http://www.neon-project.org

NeOn Methodology for Building Ontology Networks: Ontology Specification

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Extracted from:

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1. Ontology Specification

As we mentioned before, the goal of the ontology specification is to state why the ontology is being built, what its intended uses are, who the end-users are, and what the requirements the ontology should fulfil are. For specifying the ontology requirements we will use the competency questions techniques proposed in [7]. Before identifying the set of competency questions, we will identify the purpose and scope of the ontology, its level of formality, its intended uses and its intended users.

The NeOn methodology proposes the filling card, presented in Table 1, for the ontology specification activity, including the definition, goal, inputs and outputs, who carry out the activity and when the activity should be carried out.

Ontology Specification
Definition
Ontology Specification refers to the activity of collecting the requirements that the ontology should fulfill, e.g. reasons to build the ontology, target group, intended uses, possibly reached through a consensus process.
Goal
The specification activity states why the ontology is being built, what its intended uses are, who the end-users are, and what the requirements the ontology should fulfill are.

Input	*Output*
A set of ontological needs.	Ontology Requirements Specification Document (ORSD).

Who
Software developers and ontology practitioners, who form the ontology development team (ODT), in collaboration with users and domain experts.
When
This activity must be carried out in parallel with the knowledge acquisition activity.

Table 1. Ontology Specification Filling Card

The tasks for carrying out the ontology specification activity can be seen in Figure 1. The result of this activity is the Ontology Requirements Specification Document (ORSD).

The NeOn methodology proposes a template for writing the ORSD that have the following slots, and that is shown in Table 2:

- ❑ Ontology Purpose, which includes the ontology aims.
- ❑ Ontology Scope, which includes the ontology coverage and granularity.
- ❑ Ontology Level of Formality, which includes the degree of formality of the ontology.
- ❑ Ontology Intended Users, which includes the main intended users for the ontology.
- ❑ Ontology Intended Uses, which includes the main scenarios in which the ontology will be used.
- ❑ Groups of Competency Questions (CQs) and their answers, including priorities.
- ❑ Pre-Glossary of Terms with their Frequencies.

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"

Table 2. Template for the OSRD
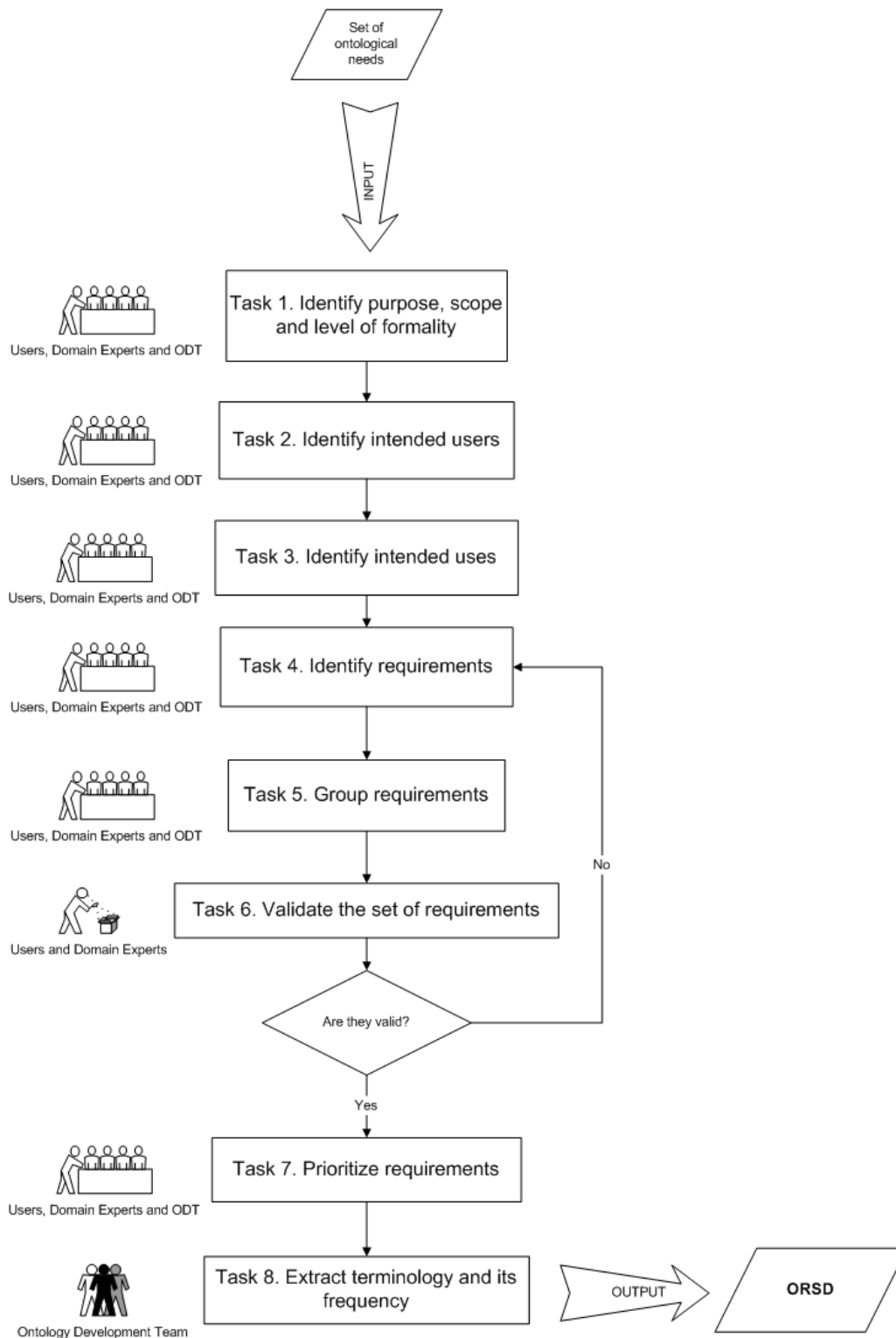
Figure 1. Tasks for Ontology Specification

The tasks for carrying out the ontology specification activity are explained in detail in the following:

Task 1. Identify purpose, scope and level of formality.

The objective of this task is to obtain the main goal or aim of the ontology, its coverage and granularity. The degree of formality to be used to codify the ontology should be also identified. This degree of formality ranges from informal natural language to a rigorous formal language. Users,

domain experts and the ontology development team carry out this task taking as input a set of ontological needs for obtaining the purpose, scope and level of formality of the ontology, using techniques as physical or virtual interviewers between them.

The task output is the purpose, scope and level of formality of the ontology, which will be included in the corresponding slots of the OSRD template.

Task 2. Identify intended users.

The goal of this task is to establish which the main intended users of the ontology are. Users, domain experts and the ontology development team carry out this task taking as input a set of ontological needs for identifying the intended users, using techniques as physical or virtual interviewers between them.

The task output is a list with the intended users, which will be included in the corresponding slot of the OSRD template.

Task 3. Identify intended uses.

The goal of this task is to obtain the main ontology intended uses, that is, in which kind of scenarios the ontology will be used. Users, domain experts and the ontology development team carry out this task taking as input a set of ontological needs for identifying the intended uses, using techniques as physical or virtual interviewers between them.

The development of an ontology is motivated by scenarios related to the application that will use the ontology. The task output is a list of intended uses in the form of scenarios. Such scenarios describe a set of the ontology's requirements that the ontology should satisfy after being formally implemented. The scenarios can be described in natural language or expressed in UML as use cases. The list of scenarios will be included in the corresponding slot of the OSRD template.

Task 4. Identify requirements.

The goal of this task is to obtain the set of requirements or needs that the ontology should fulfill. Users, domain experts and the ontology development team carry out this task taking as input a set of ontological needs for identifying the ontology requirements, using techniques as writing the requirements in natural language in the form of the so-called competency questions (CQs) and tools as mind map tools, excel, and collaborative tools.

The output of this task is a list of competency questions written in Natural Language and a set of answers for the CQs.

Different approaches for identifying competency questions can be applied, such as:

❑ Top-Down: Complex questions are decomposed in simple ones.

❑ Bottom-Up: Simple questions that are organised to form complex ones.

❑ Middle out: Mix approach between top-down and bottom-up.

Regarding the recommended tools, we can mention that MindMap tools allow representing mind maps [2]. These mind maps are diagrams used to represent words, ideas, tasks or other items linked to and arranged radically around a central key word or idea. They are used to generate, visualize, structure and classify ideas. In general, a mind map provides information about a topic that is structured in a tree. Each branch of the tree is typically named and associatively refined by its subbranches. Icons and pictures as well as different colors and fonts might be used for illustration based on the assumption that our memory performance is improved by visual aspects. Many people from academia and industry are familiar with mind maps, and for this reason we think that this recommendation will be very useful for software engineering and ontology practitioners forming the ontology development team. Another advantage is that requirements visualization in form of a hierarchy is very intuitive and easy to understand and manage.

If people are geographically distributed, wiki tools, such as Cicero[1] [5], can be used for identifying the requirements, in the form of CQs and associated responses.

Task 5. Group requirements.

The goal of this task is to group the list of CQs into several categories. Users, domain experts and the ontology development team carry out this task taking as input the list of CQs written in natural language (obtained in task 4) for obtaining different groups of CQs, using techniques as Card Sorting, when the grouping is done manually, and Clustering NL sentences or Information Extraction when the grouping is done automatically; and using tools as MindMap Tools or Cicero Tool (for distributed teams).

The task output is a set of groups including different CQs.

To group the requirements is useful for guiding the ontology development based on different ontology modules or based on prototypes involving different features of the ontology.

Competency questions are grouped in such a way that each group includes those questions that are relevant to a specific feature of the ontology.

For grouping the requirements we proposed a hybrid approach that combines:

- The analysis of the frequency of terms and the grouping of CQs based on those terms that have a higher frequency.
- The use of pre-established categories, such as time and date, units of measure, currencies, location, languages, etc.

Task 6. Validate the set of requirements.

The goal of this task is to identify possible conflicts between CQs, missing CQs, and contradictions in CQs. Users and domain experts carry out this task taking as input the set of grouped CQs for deciding if such CQs are valid or not.

The task output is a confirmation about the validity of the set of CQs.

For validating the identified CQs, the following criteria are proposed:

- *Correctness*. We can say that a set of requirements is correct if each requirement refers to some features of the ontology to be developed. That is, any requirement is necessary.
- *Completeness*. A requirement specification is considered as complete if no requirement is omitted. Practically and adapting this consideration to the ontology engineering field, we can say that if users and domain experts review the requirements and confirm that they do not know more necessary requirements, then the set of requirements can be considered complete.
- *Consistent*. The set of requirements can be considered internally consistent if no conflicts exit between requirements. Conflicts can be between terms (different terminology is used in the requirements to refer to the same need) and between characteristics (two or more requirements refer to contradictory features of the ontology to be developed).
- *Verifiable*. We can say that the set of requirements is verifiable if each requirement is verifiable. That is, a finite process with a reasonable cost exists to test that the final ontology satisfies each requirement. A necessary condition to have a verifiable requirement is that such a requirement should be unambiguous.
- *Understandable*. Each requirement must be understandable by users and domain experts.
- *No Ambiguity*. We can say that an ontology requirement is unambiguous if it has only one interpretation.

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[1] http://cicero.uni-koblenz.de/wiki

- ❑ *Conciseness*. Each and every requirement is relevant, and there are no duplicated or irrelevant requirements.

- ❑ *Realism*. Requirement meanings must make sense in the domain.

- ❑ *Modifiable*. We can say that a set of requirements is modifiable if its structure and style allow changing issues in an easy, complete and consistent way.

- ❑ *Traceable*. We can say that an ontology requirement is retraceable if its origin is known and it can be referred to in other documents during the ontology development. A necessary condition to have retraceable requirements is that such requirements should be referred in a unique way (normally using a kind of code).

Task 7. Prioritize requirements.

The goal of this task is to give different levels of priority to the different groups of CQs, and within each group to the identified requirements (in the form of CQs). Users, domain experts and the ontology development team carry out this task taking as input the groups of CQs written in natural language (obtained in task 5) for obtaining the priorities for each group and for each CQs within a group.

The task output is a set of priorities attached to each group of CQs and to each CQ in a group.

Priorities in CQs will be used for planning the ontology development.

This task is optional, but recommended. In fact, if no priorities are given to the groups of CQs, the ontology development will model all requirements at the same time.

Task 8. Extract terminology and its frequency.

The goal of this task is to extract from the list of CQs a pre-glossary to be used in the conceptualization activity. The ontology development team carries out this task taking as input the list of identified CQs and their answers for obtaining a list of the most used terms in them, using terminology extraction techniques and tools supporting such techniques.

From the requirements in form of competency questions, we extract the terminology (names, adjectives and verbs) that will be formally represented in the ontology by means of concepts, attributes and relations.

From the answers to the CQs we extract the objects in the universe of discourse that will be represented as instances.

1.1. SEEMP Reference Ontology Specification

The main objective of the SEEMP[2] project is to develop an interoperable architecture for public e-Employment services (PES). The resultant architecture will consist of: a Reference Ontology, the core component of the system, that acts as a common "language" in the form of a set of controlled vocabularies to describe the details of a job posting; a set of Local Ontologies, each PES uses its own Local Ontology, which describes the employment market in its own terms; a set of mappings between each Local Ontology and the Reference Ontology; and a set of mappings between the PES schema sources and the Local Ontologies. The SEEMP project relies on WSMO [6] that permits to semantically describe Web Services, ontologies and mediators. WSML [4] is the concrete language used in SEEMP for encoding those descriptions.

In this section we present the specification of the SEEMP Reference Ontology following the proposed guidelines of the NeOn Methodology. This specification is not intended to be exhaustive,

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[2] http://www.seemp.org

but it just describes the most important points. A detailed and complete specification is described in [2]. Next we described the steps we followed:

Task 1. Identify purpose, scope and level of formality.

The development of the Reference Ontology is motivated by scenarios related to the application that will use the ontology. Such scenarios describe a set of the ontology requirements that the ontology should satisfy after being formally implemented. The motivating scenarios are described in [1]. In summary, 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), more specifically within the ICT (Information and Communication Technology) domain. Since SEEMP project relies on WSMO, the implementation language of the resultant ontology will be WSML.

Task 2. Identify intended users.

As it was mentioned before, the Reference Ontology will be the core component of the SEEMP platform; the peers on the SEEMP interoperate with each other from their local ontologies via the Reference Ontology. The analysis of the motivating scenarios allowed us to identify the following intended users of the ontology:

   User 1. Candidate who is unemployed and searching for a job or searching another occupation for immediate or future purposes

   User 2. Employer who needs more human resources.

   User 3. Public or private employment search service which offers services to gather CVs or job postings and to prepare some data and statistics.

   User 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.

   User 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.

Task 3. Identify intended uses.

The analysis of the motivating scenarios described in [1], allowed us to identify the following main intended uses of the ontology:

   Use 1. Publish CV. Job seeker places his/her CV on the PES Portal.

   Use 2. Publish Job Offer. An Employer places a Job Offer on the PES Portal.

   Use 3. Search for Job Offers. The Employer looks for candidates for the Job Offer through PES Portal.

   Use 4. Search for Employment information. Job Seeker looks for of general information about employment in a given location at the PES Portal.

   Use 5. Provide Job Statistics. The PES Portal provides employment statistics to the Job Seeker and Employer.

Task 4. Identify requirements.

For specifying the ontology requirements we used the competency questions techniques. We followed the *bottom up* approach for identifying them. Competency questions were stored in an *Excel file* and then rewritten in a mind map tool as appears in Figure 2 and Figure 3, respectively.

In total we identified sixty competency questions, which are described in detail in [1]. Examples of some competency questions are:

- What is the job seeker nationality?

- What is the job seeker desired job?

- What is the required work experience for the job offer?

- When did the job seeker complete his/her first degree?

- What is the job seeker education level?

- Is the offered salary given in Euros?

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	What is the Job Seeker education level?	Basic education; Higher education/University
CQ4	What is the Job Seeker desired job occupation?	Radio engineer; Hardware designer; Software Engineer
CQ5	What is the Job Seeker birth date?	13/09/1984; 30/03/1970; 15/04/1978
CQ6	What is the Job Seeker current job?	Programmer; Computer Engineer; Computer Assistant
CQ7	What is the Job Seeker desired working conditions?	Autonomous; Seasonal Job; Traineeship;Consultant
CQ8	What is the Job Seeker work experience?	3 months, 6 months, 1 year, 2, years, 3 years
CQ9	What are the Job Seeker skills?	SQL programming, network administration
CQ10	What is the employer information?	CEFRIEL Research Company, Milano, Italy
CQ11	What kind of job does the employer offer?	Java Programmer; C Programmer, Database administration
CQ12	How much salary does the employer offer?	3500 euros, 3000 USD, 2000 euros
CQ13	What is the economic activity of the employer?	Research; Financial; Education; Industrial
CQ14	What is the description of the job offer?	Sun Certified Java Programmer
CQ15	What is the work condition of the job offer?	Full time; Partial time; Autonomous; Seasonal Job;
CQ16	What is the required education level for the job offer?	Basic education; Higher education/University
CQ17	What is the required work experience for the job offer?	1 year, 2 years, 3 years, 4 yerars, 5 or more years
CQ18	What is the required knowledge for the job offer?	Java, Object oriented design, Haskell, Windows
CQ19	What are the required skills for the job offer?	ASP Programmer, Data warehouse, Hardware programming
CQ20	When the job seeker completed his/her first degree?	2001; March 1999; 23/10/1970

Figure 2. Excerpt of the Competency Questions and Answers in an Excel File

CQ1. What is the Job Seeker Name?
CQ2. What is the Job Seeker nationality?
CQ3. When is the Job Seeker birthdate?
CQ4. What is the Job Seeker contact information?
CQ5. What is the Job Seeker current job?
CQ6. What is the Job Seeker desired job?
CQ7. What are the Job Seeker desired working conditions?
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?
CQ11. What is the Job Seeker work experience?
CQ12. What is the Job Seeker knowledge?
CQ13. What is the Job Seeker expertise?
CQ14. What are the Job Seeker skills?
CQ15. What publications does the Job Seeker have?
CQ16. What hobbies does the Job Seeker have?
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. When the Job Seeker completed his/her first degree?
CQ29. Is the Job Seeker older than 30 years?
CQ30. How much time did the Job Seeker spend completing his/her first degree?
CQ31. How long is the duration of the contract?
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?
CQ35. Is the job offer's salary greater than 14000 zlotes?
CQ36. Is the job offer's salary lower than 25000 kroner?
CQ37. The offered salary is given in US dollars?
CQ38. The offered salary is given in Euros?
CQ39. 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?

SEEMP Reference Ontology Competency Questions

CQ40. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skill) of the job seeker what job offers are the most appropriate?
CQ41. 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?
CQ42. Given the personal information (name, nationality, birth date, contact information), the profile (current job, education level, work experience, knowledge, expertise, skill) and the objectives (desired contract type, desired job, desired working conditions, desired salary) of the job seeker, what job offers are the most appropriate?
CQ43. Given the employer information, economic activity of the employer and the job offer profile (job, contract type, salary, work condition), what job seekers are the most appropriate?
CQ44. Given the employer information, economic activity of the employer and the required profile to seek (required education level, required work experience, required knowledge, required skills), what job seekers are the most appropriate?
CQ45. 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?
CQ46. Given the employer information, economic activity of the employer, 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?
CQ47. When the job seeker completed his/her first degree and how much time did he/she spend completing his/her first degree?
CQ48. When the job seeker completed his/her first degree and is he/she older than 30 years?
CQ49. Is the job seeker older than 30 years and how much time did he/she spend completing his/her first degree?
CQ50. Which job offers were posted in last 24 hours and how long is the duration of their contracts?
CQ51. Which job offers were posted in last 7 days and how long is the duration of their contracts?
CQ52. Which job offers were posted in last month and how long is the duration of their contracts?
CQ53. Is the job offer's salary greater than 14000 zlotes and could it be given in US dollars?
CQ54. Is the job offer's salary lower than 25000 kroner and could it be given in Euros?
CQ55. Given the age (30 years old) and the desired salary (equal or greater than 14000 €) of the job seeker, what job offers are the most appropriate?
CQ56. 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?
CQ57. Given the age (20 years old) and the desired salary (equal or greater than 14000 zlotes) of the job seeker, what job offers posted in last month are the most appropriate?
CQ58. Given the employer information, economic activity of the employer and the job offer profile (job, contract type, salary of 3400 €, work condition, contract duration), what job seekers are the most appropriate?
CQ59. Given the time spend for his/her degree (8 years) and the desired salary (equal or greater than 14000 €) of the job seeker, what job offers posted in last 7 days are the most appropriate?
CQ60. Given the time spend for his/her degree (6 years) and the desired salary (equal or greater than 14000 €) of the job seeker, what job offers posted in last 24 hours are the most appropriate?
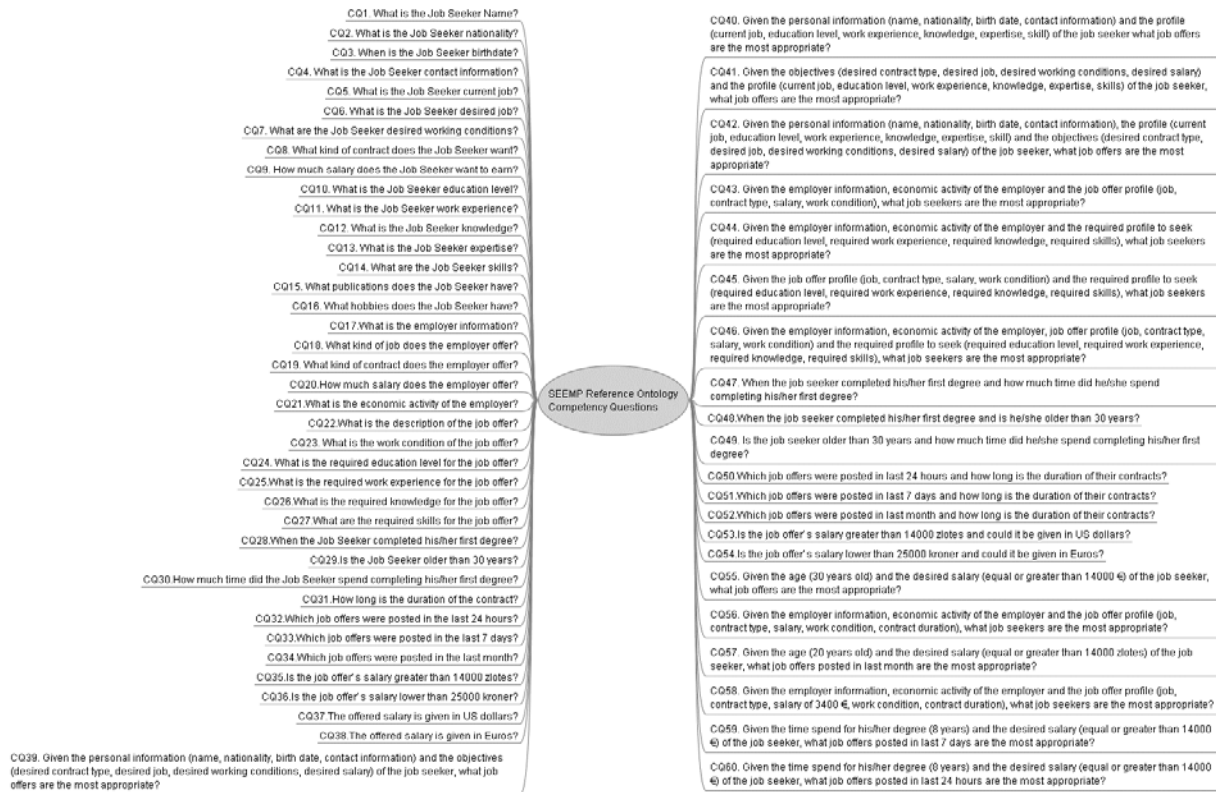
Figure 3. Excerpt of the Competency Questions in a Mind Map Tool

Task 5. Group requirements.

The sixty competency questions, described in [1], were manually grouped into five groups with the domain experts' help. Figure 4 shows the final 5 groups: Job Offer, Job Seeker, Currencies, Time and Date, and general ones. General competency questions are the result of the composition of simple queries into complex ones. The criteria for grouping the competency questions are based on the identified uses, the identified users and the domain expert suggestions. Figure 4 shows the 5 groups of competency questions.
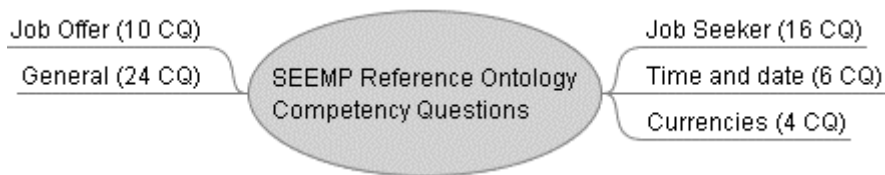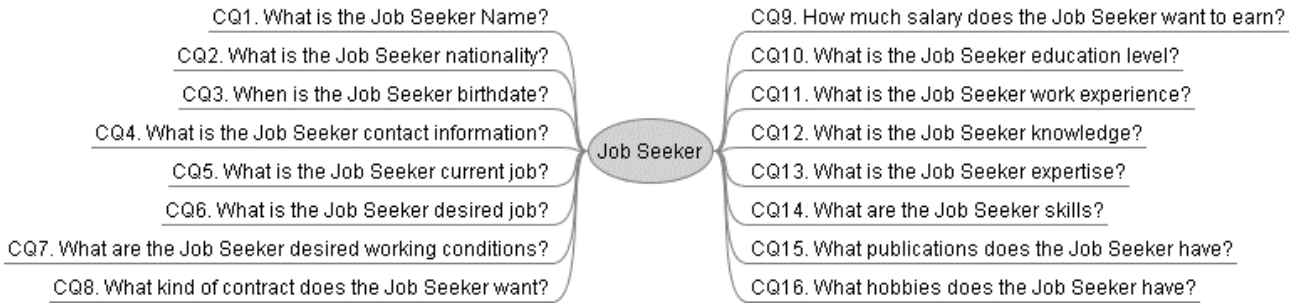

Job Offer (10 CQ)
General (24 CQ)
SEEMP Reference Ontology Competency Questions
Job Seeker (16 CQ)
Time and date (6 CQ)
Currencies (4 CQ)

Figure 4. Competency Questions Groups

CQ1. What is the Job Seeker Name?
CQ2. What is the Job Seeker nationality?
CQ3. When is the Job Seeker birthdate?
CQ4. What is the Job Seeker contact information?
CQ5. What is the Job Seeker current job?
CQ6. What is the Job Seeker desired job?
CQ7. What are the Job Seeker desired working conditions?
CQ8. What kind of contract does the Job Seeker want?

Job Seeker

CQ9. How much salary does the Job Seeker want to earn?
CQ10. What is the Job Seeker education level?
CQ11. What is the Job Seeker work experience?
CQ12. What is the Job Seeker knowledge?
CQ13. What is the Job Seeker expertise?
CQ14. What are the Job Seeker skills?
CQ15. What publications does the Job Seeker have?
CQ16. What hobbies does the Job Seeker have?

Figure 5. Job Seeker Competency Questions

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?

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?

Figure 6. Job Offer Competency Questions

CQ28. When the Job Seeker completed his/her first degree?
CQ29. Is the Job Seeker older than 30 years?
CQ30. How much time did the Job Seeker spend for completing his/her first degree?
CQ31. How long is the duration of the contract?

Time and Date

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?

Figure 7. Time and Date Competency Questions

CQ35. Is the job offer's salary greater than 14000 zlotes?
CQ36. Is the job offer's salary lower than 25000 kroner?

Currencies

CQ37. The offered salary is given in US dollars?
CQ38. The offered salary is given in Euros?

Figure 8. Currencies Competency Questions

CQ39. 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?

CQ40. Given the personal information (name, nationality, birth date, contact information) and the profile (current job, education level, work experience, knowledge, expertise, skill) of the job seeker what job offers are the most appropriate?

CQ41. 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?

CQ42. Given the personal information (name, nationality, birth date, contact information), the profile (current job, education level, work experience, knowledge, expertise, skill) and the objectives (desired contract type, desired job, desired working conditions, desired salary) of the job seeker, what job offers are the most appropriate?

CQ43. Given the employer information, economic activity of the employer and the job offer profile (job, contract type, salary, work condition), what job seekers are the most appropriate?

CQ44. Given the employer information, economic activity of the employer and the required profile to seek (required education level, required work experience, required knowledge, required skills), what job seekers are the most appropriate?

CQ45. 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?

CQ46. Given the employer information, economic activity of the employer, 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?

CQ47. When the job seeker completed his/her first degree and how much time did he/she spend completing his/her first degree?

General

CQ48. When the job seeker completed his/her first degree and is he/she older than 30 years?

CQ49. Is the job seeker older than 30 years and how much time did he/she spend completing his/her first degree?

CQ50. Which job offers were posted in last 24 hours and how long is the duration of their contracts?

CQ51. Which job offers were posted in last 7 days and how long is the duration of their contracts?

CQ52. Which job offers were posted in last month and how long is the duration of their contracts?

CQ53. Is the job offer's salary greater than 14000 zlotes and could it be given in US dollars?

CQ54. Is the job offer's salary lower than 25000 kroner and could it be given in Euros?

CQ55. Given the age (30 years old) and the desired salary (equal or greater than 14000 €) of the job seeker, what job offers are the most appropriate?

CQ56. 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?

CQ57. Given the age (20 years old) and the desired salary (equal or greater than 14000 zlotes) of the job seeker, what job offers posted in last month are the most appropriate?

CQ58. Given the employer information, economic activity of the employer and the job offer profile (job, contract type, salary of 3400 €, work condition, contract duration), what job seekers are the most appropriate?

CQ59. Given the time spend for his/her degree (8 years) and the desired salary (equal or greater than 14000 €) of the job seeker, what job offers posted in last 7 days are the most appropriate?

CQ60. Given the time spend for his/her degree (8 years) and the desired salary (equal or greater than 14000 €) of the job seeker, what job offers posted in last 24 hours are the most appropriate?
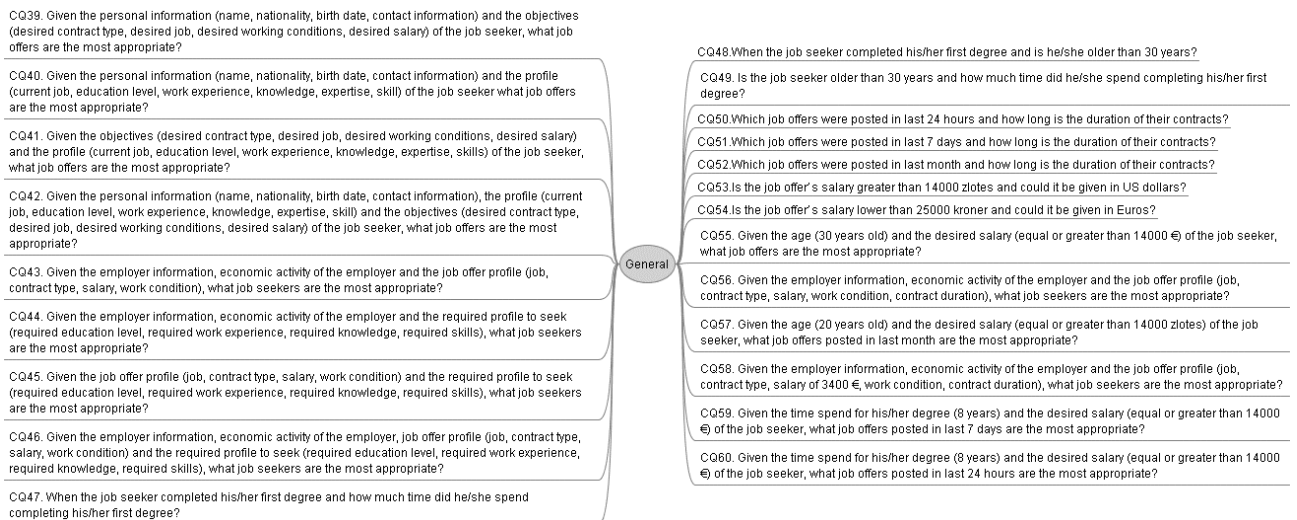
Figure 9. General Competency Questions

Task 6. Validate the set of requirements.

During the overall process we received recommendations, suggestions and advices from the domain experts, and we iterated several times until we got the final approval by the end users. They used the following criteria for validating the competency questions:

- ❑ Correctness. Domain experts checked the correctness of each competency question, verifying that its formulation and answers were correct.

- ❑ Consistent. Domain experts also verified that the competency questions did not have any possible inconsistency. For example, a Job Seeker who does not speak English cannot find a job offer in England.

Task 7. Prioritize requirements.

Within the SEEMP Reference Ontology specification we did not carry out this step. This means the first version of the ontology must be able to represent the knowledge contained in all the competency questions.

Task 8. Extract terminology and its frequency.

From the competency questions, we manually extracted the terminology that will be formally represented in the ontology by means of concepts, attributes and relations. We identified the terms and the objects in the universe of discourse.

Examples of the terms related to job seeker are shown in Table 3.

Term	Frequency
Job Seeker	27
• CV	2
• Personal Information	3
Name	4
Gender	1
Birth Date	1
Address	1
Nationality	1
Contact (phone, fax, mail)	3
• Objective	3
Job Category	3
Activity Sector	3
Location	3
Work Condition	2
Contract type	2
Salary	3
• Education and training	3
• Work Experience	3
• Competencies	3
Knowledge	3
Abilities	3
Skills	3
• Publication	1

•	Hobbies	1
•	References	1

Table 3. Examples of Terminology and Frequency – Job Seeker

Examples of the terms related to job offer are shown in Table 4.

Term	Frequency
Job Offer	27
• Employer information	1
Name	1
Address	1
Contact	1
• Vacancy	1
Job category	3
Activity sector	1
Location	3
Work condition	3
Contract type	3
Salary	3
Education	3
Work experience	2
Skills	2
Languages	1

Table 4. Examples of Terminology and Frequency – Job Offer

Table 5 shows some examples of objects, which are instances of Nationality, Job Category, Education, Currency, Languages, and Activity Sector.

Nationality	Job Category	Education	Currency	Languages	Activity Sector
Austrian	Computer System Designer	Life Science	Euro	Austrian	Telecommunication
Belgian	Computer System Analyst	Mathematics	Krone	Belgian	Justice and Judicial
Cypriot	Programmer	Computer Science	Great British Pound	Cypriot	Public Security and law
Czech	Computer Engineer	Computer Use	Zlote	Czech	Manufacture of machine tools
Danish	Computer Assistant	Statistics	US Dollar	Danish	Research and Development
Estonian	Computer Equipment Operator	Physics	Franc	Estonian	Hardware Consultancy
Finnish	Industrial Robot Controller	Chemistry	Peso	Finnish	Software Consultancy and Supply
French	Telecommunication Equipment Operator	Earth Science		French	Data processing
German	Medical Equipment	Network		German	Database

		Administration			
	Operator				
Greek	Electronic Equipment Operator	Operating Systems		Greek	Publishing of Software
Hungarian	Image Equipment Operator	Informatics		Hungarian	Maintenance of computing machinery
Irish	Software Engineer	Programming Language		Irish	Government
Italian	Computer code recorder	Sports		Italian	Culture, Media, Design

Table 5. Examples of Objects

After following these tasks, the output of the Ontology Specification activity is the Ontology Requirements Specification Document. An excerpt of this document is shown in Table 6.

	SEEMP Reference Ontology Requirements 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**
	User 1. Candidate who is unemployed and searching for a job or searching another occupation for immediate or future purposes
	User 2. Employer who needs more human resources.
	User 3. Public or private employment search service which offers services to gather CVs or job postings and to prepare some data and statistics.
	User 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.
	User 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.
5	**Intended Uses**
	Use 1. Publish CV. Job seeker places his/her CV on the PES Portal.
	Use 2. Publish Job Offer. An Employer places a Job Offer on the PES Portal.
	Use 3. Search for Job Offers. The Employer looks for candidates for the Job Offer through PES Portal.
	Use 4. Search for Employment information. Job Seeker looks for of general information about employment in a given location at the PES Portal.
	Use 5. Provide Job Statistics. The PES Portal provides employment statistics to the Job Seeker and Employer.
6	**Groups of Competency Questions**

CQG1. Job Seeker (16 CQ)	CQ1. What is the Job Seeker Name? / CQ2. What is the Job Seeker nationality? / CQ3. When is the Job Seeker birthdate? / CQ4. What is the Job Seeker contact information? / CQ5. What is the Job Seeker current job? / CQ6. What is the Job Seeker desired job? / CQ7. What are the Job Seeker desired working conditions? / CQ8. What kind of contract does the Job Seeker want? / Job Seeker / CQ9. How much salary does the Job Seeker want to earn? / CQ10. What is the Job Seeker education level? / CQ11. What is the Job Seeker work experience? / CQ12. What is the Job Seeker knowledge? / CQ13. What is the Job Seeker expertise? / CQ14. What are the Job Seeker skills? / CQ15. What publications does the Job Seeker have? / CQ16. What hobbies does the Job Seeker have?
CQG2. Job Offer (10 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? / 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?
CQG3. Time and Date (6 CQ)	CQ28.When the Job Seeker completed his/her first degree? / CQ29.Is the Job Seeker older than 30 years? / CQ30.How much time did the Job Seeker spend for completing his/her first degree? / CQ31.How long is the duration of the contract? / Time and Date / 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?
CQG4. Currencies (4 CQ)	CQ35.Is the job offer's salary greater than 14000 zlotes? / CQ36.Is the job offer's salary lower than 25000 kroner? / Currencies / CQ37.The offered salary is given in US dollars? / CQ38.The offered salary is given in Euros?
CQG5. General (24 CQ)	

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

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

Table 6. Excerpt of SEEMP Reference Ontology Requirement Specification Document

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