Ontology Engineering: How can we build ontologies? Methods, Techniques and Methodologies

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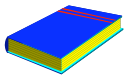
Main References

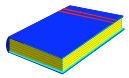
Gómez-Pérez, A.; Fernández-López, M.; Corcho, O. **Ontological Engineering.** *Springer Verlag. 2003*

http://www.ontoweb.org



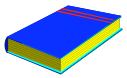
Deliverables
- D1.4
- D1.5

http://knowledgeweb.semanticweb.org



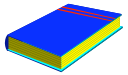
Research deliverables
Industry deliverables

http://www.seemp.org



Research deliverables

http://www.neon-project.org



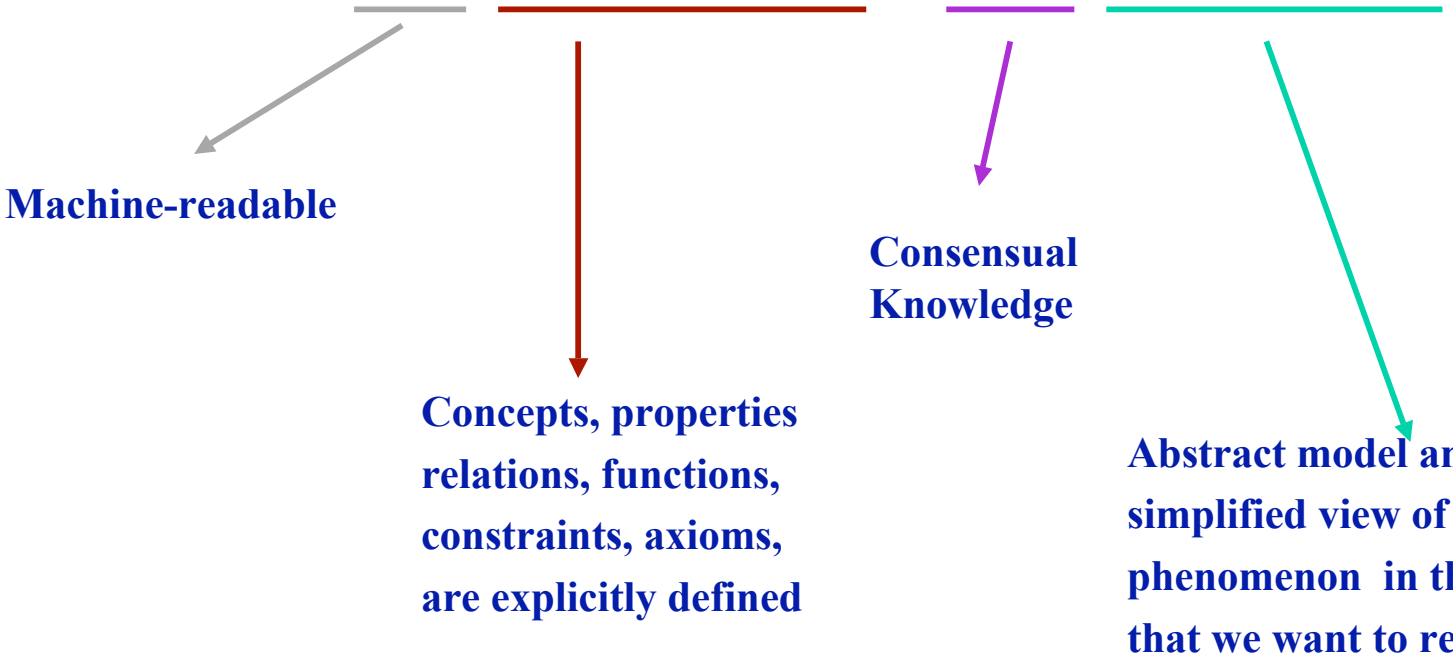
Research deliverables

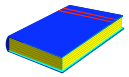
Acknowledgements

- Asunción Gómez-Pérez, Mariano Fernández-López, and Boris Villazón
  - Most of the slides have been done jointly with them
- Jeremy Roberts (University of Manchester)
  - Knowledge elicitation techniques

Ontology Definition

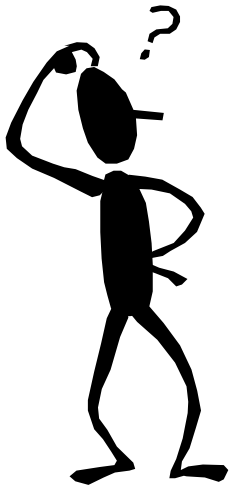
"An ontology is a formal, explicit specification of a shared conceptualization"



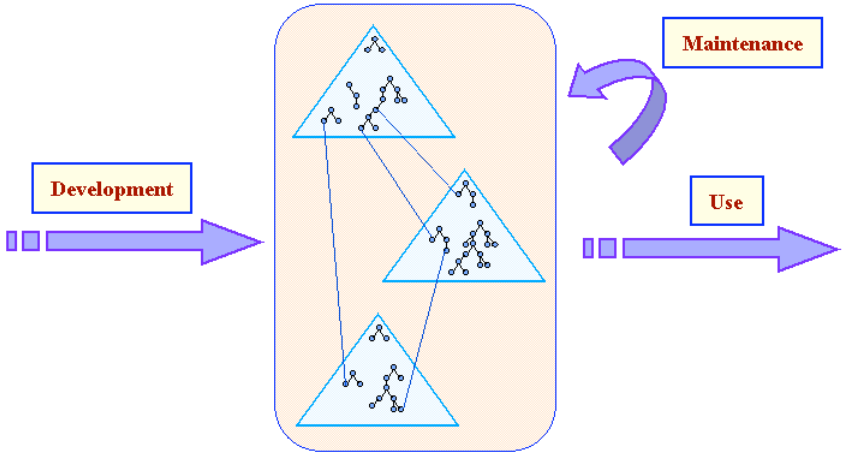


Studer, Benjamins, Fensel. **Knowledge Engineering: Principles and Methods.** ***Data and Knowledge Engineering.*** **25 (1998) 161-197**

I want to build my ontology



- Which one are the activities involved in the ontology development process?
- Which one is the goal of each activity?
- When should I carry out each activity?
- What is the relationship of one activity with the others?
- Where can I find ontologies with the goal of reusing them?
- How can I use the ontology in my application?



Ontology Engineering

It refers to the set of activities that concern

the ontology development process,

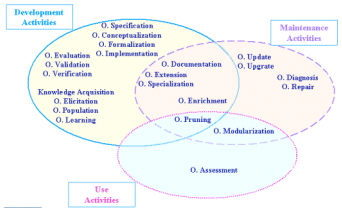
the ontology life cycle,

the methods and methodologies for building ontologies,

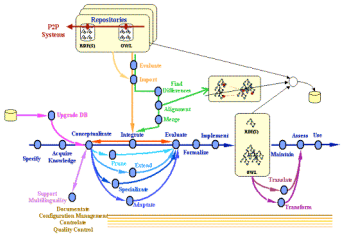
and the tool suites

and languages that support them

Three aspects of ontology development

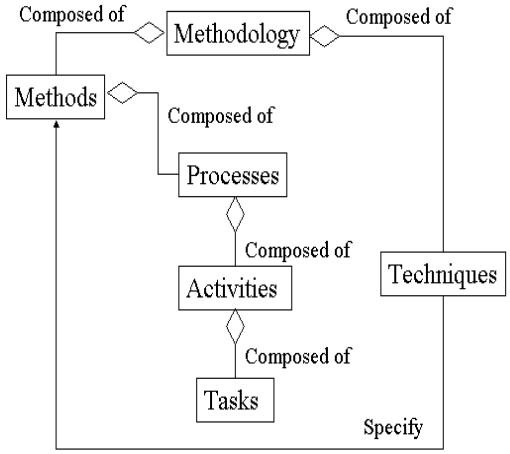


Development Process: Which activities



Life Cycle: Order of activities

1. **Intra-ontology dependencies**
2. **Inter-ontology dependencies**



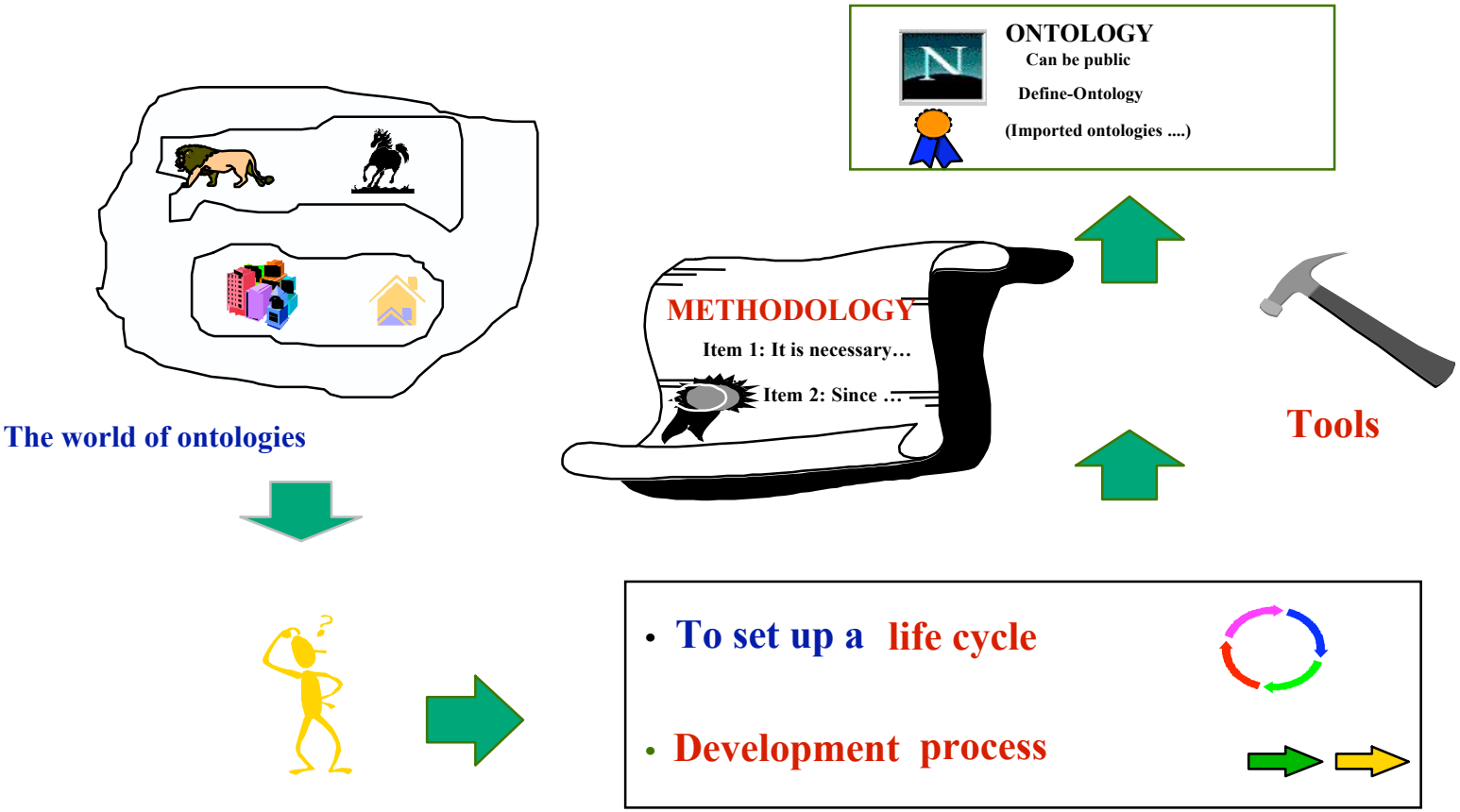
Methodologies: How to carry out the activities

1. **Input and outputs**
2. **Methods, tasks, techniques, tools**
3. **Who, When, What, How, Where, Which**

Outline

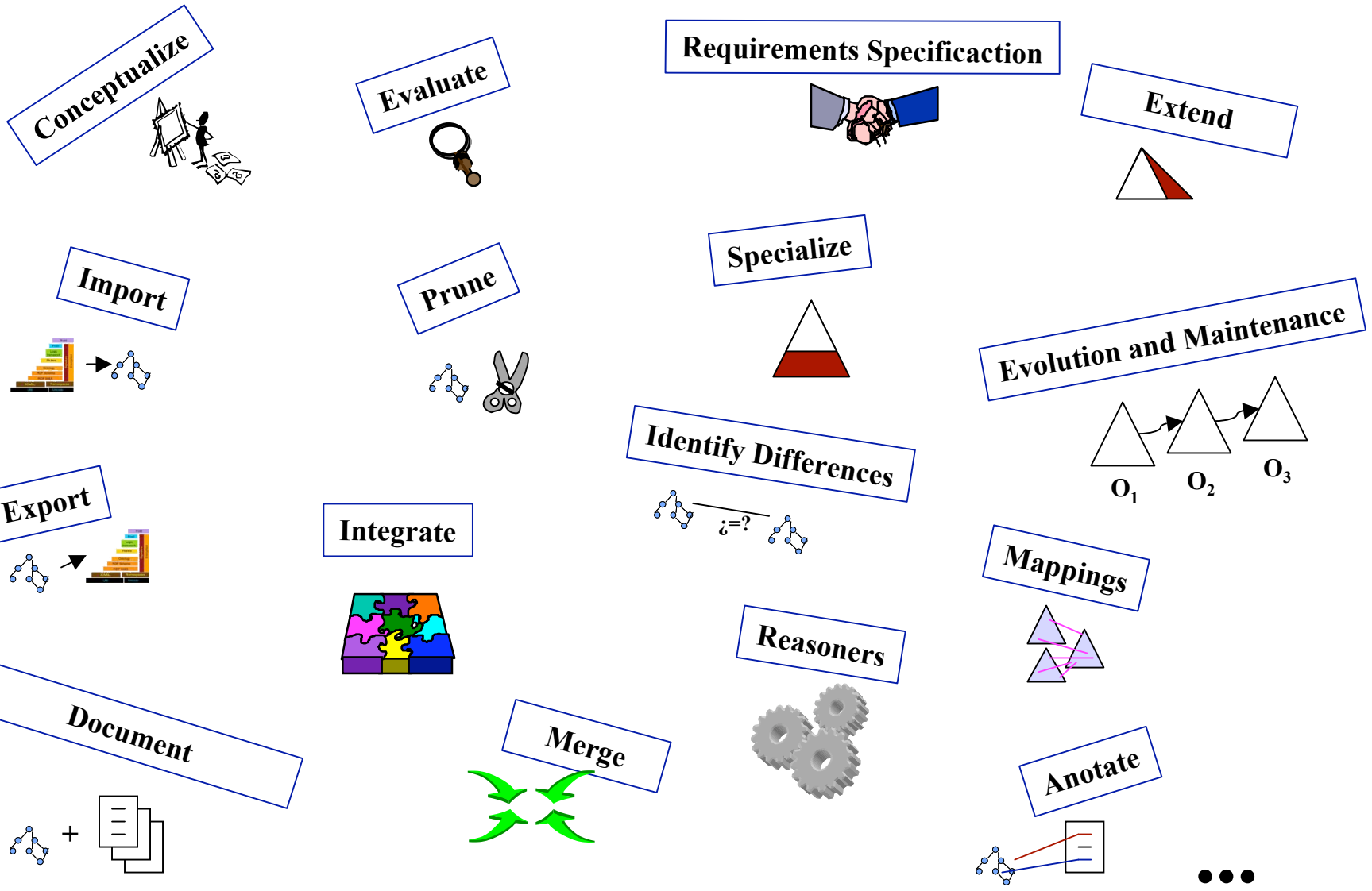
- **Ontology Development Process**
- Ontology Development Lifecycle
- Methodologies for Building Ontologies
- An example: An ontology about human resources

The Framework



Gómez-Pérez, A. *Knowledge Sharing and Reuse.* **In the Handbook of Applied Expert Systems.** CRC Press. 1998.

Ontologies are available anywhere in Internet



The NeOn Glossary of Activities

Collaboratively Ontology Activity identification and definition

- 53 activity definitions consensuated

On-going Steps:

- Publication in the NeOn website (http://www.neon-project.org)
- Procedure for getting feed-back from the community (http://cicero.uni-koblenz.de)

The NeOn Glossary of Activities

- Ontology Adaptation
- Ontology Alignment / Aligning
- Ontology Annotation
- Ontology Articulation
- Ontology Assessment
- Ontology Combining
- Ontology Comparing
- Ontology Conceptualization
- Ontology Configuration Management
- Ontology Coordination
- Ontology Customization
- Ontology Diagnosis
- Ontology Documentation
- Ontology Elicitation
- Ontology Enrichment
- Ontology Evaluation
- Ontology Evolution
- Ontology Extension
- Ontology Formalization
- Ontology Generation
- Ontology Implementation
- Ontology Integration
- Knowledge Acquisition for Ontologies
- Ontology Learning
- Ontology Localization
- Ontology Mapping
- Ontology Matching
- Ontology Mediation
- Ontology Merging
- Ontology Modification
- Ontology Modularization
- Ontology Module Extraction
- Ontology Partitioning
- Ontology Personalization
- Ontology Population
- Ontology Pruning
- Ontology Reconciliation
- Ontology Reengineering
- Ontology Repair
- Ontology Reuse
- Ontology Searching
- Ontology Selection
- Ontology Specialization
- Ontology Specification
- Ontology Summarization
- Ontology Transforming
- Ontology Translating
- Ontology Update
- Ontology Upgrade
- Ontology Validation
- Ontology Valuation
- Ontology Verification
- Ontology Versioning
- Scheduling
- Control
- Quality Assurance
- Environment Study
- Feasibility Study
- Reverse Engineering
- Reestructuring
- Forward Engineering

The NeOn Glossary of Activities

article | discussion | edit | history | protect | delete | move | watch | refresh

WP5WorkingArea: Knowledge Acquisition for Ontologies

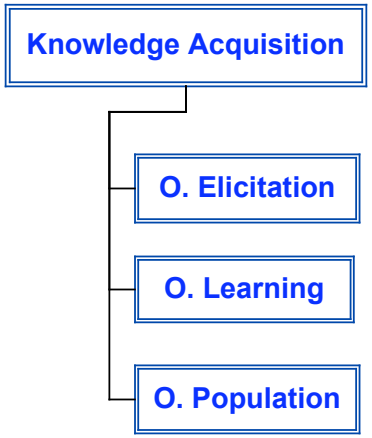
- **Final Definition**: *Knowledge Acquisition for Ontologies* comprises activities for capturing knowledge (e.g., T-Box and A-Box) from a variety of sources. We distinguish between: **Ontology Elicitation**, **Ontology Learning** and **Ontology Population**.

WP5WorkingArea: Ontology Elicitation

- **Final Definition**: *Ontology Elicitation* is a knowledge acquisition activity in which conceptual structures (e.g. T-Box) and their instances (e.g. A-Box) are acquired from domain experts.

WP5WorkingArea: Ontology Learning

- **Final Definition**: *Ontology Learning* is a knowledge acquisition activity that relies on (semi-) automatic methods to transform unstructured (e.g. corpora), semi-structured (e.g. folksonomies, html pages, etc.) and structured data sources (e.g. data bases) into conceptual structures (e.g. T-Box).



WP5WorkingArea: Ontology Population

(Redirected from WP5WorkingArea: Ontology Population/Grounding)

- **Final Definition**: *Ontology Population* is a knowledge acquisition activity that relies on (semi-) automatic methods to transform unstructured (e.g. corpora), semi-structured (e.g. folksonomies, html pages, etc.) and structured data sources (e.g. data bases) into instance data (e.g. A-Box).

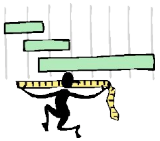
Table of "Required and If-Applicable" Activities

- **Required activities** refer to those activities that should be carried out when developing networks of ontologies.
- **If Applicable activities** refer to those activities that can be carried out or not, depending on the case, when developing ontology networks.

	Required	If Applicable
Ontology Enrichment		X
Ontology Environment Study	X	
Ontology Evaluation	X	
Ontology Evolution	X	
Ontology Extension		X
Ontology Feasibility Study	X	
Ontology Formalization	X	
Ontology Forward Engineering		X
Ontology Implementation	X	
Ontology Integration	X	
Knowledge Acquisition for Ontologies	X	
Ontology Learning		X
Ontology Localization		X
Ontology Matching		X

Ontology Network Development Process

Management



Scheduling

Control

O. Quality Assurance

Development-oriented

Pre-Development

O. Environment Study

O. Feasibility Study

Development

O. Specification

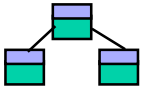
O. Conceptualization

O. Reuse

O. Translation

Non Ontological Resource Reengineering

O. Restructuring



O. Formalization

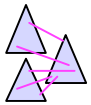
O. Implementation

O. Annotation

Non Ontological Resource Reuse

O. Reengineering

O. Customization



O. Aligning

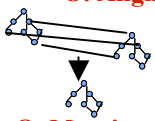
O. Integration

O. Modularization

O. Update

O. Modification

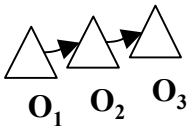
O. Localization



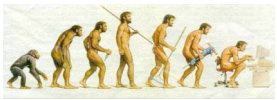
O. Merging

Post-Development

O. Upgrade



O. Versioning



O. Evolution

Support

Knowledge Acquisition

O. Documentation

O. Summarization

O. Evaluation (V&V)

O. Configuration Management

O. Assessment

Ontology Life Cycle. Intra-dependencies

Time

Pre-Development

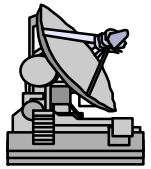
O. Environment Study

O. Feasibility Study

Management

Scheduling

Management



Control

O. Quality Assurance

Development-oriented

Development

Post-Development

Support

Knowledge Acquisition

O. Documentation

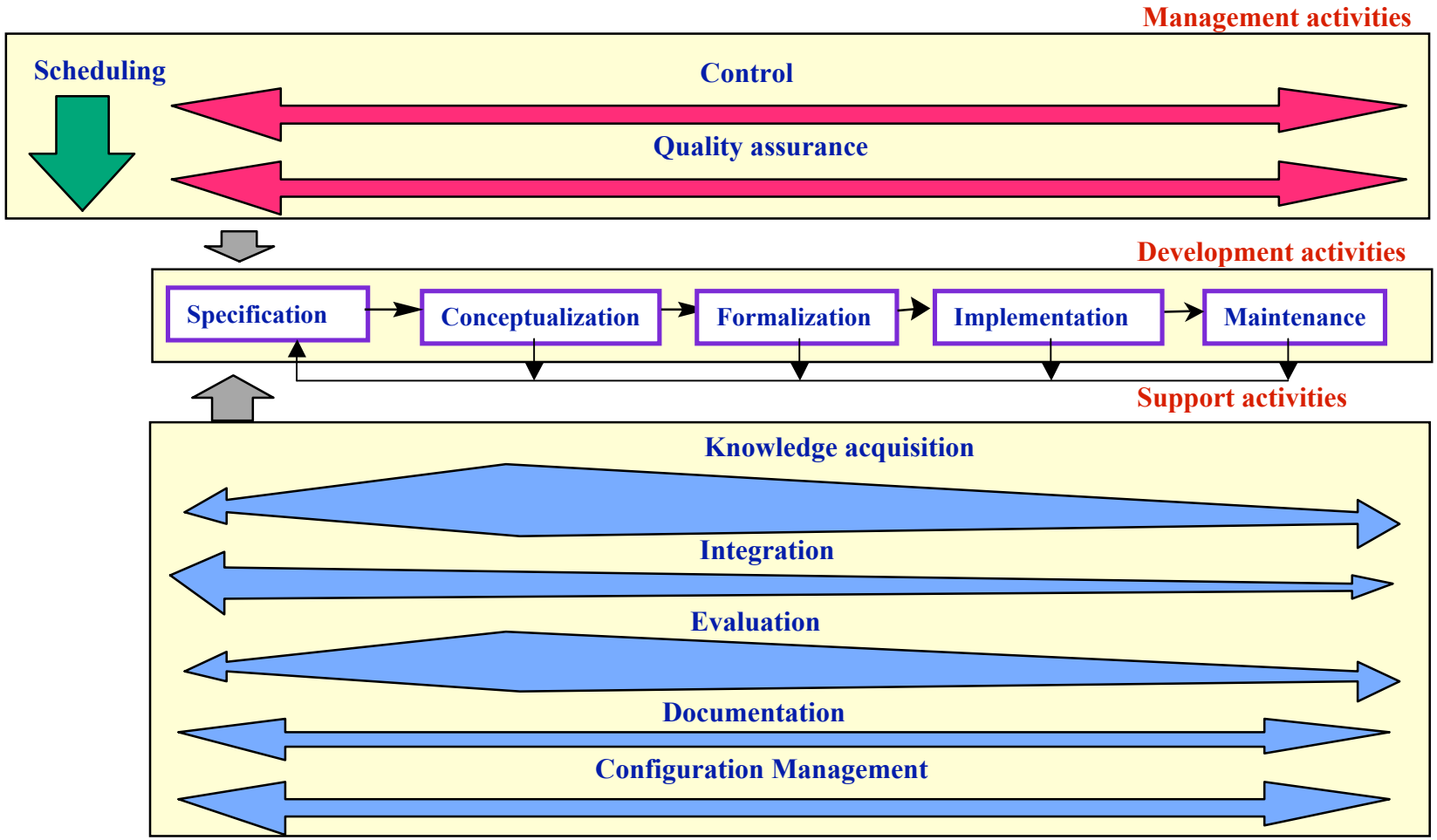
O. Summarization

O. Evaluation (V&V)

O. Configuration Management

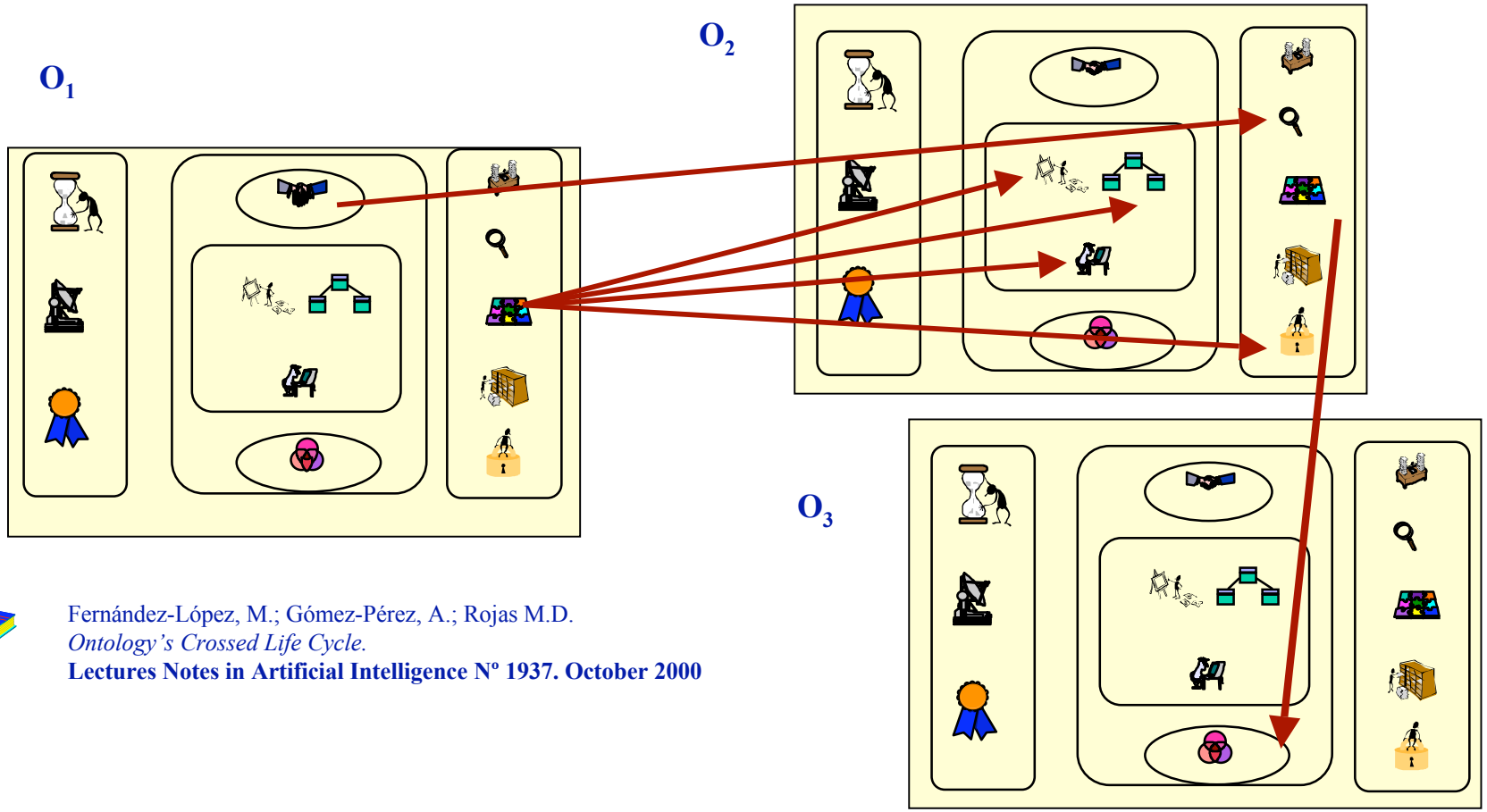
O. Assessment

Ontology Life Cycle. Intra-dependencies



Ontology Life Cycle. Inter-dependencies

Inter-dependencies refer the relationship between activities carried out when building different ontologies



Fernández-López, M.; Gómez-Pérez, A.; Rojas M.D.
Ontology's Crossed Life Cycle.
Lectures Notes in Artificial Intelligence Nº 1937. October 2000

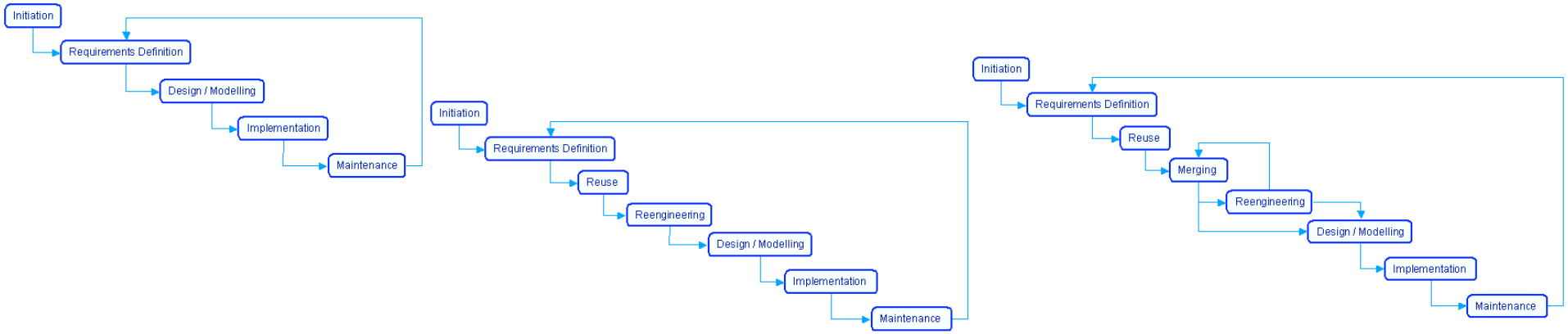
Outline

- Ontology Development Process
- **Ontology Development Lifecycle**
- Methodologies for Building Ontologies
- An example: An ontology about human resources

Life Cycle Models and Life Cycles in Ontological Engineering

- An **ontology (network) 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.
- The **ontology (network) life cycle** is the project specific sequence of activities, created by mapping the activities identified in the ontology development process onto a selected ontology life cycle model.

Example: three versions of the waterfall ontology network life cycle model

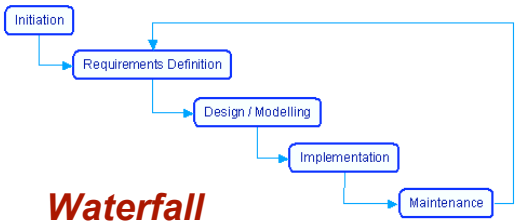


Several Ontology Life Cycle Models are possible

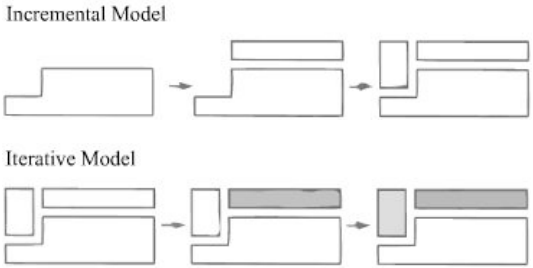
There is **no a unique life cycle model** valid for all the ontology development projects and that each life cycle model is appropriate for a concrete project, depending on several features.

For example, sometimes it is better a simple one (like waterfall), whereas other times it is most suitable a spiral one (if the analysis of the risk is needed within the project).

- **Assumption: Ontology requirements are known at the begining of the ontology development project.**



Waterfall



- **Assumption: Ontology requirements can be not known at the begining of the ontology development project and can change during the project.**

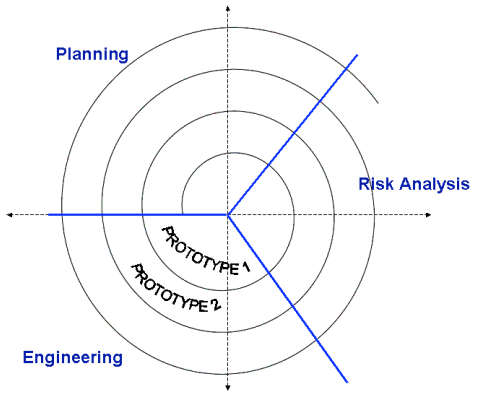
Evolutionary Prototyping

Rapid Throwaway Prototyping

Several Ontology Life Cycle Models are possible

- **Assumption: Uncertainties in the ontology requirements can derive into risks in the project.**

Spiral



Risks can be:

- **Properties became classes**
- **Move from frames to DL**
- **Reuse new existing resources**

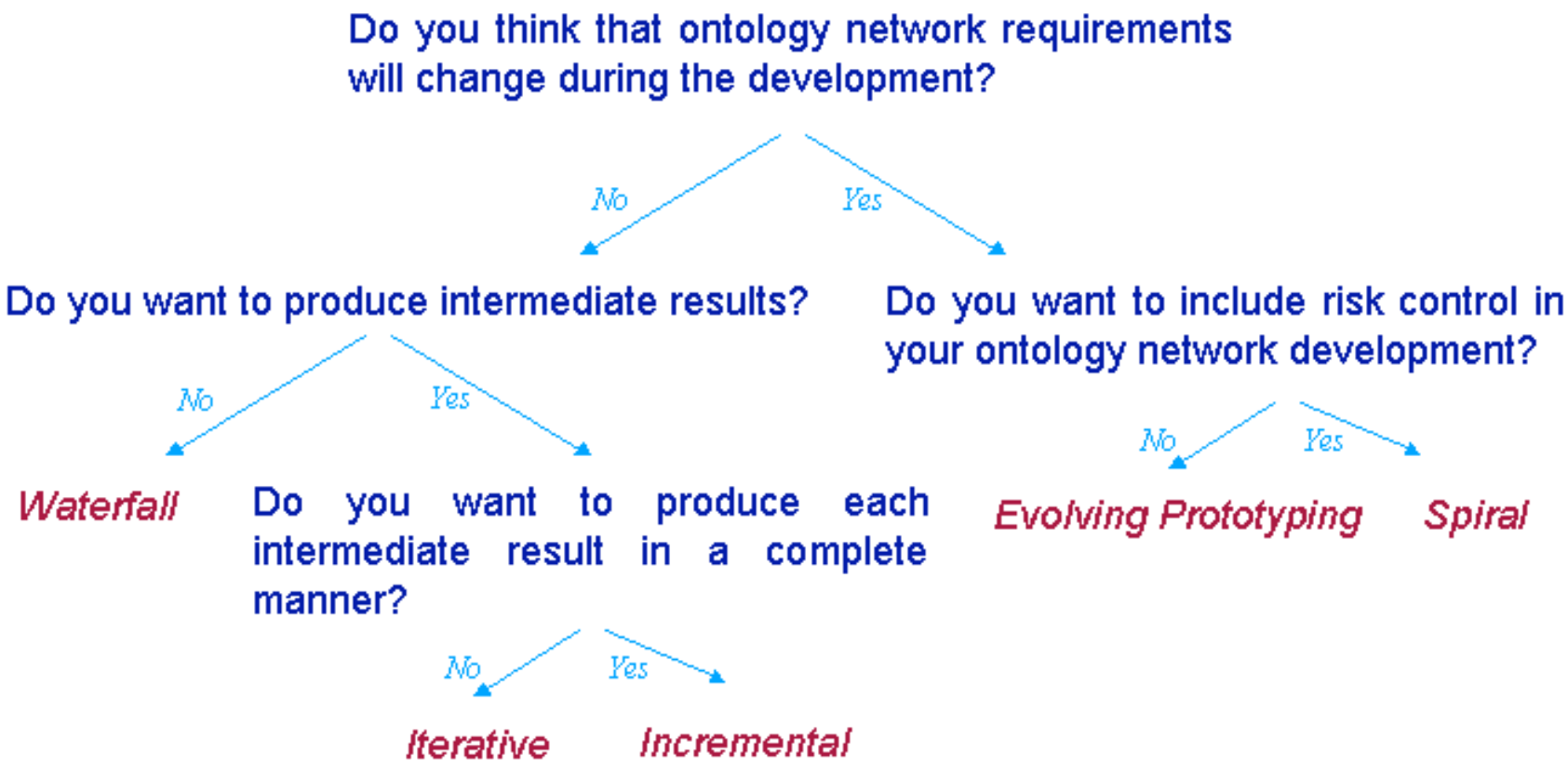
- **Planning**: in this phase it is carried out the whole schedule for the ontology network development and the specification of the ontology network requirements.
- **Risk analysis**: after analysing the possible risk within the ontology network development, the decision of continuing or not with a new iteration around the spiral is taken.
- **Engineering**: in this phase it is developed a prototype of the ontology network based on the specified requirements, following any type of waterfall ontology network life cycle model.

How software developers and ontology practitioners decide which **ontology network life cycle model** is the most appropriate for their ontology network and which **concrete activities** should be carried out in their ontology network life cycle?

Proposed steps:

- Identify ontology network development requirements.
- Select the ontology network life cycle model (ONLCM) to be used.
- Select activities to be carried out from the "Required–if Applicable" table.
- Map the selected activities into the selected ontology network life cycle model.
- Set the order of the activities: the result is the ontology network life cycle for the ontology network.

Step 2: Decision Tree for Selecting the Ontology Network Life Cycle Model



Step 3: Decision Tree for Selecting Activities to be mapped in the Ontology Network Life Cycle Model

Have you developed more than 5 ontologies?

No

Set of "yes/no" natural language questions for identifying the 'if-applicable' activities to be carried out.

- Do you want to have your ontology network in different natural languages, as for example, in English, Spanish and French? YES → *O. Localization*.
- Do you want to take an existing and implemented ontology, in order to enhance it and implement it again? NO → *O. Reengineering is not selected*.

Yes

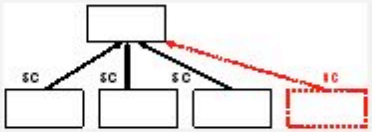
Software developers and ontology practicioners select the activities to be carried out from the "Required-If Applicable" table

	If Applicable	Selected
Ontology Aligning	X	X
Ontology Customization	X	
Ontology Learning	X	
Ontology Localization	X	X
Ontology Matching	X	X
Ontology Modification	X	
Ontology Reengineering	X	
Ontology Restructuring	X	X

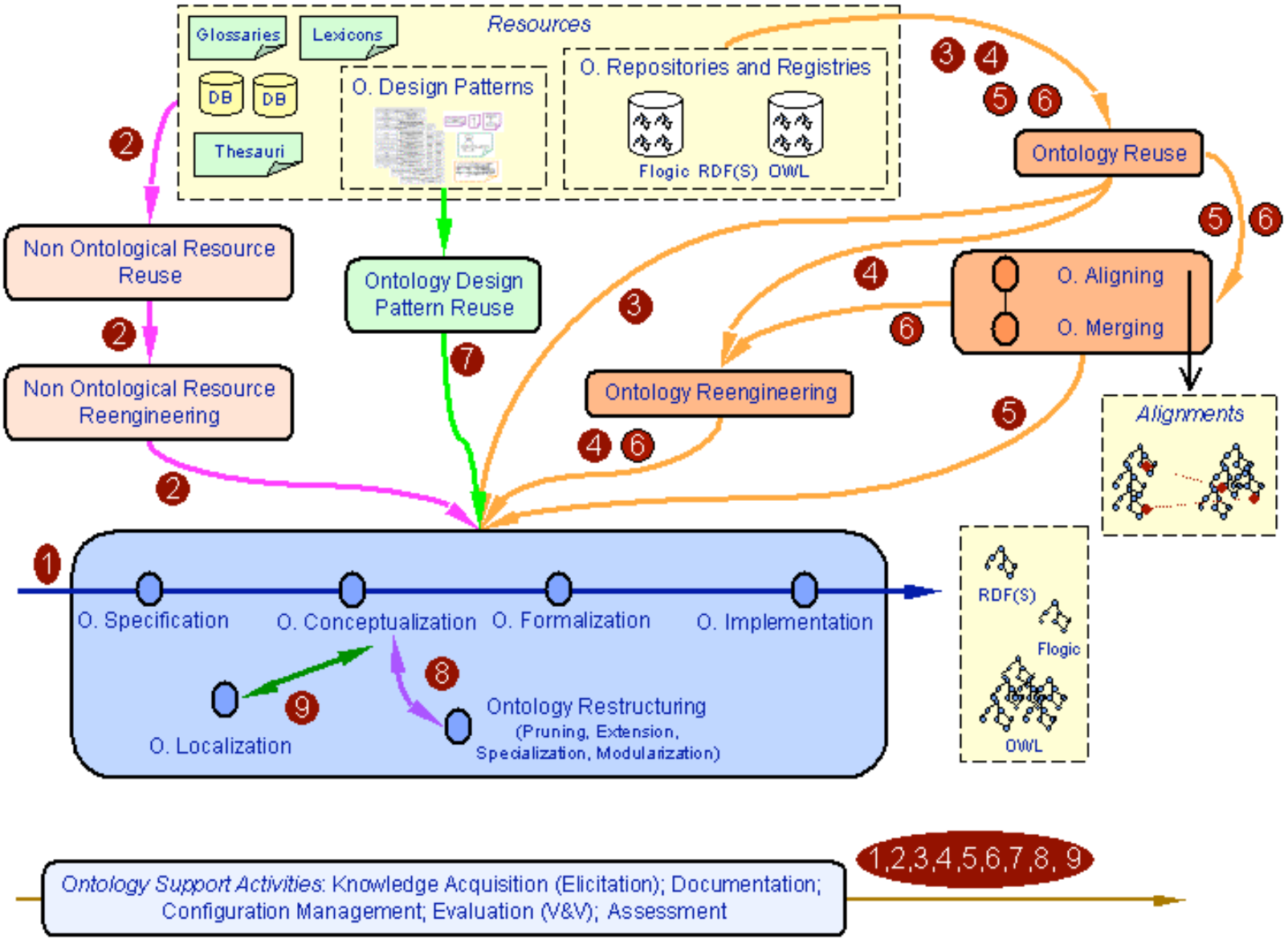
Automatically

"Yes/No" Natural Language Questions

Set of "yes/no" natural language questions for identifying the 'if-applicable' activities to be carried out.

Activity	*Natural Language Questions*
Ontology Aligning **(or Ontology Mapping)**	Do you have two or more ontologies at your disposal that you want to examine to find correspondences and to take advantage of them? Do you want to find out correspondences among ontologies to use them?
Ontology Customization	Do you want to adapt the ontology network to a specific user profile? Do you want to modify the ontology network to meet specific user needs?
Ontology Enrichment	Do you want to widen/extend your current ontology network with additional elements (e.g., concepts, roles, axioms, etc.)?
Ontology Extension	Do you want to stretch, widen, broaden or expand your current ontology network by adding new concepts "in a horizontal way/direction" with the aim of widenning its sphere of action?  (cf. Ontology Specialization)
Ontology Forward Engineering	Are you going to carry out a new implementation for a previously modified conceptual model? Are you going to produce a new implementation for a modified conceptual model, whose previous version had already been implemented?

Scenarios for Building Ontology Networks

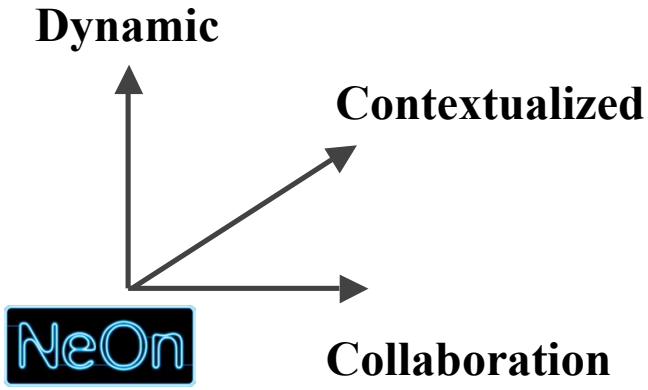


Outline

- Ontology Development Process
- Ontology Development Lifecycle
- **Methodologies for building ontologies**
- An example: An ontology about human resources

Most relevant methodologies

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



None deals with the three dimensions simultaneously

NeOn Methodology V1 will be available in February 2008

Uschold's Methodology

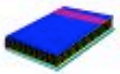
1. Identify Purpose and Scope

2. Building the ontology

   - Ontology Capture → • Identify key concepts and relationships • Produce unambiguous text definitions • Identify terms to refer to such concepts and relations
   - Ontology Coding → • Commit to a meta-ontology • Choose a representation language • Write the code
   - Integrating existing ontologies → How and whether to reuse ontologies that already exist

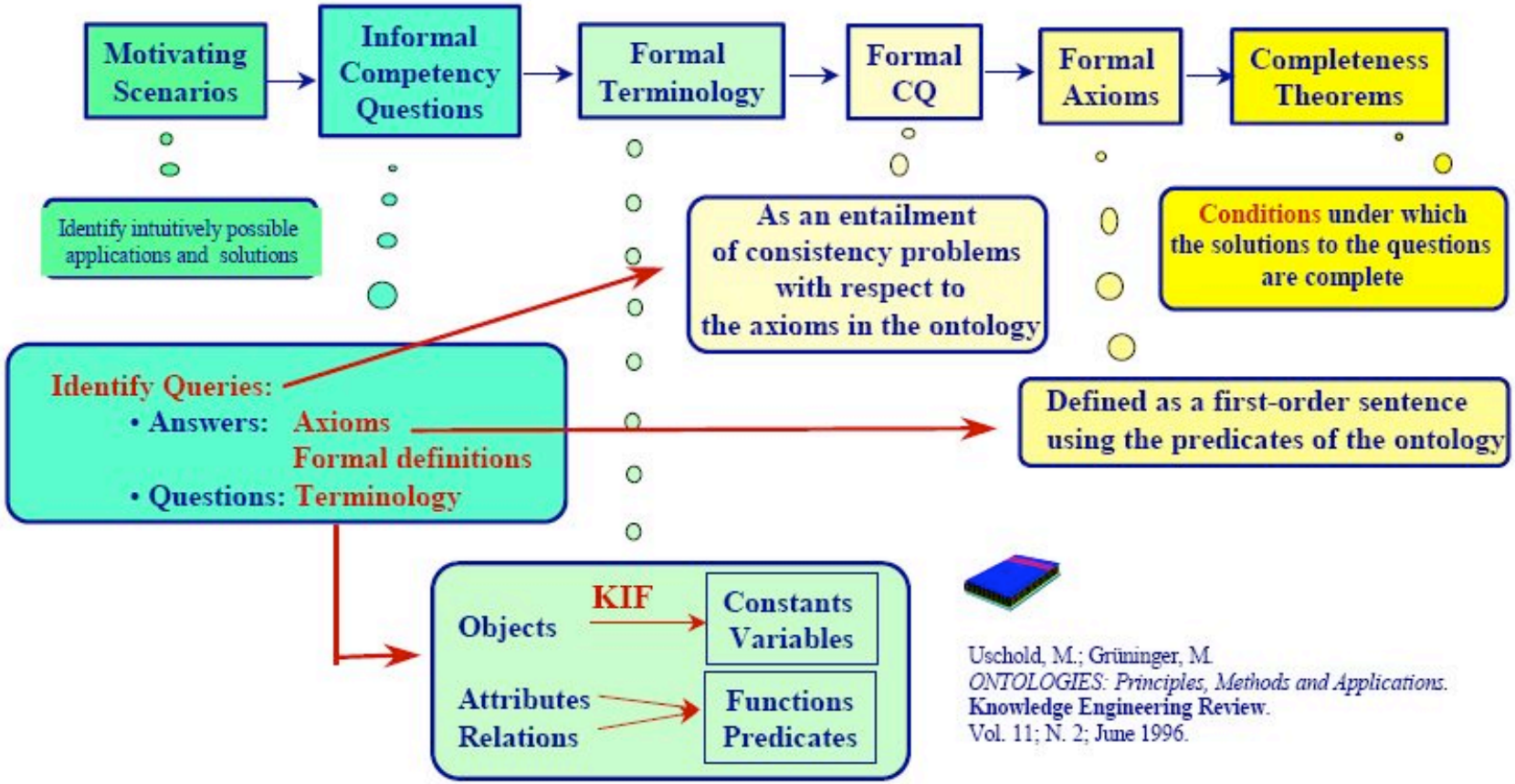
3. Evaluation

4. Documentation



Uschold, M.; Grüninger, M. *ONTOLOGIES: Principles, Methods and Applications.* **Knowledge Engineering Review**. Vol. 11; N. 2; June 1996.

TOVE Methodology

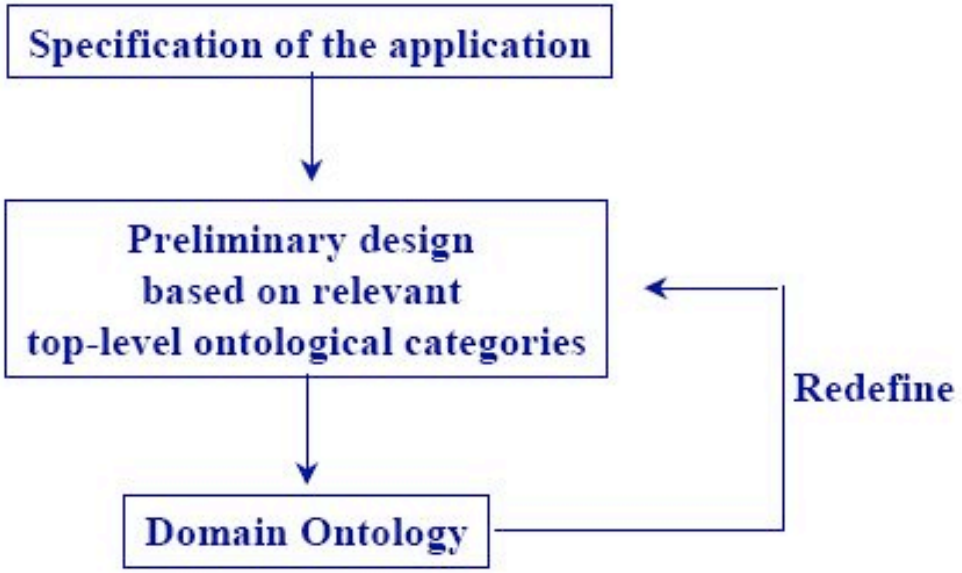


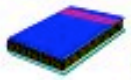
Uschold, M.; Grüninger, M.
ONTOLOGIES: Principles, Methods and Applications.
Knowledge Engineering Review.
Vol. 11; N. 2; June 1996.

Methodology used on the KACTUS project

A botton-up approach for building ontologies

Build a preliminary ontology for refinement and augment with new definitions



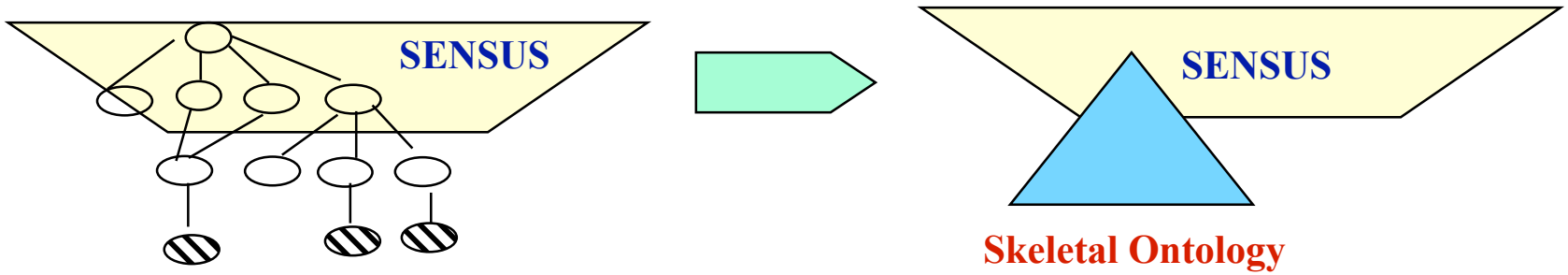


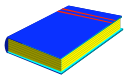
A. Bernaras; I. Laresgoiti; J. Corera. *Building and reusing ontologies for electrical network applications* ECAI96. 12th European Conference on Artificial Intelligence. 1996. 298-302

SENSUS Method

Linking Domain Specific Terms to a broad Coverage Ontology

To identify the terms in SENSUS that are relevant to a particular domain and then prune the skeletal ontology using heuristics





B. Swartout; R. Patil; k. Knight; T. Russ. *Toward Distributed Use of Large-Scale Ontologies* **Ontological Engineering.** AAAI-97 Spring Symposium Series. 1997. 138-148.

SENSUS method (II)

METHOD

1. Identify "seed" terms
2. Link seed terms to SENSUS by hand
3. Include nodes on the path to root
4. Add entire subtrees using the heuristic:

   If many nodes in a subtree are relevant,

   the other nodes in the subtree are relevant

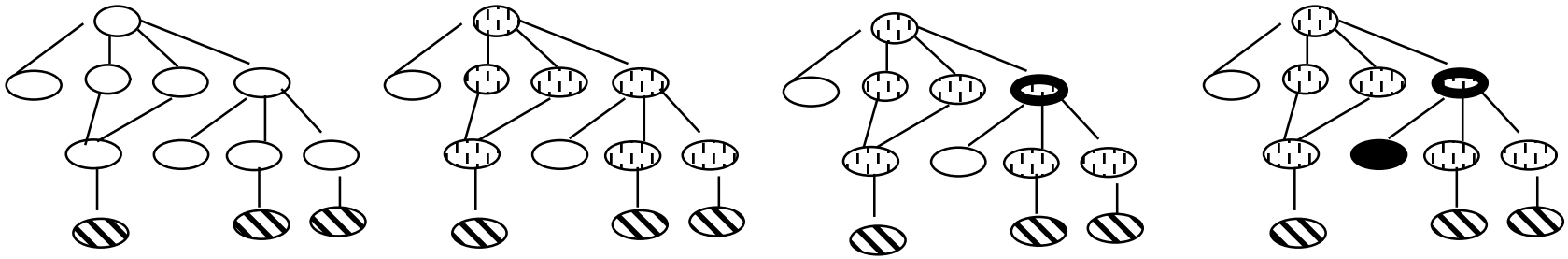

Sensus Term

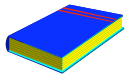

Seed


Path to root


Frequent Parent


Subtree Term

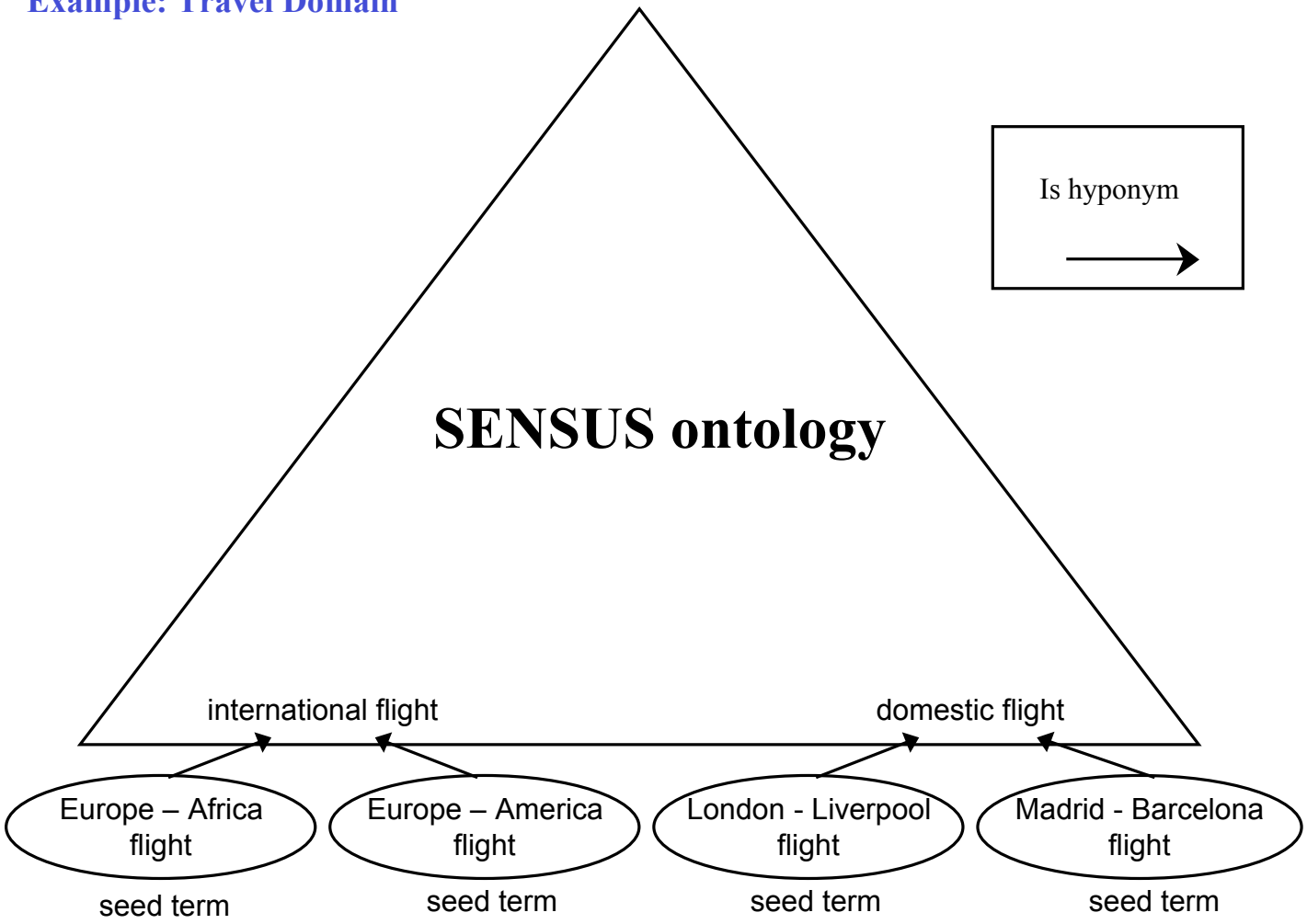




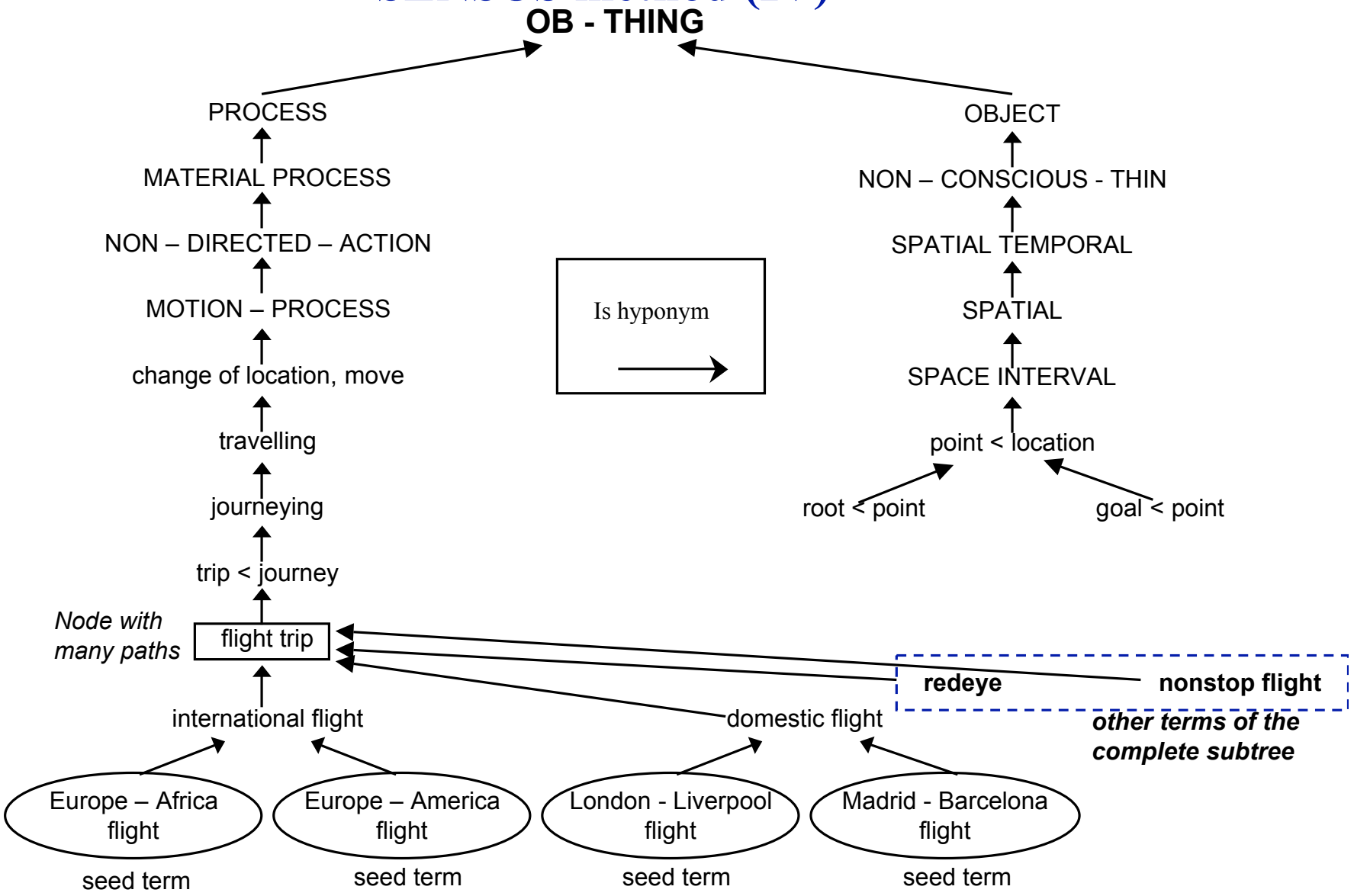
B. Swartout; R. Patil; k. Knight; T. Russ. *Toward Distributed Use of Large-Scale Ontologies* **Ontological Engineering.** AAAI-97 Spring Symposium Series. 1997. 138-148.

SENSUS method (III)

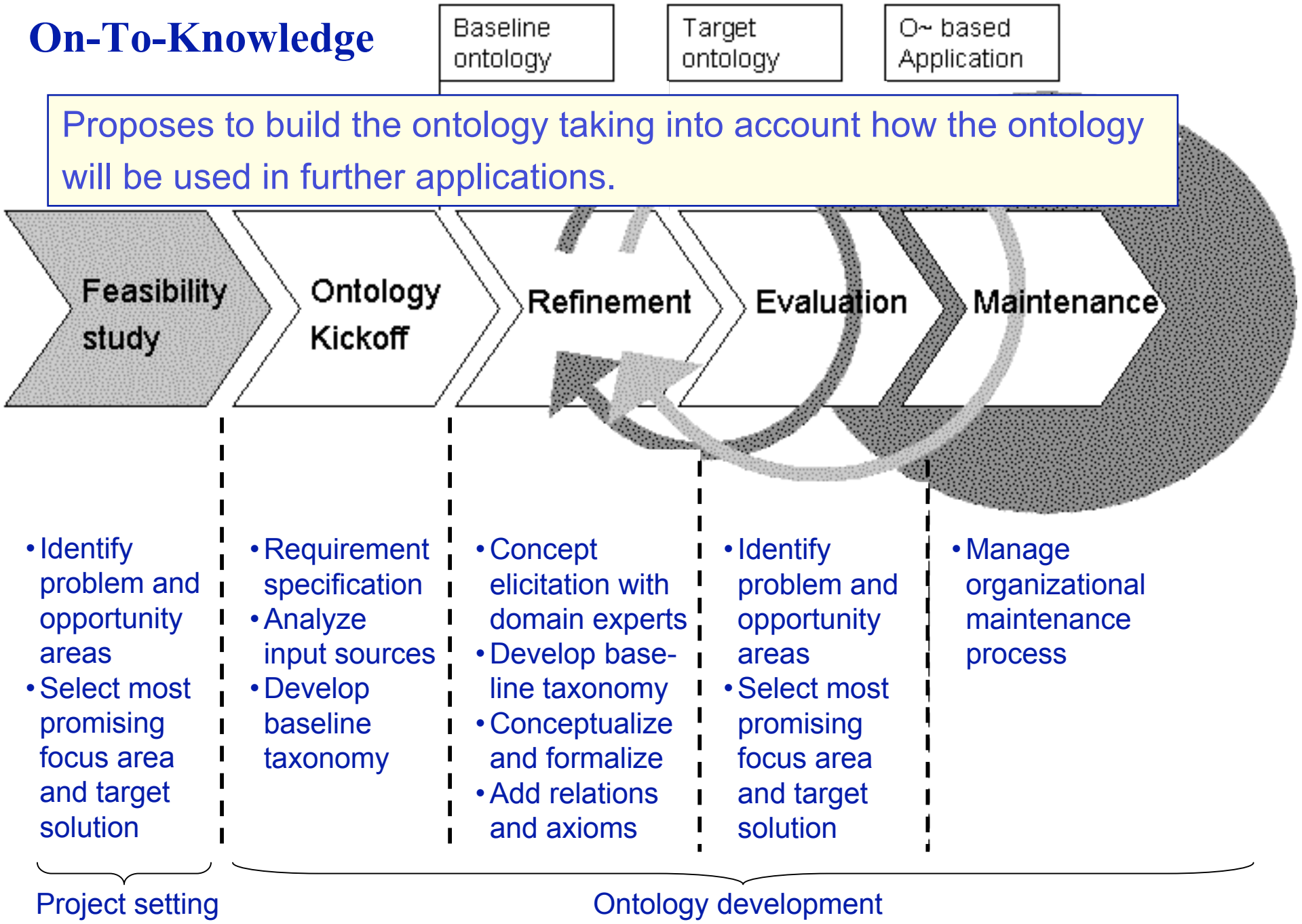
Example: Travel Domain



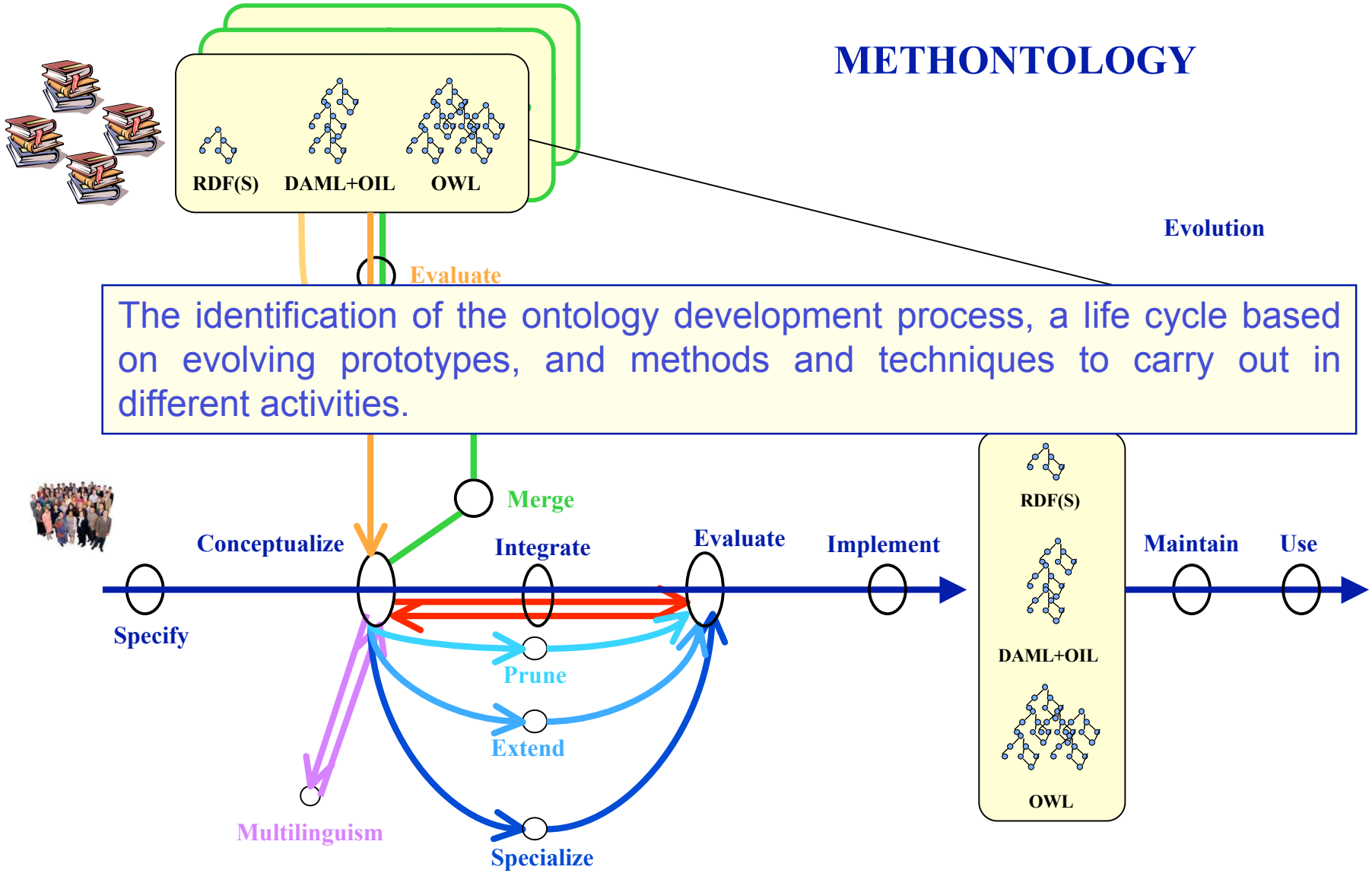
SENSUS method (IV)



On-To-Knowledge



METHONTOLOGY



Summary of the Methodologies

With respect to the activities in the ontology development process

Feature			Cyc	Uschold & King	Grüninger & Fox	KACTUS	METHONTOLOGY	SENSUS	On-To-Knowledge
Ontology management activities	Scheduling		NP	NP	NP	NP	*Proposed*	NP	*Described*[12]
	Control		NP	NP	NP	NP	*Proposed*	NP	*Described*
	Quality assurance		NP	NP	NP	NP	NP	NP	*Described*
Ontology development-oriented activities	Pre-development processes	Environment study	NP	NP	NP	NP	NP	NP	*Proposed*
		Feasibility study	NP	NP	NP	NP	NP	NP	*Described*
	Development processes	Specification	NP	*Proposed*	*Described in detail*	*Proposed*	*Describe in detail*	*Proposed*	*Describe in detail*
		Conceptualization	NP	NP	*Described in detail*	*Proposed*	*Described in detail*	NP	*Proposed*
		Formalization	NP	NP	*Described in detail*	*Described*	*Described*	NP	*Described*
		Implementation	*Proposed*	*Proposed*	*Described*	*Proposed*	*Described in detail*	*Described*	*Described*
	Post-development processes	Maintenance	NP	NP	NP	NP	*Proposed*	NP	*Proposed*
		Use	NP	NP	NP	NP	NP	NP	*Proposed*
Ontology support activities	Knowledge acquisition		*Proposed*	*Proposed*	*Proposed*	NP	*Described in detail*	NP	*Described*
	Evaluation		NP	Proposed	*Described in detail*	NP	*Described in detail*	NP	*Proposed*
	Integration		*Proposed*[13]	*Proposed*	*Proposed*	*Proposed*	*Proposed*	NP	*Proposed*
	Configuration management		NP	NP	NP	NP	*Described*	NP	*Proposed*
	Documentation		*Proposed*	*Proposed*	*Proposed*	NP	*Described in detail*	NP	*Described*
	Merging and Alignment		NP	NP	NP	NP	NP	NP	NP

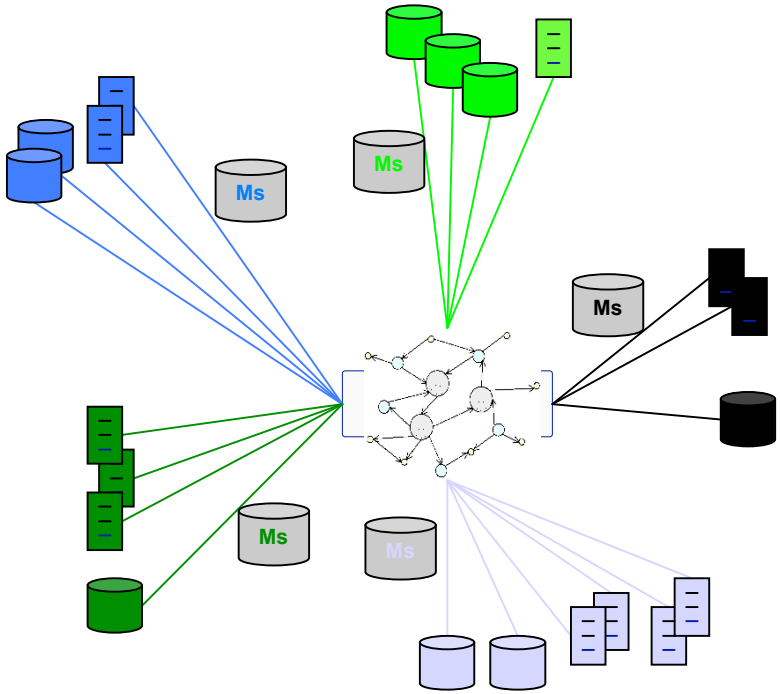
Outline

- Ontology Development Process
- Ontology Development Lifecycle
- Methodologies for building ontologies
- **An example: An ontology about human resources**

Looking for an European Employment

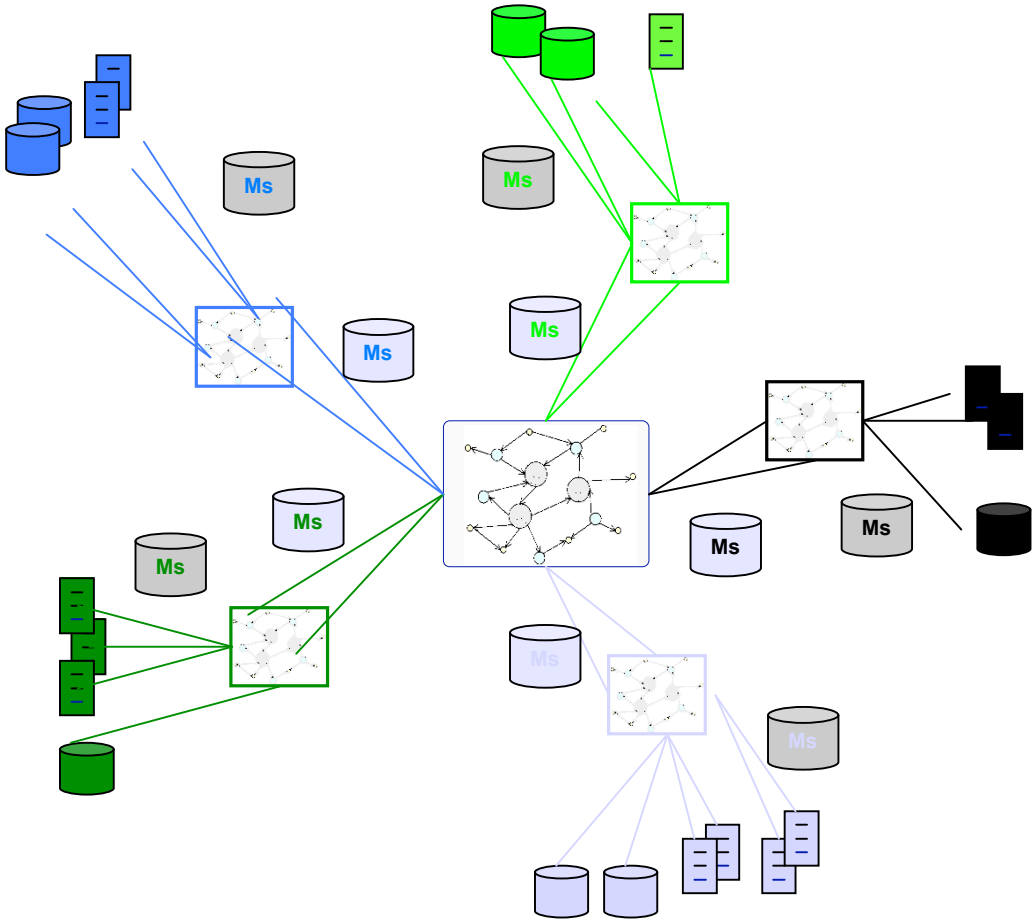
The Goal: Helping Job Seekers on their way

Centralized network of ontologies



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

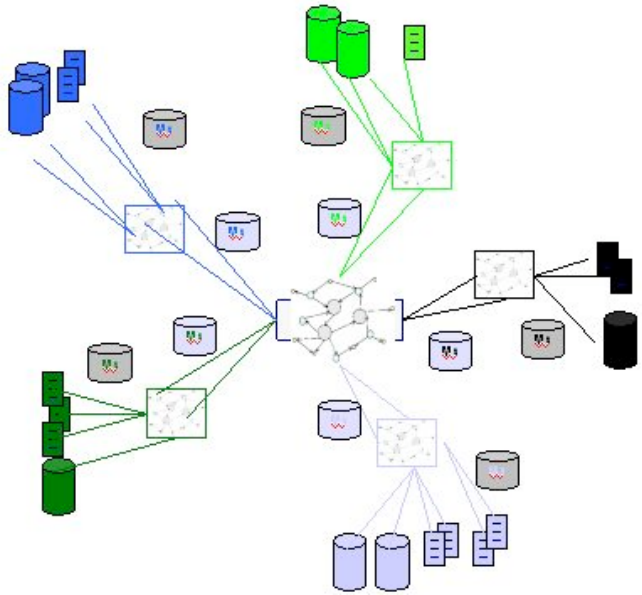
Federated network of ontologies

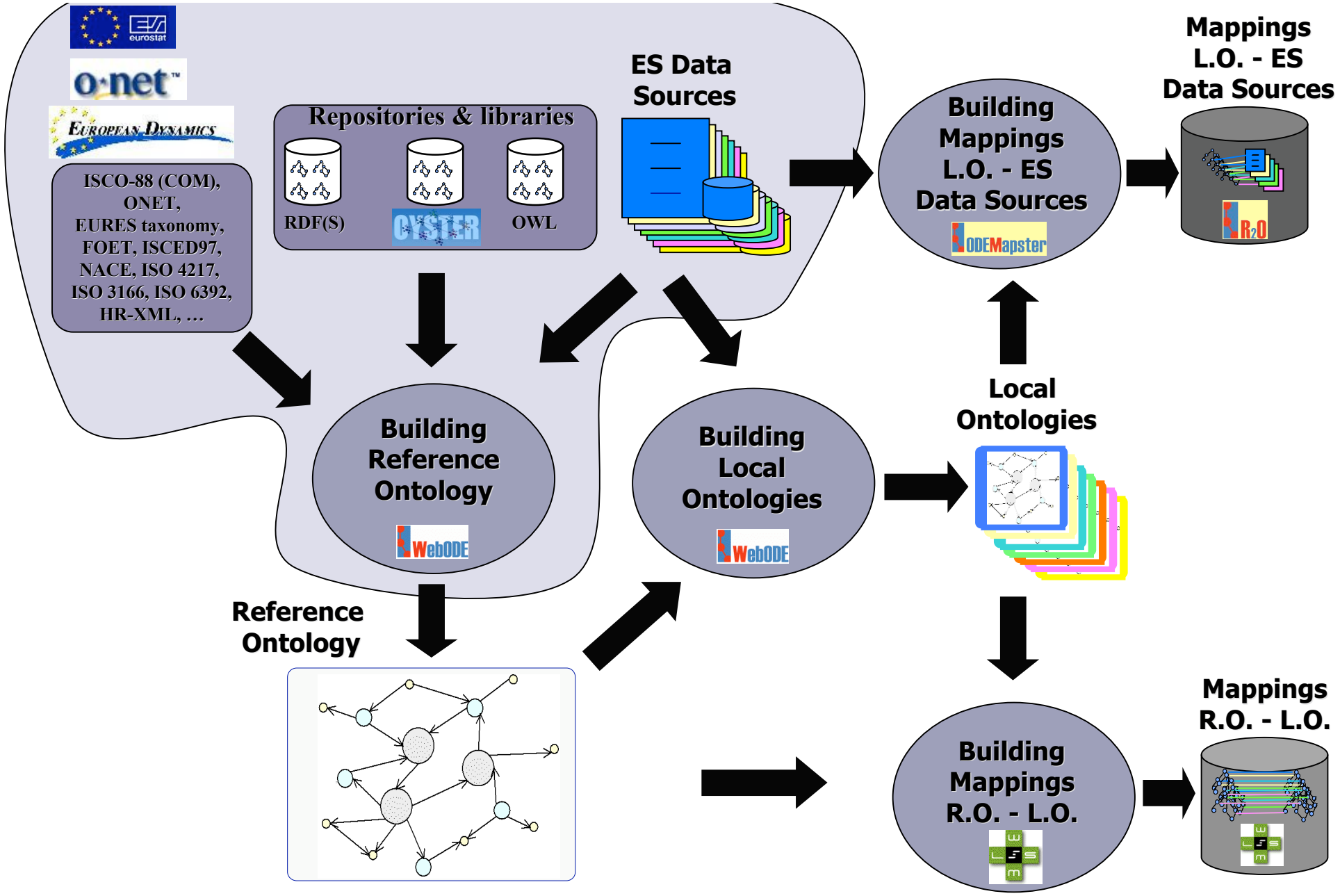


- Build a reference ontology for the domain
- Build local ontologies
- Build mappings between the core and local ontologies
- Build mappings between the local ontologies and the data sources

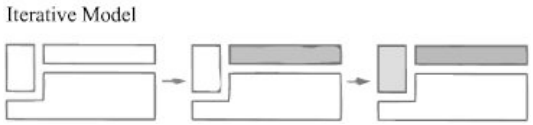
Federated Network of Ontologies

- Build a **reference ontology for the domain**. This Reference Ontology is the core semantic component of the system. It acts as a common "language" in the form of a set of controlled vocabularies to describe the details of a job posting and the CV of a job seeker.
- Build **local ontologies**. Each ES uses its own Local Ontology, which describes the employment market in its own terms.
- Build **mappings between the core and local ontologies**.
- Build **mappings between the local ontologies and the data sources** (ES schema).

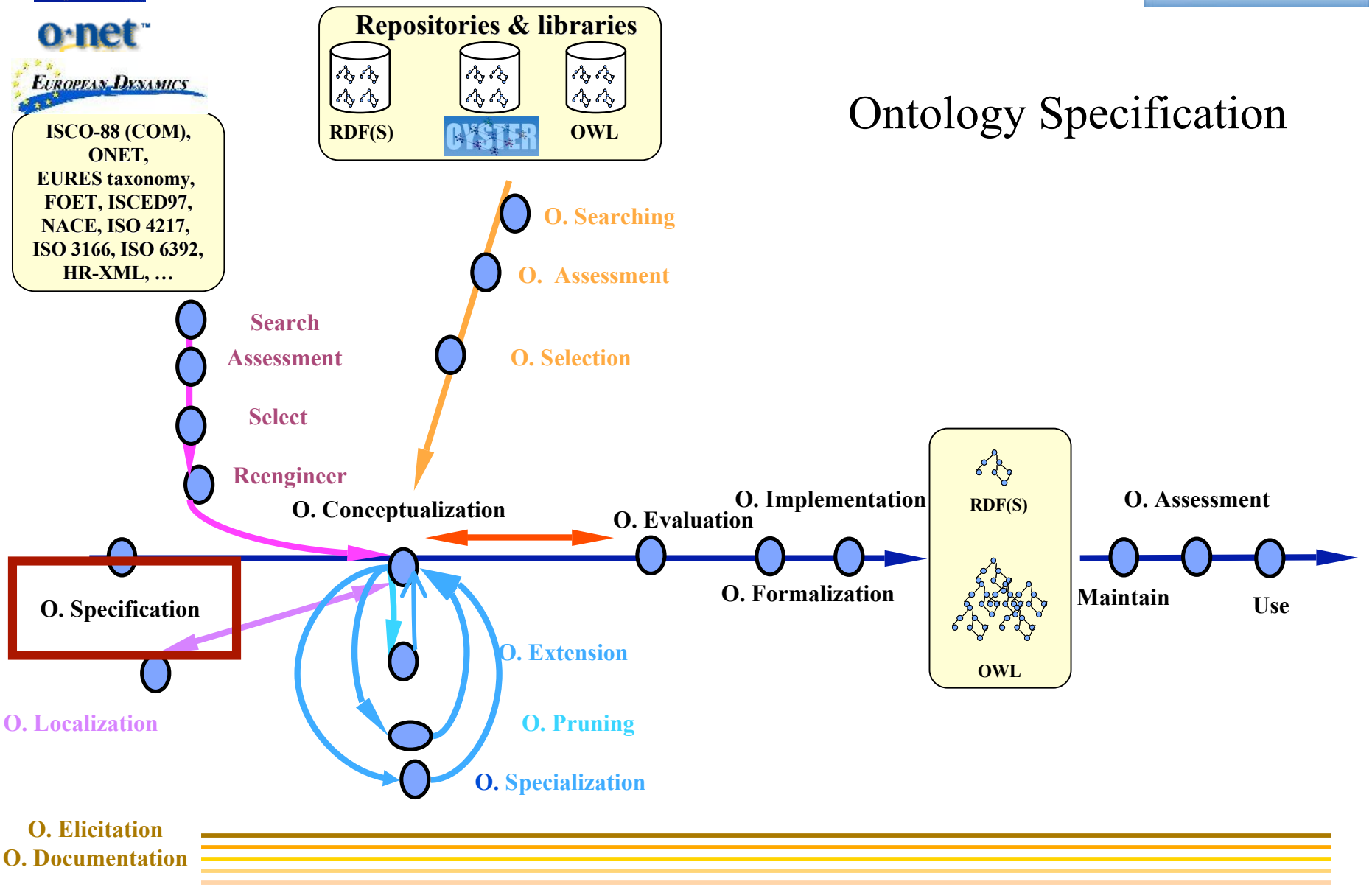



eurostat
o·net
European Dynamics
ISCO-88 (COM), ONET, EURES taxonomy, FOET, ISCED97, NACE, ISO 4217, ISO 3166, ISO 6392, HR-XML, …
Repositories & libraries
RDF(S)
OYSTER
OWL
ES Data Sources
Building Mappings L.O. - ES Data Sources
ODEMapster
Mappings L.O. - ES Data Sources
R2O
Building Reference Ontology
WebODE
Building Local Ontologies
WebODE
Local Ontologies
Reference Ontology
Building Mappings R.O. - L.O.
Mappings R.O. - L.O.

SEEMP Ontology Network Life Cycle: Iterative model life cycle



Ontology Specification



Specification of the Reference Ontology

60 Competency Questions grouped into 5 categories (modular approach)

- Job Seeker (12)
  - What is his/her education level?
- Job Offer (12)
  - What are the required skills for the job offer?
- Time and date management (7)
  - When the job seeker completed his/her first degree?
- Currencies (4)
  - The offered salary is given in US dollars?
- General (25)
  - Given the employer information, economic activity of the employer and the job offer profile (job, contract type, salary, work condition, contract duration), what job seekers are the most appropriate?

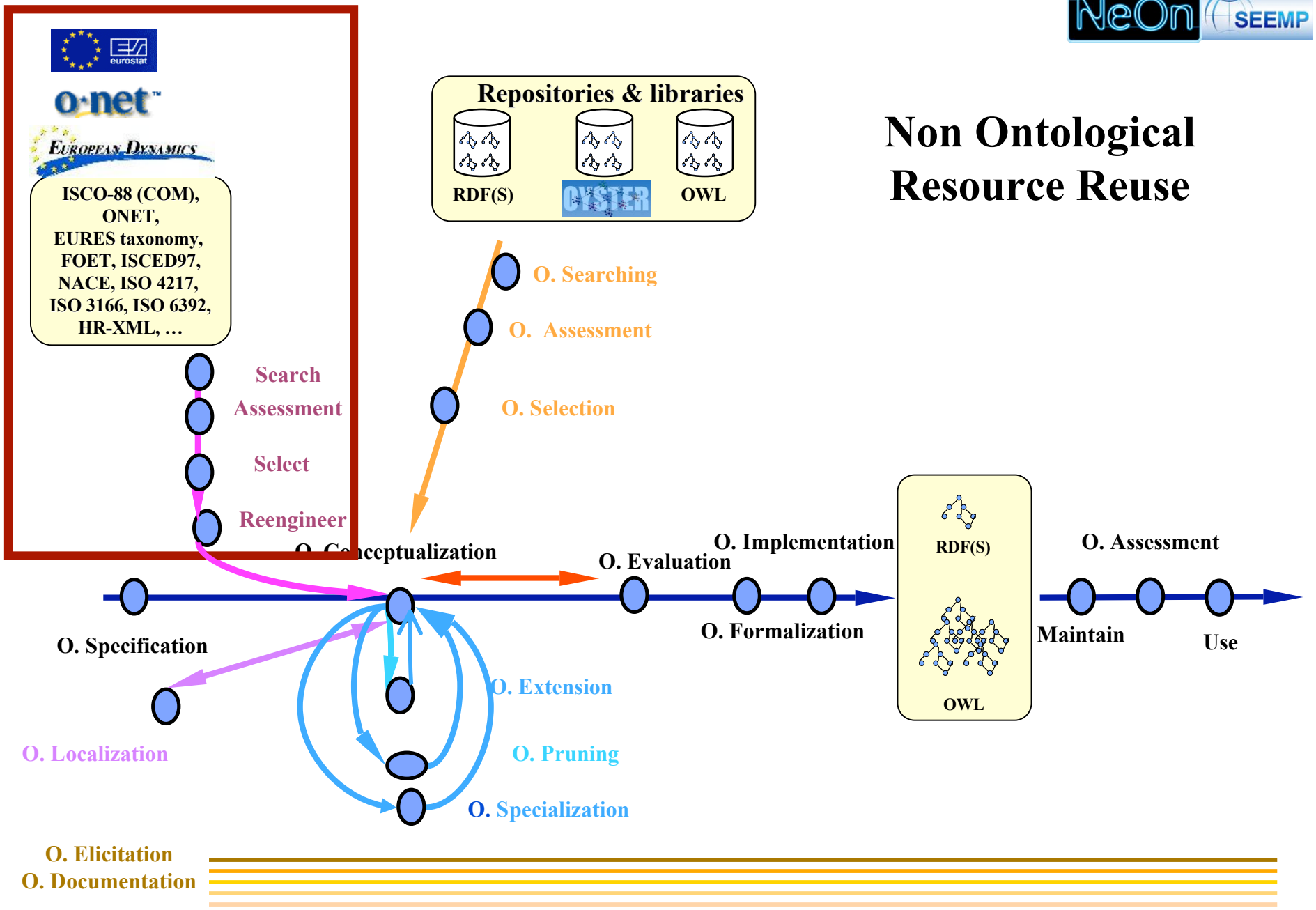
Given the job offer profile (job, contract type, salary, work condition) and the required profile to seek (required education level, required work experience, required knowledge, required skills), what job seekers are the most appropriate?

Each organization has job offers for job seekers

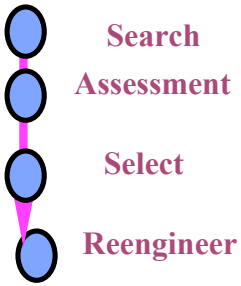
Vocabulary:
Questions: contract type, salary, work condition, job seeker, job offer, …
Answers: autonomous, 3000 euro, holliday job, …

Classes: Contract Type, Compensation, Work Condition, Job Seeker, Job Offer …
Relations: has job category, has compensation, requires work experience …
Attributes: Name, date of birth, email …

Non Ontological Resource Reuse



Search and Assess Standards and Taxonomies



- *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

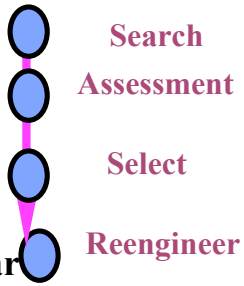
Language Classification
ISO 6392, CEF
Driving License Classification
European Legislation
Skill Classification
Eures Taxonomy
Contract Types Classification
LE FOREM, Eures and BLL Classification
Work Condition Classification
LE FOREM, Eures and BLL Classification

- *The IDABC[1] identifies as one of the successful factors at facilitating the development of pan-European interoperable information systems:*
  - "Identify, reuse and extend existing assets (taxonomies, thesauri, etc.)"

Assessment activity:
Matching terminology from Competency Questions against the Standards

(1) -> IDABC Content Interoperability Strategy. Working paper. Sep 2

Selection of Human Resources Management Standards



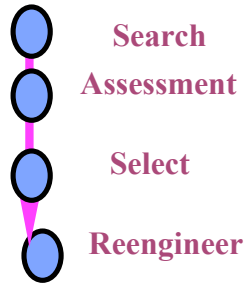
Reference Ontology shall be based on the international, European or de-facto industrial standar

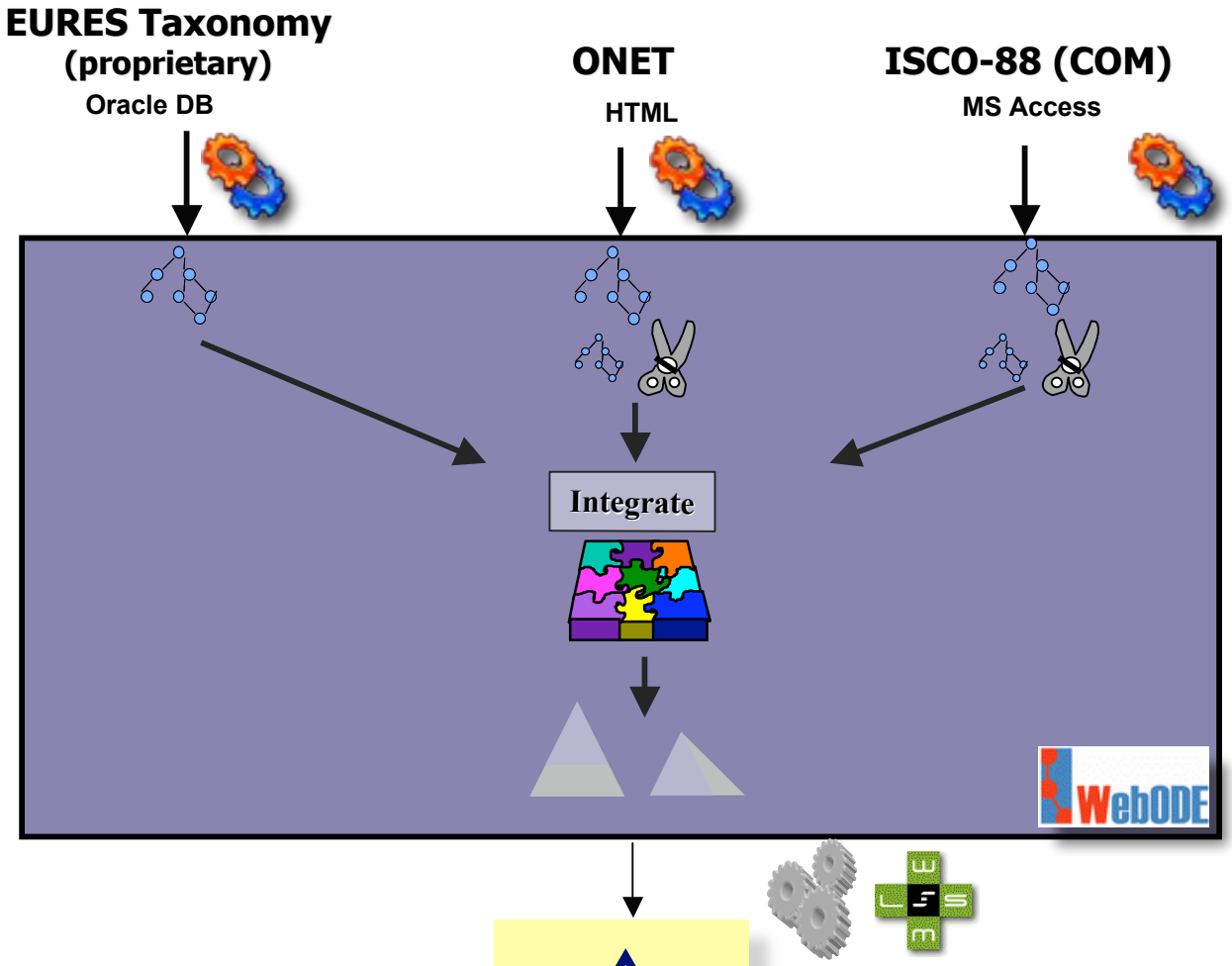
	Occupation Classification				Classification of Economic Activities			Apprenticeship Classification	
	SOC	ONET	ISCO-88	ISCO-88 (COM)	ISIC Rev. 3.1	NACE Rev. 1.1	NAICS	ISCED 97	FOET
The degree of coverage		☑	☑	☑	☑	☑			☑
The current European needs				☑		☑		☑	☑

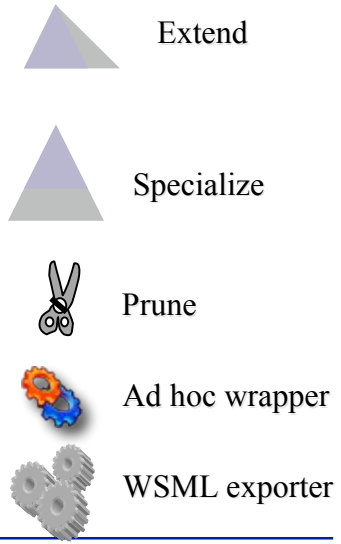
Currency Classification	Geography Classification	Language Classification	Driving License
ISO 4217	ISO 3166	ISO 6392	Community Driving License

But, we need also proprietary taxonomies …

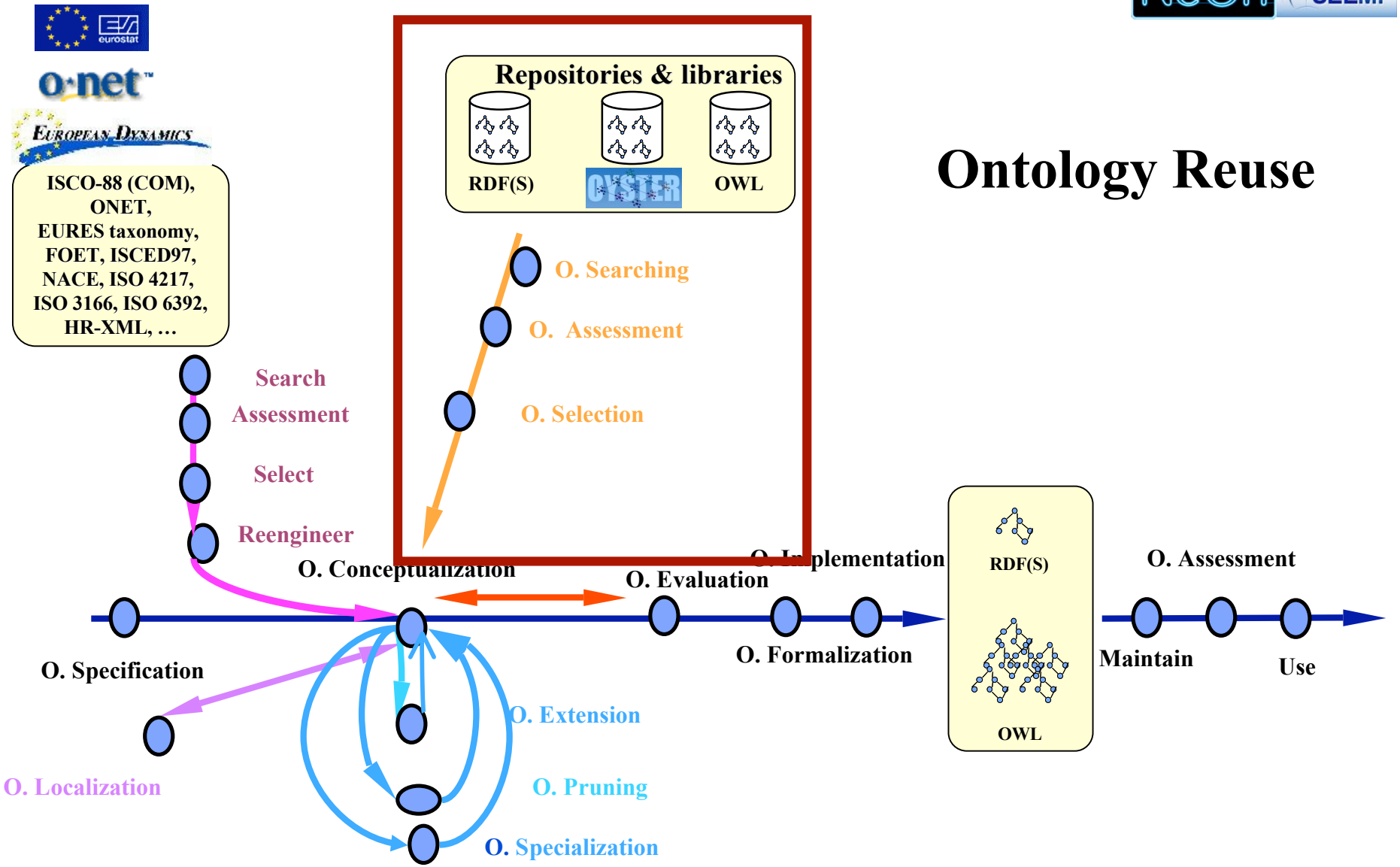
Knowledge Resource Reengineering







Ontology Reuse



Ontology Searching in Ontology Metadata Repositories

Ontology to describe ontology metadata information

- OMV – Ontology Metadata Vocabulary (http://ontoware.org/projects/omv)
- Knowledge Zone vocabulary (http://tinyurl.com/qfp2s)

4 Ontology Metadata Repositories

- Oyster (P2P system , http://oyster.ontoware.org)
- ONTHOLOGY.org (centralized, http://www.onthology.org/)
- Knowledge Zone (centralized, http://smiprotege.stanford.edu:8080/KnowledgeZone/)
- Swoogle (http://swoogle.umbc.edu/)

knowledge zone one stop shop for ontologies

Searching ontologies: Obtain the set of candidate ontologies using Oyster

O. Searching

O. Assessment

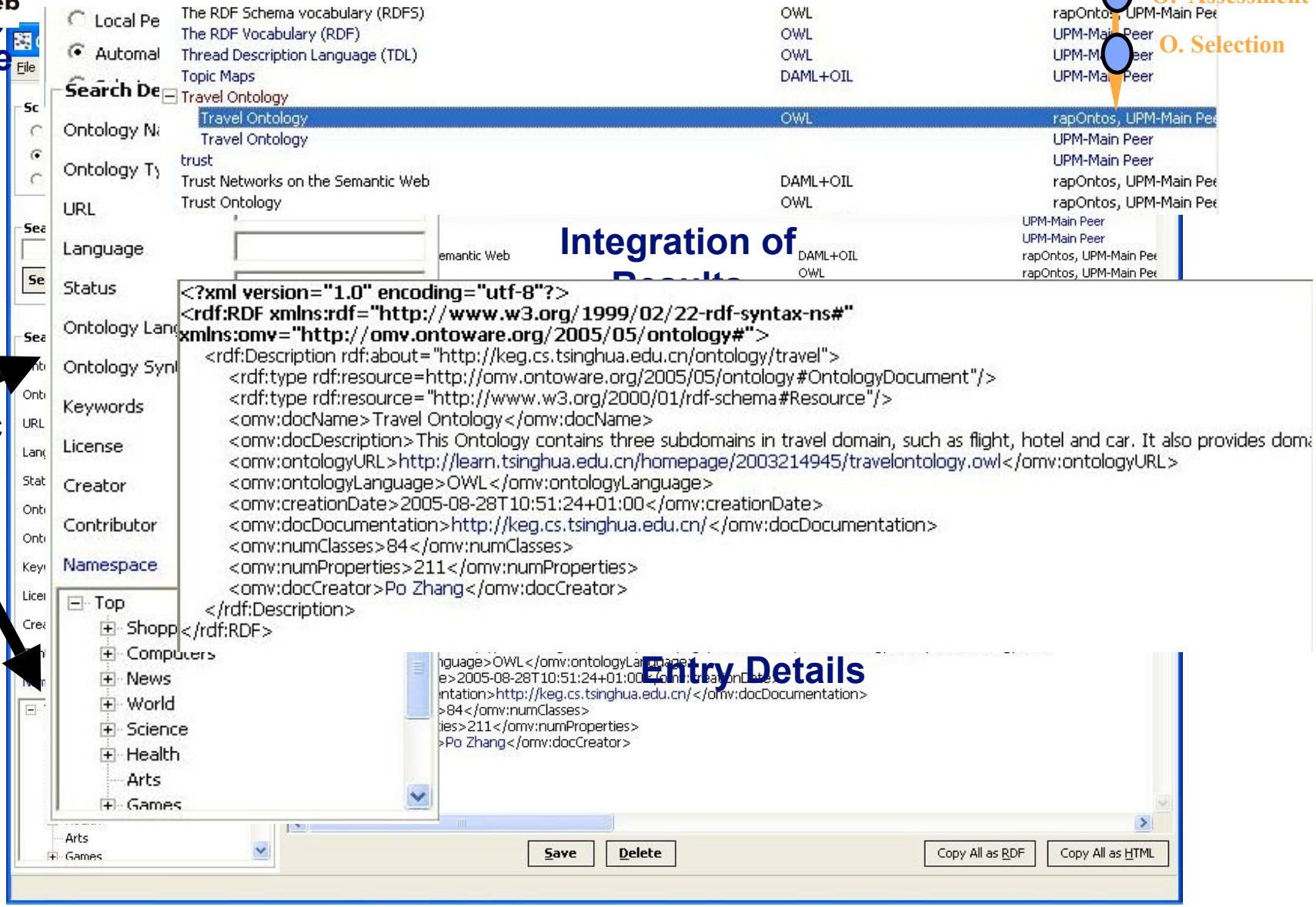
O. Selection

Scope

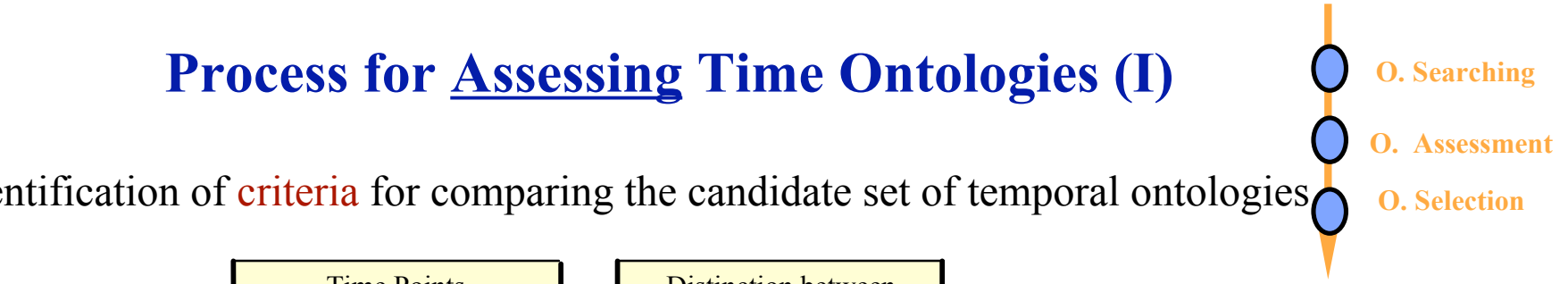
Semantic Search

Integration of Results

Entry Details



Process for Assessing Time Ontologies (I)



1. Identification of criteria for comparing the candidate set of temporal ontologies

Time Points
Time Interval
Absolute and Relative Time
Relations between time intervals
Convex and non convex intervals

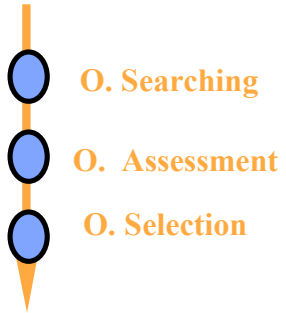
Distinction between open and closed intervals
Explicit modeling of proper intervals
Concatenation of intervals
Different temporal granularities

General criteria for the time domain

2. Assess all existing temporal ontologies against the criteria

	Cyc's Upper Ontology	Unrestricted Time Ontology	Simple Time Ontology	Reusable Time Ontology	Kestrel Time Ontology	SRI's Time Ontology	SUMO Time Ontology	DAML Time Ontology	AKT Time Ontology
Time Points	☑	☑	☑	☑	☑	☑	☑	☑	☑
Time Interval	☑				☑	☑	☑	☑	☑
Absolute and Relative Time			☑	☑				☑	☑
Relations between time intervals					☑		☑	☑	
Convex and non convex intervals				☑				☑	
Distinction between open and closed intervals				☑			☑	☑	
Explicit modeling of proper intervals								☑	
Concatenation of intervals								☑	
Different temporal granularities	☑					☑	☑	☑	☑
Provides axioms		☑	☑	☑			☑	☑	

Process for Assessing Time Ontologies (II)



3. Checking which temporal properties are needed for answering the Competency Questions (identified in the Ontology Specification activity)

   a. When the job seeker completed his/her first degree?

   b. Is the job seeker older than 30 years?

   c. How much time did the job seeker spend completing his/her first degree?

   d. How long is the duration of the contract?

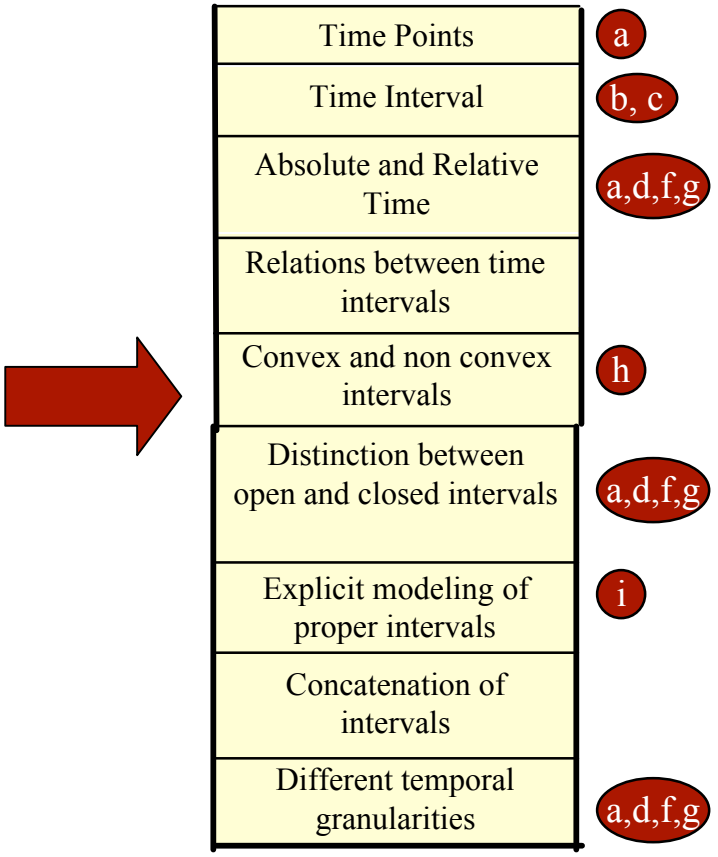
   e. Which job offers were posted in last 24 hours?

   f. Which job offers were posted in last 7 days?

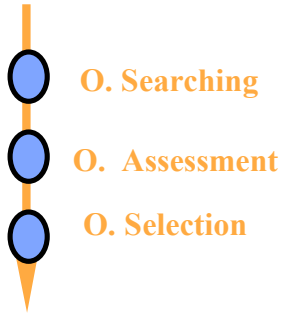
   g. Which job offers were posted in last month?

   h. Was the job seeker unemployed?

   i. Was the job seeker a student between 1995 and 2000?

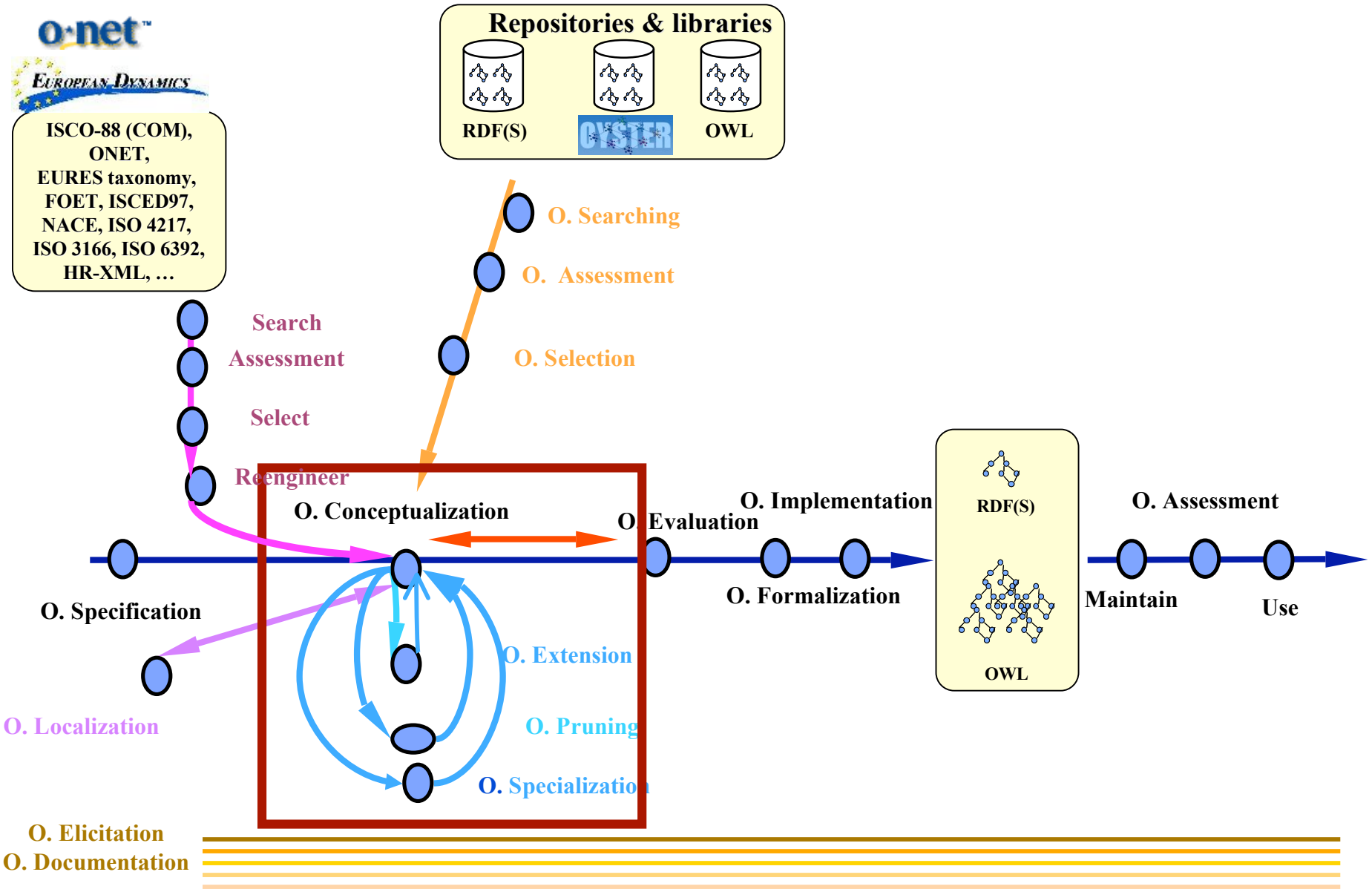


The Time Ontology Selection

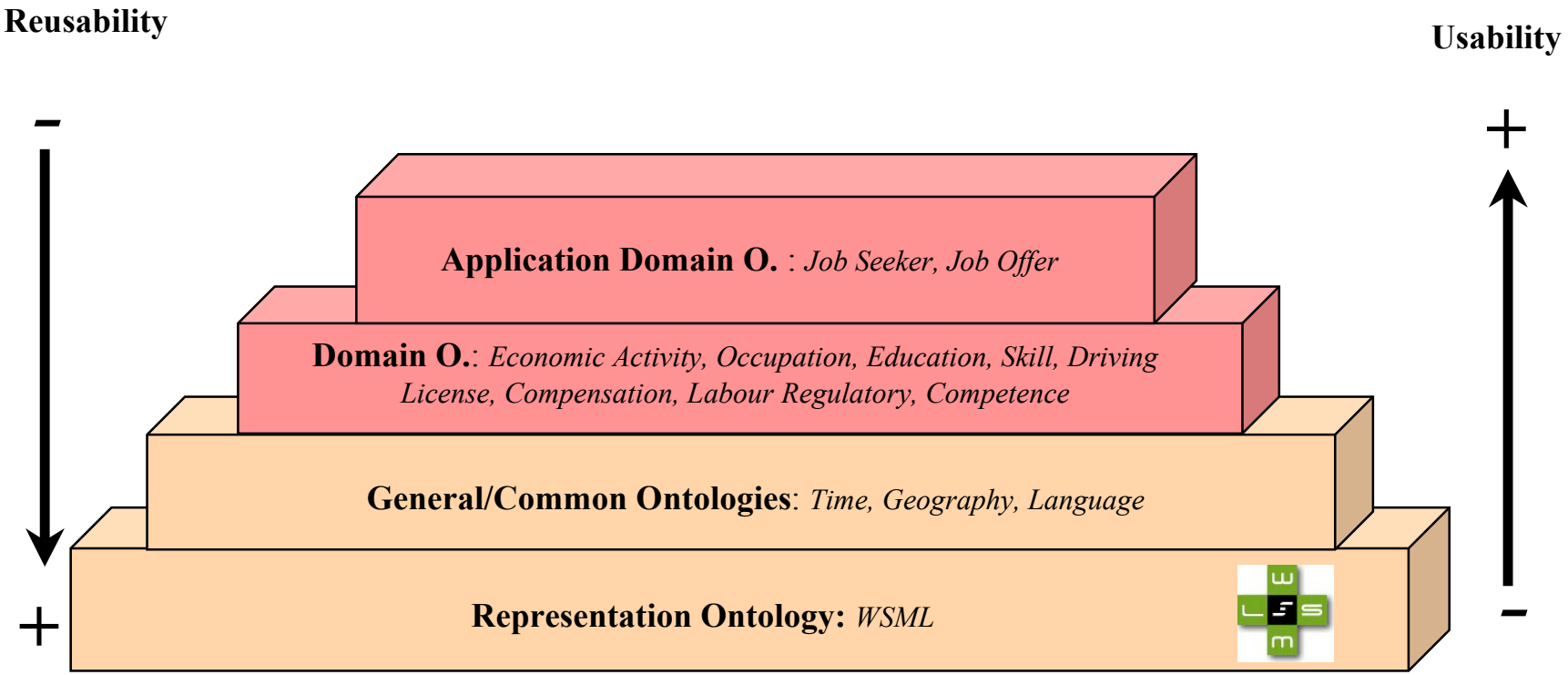


	Cyc's Upper Ontology	Unrestricted Time Ontology	Simple Time Ontology	Reusable Time Ontology	Kestrel Time Ontology	SRI's Time Ontology	SUMO Time Ontology	DAML Time Ontology	AKT Time Ontology
Time Points	☑	☑	☑	☑	☑	☑	☑	☑	☑
Time Interval	☑				☑	☑	☑	☑	☑
Absolute and Relative Time			☑	☑				☑	☑
Relations between time intervals					☑		☑	☑	
Convex and non convex intervals				☑				☑	
Distinction between open and closed intervals				☑			☑	☑	
Explicit modeling of proper intervals								☑	
Concatenation of intervals								☑	
Different temporal granularities	☑					☑	☑	☑	☑
Provides axioms		☑	☑	☑			☑	☑	

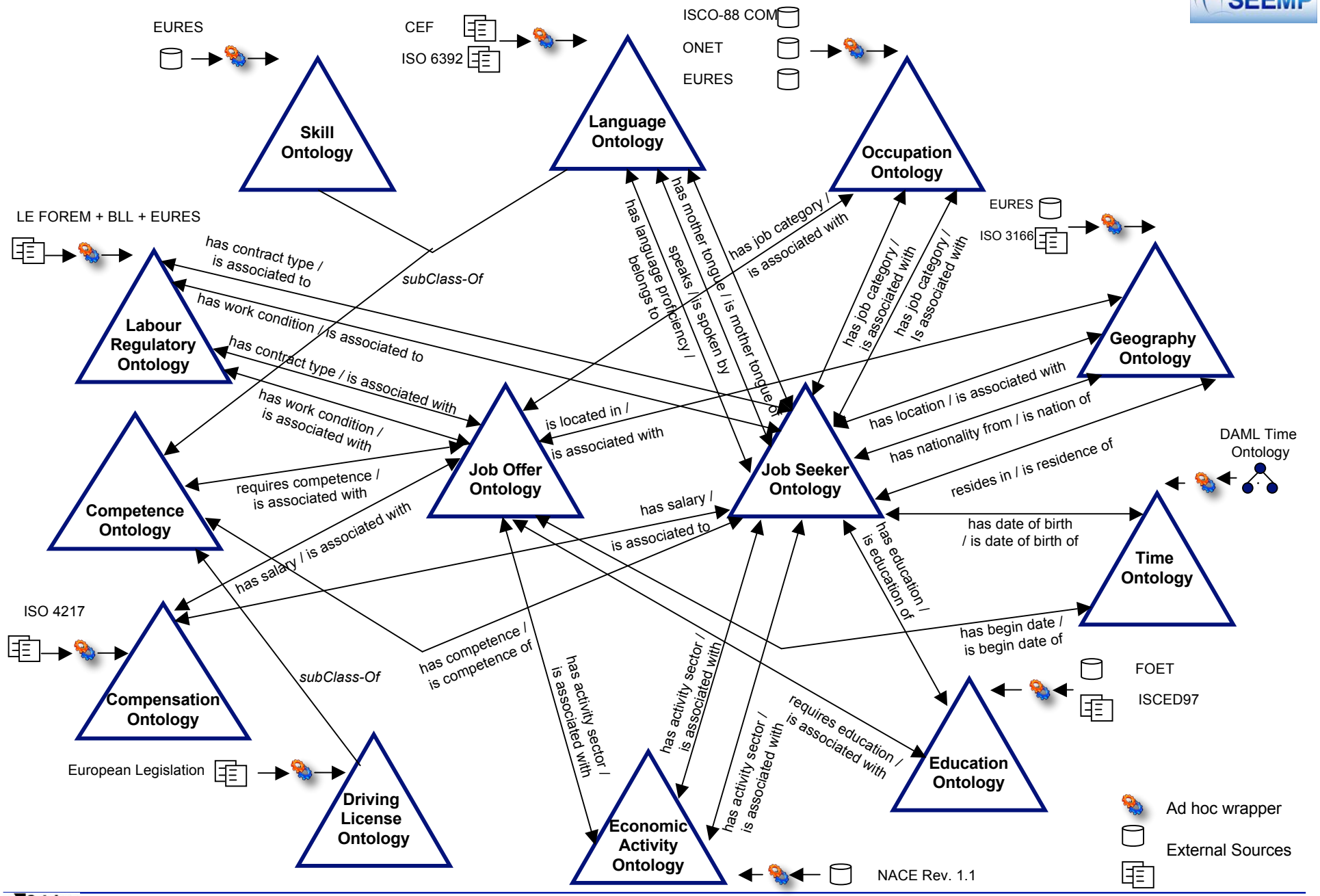
Conceptualization

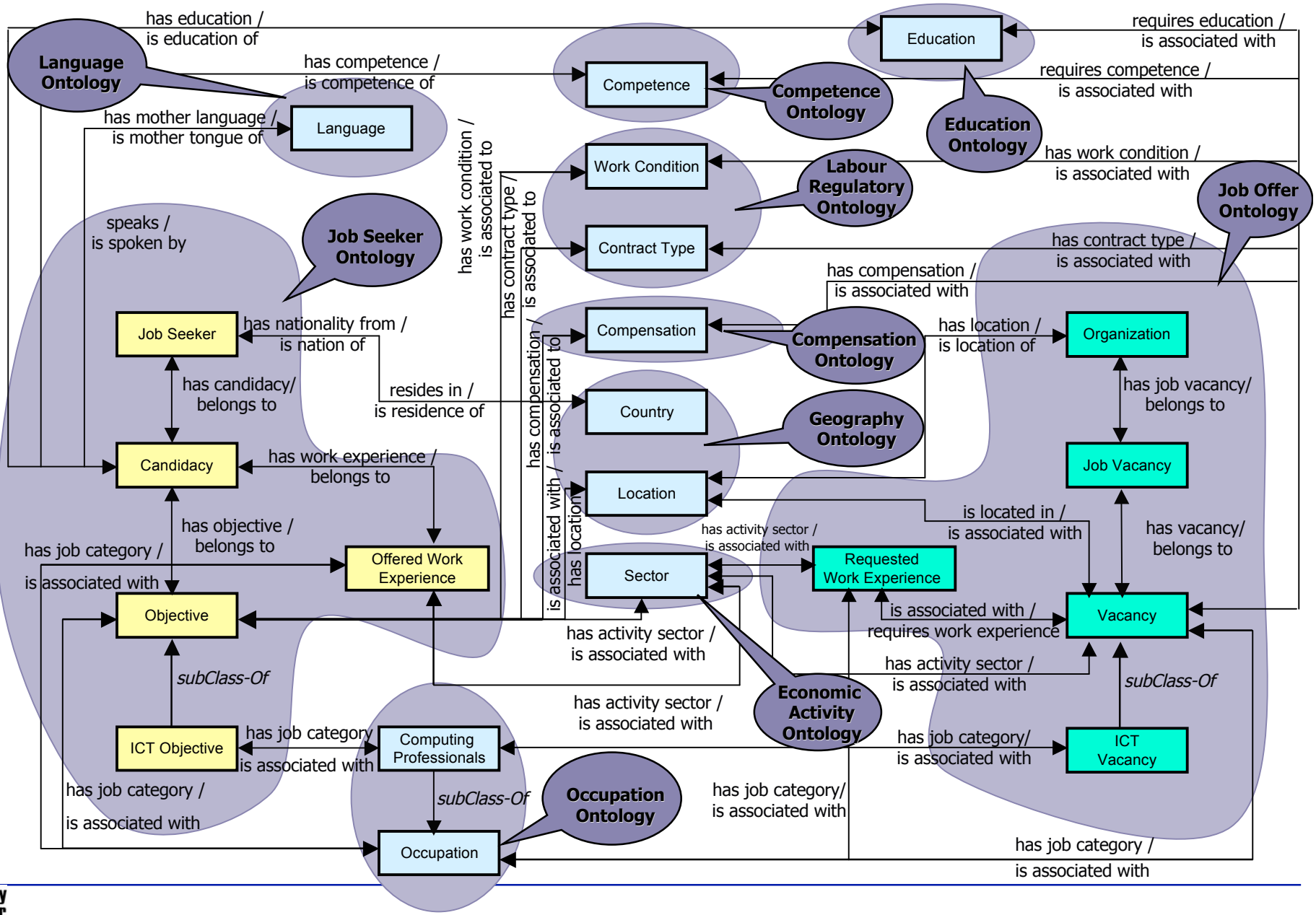


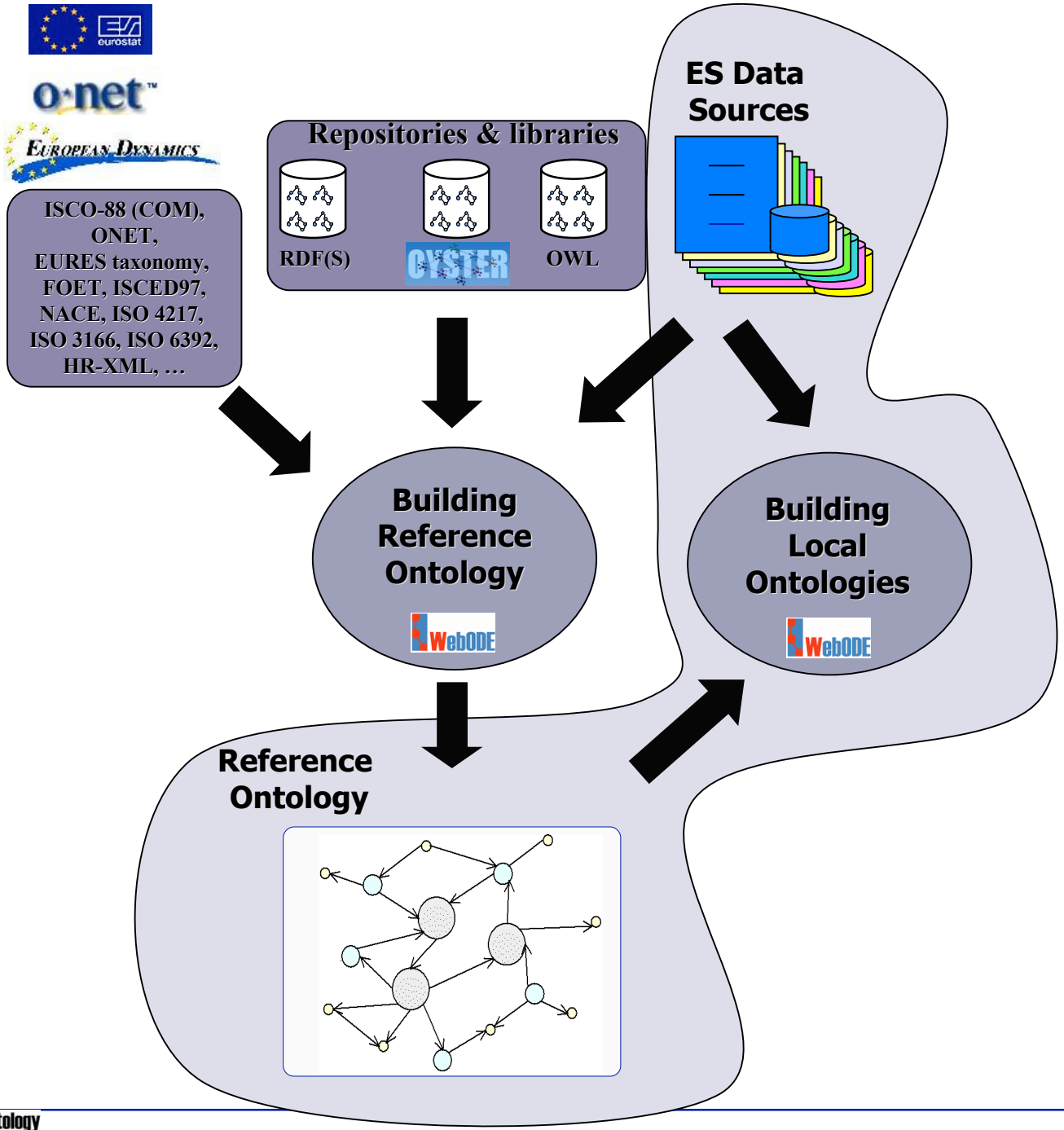
Conceptualization:
Modular approach for ontology construction



Reference Ontology

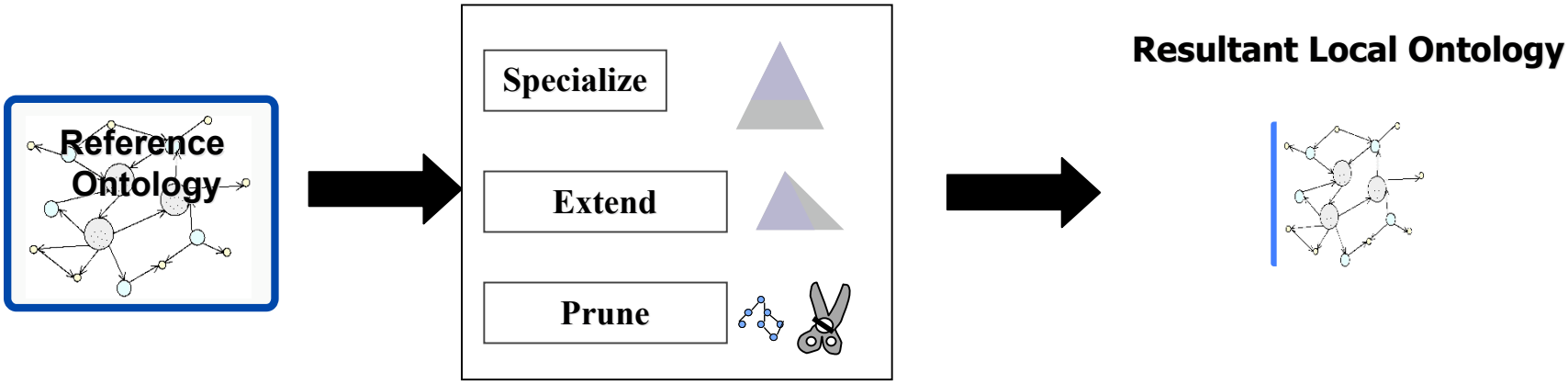



Language Ontology
has education / is education of
has competence / is competence of
has mother language / is mother tongue of
Language
Competence
Competence Ontology
Education
Education Ontology
requires education / is associated with
requires competence / is associated with
has work condition / is associated with
Work Condition
Labour Regulatory Ontology
Job Offer Ontology
has work condition / is associated to
has contract type / is associated to
Contract Type
has contract type / is associated with
has compensation / is associated with
speaks / is spoken by
Job Seeker Ontology
Job Seeker
has nationality from / is nation of
Compensation
Compensation Ontology
has location / is location of
Organization
has compensation / is associated to
has candidacy/ belongs to
resides in / is residence of
Country
Geography Ontology
has job vacancy/ belongs to
Candidacy
has work experience / belongs to
Job Vacancy
Location
has objective / belongs to
is located in / is associated with
has vacancy/ belongs to
has job category / is associated with
Offered Work Experience
has activity sector / is associated with
Requested Work Experience
has location
Sector
Objective
is associated with / requires work experience
Vacancy
has activity sector / is associated with
subClass-Of
has activity sector / is associated with
Economic Activity Ontology
ICT Objective
has job category / is associated with
Computing Professionals
has job category/ is associated with
ICT Vacancy
subClass-Of
Occupation Ontology
has job category / is associated with
Occupation
has job category / is associated with

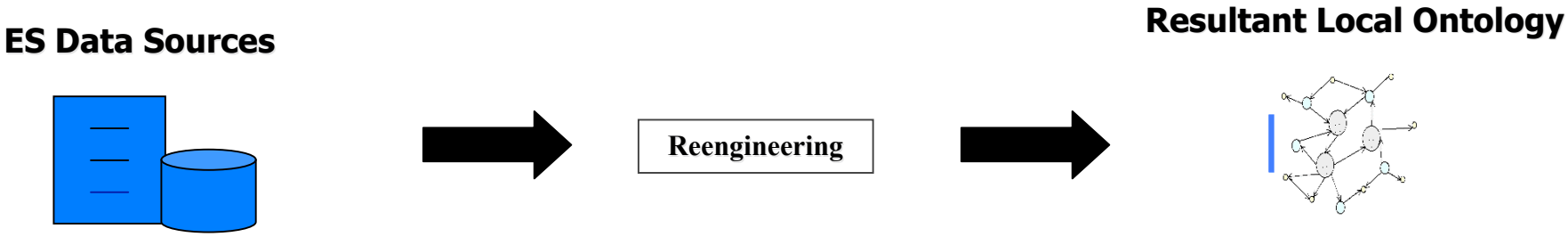

ES Data Sources
Repositories & libraries
RDF(S)
OWL
ISCO-88 (COM), ONET, EURES taxonomy, FOET, ISCED97, NACE, ISO 4217, ISO 3166, ISO 6392, HR-XML, …
Building Reference Ontology
Building Local Ontologies
Reference Ontology

Local Ontologies Building Process

- Option 1: *Building Local Ontologies from the Reference Ontology.*



- Option 2: *Building Local Ontologies as a reengineering process from ES Data Sources.*



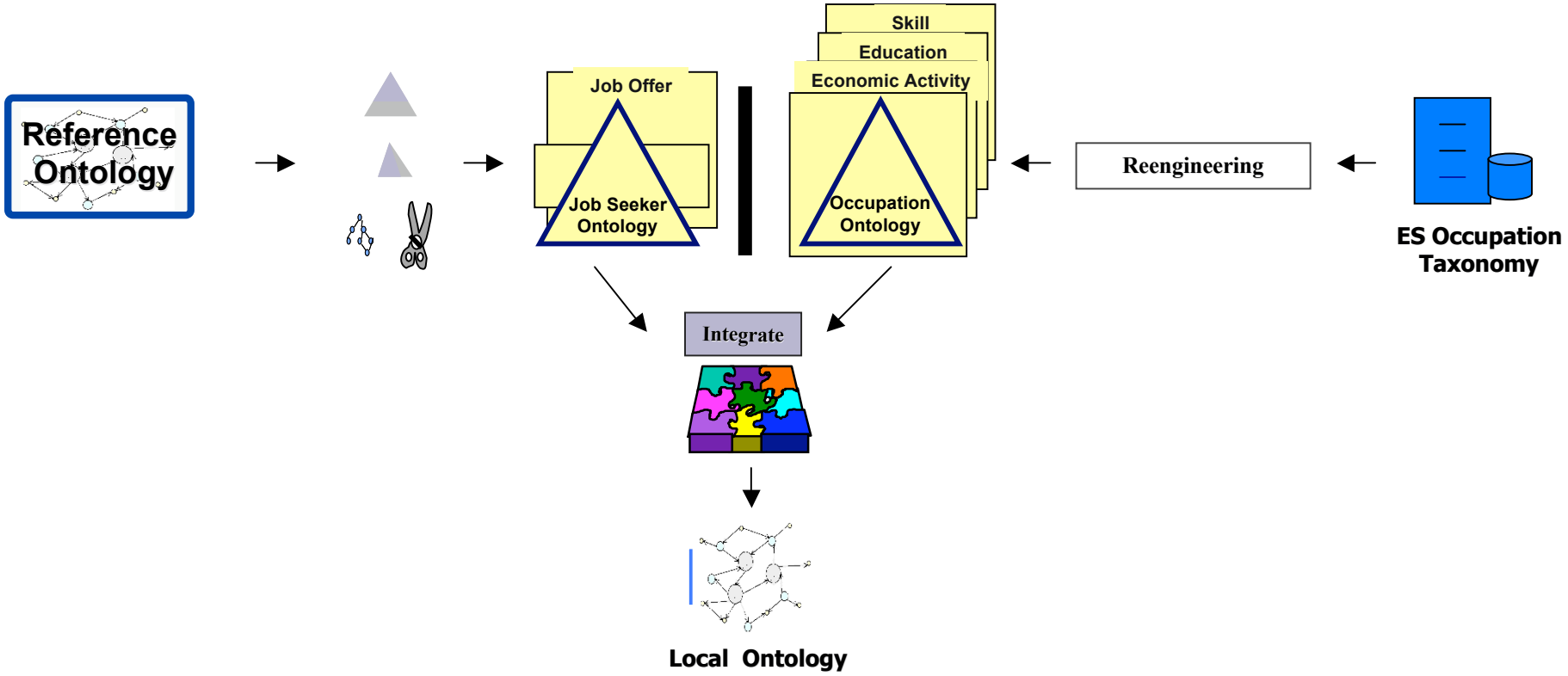
Which option is the most appropriate for the use case?

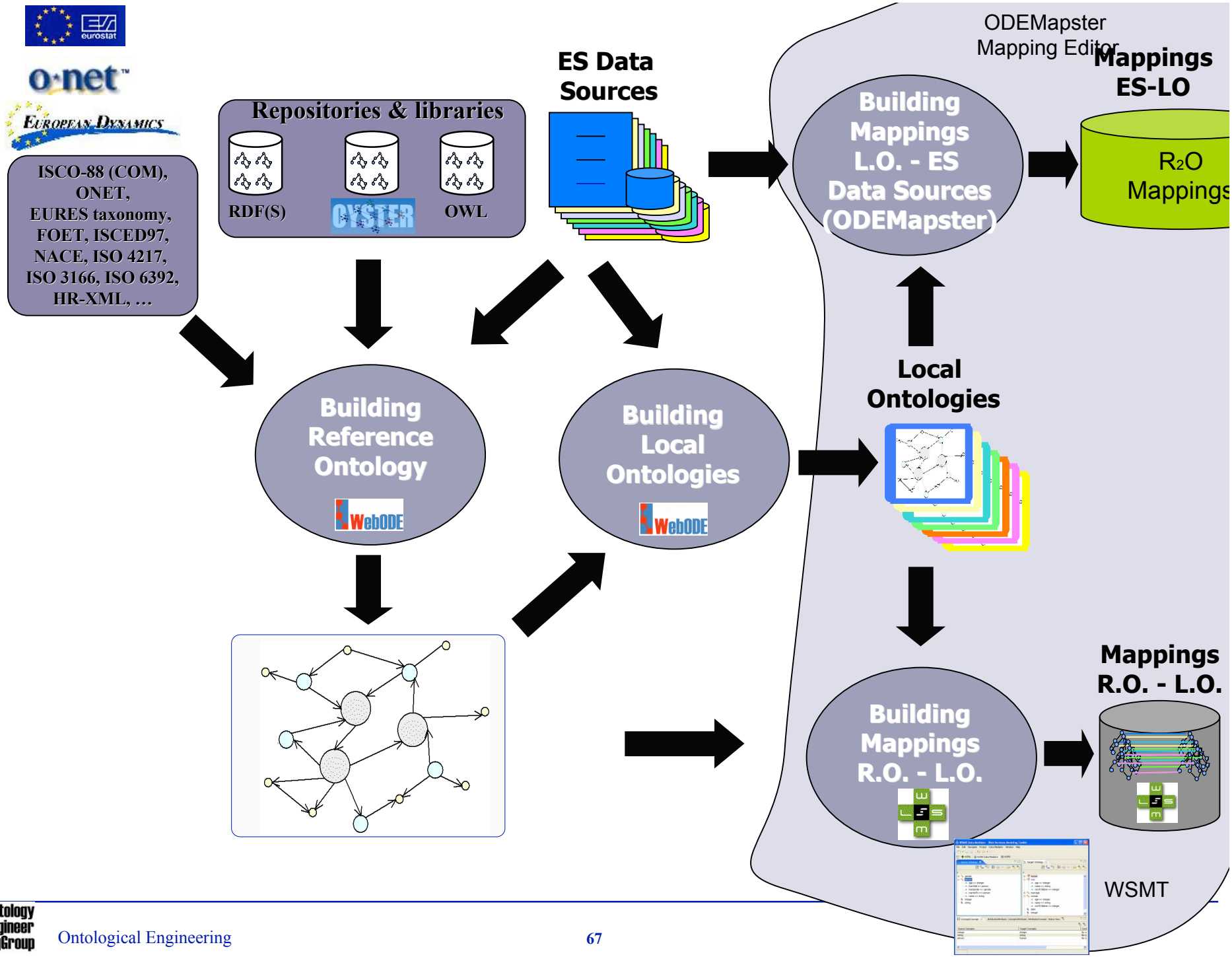
	Option 1: Building Local Ontologies from the Reference Ontology.	Option 2: Building Local Ontologies as a reverse engineering process from ES Data Sources.
Mappings between Local Ontologies and Reference Ontology	Mappings are not complex. They use the same terms.	Complex mappings due to terminology heterogeneity.
Mappings between Local Ontologies and ES schema sources	Complex mappings due to terminology and structural heterogeneity.	Mappings are not complex. They use the same terms.
Building process	Structured/guided by the architecture of the Reference Ontology and scoped with applications needs.	Requires more sophistication of knowledge engineering and good acquaintance of all the data and their structures of the application.
Changes in the Reference Ontology	Imply changes in · the mappings between local and reference ontologies. · the mappings between the local ontologies and the ES schema sources. · the Local Ontology.	Imply changes in · the mappings between Local Ontologies and the Reference Ontology.
Changes in the ES schema sources	Imply changes in · its Local Ontology (probably the part that is not a mirror of the Reference Ontology). · the mappings between Local Ontologies and ES schema sources. · in the mappings between Local Ontology and the Reference Ontology.	Imply changes in · the Local Ontologies. · in mappings between ES sources and Local Ontologies. · mappings between local and the Reference Ontology.

Approach followed by SEEMP for building Local Ontologies

A hybrid approach

- Option 1 for Job Seeker and Job Offer Ontologies
- Option 2 for Occupation, Education, etc.




ODEMapster
Mapping Editor
ISCO-88 (COM), ONET, EURES taxonomy, FOET, ISCED97, NACE, ISO 4217, ISO 3166, ISO 6392, HR-XML, …
Repositories & libraries
RDF(S)
OWL
ES Data Sources
Building Mappings L.O. - ES Data Sources (ODEMapster)
Mappings ES-LO
R2O Mappings
Building Reference Ontology
WebODE
Building Local Ontologies
WebODE
Local Ontologies
Building Mappings R.O. - L.O.
Mappings R.O. - L.O.
WSMT

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