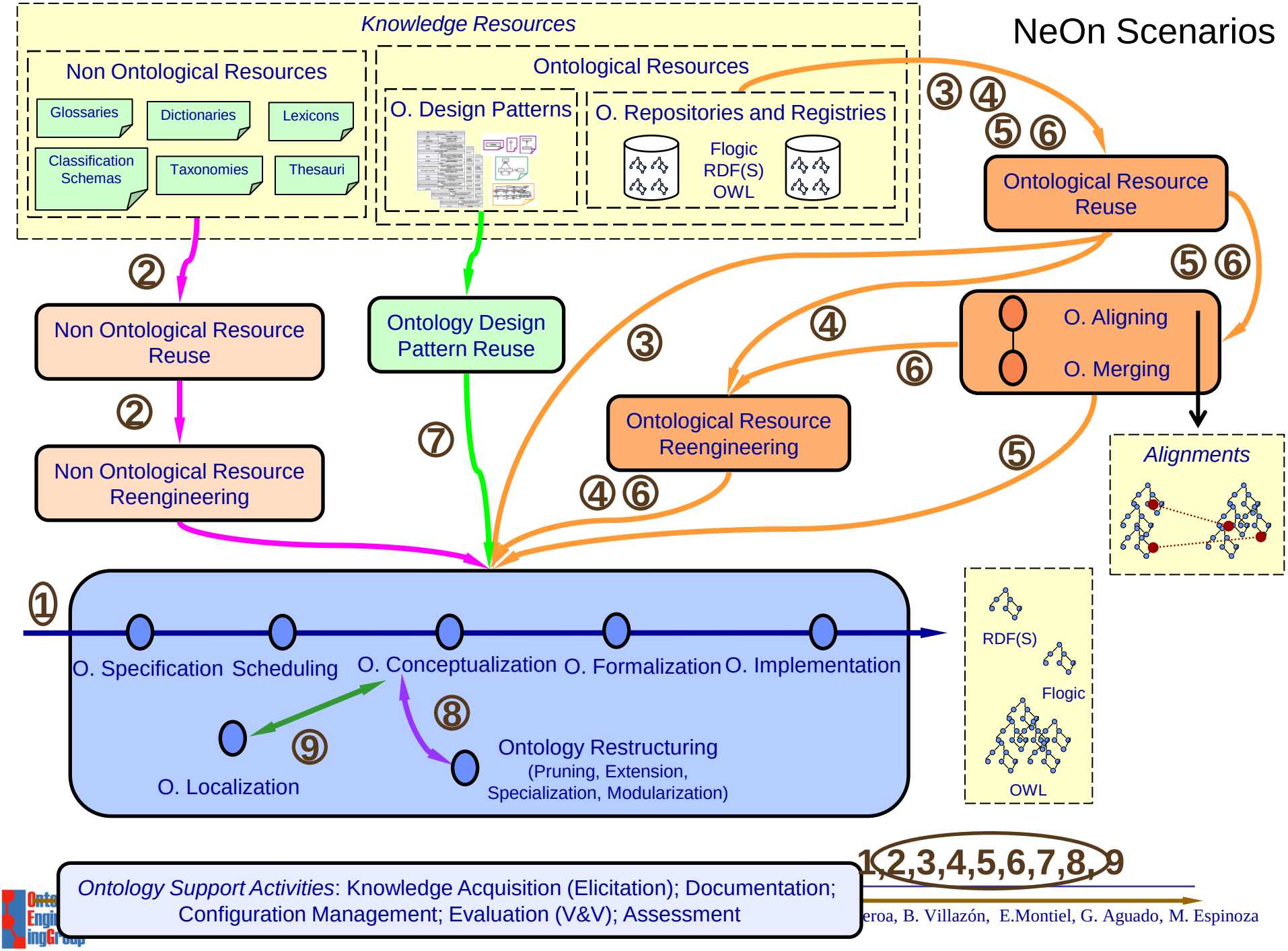
NeOn Scenarios



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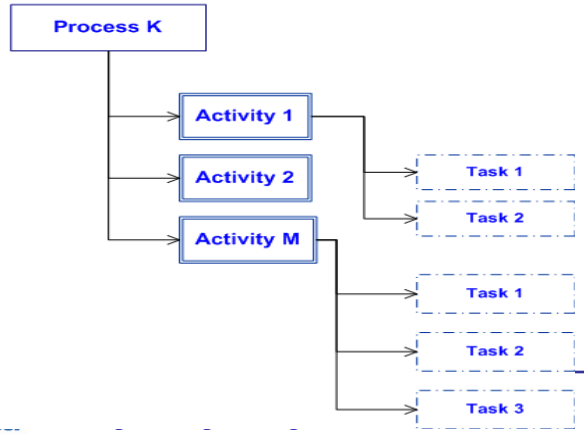
NeOn Methodology

Process and activities covered:

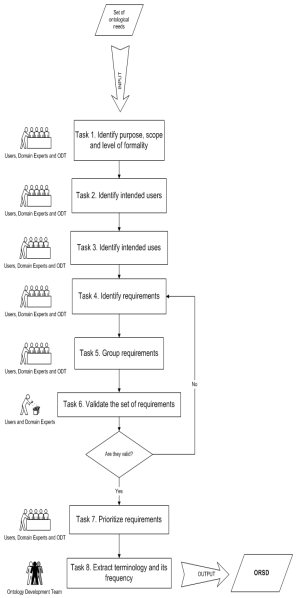
- Ontology Specification
- Scheduling
- Non-Ontological Resource Reuse
- Non-Ontological Resource Re-engineering
- Reuse General Ontologies
- Reuse Domain Ontologies
- Reuse Ontology Statements
- Reuse Ontology Design Patterns



All processes and activities are described with:

- A filling card
- A workflow
- Examples

Process or Activity Name	
Definition	
Goal	
Input	*Output*
Who	
When	



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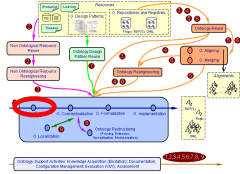
Ontology Requirement Specification Document



Ontology Requirements 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**
	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"

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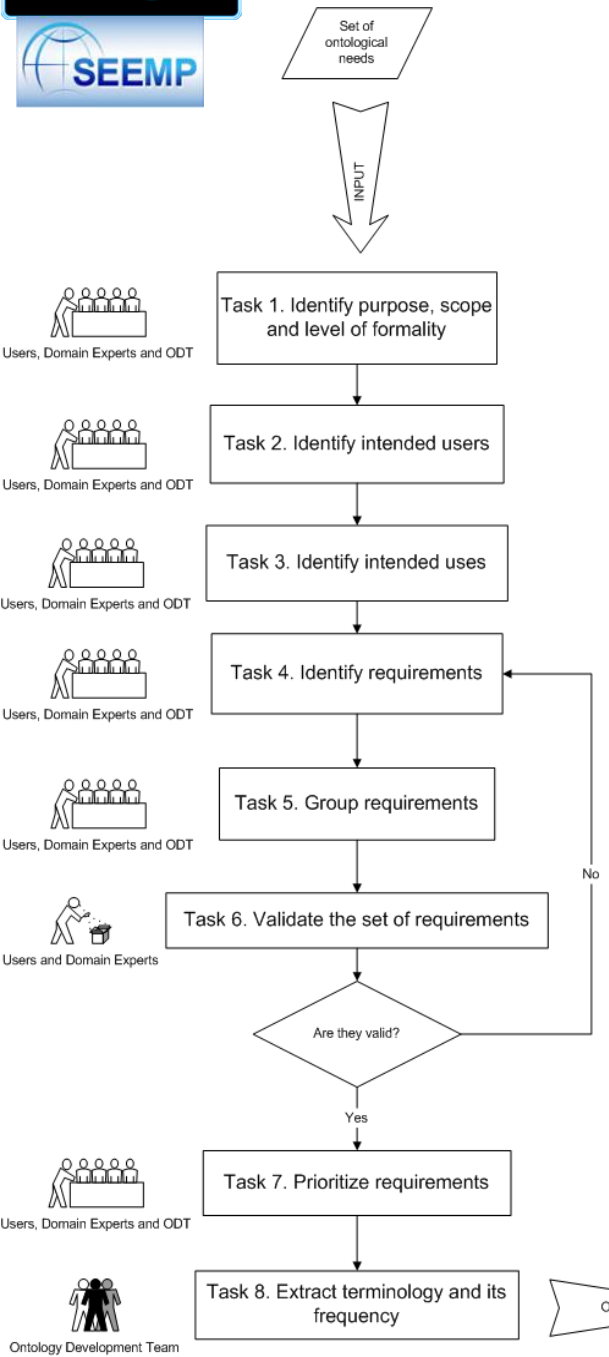
Ontology Specification



1	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).
2	**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.
3	**Level of Formality**
	The ontology has to be implemented in WSML language
4	**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 [illegible] policy. 5. European Commission and the governments of EU countries which want to analyze the statistics and prepare international agreements on employment and education.
5	**Intended Uses**
	1. Publish CV. Job seeker places his/her CV in the PES Portal. 2. Publish Job Offer. An Employer places a Job Offer on the PES Portal. 3. Search for Job Offers. The Employer looks for candidates for the Job Offer through PES Portal. 4. Search for Employment information. Job Seeker looks for of general information about employment in a given location at 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

N	Competency Questions	Answers
CQ1	What is the Job Seeker Name?	Lewis Hamilton
CQ2	What is the Job Seeker nationality?	British; Spanish; Italian; French; German
CQ3	When is the Job Seeker birthdate?	13/09/1984; 30/03/1970; 15/04/1978
CQ4	What is the Job Seeker contact information?	
CQ5	What is the Job Seeker current job?	Programmer; Computer Engineer; Computer Assistant
CQ6	What is the Job Seeker desired job?	Radio engineer; Hardware designer; Software Engineer
CQ7	What are the Job Seeker desired working conditions?	Autonomous; Seasonal Job; Traineeship;Consultant
CQ8	What kind of contract does the Job Seeker want?	
CQ9	How much salary does the Job Seeker want to earn?	
CQ10	What is the Job Seeker education level?	Basic education; Higher education/University
CQ11	What is the Job Seeker work experience?	3 months, 6 months, 1 year, 2, years, 3 years
CQ12	What is the Job Seeker knowledge?	
CQ13	What is the Job Seeker expertise?	
CQ14	What are the Job Seeker skills?	SQL programming, network administration
CQ15	What publications does the Job Seeker have?	
CQ16	What hobbies does the Job Seeker have?	
CQ17	What is the employer information?	CEFRIEL Research Company, Milano, Italy
CQ18	What kind of job does the employer offer?	Java Programmer; C Programmer, Database administration
CQ19	What kind of contract does the employer offer?	
CQ20	How much salary does the employer offer?	3500 euros, 3000 USD, 2000 euros
CQ21	What is the economic activity of the employer?	Research; Financial; Education; Industrial
CQ22	What is the description of the job offer?	Sun Certified Java Programmer
CQ23	What is the work condition of the job offer?	Full time; Partial time; Autonomous; Seasonal Job;
CQ24	What is the required education level for the job offer?	Basic education; Higher education/University
CQ25	What is the required work experience for the job offer?	1 year, 2 years, 3 years, 4 yerars, 5 or more years
CQ26	What is the required knowledge for the job offer?	Java, Object oriented design, Haskell, Windows
CQ27	What are the required skills for the job offer?	ASP Programmer, Data warehouse, Hardware programming
CQ28	When the Job Seeker completed his/her first degree?	2001; March 1999; 23/10/1970
CQ29	Is the Job Seeker older than 30 years?	
CQ30	How much time did the Job Seeker spend completing his/her first degree?	4 years, 6 years, 7 years and 6 months
CQ31	How long is the duration of the contract?	1 month, 6 months, 1 year, 2 years, 3 years
CQ32	Which job offers were posted in the last 24 hours?	
CQ33	Which job offers were posted in the last 7 days?	
CQ34	Which job offers were posted in the last month?	

Competency Questions

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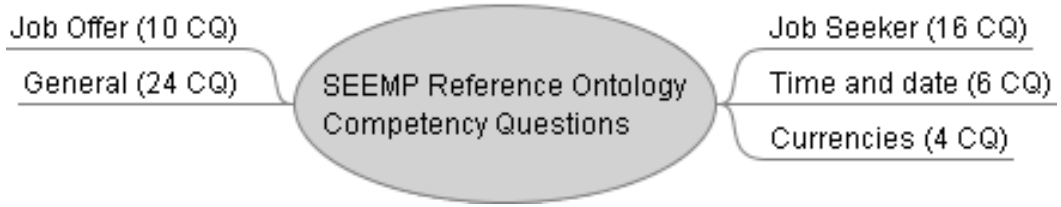
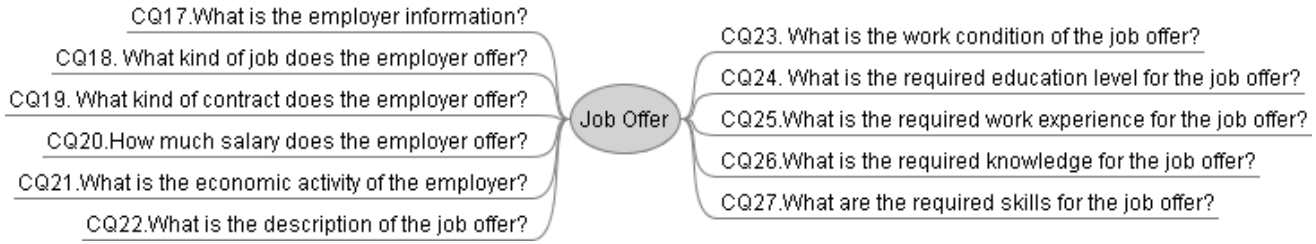
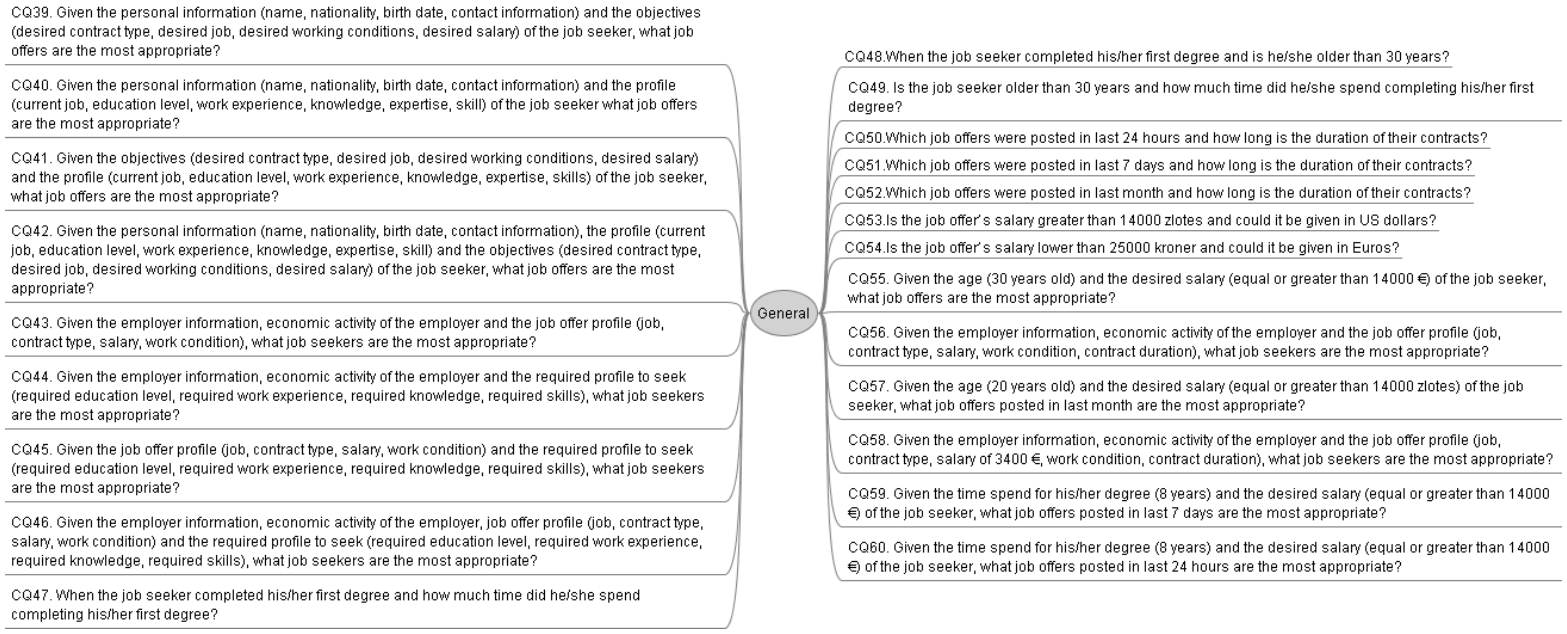
Ontology Specification: Group requirements.







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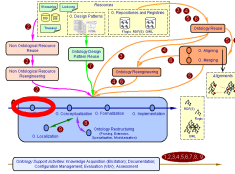
Ontology Specification. The Ontology Requirement Specification Document



SEEMP Reference Ontology Requirements Specification	
1	**Purpose**
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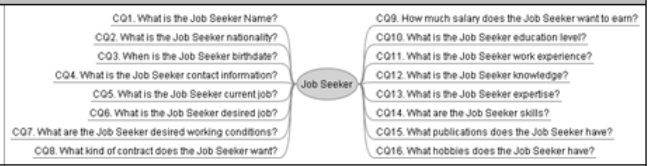
3	**Level of Formality**
	The ontology has to be implemented in WSML language
4	**Intended Users**
	User 1. Candidate who is unemployed and searching for a job or searching another occupation for immediate or future purposes
	User 2.
	User 3.
	User 4.
	User 5.
5	**Intend**
	Use 1.
	Use 2.
	Use 3.
	Use 4.
	Use 5.

7	Pre-Glossary of Terms		
	Terms		**Frequency**
	a.	Job Seeker	27
	b.	CV	2
	c.	Personal Information	3
	d.	Name	5
	e.	Gender	1
	f.	Birth date	1
	g.	Address	2
	h.	Nationality	1
	i.	Contact (phone, fax, mail)	4
	j.	Objective	3
	k.	Job Category	6
	l.	Job Offer	27
	m.	Employer Information	1
	n.	Vacancy	1
	o.	Activity Sector	1
	p.	Location	3
	q.	Work Condition	3
	r.	Contract Type	3
	s.	Salary	3
	t.	Education	3
	u.	Work Experience	3

6	Groups of Competency Questions	
	CQG1. Job Seeker (16 CQ)	
	CQG2. Job Offer (10 CQ)	
	CQG3	

Objects

Objects in the universe of discourse, which are instances of:

- Job Category
  - O1. Computer System Designer
  - O2. Computer System Analyst
  - O3. Programmer
  - O4. Computer Engineer
  - O5. Computer Assistant
  - O6. Computer Equipment Operator
  - O7. Industrial Robot Controller
  - O8. Telecommunication Equipment Operator
  - O9. Medical Equipment Operator
  - O10. Electronic Equipment Operator
  - O11. Image Equipment Operator
- Nationality
  - O12. Austrian
  - O13. Belgian
  - O14. Danish
  - O15. Estonian
  - O16. Finnish
  - O17. French
  - O18. German
  - O19. Greek
  - O20. Italian
- Activity Sector
  - O21. Telecommunication
  - O22. Justice and Judicial
  - O23. Public Security and law
  - O24. Manufacture of machine tools
  - O25. Research and Development
  - O26. Hardware Consultancy
  - O27. Software Consultancy and Supply
  - O28. Data processing
- Education
  - O29. Life Science
  - O30. Mathematics
  - O31. Computer Science
  - O32. Computer Use
  - O33. Statistics
  - O34. Physics
  - O35. Network Administration
- Languages
  - O36. Swedish
  - O37. Spanish
  - O38. Slovenian
  - O39. Portuguese
  - O40. English
  - O41. French
  - O42. German
- Currency
  - O43. Euro
  - O44. Krone
  - O45. Great British Pound
  - O46. Zlote
  - O47. US Dollar
  - O48. Franc
- Location
  - O49. Austria
  - O50. Belgium
  - O51. Danmark
  - O52. Estonia
  - O53. Finland
  - O54. France
  - O55. Germany
  - O55. Greece

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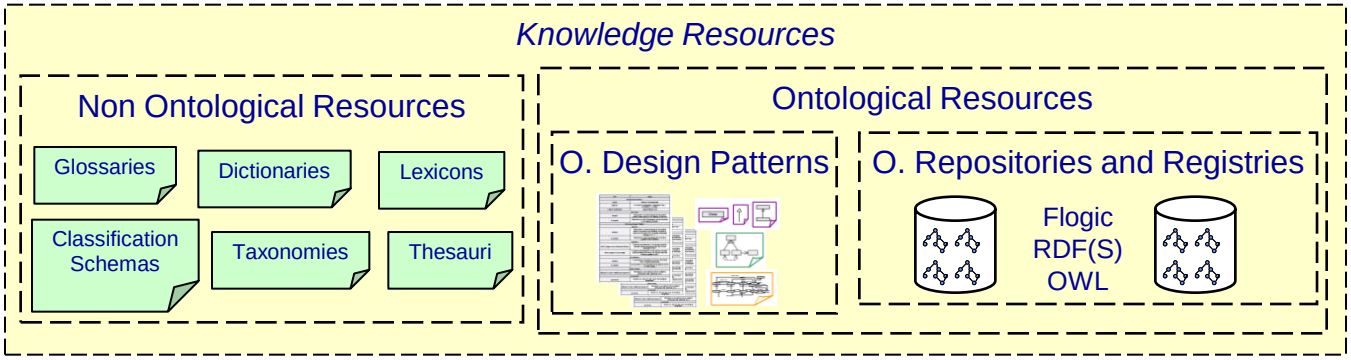
Searching Resources

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



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  - O11. Image Equipment Operator
- Nationality
  - O12. Austrian
  - O13. Belgian
  - O14. Danish
  - O15. Estonian
  - O16. Finnish
  - O17. French
  - O18. German
  - O19. Greek
  - O20. Italian

- Where:
  - Internet
  - Standardization bodies (ISO,…)
  - Intranet of the organization
  - Ontology Registries

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Search and Select non-ontological resources

- *We select the most appropriate standards and taxonomies for:*
  - Occupation Classification
    ISCO-88 (COM), SOC, ISCO-88, ONET, Eures Taxonomy.
  - Classification of Economic Activities
    ISIC Rev. 3.1, NACE Rev. 1.1, NAICS
  - Apprenticeship classifications
    ISCED 97, FOET
  - Currency Classification
    ISO 4217
  - Geography Classification
    ISO 3166, Eures Taxonomy

Language Classification
ISO 6392, CEF
Driving License Classification
European Legislation
Skill Classification
Eures Taxonomy
Contract Types Classification
LE FOREM, Eures and BLL Classification
Work Condition Classification
LE FOREM, Eures and BLL Classification

Is the terminology included in the Ontology Requirements Specification Document covered by the resources?

ISO 4217 (currencies)

Entitiy	Currency	Code	
		Alphabetic	Numeric
AFGHANISTAN	Afghani	AFN	971
ALBANIA	Lek	ALL	008
ALGERIA	Algerian Dinar	DZD	012
AMERICAN SAMOA	US Dollar	USD	840
ANDORRA	Euro	EUR	978
ANGOLA	Kwanza	AOA	973
ANGUILLA	East Caribbean Dollar	XCD	951
ANTARCTICA	No universal currency		
ANTIGUA AND BARBUDA	East Caribbean Dollar	XCD	951
ARGENTINA	Argentine Peso	ARS	032
ARMENIA	Armenian Dram	AMD	051
ARUBA	Aruban Guilder	AWG	533
AUSTRALIA	Australian Dollar	AUD	036
AUSTRIA	Euro	EUR	978
AZERBAIJAN	Azerbaijanian Manat	AZN	944
BAHAMAS	Bahamian Dollar	BSD	044
BAHRAIN	Bahraini Dinar	BHD	048
BANGLADESH	Taka	BDT	050
BARBADOS	Barbados Dollar	BBD	052
BELARUS	Belarussian Ruble	BYR	974

ISO 3166 (countries)

```
<?xml version="1.0" encoding="ISO-8859-1" standalone="yes"?>
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  <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_Entry>
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Non-ontological resources - ISCO-88 (COM)

level	description EN	description FR	description DE	texte auto EN	
3	Religious professionals	Membres du clergé	Geistliche, Seelsorger		
3	Public service administrative professionals	Cadres administratifs des services publics	Wissenschaftliche Verwaltungsfachkräfte des öffentlichen Dienstes	This is a new minor group, designed explicitly for the classification of occupations in which the primary tasks consist of general administrative functions within the public	Hier han ausdrück deren Ha
3	Physical and engineering science technicians	Techniciens des sciences physiques et techniques	Material- und ingenieurtechnische Fachkräfte		
3	Computer associate professionals	Pupitreurs et autres opérateurs de matériels informatiques	Datenverarbeitungsfachkräfte	If the job title and associated information on activities does not permit a clear distinction, additional information on a level of relevant qualifications or description of tasks may	Wenn di Informati erlauben
3	Optical and electronic equipment operators	Techniciens d'appareils optiques et électroniques	Bediener optischer und elektronischer Anlagen		
3	Ship and aircraft controllers and technicians	Techniciens des moyens de transport maritime et aérien	Schiffs-, Flugzeugführer und verwandte Berufe		
3	Safety and quality inspectors	Inspecteurs d'immeubles, de sécurité, d'hygiène et de qualité	Sicherheits- und Qualitätskontrolleure		
3	Life science technicians and related associate professional	Techniciens et travailleurs assimilés des sciences de la vie et de la santé	Biotechniker und verwandte Berufe		
3	Health associate professionals (except nursing)	Professions intermédiaires de la médecine moderne (à l'exception du personnel infirmier)	Medizinische Fachberufe (ohne Krankenpflege)		
3	Nursing and midwifery associate professionals	Personnel infirmier et sages-femmes (niveau intermédiaire)	Nicht-wissenschaftliche Krankenpflege- und Geburtshilfefachkräfte	Concerning "Nursing and midwifery professionals", see notes to sub-major group 22.	Für "Wis Geburtsh
3	Primary education teaching associate professionals	Professions intermédiaires de l'enseignement primaire	Nicht-wissenschaftliche Lehrkräfte des Primarbereiches		
3	Pre-primary education teaching associate professionals	Professions intermédiaires de l'enseignement préprimaire	Nicht-wissenschaftliche Lehrkräfte des Vorschulbereiches		
3	Special education teaching associate professionals	Professions intermédiaires de l'éducation des handicapés	Nicht-wissenschaftliche Sonderschullehrkräfte		

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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

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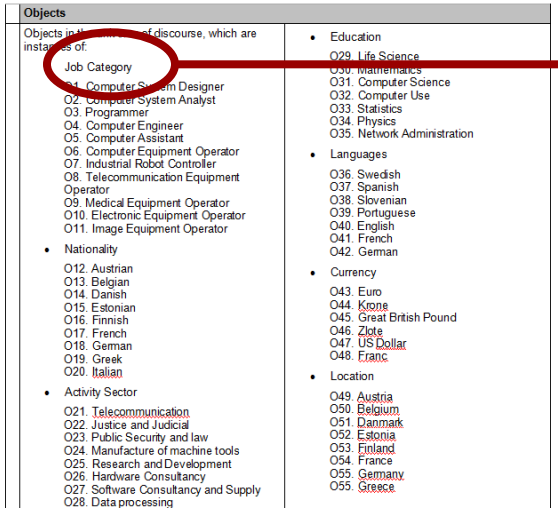
Searching Ontologies in Watson

Ontology Requirement Specification Document



Objects

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
010. Electronic Equipment Operator
011. 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. Manufacture 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

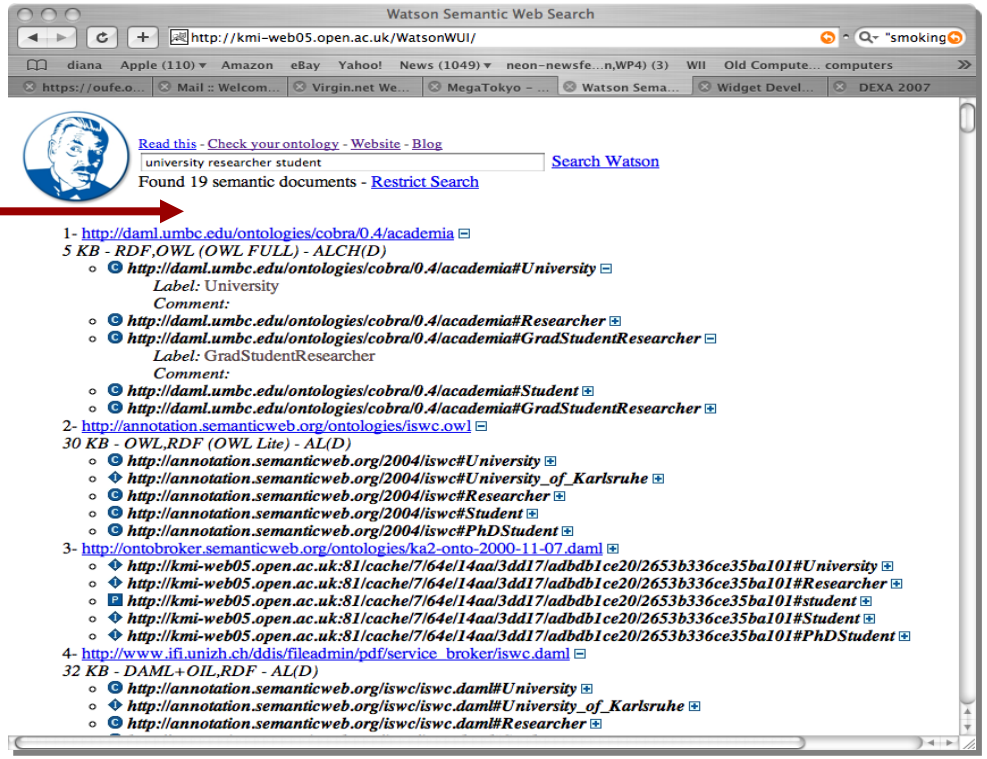
036. Swedish
037. Spanish
038. Slovenian
039. Portuguese
040. English
041. French
042. German

- Currency

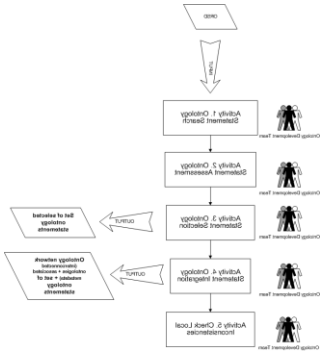
043. Euro
044. Krone
045. Great British Pound
046. Zlote
047. US Dollar
048. Franc

- Location

049. Austria
050. Belgium
051. Danmark
052. Estonia
053. Finland
054. France
055. Germany
055. Greece



The NeOn methodology includes guideliness for reusing statements



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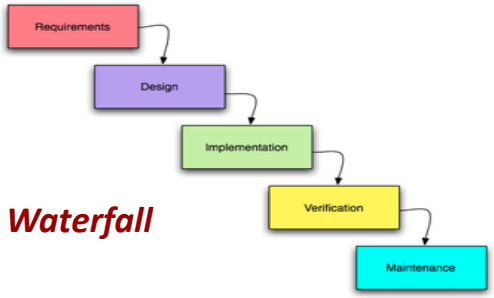
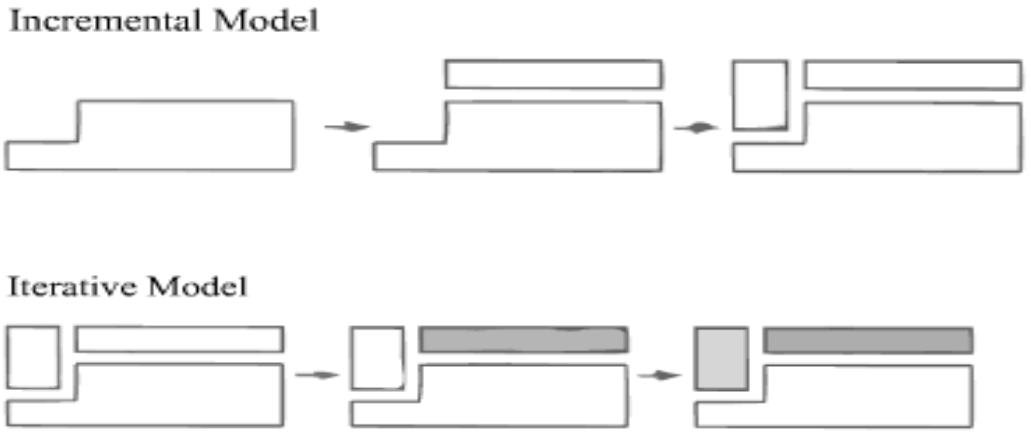
Life Cycle Models and Life Cycles

- An **ontology life cycle model** is the framework (waterfall, evolving prototyping, spiral, etc.), selected by each organization, on which to map the activities identified in the ontology development process.



Waterfall



- The **ontology life cycle** is the specific sequence of activities that the ontology practitioners carry out for developing an ontology.
- There is **not a unique life cycle model** valid for all ontology development projects

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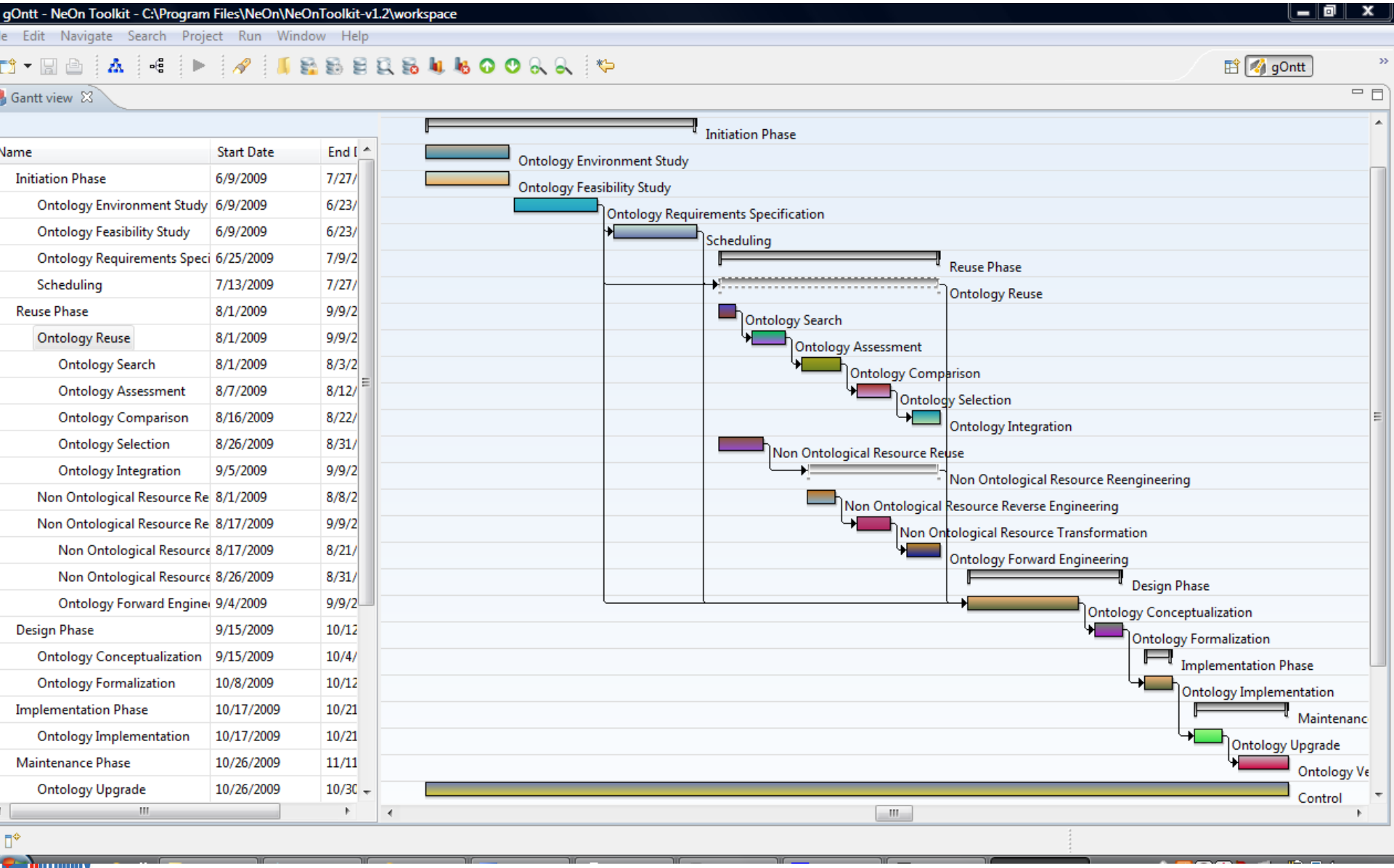
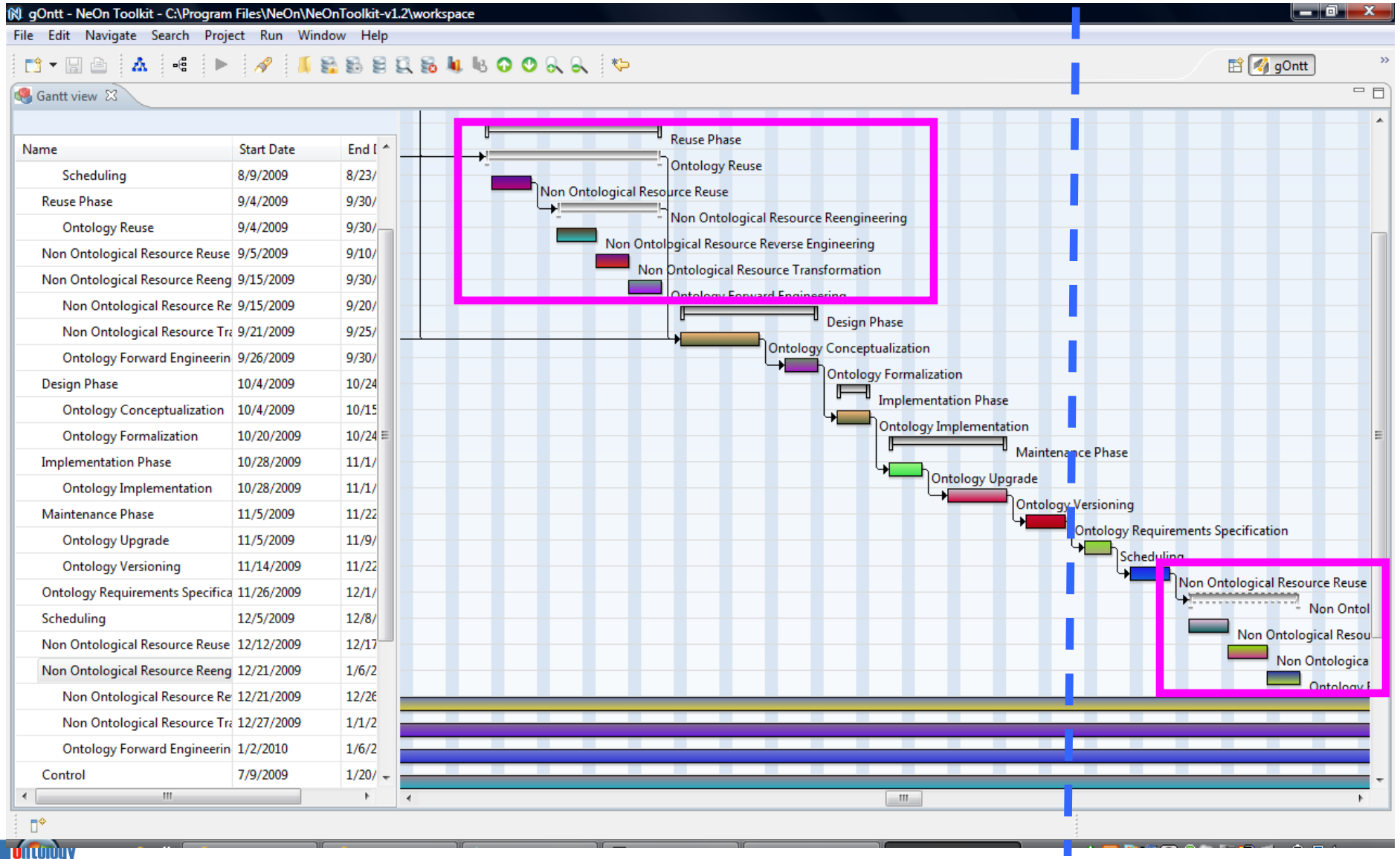
Gantt chart for your project. Waterfall model



Reuse and Re-engineering + Incremental



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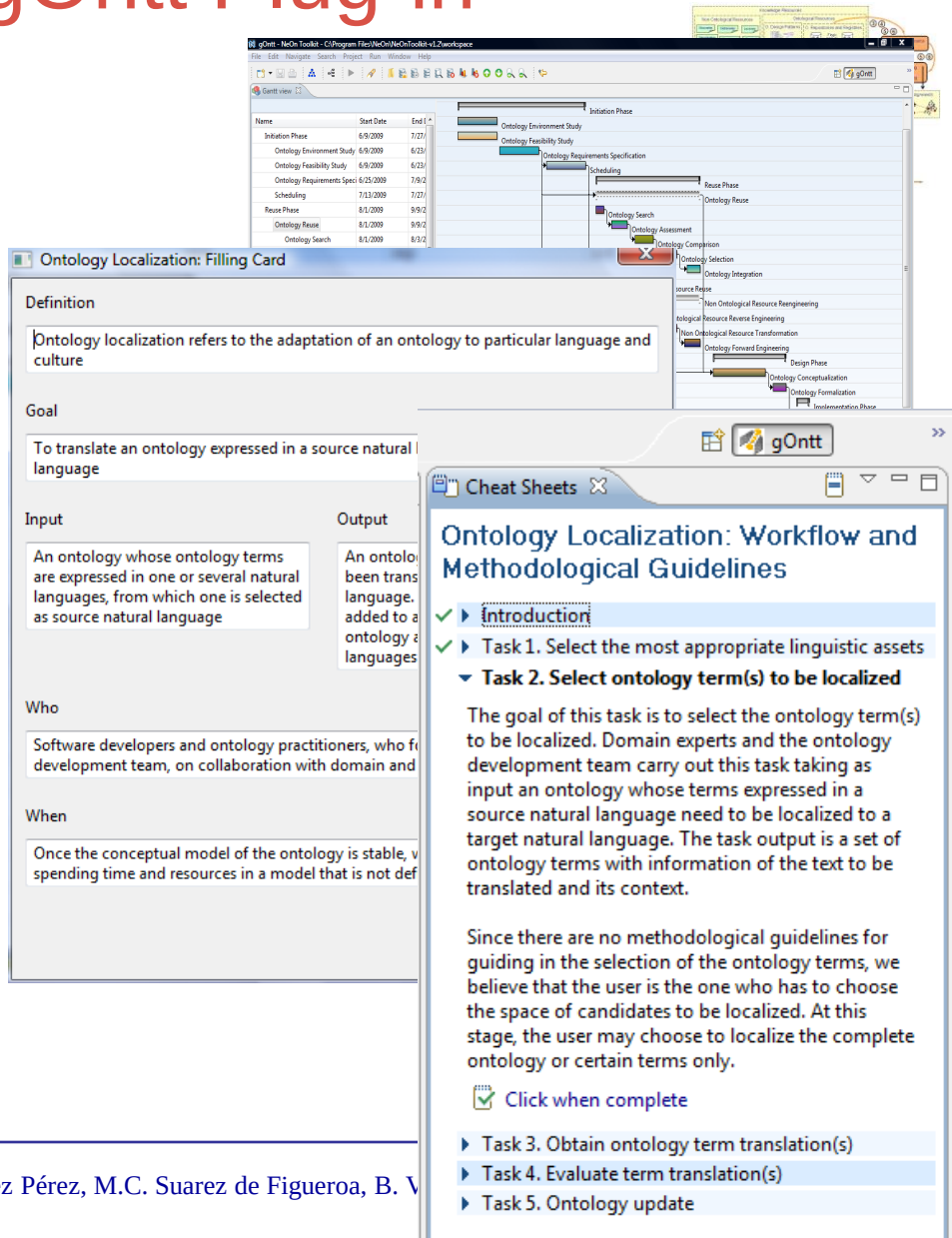
Scheduling. gOntt Plug-in

- **gOntt** helps in **scheduling an ontology network development**.
- **gOntt** integrates the **NeOn Methodology and the NeOn Toolkit.**
  - gOntt provides filling cards, workflows, and methodological guidelines for many activities
  - gOntt triggers the NeOn plug-ins associated to each process and activity planned.



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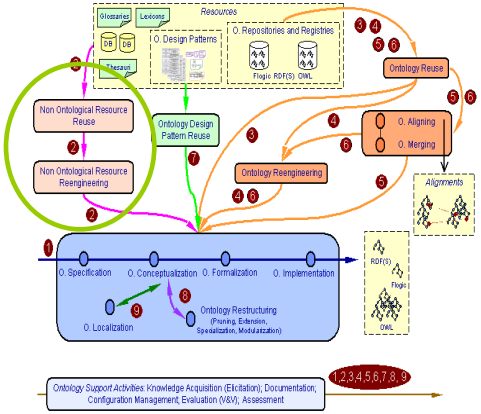
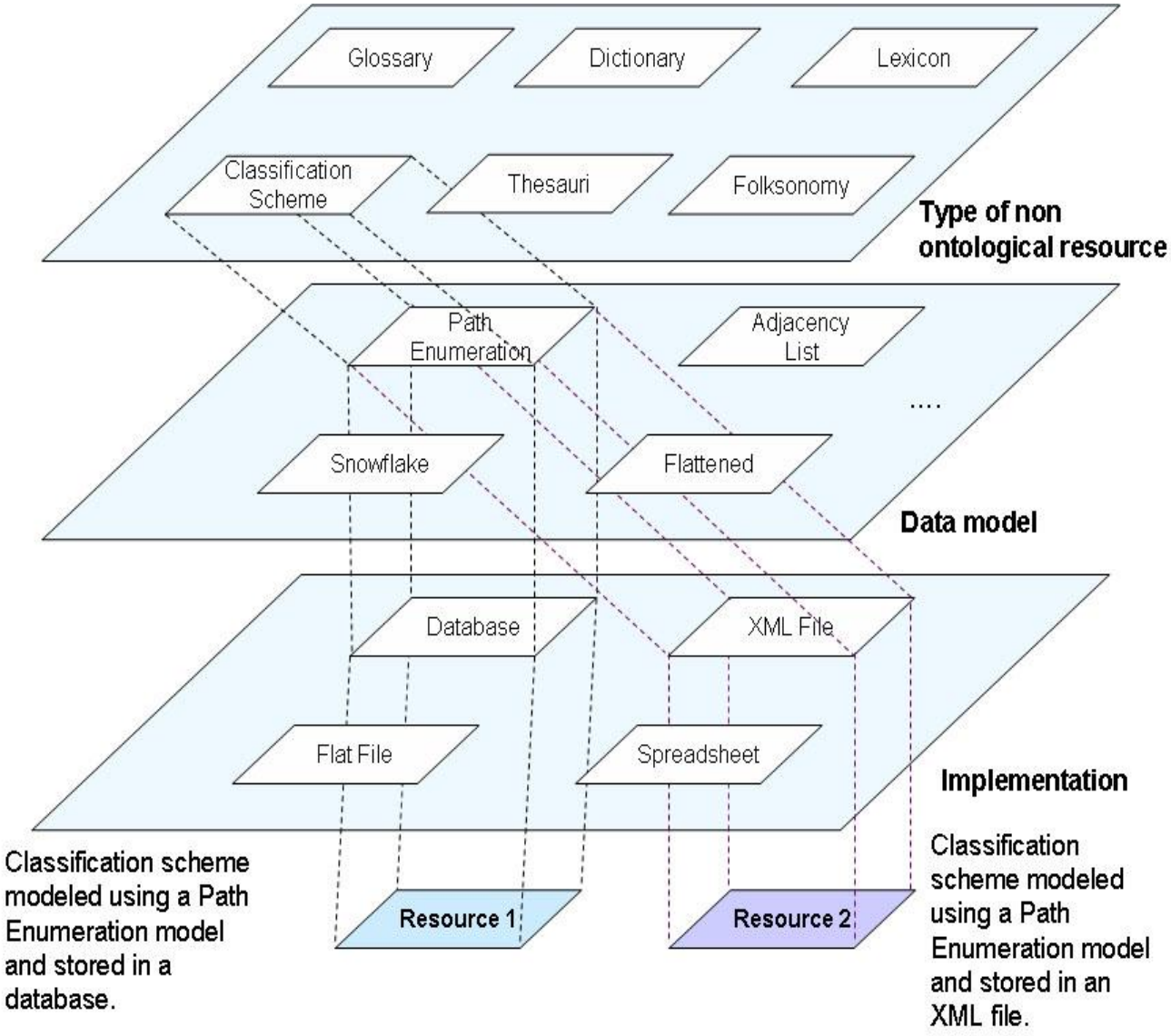
Types of non-ontological resources



Non-Ontological Resources *are knowledge-aware resources whose semantics have not been formalized yet by means of an ontology*



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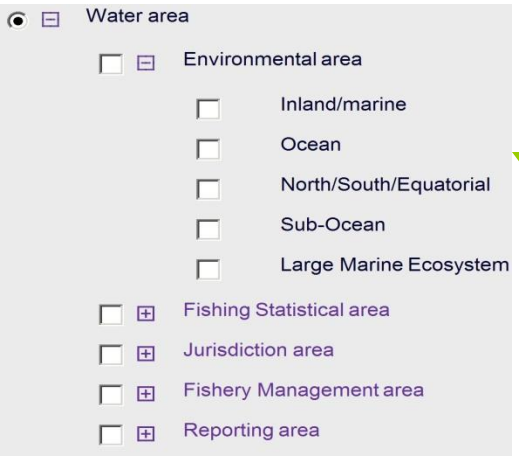
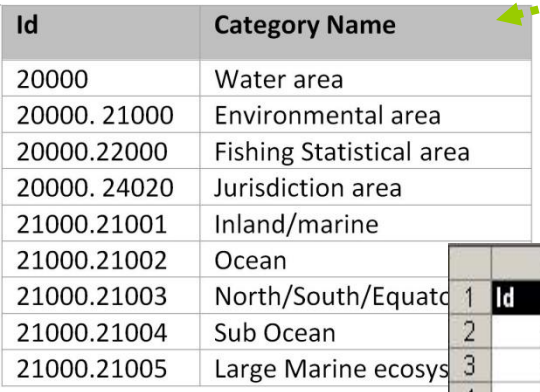
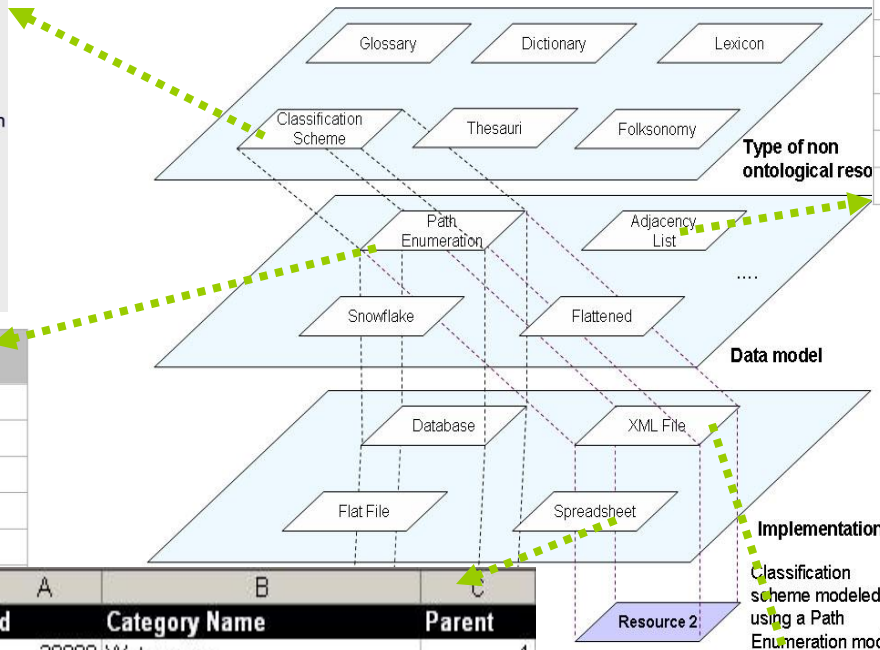
Types of non-ontological resources



Id	Category Name	Parent
20000	Water area	1
21000	Environmental area	20000
22000	Fishing Statistical area	20000
24020	Jurisdiction area	20000
21001	Inland/marine	21000
21002	Ocean	21000
21003	North/South/Equatorial	21000
21004	Sub Ocean	21000
21005	Large Marine ecosystem	21000



Id	Category Name
20000	Water area
20000. 21000	Environmental area
20000.22000	Fishing Statistical area
20000. 24020	Jurisdiction area
21000.21001	Inland/marine
21000.21002	Ocean
21000.21003	North/South/Equato
21000.21004	Sub Ocean
21000.21005	Large Marine ecosys



	A	B	C
1	Id	Category Name	Parent
2	20000	Water area	1
3	21000	Environmental area	20000
4	22000	Fishing Statistical area	20000
5	24020	Jurisdiction area	20000
6	21001	Iland/marine	21000
7	21002	Ocean	21000
8	21003	North/South/Equatorial	21000
9	21004	Sub Ocean	21000
10	21005	Large Marine ecosystem	21000

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```


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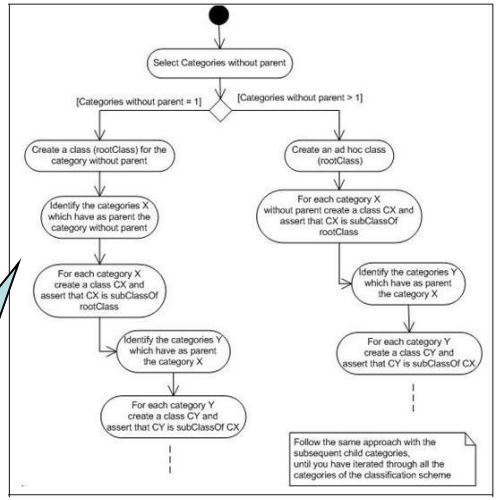
Motivation

resource

Id	Category Name	Parent
20000	Water area	1
21000	Environmental area	20000
22000	Fishing Statistical area	20000
24020	Jurisdiction area	20000
21001	Inland/marine	21000
21002	Ocean	21000
21003	North/South/Equatorial	21000
21004	Sub Ocean	21000
21005	Large Marine ecosystem	21000

Algorithm

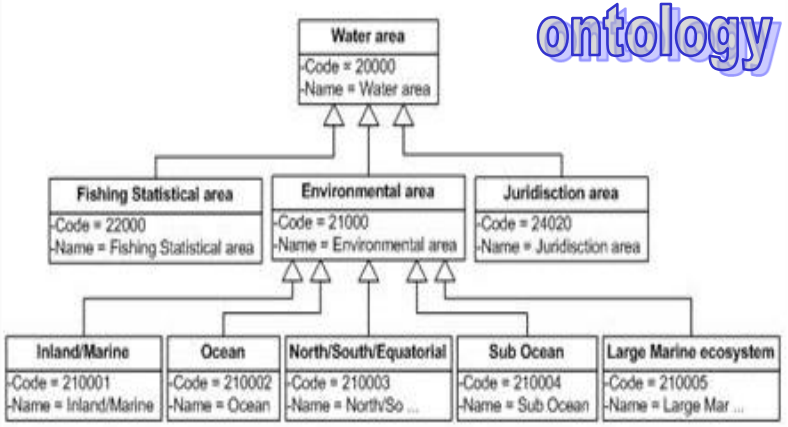


I want to transform my adjacency list-based classification into an ontology

(UML)

Example Solution Ontology

ontology



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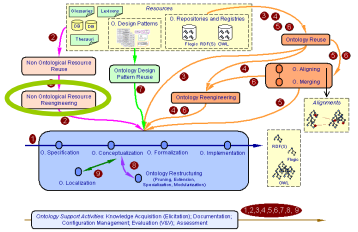
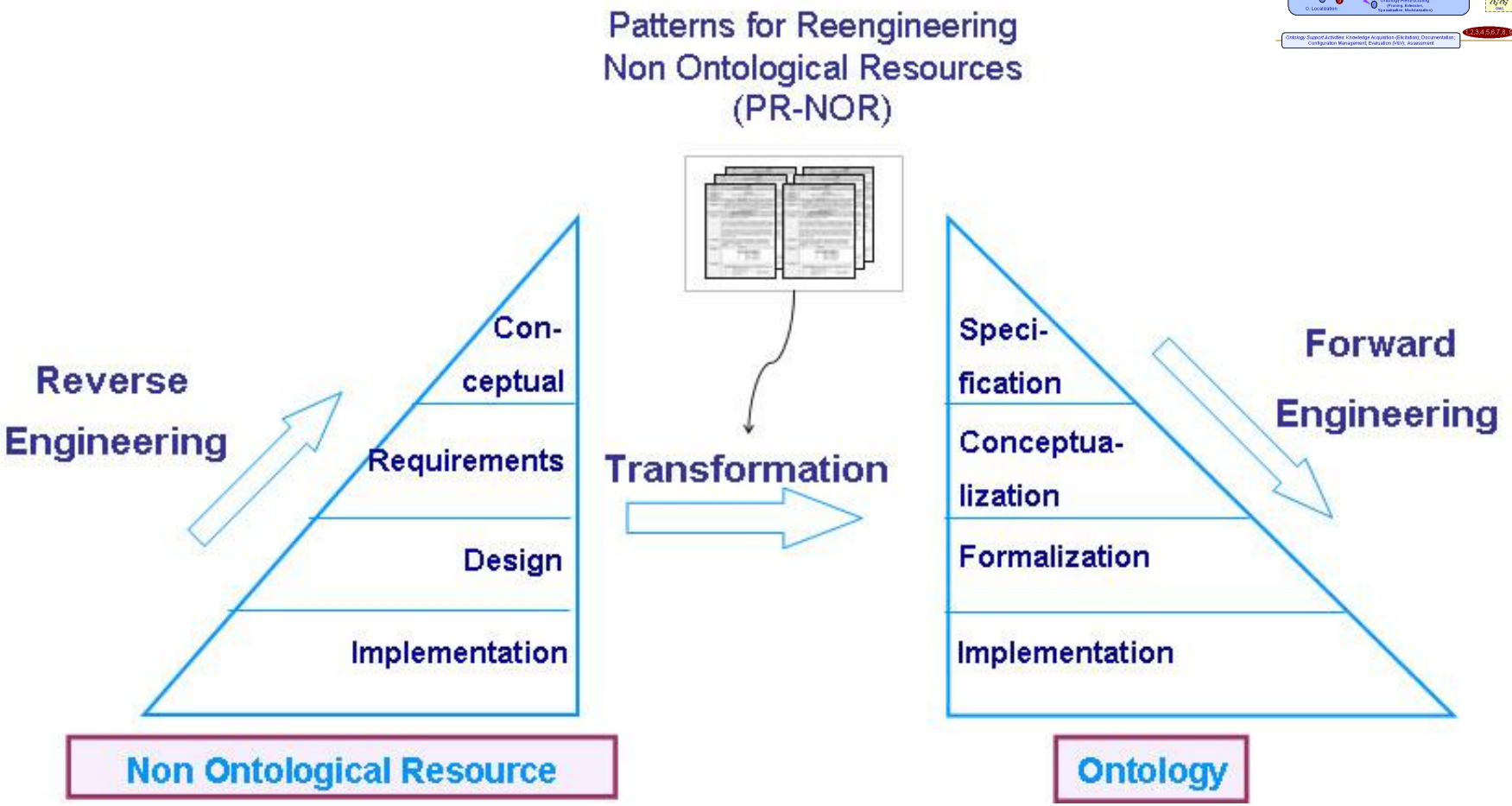
Approach for Re-engineering Non-Ontological Resources





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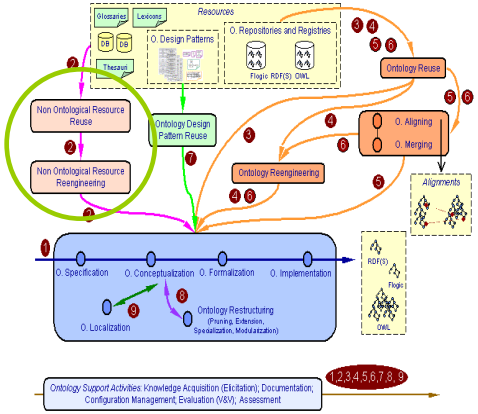
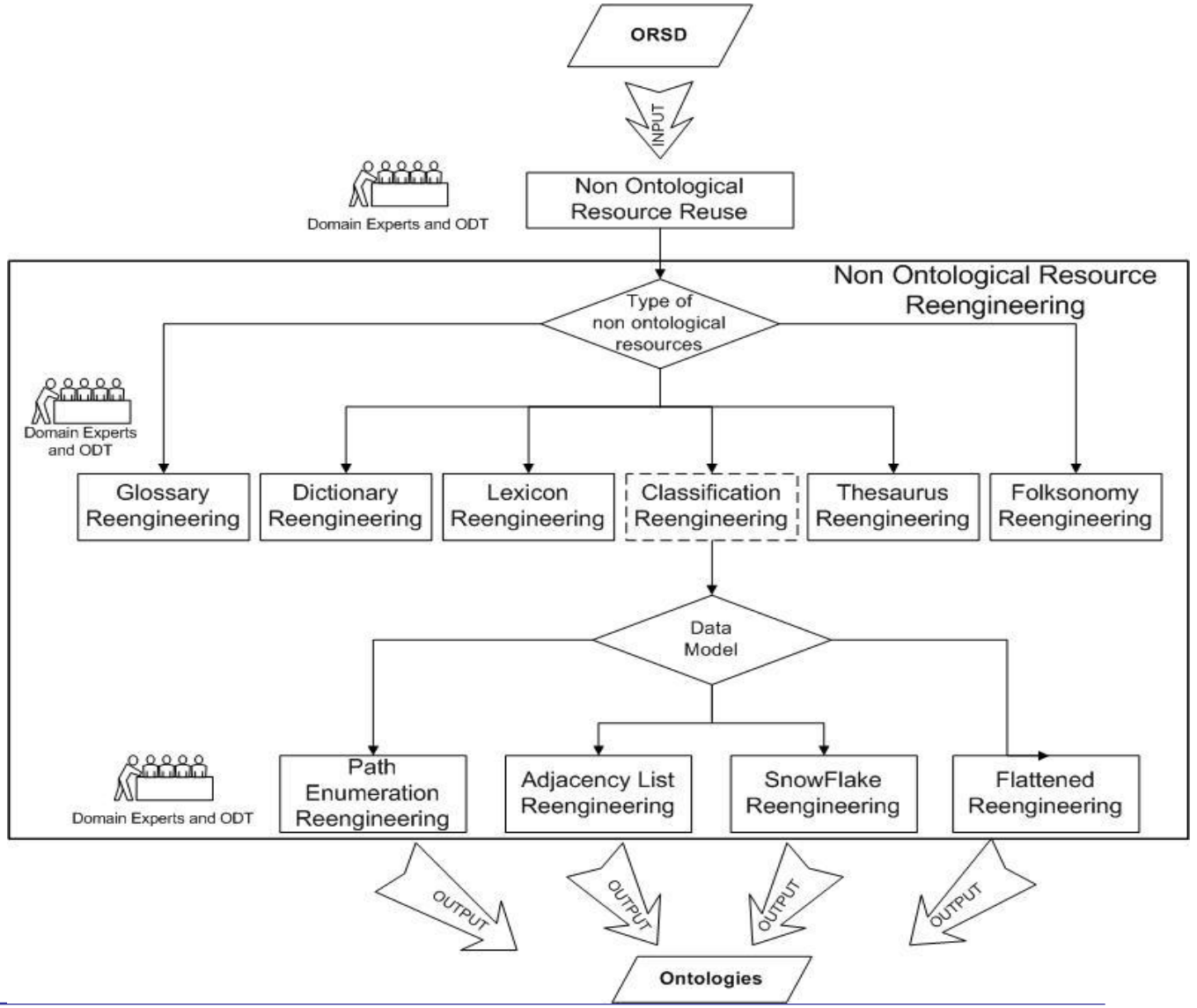
Reuse and Re-engineering Non-ontological Resources





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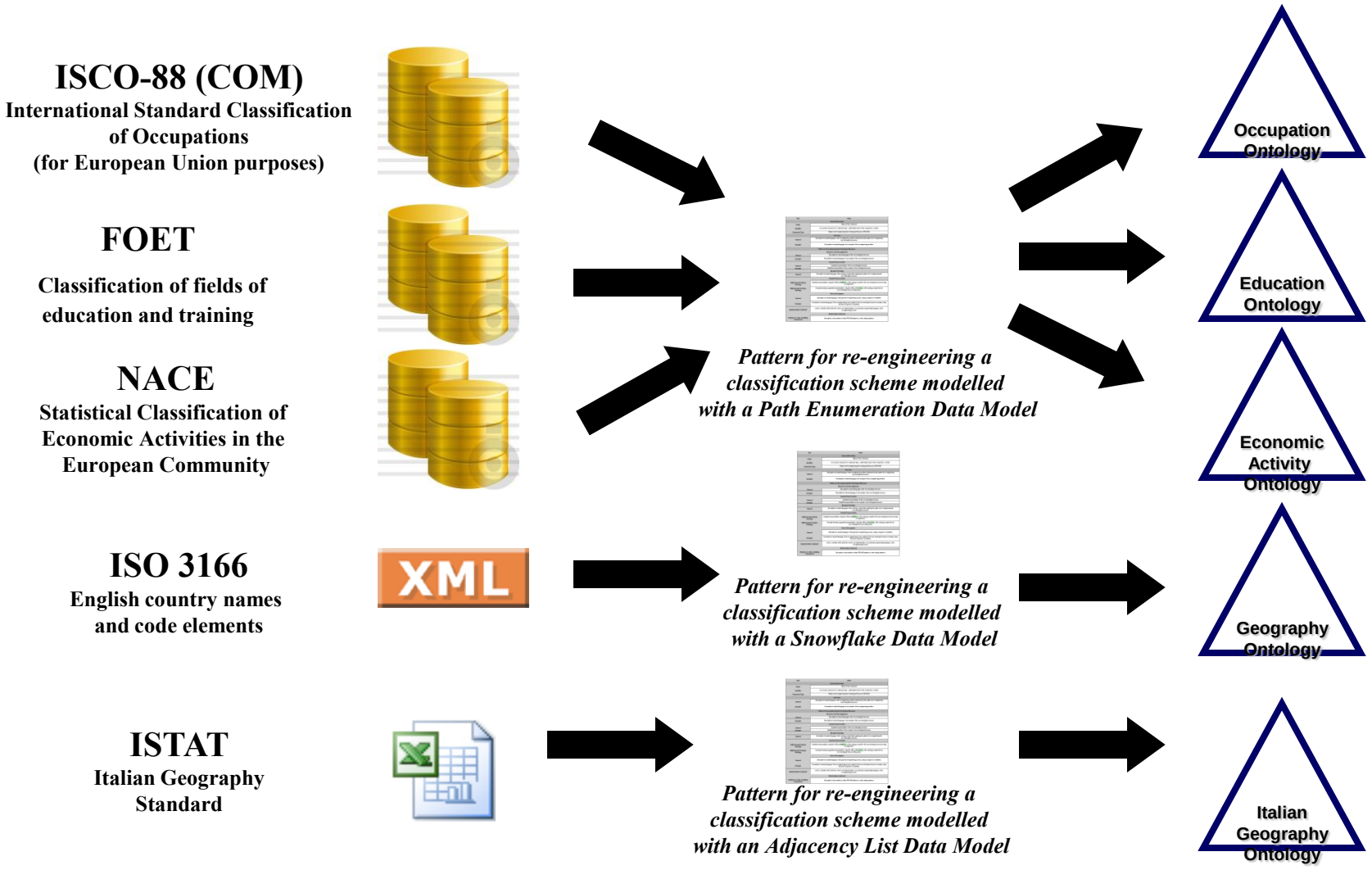
Pattern based approach for re-engineering non ontological resources



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Knowledge Resource Re-engineering and Aggregation

ISO 3166-1 (XML)

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...

Regions Table (Eures Oracle DB)

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100	ES	Cataluña
101	ES	Canarias
102	ES	Galicia
103	ES	Andalucia
104	ES	Navarra
105	ES	Asturias
106	ES	Baleares
107	ES	Murcia
108	ES	Aragon

Excerpt of the Geography Ontology

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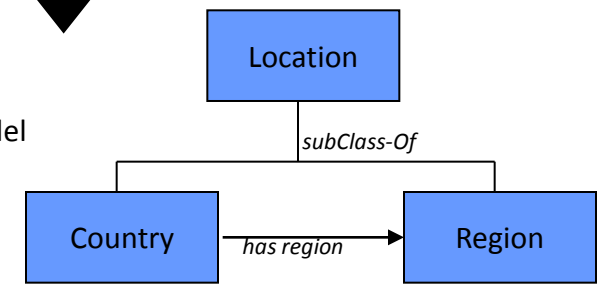
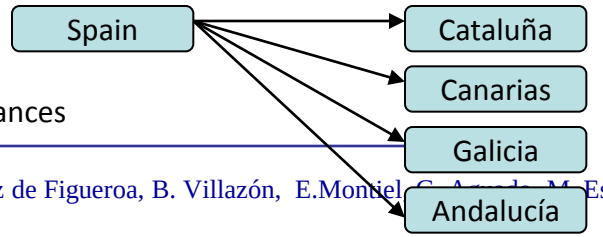
Ontology model



Ontology instances



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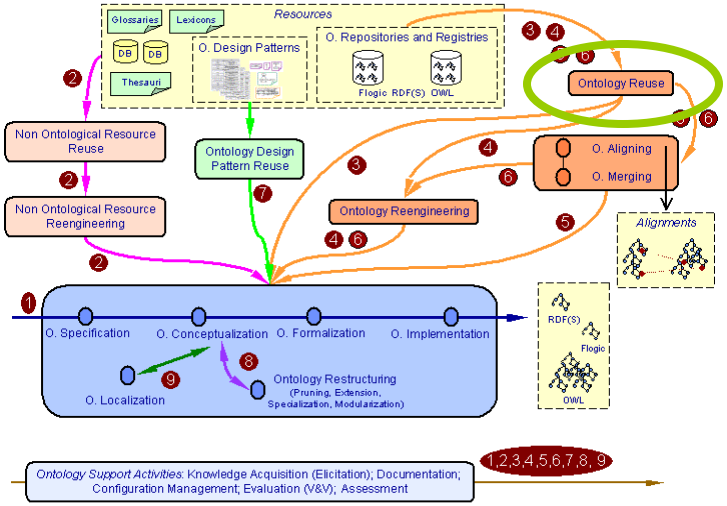
Ontological Resource Reuse Process



Ontological Resource Reuse is defined as the process of using available ontological resources (ontologies, modules, statements) in the solution of different problems.

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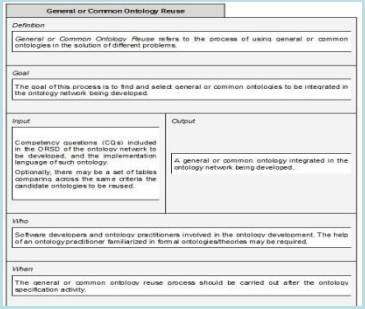
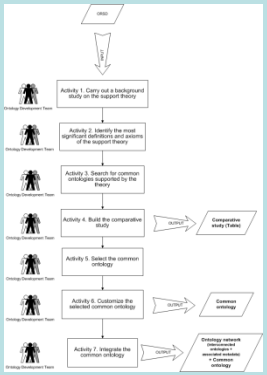
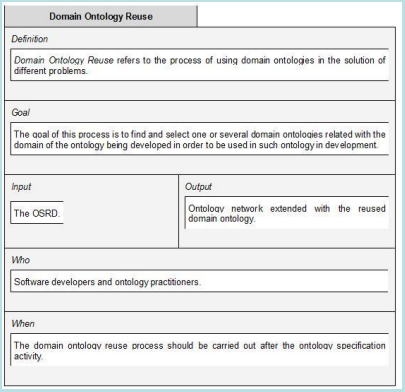
Detailed descriptions in D5.4.1

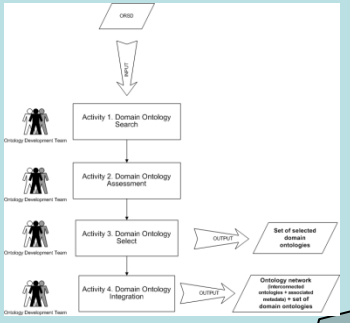
Reuse Common Ontologies



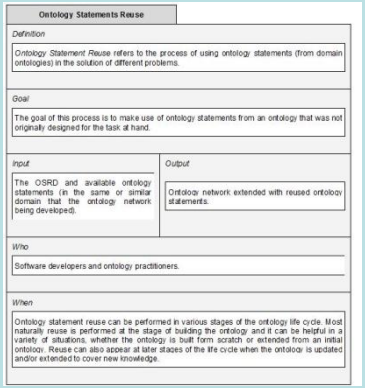


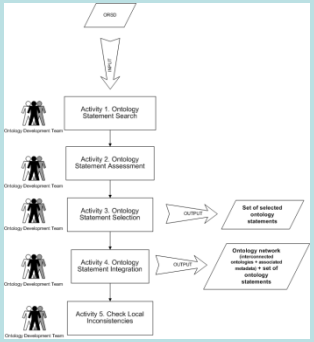
Reuse Domain Ontologies





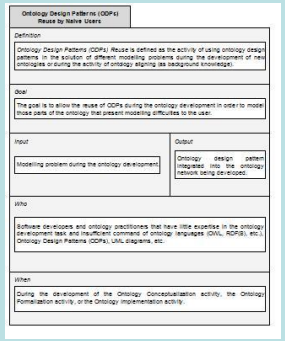
Reuse Ontology Statements

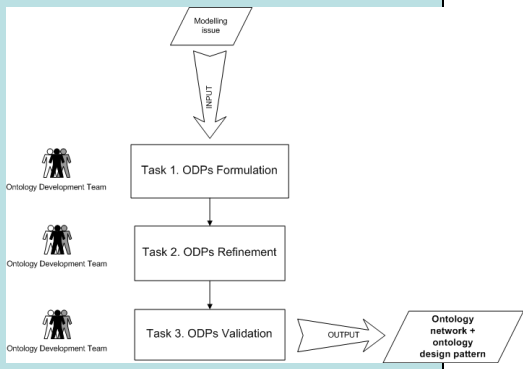




Watson plug-in

Reuse ODPs by naive users





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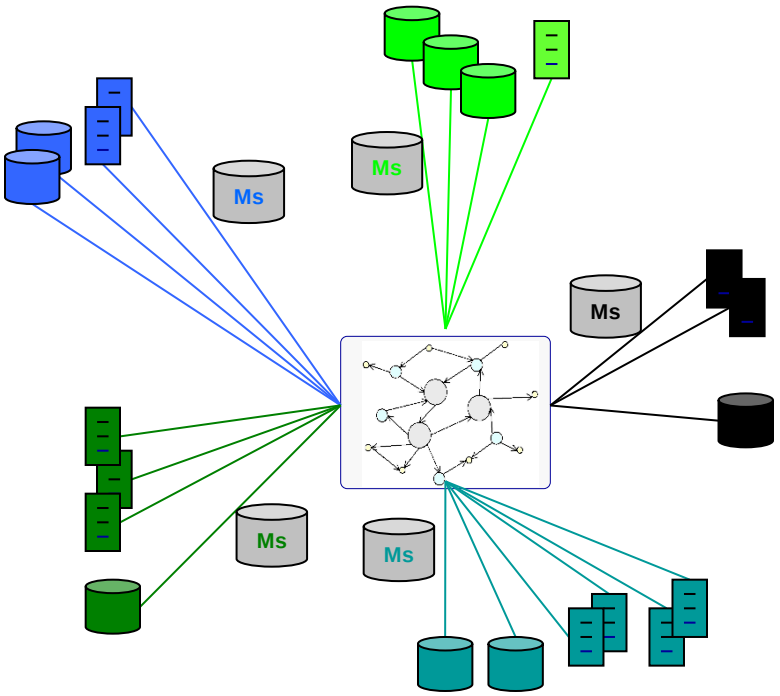
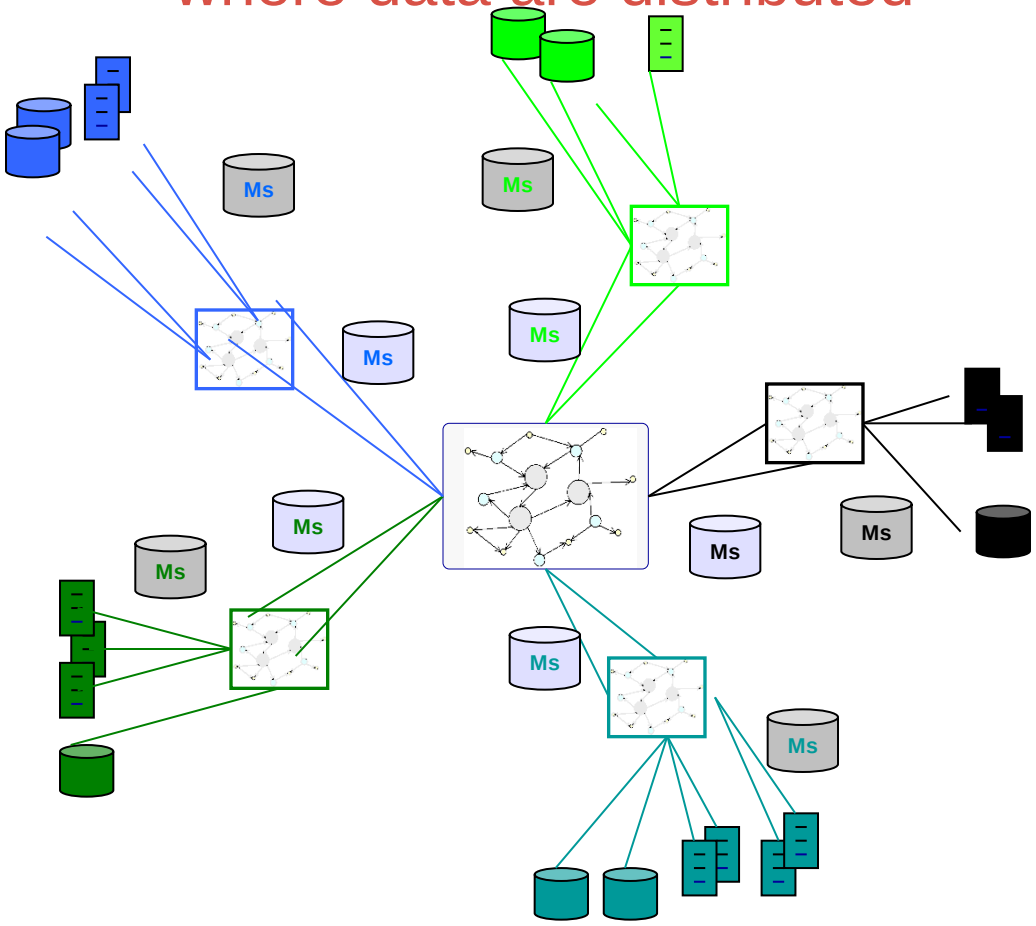
Centralized network of ontologies where data are distributed



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

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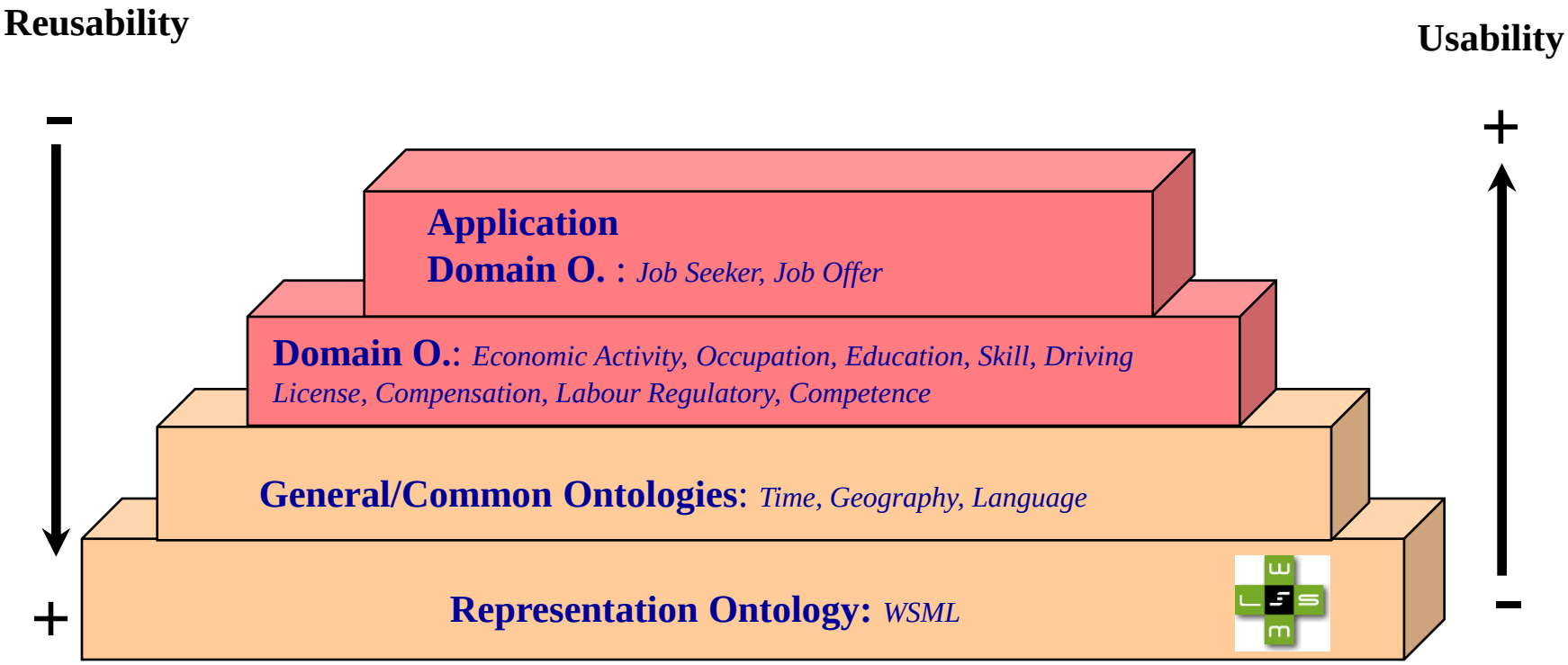
Conceptualization:
Modular approach for ontology construction



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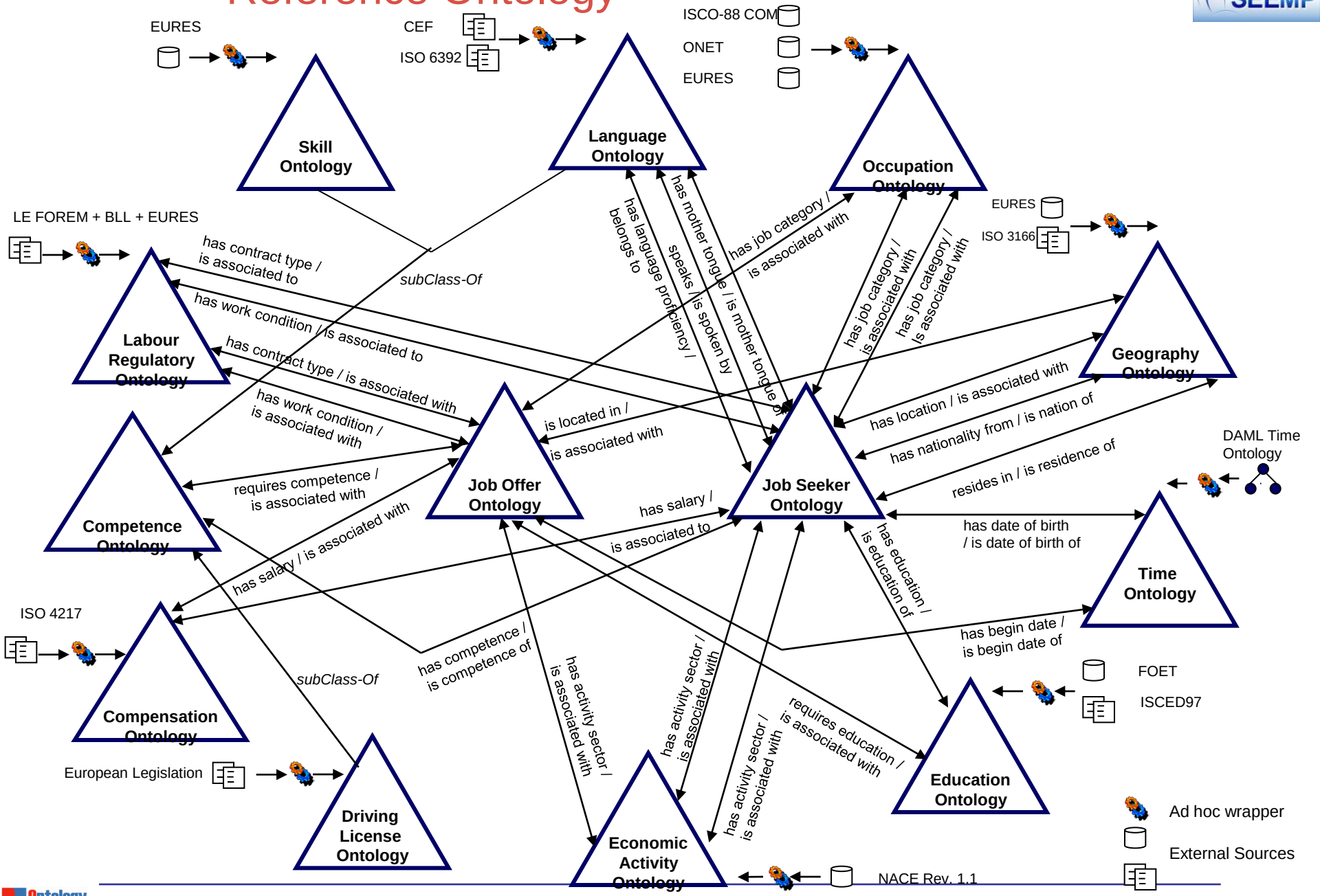
Reference Ontology



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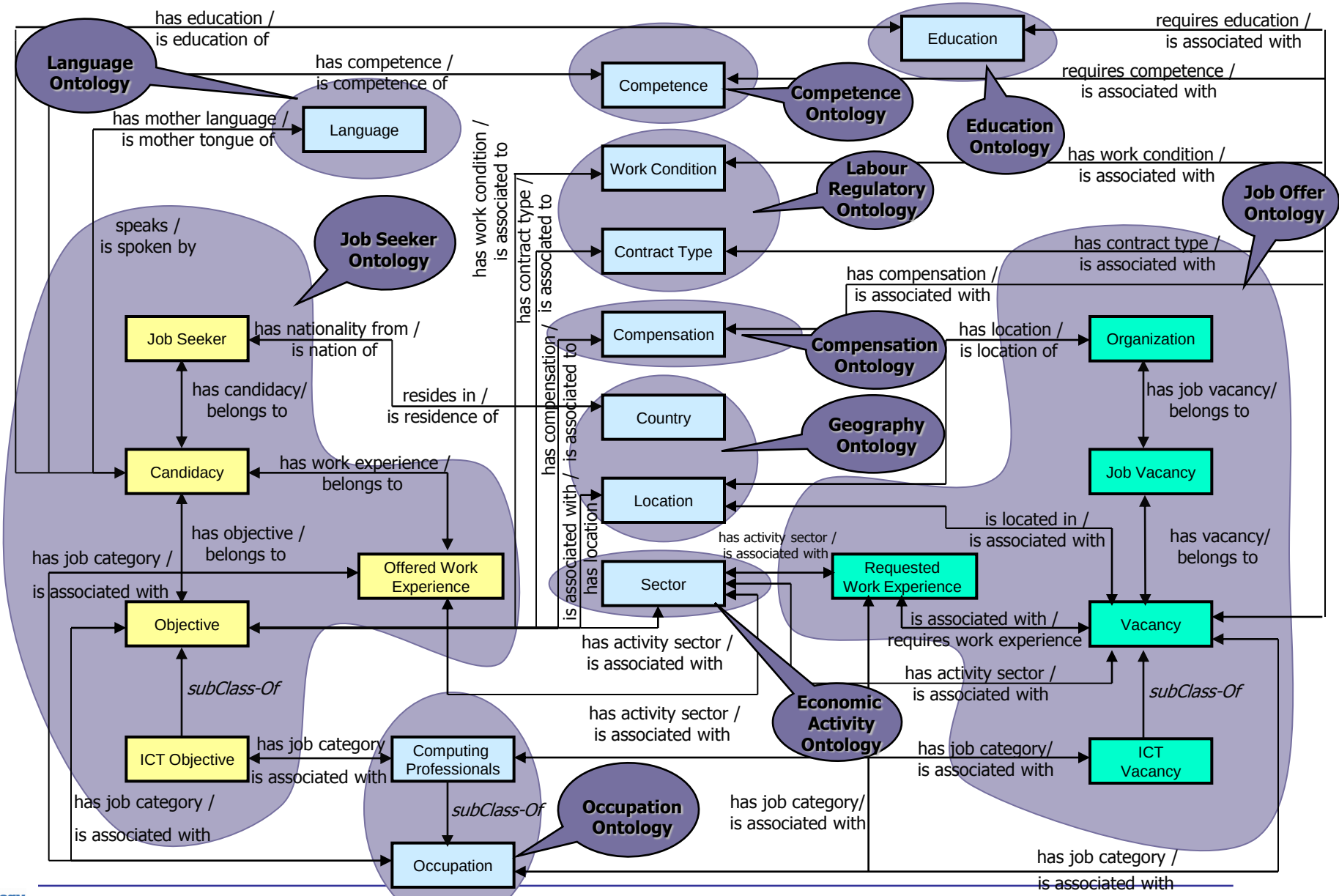
Details of the ontology



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Conclusions

- Which are the key process and activities in ontology development?
  - NeOn Scenarios for Building Ontology Networks
- How do I collect the requirements of my ontology?
  - Ontology Requirements Specification
- Which specific sequence of activities should carry out for building my ontology?
- When should I carry out each activity?
- Where is the relationship of one activity with the others?
  - Ontology Network Life Cycle models
  - Ontology Network Life Cycles
  - Scheduling and gOntt
- How do I reuse existing non-ontological resources to build my ontology?
  - Non Ontological Resource Reuse and Reengineering
- Where can I find ontologies with the goal of reusing them?
  - OMV and Watson
- How do I reuse existing ontological resources to build my ontology?
  - Ontological Resource Reuse
- How do I have my ontology in different natural languages?
  - Ontology Localization
- How can I build the ontology for my application?
  - SEEMP example

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NeOn Methodology Pointers

- http://www.neon-project.org/nw/NeOn_Book
- Scenarios for Building Ontology Networks → **D5.3.1 and D5.4.2**
- NeOn Glossary of Processes and Activities → **D5.3.1 and D5.3.2**
- Set of Ontology Network Life Cycle Models → **D5.3.2**
- Methodological Guidelines for Ontology Requirements Specification → **D5.4.1**
- Methodological Guidelines for Scheduling and gOntt plug-in → **D5.3.2**
- Methodological Guidelines for Non-Ontological Resource Reuse and Reengineering → **D5.4.1 and D2.2.2**
- Methodological Guidelines for Ontological Resource Reuse → **D5.4.1**
- Methodological Guidelines for ODP Reuse → **D5.4.1 and D5.4.2**
- Methodological Guidelines for Ontology Modularization → **D5.4.2**
- Methodological Guidelines for Ontology Evaluation → **D5.4.2**
- Methodological Guidelines for Ontology Evolution → **D5.4.2**
- Methodological Guidelines for Ontology Localization → **D5.4.2**