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Management Summary

This deliverable presents S-Cube's vision for its Knowledge Model (KM) and reports on the developments to the KM content and structure since its previous version (September 2008). The major work achieved during this period was to develop a new version of the KM which builds on the previous content.

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List of acronyms

KM	Knowledge Model
NoE	Network of Excellence
SBA	Service-Based Application
SSAI&E	Software and Service Architectures, Infrastructures, and Engineering

1 Introduction

The objective of the *Convergence Knowledge Model* work package as defined in the S-Cube DoW is:

To develop a convergence knowledge model that captures terminology, classifies competences of beneficiaries and their research. The convergence knowledge model will support elimination of duplication of research efforts, better attuning of the research activities of beneficiary institutions and restructuring of already existing research agendas toward a common research objective, integration of knowledge, and, production and harmonisation of research results.

S-Cube's Knowledge Model (KM) aims therefore to map, integrate and synthesize the diverse concepts and knowledge of partners from different research areas in the network (Engineering and Design (ED), Adaptation and Monitoring (AM), Quality Definition, Negotiation and Assurance (QA), Business Process Management (BPM), Service Composition (SC) and Service Infrastructure (SI)), as represented by the project work packages. It helps to identify research gaps, determine the research issues that are of importance for the next generation of services technologies, and harmonize research results. In doing so, the KM will enable the streamlining of the research activities of the six joint research areas in S-Cube.

The purpose of the KM is to provide a common understanding of diverse knowledge in the form of a free, open-content "living" encyclopedia, accessible through the Web. The S-Cube KM will offer a dynamic, interactive application to define associations between concepts, approaches and methodologies. The KM will help users to negotiate a large body of knowledge by providing them with mental cues for navigating across different knowledge domains related to all aspects of service-oriented research and associated methodologies and supporting environments.

The rest of this deliverable elaborates on S-Cube's vision for the KM and reports on the developments to its content and structure since its previous version released as part of deliverable CD-IA-1.1.1 [8].

2 Vision for the Knowledge Model

The following section outlines the vision and planning for the KM in terms of its envisioned content, architecture, purpose and positioning both within the S-Cube NoE and with respect to other projects and initiatives.

2.1 Positioning of the Knowledge Model

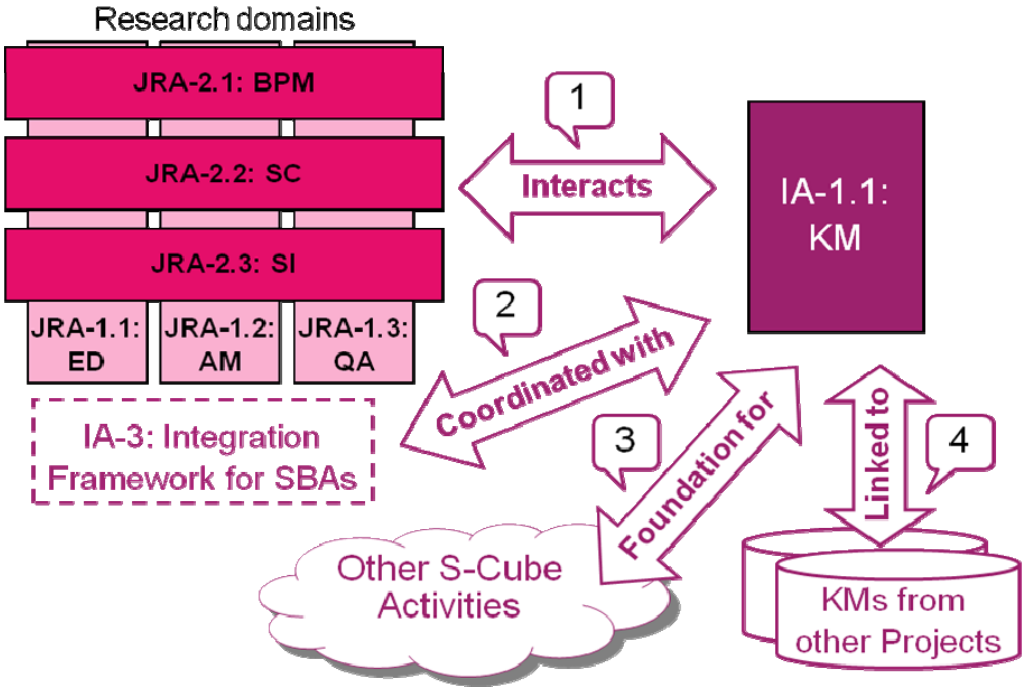

Figure 1: Integration of KM and other activities

Figure 1 illustrates the positioning of the KM activity in relation to the other activities of the network. More specifically:

1. The KM interacts with the functional SBA layers of S-Cube, i.e., the intersections between the JRA-1 and -2 activities, by using these activities as input for its development.
2. The analysis and construction of the KM is performed in coordination with the Integration Framework for SBAs developed in IA-3, which integrates, aligns and coordinates the results of the JRAs.
3. The KM allows for a common understanding and positioning of the S-Cube activities into a holistic and consistent framework by acting as a foundation on which they can develop and interact with each other. This is required for achieving integration and coordination within the project.
4. By providing links to knowledge models from other EU projects the KM will facilitate the synthesizing and harmonization of research on SBAs across communities and initiatives.

A more detailed view of the structure of the KM and its interactions with the other activities of S-Cube, emphasizing on the non-JRA activities and the KMs from other projects and initiatives is given in Figure 2.

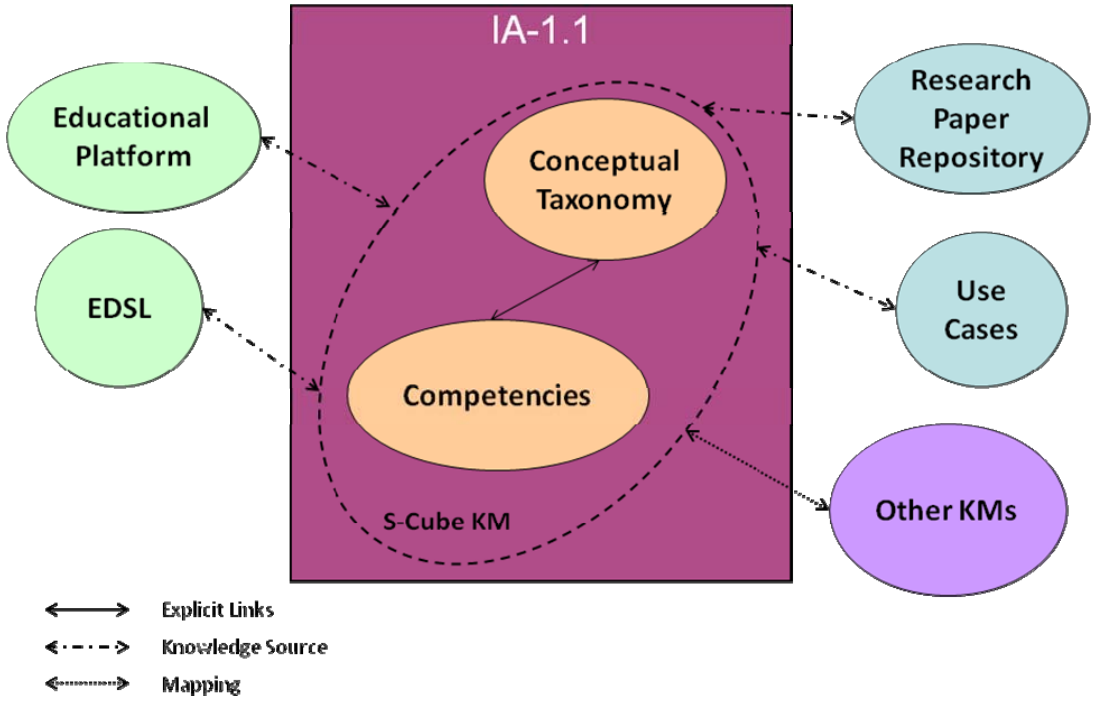

Figure 2: The S-Cube KM and other knowledge sources and knowledge-intensive activities

In summary, the KM is a repository of *terminological definitions*. These definitions are the result of consolidation and reconciliation of conflicting or overlapping definitions of the vocabulary used in the *research domains* of S-Cube (Engineering and Design, Adaptation and Monitoring, Quality Definition, Negotiation and Assurance, Business Process Management, Service Composition and Service Infrastructure). In addition, the KM will also include *competencies* (expertise lists) that will not only allow the development and querying of a list of experts in S-Cube's research domains, but also analyze the extent to which research groups in S-Cube are collaborating with each other in the next steps of the work package.

2.2 Content

S-Cube's KM is structured along a baseline architecture that is depicted in Figure 2. The two key components of the KM are:

1. *Conceptual taxonomy:* contains *terms* for each research domain as identified by the JRA activities, together with their *definitions* and *relationships* with other terms inside and across the S-Cube research domains. A *knowledge domain* is one of the research areas of S-Cube and is itself a term in the conceptual taxonomy. Each term may have different meanings in different domains, and consequently it may have different definitions and relationships across different domains.
2. *Competencies*: represent key *contributors* and *experts* relating to terms and knowledge domains in terms of research output (volume and relevance) from both inside and outside the S-Cube consortium, with the emphasis on the former.

Explicit links exist between these two components; that is, entries in the competencies lists are described by and affiliated with terms in the conceptual taxonomy. Conversely, terms in the conceptual taxonomy will allow the lookup of competencies relating to those terms.

Adding new entries, creating new relationships and editing existing entries in the KM can be done at any time (see Quality Assurance section for more details) but since the KM depends mainly on the

output of JRAs the main body of its development is connected to the JRA deliverable life cycle and will therefore evolve as the project does.

2.3 Knowledge sources

Figure 2 also describes the types of relationship the KM will have with other knowledge sources and knowledge-intensive activities (*components*) both inside and outside the network. These relationship types can be:

1. *Knowledge Source*: the related component is in a feedback loop that enriches and consolidates the contents of the KM with knowledge produced within the component scope. The component itself may be using entries from the KM to describe its contents.
2. *Mapping*: the KM refers to an external knowledge source, either by replicating knowledge from that source or by providing a link to the knowledge repository of the source.

In particular, the S-Cube KM relates to the following knowledge sources:

- *Use Cases*: they represent scenarios described by using terms from the KM that are useful for the wider community to understand the S-Cube approach. For instance, scenarios could be drawn from WP-JRA-2.3 to describe situations where run-time service adaptation is required and illustrate how it is handled.
- *Research Paper Repository*: a centralized database of software services-related research papers that were produced within the context of S-Cube and assembled as part of the community outreach activity (WP-SoE-1.2).

Furthermore, the S-Cube KM relates to the following knowledge intensive activities that also act as knowledge sources:

- *Educational Platform* (the *Virtual Campus* and *Joint PhD programs* activities in WP-SoE-1.1): it is expected that students and professionals will use the KM as a source for producing course materials, as it will provide unambiguous definitions, cross-correlation of terms from different disciplines, and access to case studies and publications relating to specific domains or terms.
- *EDSL* (WP-IA-1.2 output): apart from used as a source of knowledge for the distributed service laboratory, the KM will serve as the conceptual underpinnings for leveraging the integration of different tools and implementations.

In addition to these sources, the knowledge models produced by other EU projects, and especially the ones that are part of the SSA&I FP7 collaboration activity [9] (i.e., NEXOF-RA Glossary and Gridipedia) are also valuable sources of related knowledge for the S-Cube KM. For the current version of the S-Cube KM though it was decided to focus on the knowledge and competencies inside the Network of Excellence. For that purpose no references to the Gridipedia or other knowledge sources have been added to the ones established in the previous version. The collaboration with these sources and the respective initiatives will be leveraged during the creation of the next version of the KM, as part of the deliverable CD-IA-1.1.3 "Integrated knowledge model".

2.4 KM Data Schema

The KM will be based on a tool agnostic, multi-dimensional, and extensible data schema that helps ensuring the data integrity and consistency throughout the knowledge base of the KM. Hence, the data schema will allow access through multiple front-ends, and will be based on existing standards for Knowledge Bases wherever possible. Also, the data schema will be developed and evolved in an incremental and iterative fashion with extensibility in mind. Furthermore, it will allow for multiple representations of the terms and their relationships at multiple levels of abstraction. The knowledge base will provide the physical access point for storing and retrieving the KM entries (both terms and competencies), independently of their representation.

More specifically the knowledge base will store at least the following information:

- For each term:
    - Domain(s) and work packages in which the term is encountered.
    - Domain-specific definition.
    - Inter- and intra- domain relationships between terms.
    - Examples of usage (optional).
    - Explanatory visualizations such as UML diagrams (optional).
    - List of papers that use term as a keyword (optional).
    - Reference to use case(s) (optional).
- For each knowledge domain:
    - Definition of the scope of the domain.
    - List of terms contained in the domain (this can also be inferred instead of explicitly recorded).
    - Links to applicable competencies.
    - List of relevant to the domain papers (optional).
- For each competency:
    - Description of the competency using terms (including domains) from the conceptual taxonomy.
    - A list of people inside and outside the S-Cube network recognised as being an expert in and/or associated with the competency, together with their contact information.

The knowledge base will also offer versioning and logging mechanisms for all its entries (terms, their relationships, domains, and competencies) and will allow for rollback to previous versions of an entry.

2.5 KM Representation

The KM is built on the explicit separation of data from its representation. This explicit separation caters for multiple representations that are geared towards the specific needs of different stakeholders, e.g., the research and industrial community. Essentially, the multiple representations are *structured* and each of these structures uses the stored terminological information in the knowledge base.

To position the S-Cube KM representation we selected a number of representative EU and international projects and initiatives that deal with knowledge collection and representation and we evaluated their design decisions. This exercise presented us with a number of *representation options* in selecting a presentation method for the S-Cube KM.

For example, a hyper-textual representation could render the detailed and consolidated information for each KM entry in HTML. An example of how this may be achieved is the NEXOF-RA Glossary (a screen-shot of which is shown in Figure 3).

Figure 3: Some terms from the NEXOF-RA Glossary [1]

Hypertext-based representations could allow for a more browser-oriented access to the KM, similar, for example, to how Wikipedia presents information (Figure 4).

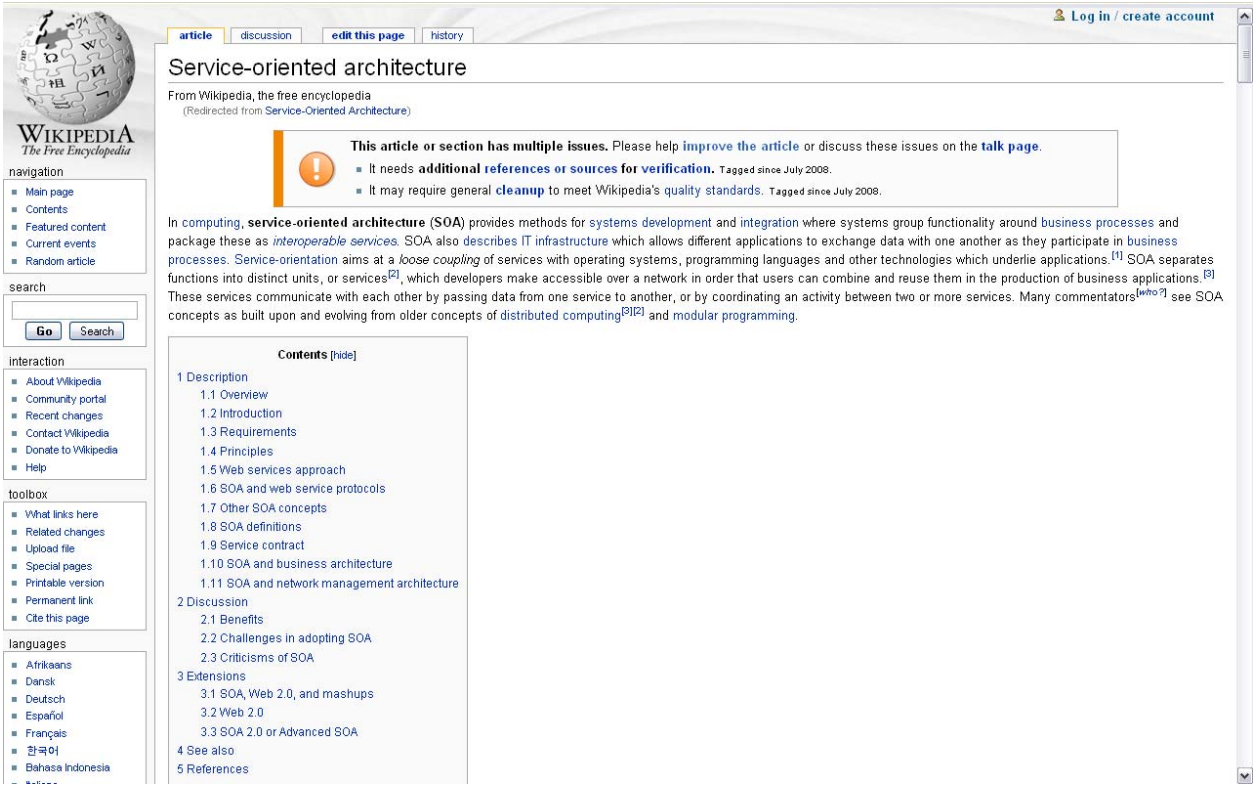

Figure 4: The Wikipedia entry on SOA [2]

Graphical representations on the other hand could visualize terms and domains at various levels of abstraction, allowing the user to browse through the contents of the knowledge base in an intuitive manner and to drill down from top level concepts to lower level concepts, and vice versa. Non-technical users may use a browser or another GUI to browse through abstract visual representations of top level terms in the KM. Technical experts on the other hand, are expected to browse the KM at lower levels of abstraction with more fine-grained and specific entries in mind.

The INTEROP Taxonomy for example (Figure 5), while using a traditional database-based storage scheme for its KM allows for easier navigation of the KM through a tree-structured representation of its hierarchically organized terms.

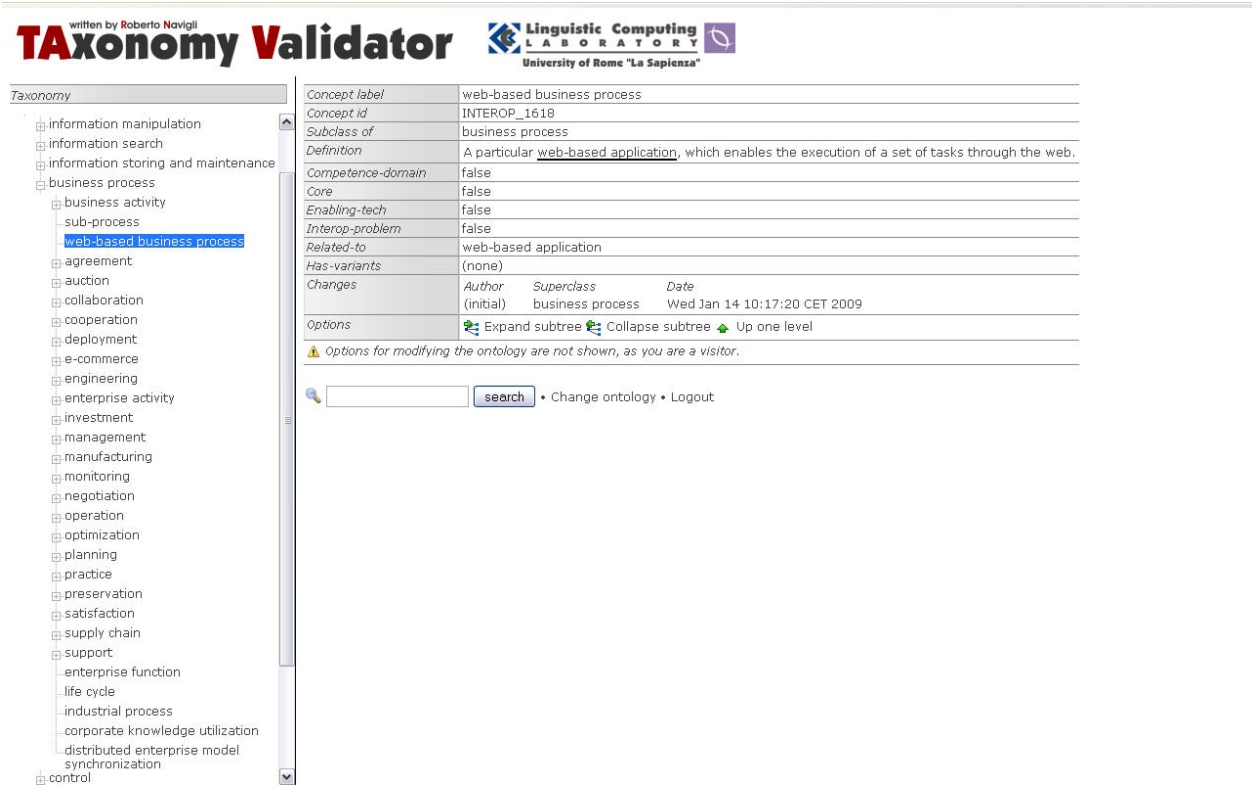

Figure 5: The INTEROP Taxonomy browser [3]

Other representation tools like Concept Maps (Figure 6) are more visually-oriented, relying more on the graphical environment itself and less on the textual description of a concept to show its relationships with other concepts.

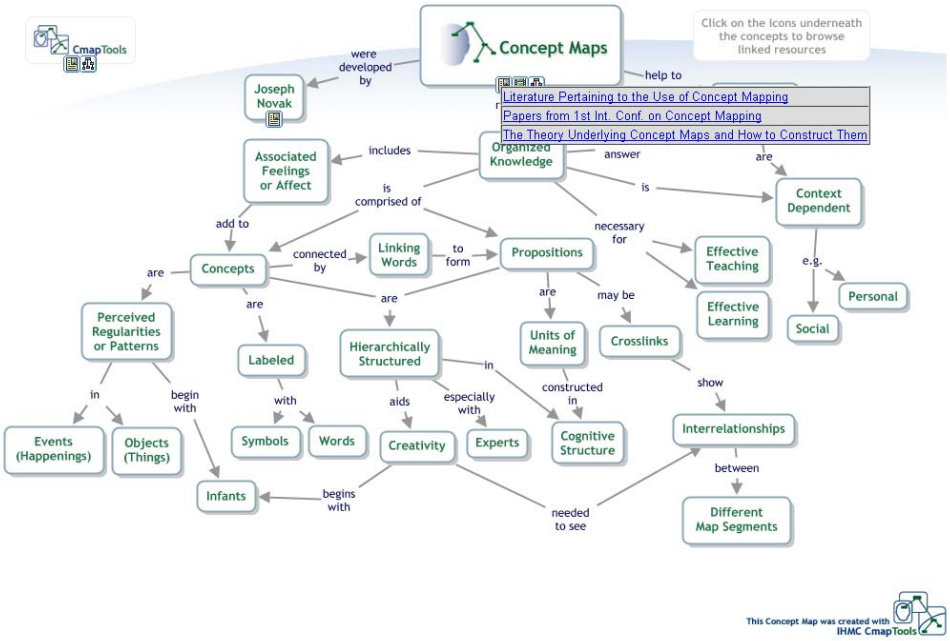

Figure 6: A Concept Map view of the Concept Map web page [4]

Machine-readable representations (e.g., in XML and/or RDF/OWL) could allow for a more formal definition of the concepts and their relationships (see for example the OpenCyc initiative in Figure 7). Furthermore they allow for multiple uses of the KM in a number of application domains like service discovery and SLA negotiation.

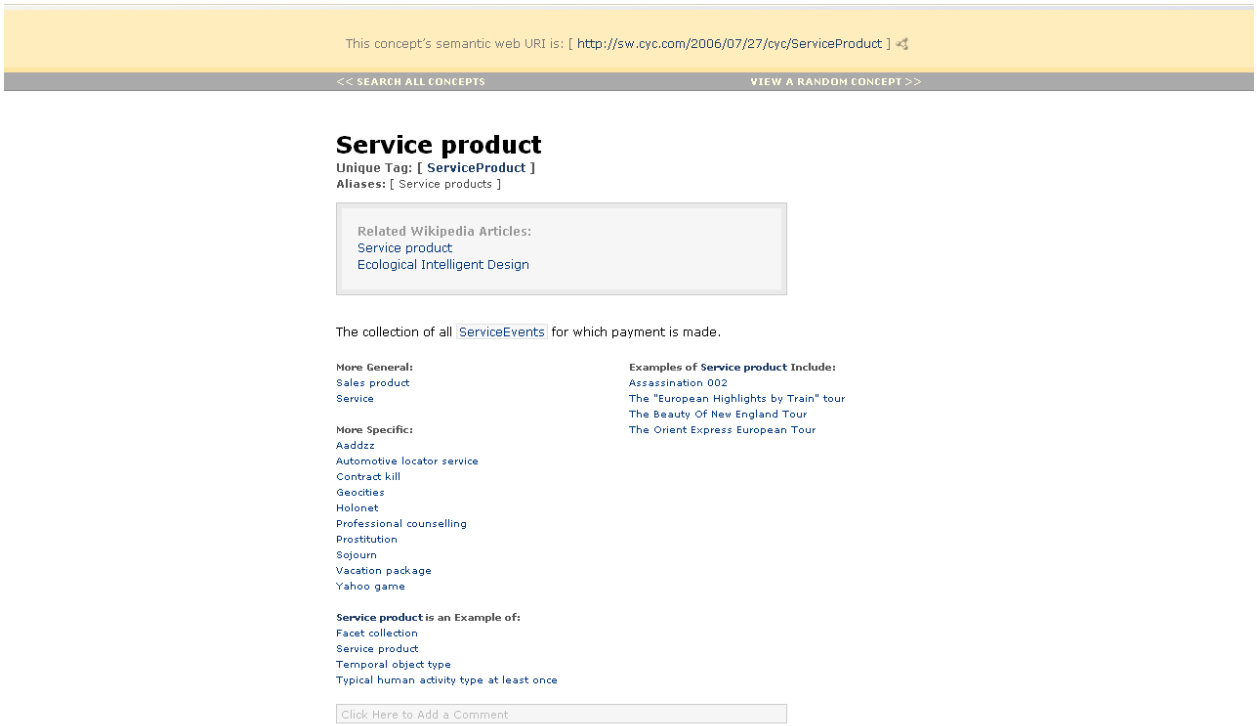

Figure 7: A concept from the OpenCyc initiative [5]

The different representation methods presented so far are *not* mutually exclusive. Swapping between representations is also possible, facilitating a multi-dimensional experience that enables the creation, search and management of knowledge and expertise accumulated in the KM. The Grid Workflow forum for example (Figure 8) combines a number of representation options presented above by allowing for interactive hypertext-based visual access to its content through a wiki page that at the same time provides a machine-readable view of the content.

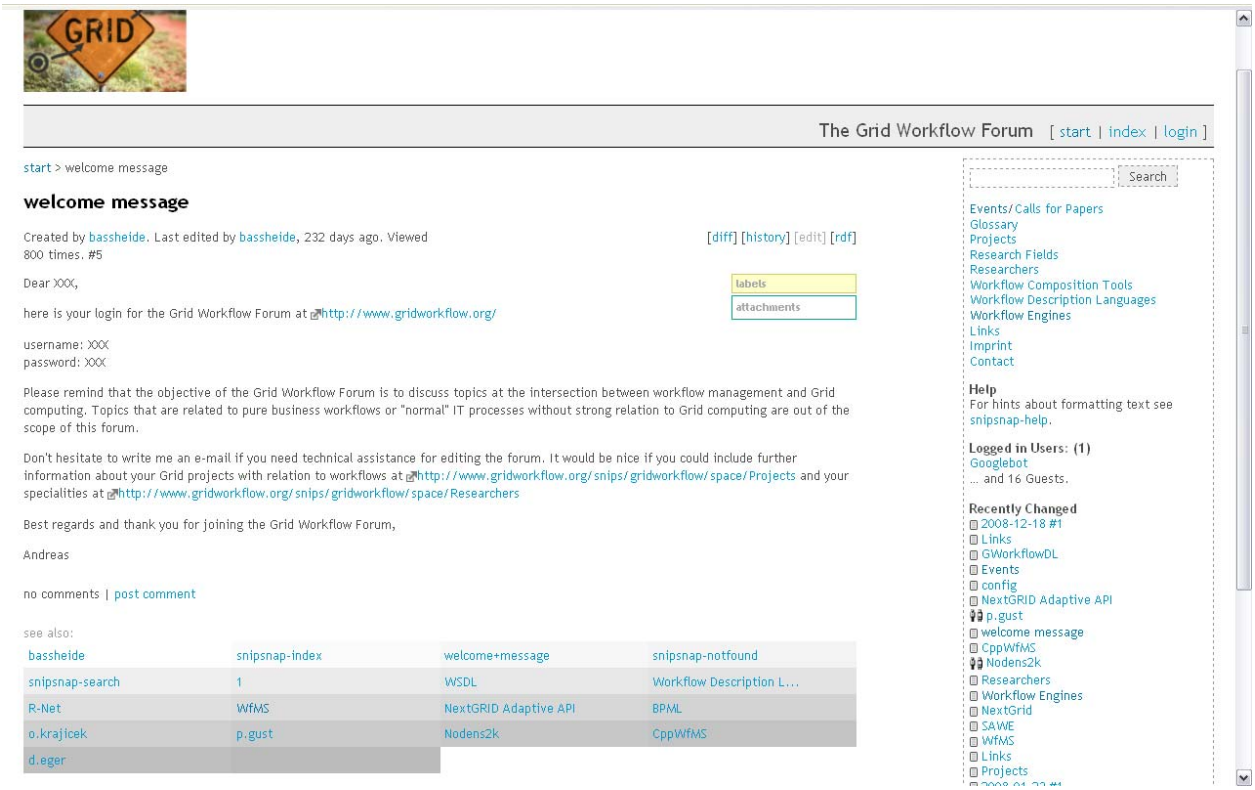

Figure 8: The Grid Workflow forum starting page [6]

Given the goal of the KM to serve as a free, open-content "living" encyclopedia, accessible through the Web, and the disparate needs of possible users for it (academia, industry, other projects and initiatives) we will aim to provide as a wide number of representation options as possible within the scope of this project.

2.6 Quality Assurance

The KM will be open in nature, allowing for contributions from all the partners in the network and the wider research community. To ensure the quality, homogeneity, and consistency amongst terms, the KM will adopt a well-defined governance structure, including a quality assurance process. The quality assurance process will prescribe a procedure to review additions, changes or removal of KM entries, define or modify user access rights, release parts of the knowledge model to the broader research community and consolidate terminology.

In particular, a formal peer review process will be in place to give selected users from each domain (e.g., the work package leaders) editorial roles. These editors will have the responsibility to process new and modified entries by the network members to the KM, resolve conflicts and revert to previous versions of an entry if necessary. Special care will be taken with entries added or modified by the non-network users, and their content will be reviewed and edited accordingly. An editor-in-chief is the final authority in approving the content of the KM and resolving important issues and refer to the Steering Committee if necessary. Dedicated integration workshops could also be organized for the reviewing and enrichment of the KM with the participation of domain experts.

2.7 Application of KM to the Research Agendas

IA-1.1 has two future tasks (T-IA-1.1.3 and T-IA-1.1.4) that apply the S-Cube KM to monitor the progress of research inside and outside the network. These tasks build on the short- and medium-term work of this work package (described below) and use the accumulated knowledge to identify research

areas where progress is incomplete, missing or duplicated. This will allow the streamlining and consolidation of the research agendas of the partners in the network as a first step and to the European SBA community in the future.

As a first step towards this integration between S-Cube activities the KM has been used in the IA-2.1 activity (Mobility of Researchers) to produce deliverable CD-IA-2.1.2 [7]: by using the competency information in the KM it has been possible to identify not only common scientific research areas of interest but also complementary research topics that will be the focus for researcher mobility within the S-Cube NoE. Due to the fact that the competency information contains details of individual researcher's interests it has also been possible to pro-actively target suitable candidates for the mobility program by classifying them with respect to the identified scientific subjects.

2.8 Planning

2.8.1 Short term activities

1. S-Cube members will edit existing terms and include new terms for functional layers and cross-cutting terms (like adaptation) by exploiting the project (i.e., private) working area of the S-Cube Web Portal.
2. S-Cube members will update and correct competency lists for each term, listing people and organizations from the S-Cube consortium. Again, the S-Cube Web Portal facilities (i.e., project-internal Working Area) will be used to achieve this activity.
3. The network will provide public, read-only access for non-network users to the KM through the S-Cube Web Portal.

2.8.2 Medium term activities

1. Develop the next iterations of the KM by accumulating terminology from JRAs and non-network users and institutions. Non-network members will be added to the competencies list.
2. The QA process and procedures will be developed together with the data schema for the knowledge repository.
3. Allow for multiple representations of entries from the KM; we may consider an alternative to the S-Cube Web Portal for this purpose. Note that the current repository, which stores the initial Knowledge Model, will be developed in such a way that it can be easily transformed into a stand-alone, tool-agnostic knowledge-base for future knowledge model platform implementations.

2.8.3 Long term activities

1. To promote the use of the S-Cube KM outside the network, encouraging its use in academia, industry through dissemination and 'spread of excellence' activities.
2. Use the accumulated knowledge to identify research areas where progress is incomplete, missing or duplicated. This will allow the streamlining and consolidation of the research agendas of the partners in the network as a first step and to the European SBA community in the future.
3. Investigate the sustainability options for the KM after the end of the project. The KM represents an important knowledge resource that may be used in a number of different fields and for different purposes, ranging from reference material for educational purposes to a direct application in service description. Maintaining the KM in the post-project period is therefore of great interest to the NoE.

3 Knowledge Models for Functional Layers

This section provides a summary of the key approach (Section 3.1), contents and results (Section 3.2) for deliverable CD-IA-1.1.2 "Separate knowledge models for functional layers". This constitutes the version of the S-Cube Knowledge Model as of month 12.

The KM contains 275 entries, each of which contain relevant SBA terms, their definitions as well as a correlation between the competencies of the S-Cube members and the KM terms (see Section 3.2 for more details on the data in the KM).

Please note that the actual knowledge model deliverable is provided as a living document on the S-Cube Web Portal, which is accessible at the following URL:

http://www.s-cube-network.eu//knowledge-model

3.1 Overview of KM Definition and Quality Control Process

To arrive at the month 12 version of the S-Cube Knowledge Model, the S-Cube members have followed the below steps:

1. Agreement on S-Cube members on a KM template.
2. Transformation of initial KM entries (month 6 version) into the new format.
3. Two-step approach for adding and updating terms and their definitions
   a. Fix, polish, and update the definitions of the transformed entries (from step 2).
   b. Provide new terms and definitions for the KM based on the WP deliverables as well as the WP vision and challenges.
4. For the updated set of entries, each S-Cube member related its competencies to the key terms.
5. For what concerns quality control of the entry, the below considerations have been taken into account:
   a. Many terms have been taken from the WP deliverables/visions and thus have gone through quality control already (e.g., following the S-Cube guidelines for internal deliverable reviews)
   b. Identify and resolve inconsistencies, such as incomplete references or insufficiently defined competencies, by exploiting a checklist-based approach.
6. Publishing the quality controlled entries.

3.2 Contents of the S-Cube KM

3.2.1 Data Model for KM

Figure 9 provides a data model for the S-Cube KM entries. As can be seen, the major pieces of information are terms, their definitions, the relationships between terms, as well links to partner competencies. Details on the elements are explained below.

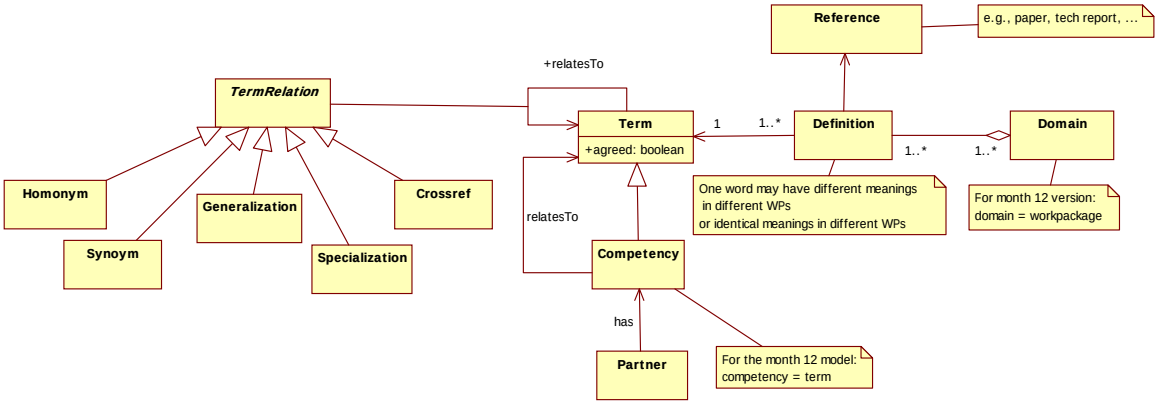

Figure 9: Data Model for Month 12 KM

3.2.2 Template for Representing Terms

The current implementation of the KM is based on the content management system of the S-Cube Web Portal, which provides a Wiki-like interface for entering content.

To structure the information entered, the template shown in Table 1 has been defined, reflecting the data model from above.

Term: <term>		*Domain: Cross-cutting issues*			
		Engineering & Design (KM-ED)	*Adaptation & Monitoring (KM-AM)*	*Quality Definition, Negotiation & Assurance (KM-QA)*	*Generic (domain independent)*
Domain : Layers	*Business Process Management (KM-BPM)*	<definition>	<definition>	<definition>	<definition>
	Service Composition & Coordination (KM-SC)	<definition>	<definition>	<definition>	<definition>
	Service Infrastructure (SI)	<definition>	<definition>	<definition>	<definition>
	Generic (domain independent)	<definition>	<definition>	<definition>	<definition>

Table 1 The S-Cube KM Template

In addition, each term has the following information associated with it:

Competencies: Provides a list of key people / institutions (including links to personal web pages and web sites of institutions) who have expertise in the area related to the defined term.

Scenarios: Reference to S-Cube scenarios to illustrate the defined term.

References: List of references used in the definitions above.

The template has a matrix structure, following the aim of cross-correlation of terms, as discussed in Section 2. This structure acknowledges that fact that each research discipline and area can use a different definition of terms; i.e., depending on the context in which the term is used, its definition or meaning can differ. If a term is generic across more than one domain or layer, the term will be placed in the respective "generic" cell. Although the S-Cube KM strives to align and integrate the different views, we also acknowledge the fact that each researcher has to communicate with the wider research community using established terms and definitions. Thus, the matrix structure for the S-Cube KM definition allows cross-correlating and aligning definitions where needed, while still maintaining the traceability to the fundamental definitions of the respective research fields.

Details on the syntax for cross-referencing terms are provided in the online version of the KM at the following URL:

http://www.s-cube-network.eu/working-area/knowledge-model/key-to-syntax

Please note the scenario element is a placeholder for the future versions of the KM and those will be provided based on the S-Cube vision documents and as defined in deliverable CD-IA-2.2.2.

3.2.3 Search facilities

The KM at this stage offers the following search and browse facilities:

- *Browse Alphabetically:* An alphabetic list of terms defined and cross-correlated within the Knowledge Model.
  http://www.s-cube-network.eu/knowledge-model/browse-alphabetically
- *Browse by Domain:* Allows browsing the KM based on a short description of the respective domain. An example for the "Quality Definition, Negotiation and Assurance" domain is: "Where the goal of *constructive quality assurance* is to prevent the introduction of faults (or defects) while the artifacts are created (in the sense of 'correctness by construction'), the goal of *analytical quality assurance* is to uncover faults in the artifacts after they have been created." The underlined entries are hyperlinked to the KM definitions.
  http://www.s-cube-network.eu/knowledge-model/browse-by-domain
- *Full Text Search:* Free text search of all entries in the KM.
  http://www.s-cube-network.eu/search_form
- *List all Entries:* Alphabetic list of all entries of the KM on one single page.
  http://www.s-cube-network.eu/knowledge-model/all-entries
- *Find Competencies Related to Terms:* Allows browsing the KM entries based on terms related to competencies of individual S-Cube members. As an example, when selecting the member "FBK", all terms associated to which FBK has competencies will be listed.
  http://www.s-cube-network.eu/knowledge-model/browse-by-member

3.2.4 Evolution of the KM

Figure 10 presents the number of definitions per domain in the new version of the KM:

Issues/Layers	Engineering & Design	Adaptation & Monitoring	Quality Assurance	Generic Issue
Business Process Management	2	2	1	25
Service Composition	1	5	1	37
Service Infrastructure	6	10	1	0
Generic Layer	68	43	80	39

Figure 10: Number of definitions per domain

Since a term may have more than one definition in more than one domain then the number of definitions will always be greater than the actual number of terms in the KM. For example there are two terms that have a definition that is common to the Engineering & Design and BPM research domains and six between Engineering & Design and Service Infrastructure.

The following table compares some characteristics of the previous and the current version of the KM:

	September 2008	***March 2009***
Number of terms:	72	275
Number of definitions:	79	282 (321[1])
Average number of terms per domain:	12	46 (39)
Average number of definitions per domain:	13	47 (40)

In addition the KM includes 106 competencies declared by S-Cube partners [7]. It is not possible to give a comparison with the September 2008 figure on competencies because the KM term structure has fundamentally changed and the competencies definitions have been moved from the domain definitions to a separate section within each term.

It has to be taken into account that due to the evolving nature of the KM the statistical figures discussed above are subject to change in the short term.

[1] Numbers within brackets are taking into account non-domain specific terms, represented in the template by an entry in the Generic/Generic cell.

4 Conclusions

The purpose of the KM is to provide a common understanding of diverse knowledge in the form of a free, open-content "living" encyclopedia, accessible through the Web. The S-Cube KM will offer a dynamic, interactive application to define associations between concepts, approaches and methodologies. This deliverable elaborated further on the S-Cube vision for its KM and reported on the development of its content and structure since its previous version was released in September 2008. The main progress achieved through that period was to produce a new version of the KM which restructured the presentation of definitions of terms and competencies and the addition of over 200 new terms using this template. The KM also demonstrated its value to other S-Cube activities such as the proactive identification of scientific subjects for researcher mobility.

The next step for this work package is to integrate the knowledge contained in each functional layer into one coherent model by identifying terms that overlap between domains and missing content. Furthermore, the KM will be assessed in terms of KPIs such as number of users and number of issues resolved in comparison to the total number of terms per functional layer. Deliverable CD-IA-1.1.3 "Integrated knowledge model" containing a report on these tasks will be produced in M21 of the NoE.

5 References

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