Formulating an Expertise Map in the VRL-KCiP

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Abstract The Virtual Research Laboratory for a Knowledge Community in Production (VRL-KCiP) is a network of 27 carefully selected partner research laboratories located in 16 different countries that have coordinated to build a knowledge community in the field of design and manufacturing research (www.vrl-kcip.org). The VRL-KCiP comprises over 300 multilingual, multicultural and multidisciplinary researchers, both permanent staff and graduate students. Expertise mapping was identified as a key process for integrating the network researchers to create the desired cooperation, collaboration and synergy required for network success, due to the inherent nature of the network.

Keywords: Expertise; Mapping; Networks; Knowledge

1 Introduction

The central aim of the VRL-KCiP is to create synergy by integrating the research expertise and capabilities of the different member teams to support research in the field of product life cycle engineering in the modern manufacturing environment [1]. Hence, knowledge sharing and collaborative research constitute the core potential for the network's success, and the essence of its existence.

Expertise mapping was identified as the basis for this knowledge sharing and collaborative research, as it enables (a) analysis of network strengths and weaknesses; (b) formulation of efficient and effective project groups; (c) identification of potential research synergy and (d) enhanced expertise visibility.

This chapter describes the process of creating an online expertise map for the VRL-KCiP Network of Excellence (NoE).

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1.1 Opportunities Envisioned

Developing an expertise map was identified as the first step for structuring knowledge in the network. Structuring knowledge is a key means for people to highlight similar ideas and build cooperation, collaboration and synergy among experts in particular fields of research. Furthermore, structured knowledge is of extreme importance in the digital domain for enhancing and extending both internal and external communication and collaboration [2].

Targeted users of the expertise map include both internal VRL members and external researchers or industries seeking experts in a given field. The expected uses of the map are many and include:

- Analyzing network competencies to reduce duplication of research and identify missing expertise, which could then be acquired via new members, subcontractors or industrial support.
- Determining strategic research trends based on the strengths and weaknesses of the network.
- Learning about the current expertise of each network member and lab as a basis for collaboration, cooperation and synergy in the VRL-KCiP NoE.
- Improving knowledge sharing within the network by determining how to assemble the collective knowledge in order to work together and enable easy access and synergy of research tools, methods and results.
- Improving the network position to respond to new calls from the EU or to obtain projects driven by industry.
- Providing a basis for internal project team formulation by combining groups from the network under different constraints to put together the best team to carry out different projects.
- Providing contact details for experts in the different fields.
- Providing a marketing tool for joint research with external partners, either academic or industrial.
- Facilitating an improved visualization of related fields of research. This will enable the user to focus on his/her area of interest while at the same time being able to see the surrounding and related fields.

The overall goal was therefore to create an infrastructure for knowledge sharing, spatial analysis, resource decision-making and policy-making. Making this knowledge available and accessible will increase communication and synergy of researchers in similar or complementary fields, thus increasing coordination and reducing redundancy.

1.2 Challenges

The most difficult challenge in developing the expertise maps was to determine how to map everything in a sensible way that could be expanded and searched with ease.

Additional challenges and issues that were addressed included:

- Analyzing the type of scenarios expected for internal and for external partners regarding use and updating of the expertise maps;
- Enabling both internal and external members to use the map without getting lost in a sea of words;
- Ensuring map consistency – making sure that everyone and everything is included with minimal bias;
- Considering the question of willing participation of the VRL members;
- Defining topic scope – The goal of knowledge mapping for the VRL network is to be able to find competencies from a knowledge map to tackle a given problem in modern manufacturing (the entire product lifecycle). Care was taken to limit the scope and collect only network-relevant expertise within the project scope of lifecycle engineering.
- Developing search capabilities – The expertise map and its realization within the VRL Knowledge Management System (KMS) must enable software agents to search for relevant information, as well as facilitate human examination and search.

For this holistic endeavor to come to fruition, information visualizations had to be constructed effectively, allowing users to search efficiently while understanding the overall scope. We found nothing in the current literature with a focus on mapping this kind of knowledge for these purposes.

2 Creating Map Coordinates

In order to understand the network strengths and weaknesses it was decided to develop a spatial map to demonstrate and analyze network expertise. The first step in this process was defining the expertise map "coordinates".

For this purpose it was decided to build a network ontology that would (a) provide the coordinates of the spatial expertise map, clearly defining expertise and location of experts within the network; (b) ensure a common understanding of specific terms describing members' fields of expertise and research relevant to life cycle engineering in the multilingual, multidisciplinary network; and (c) provide the structured context required to cultivate high quality knowledge bases for accessing, archiving and validation of knowledge objects.

Because the ontology was considered to have a major impact on the success of the network, much emphasis was placed on defining the ontology and mapping the knowledge of all network members.

2.1 Creating a Network Ontology

Ontologies have been defined as explicit specifications of a particular conceptualization [3]. They aim at explicating the knowledge for a particular domain contained within software applications and/or within an organization and its business procedures. An ontology expresses, for a particular domain, the set of terms, entities, objects and classes and the relationships among them, and provides formal definitions and axioms that constrain the interpretation of these terms [4]. Ontology definition is an art. Even with the aid of the many tools that have been developed to help build ontologies, the process is often based on years of research. Since the results of ontology-building were required as a basis for the VRL-KCiP network to function, lengthy research over the course of years was not viable, and compromises had to be made. While the consensus was that the success of this task was central to the success of the network, many concerns were raised:

- Ontology construction is not yet a well understood process.
- The size and complexity of the research domain is large; therefore, care had to be taken to clearly define the scope.
- There is no single correct methodology for ontology building.

Many discussions were held to decide how to achieve the best results given the available time frame. Two decisions were taken that shaped the process of the ontology formulation:

a. The first stage of creating an ontology to be used as map coordinates would be a two-dimensional hierarchical taxonomy tree (the expertise tree), which would provide the outline for bisecting the field of life cycle engineering.
b. It was decided that although the top-down approach of ontology construction and validation may perhaps be the most common, the time constraints of the network determined we had to work interactively to achieve the best possible results. Hence, a bottom-up approach was adopted, based on input from network members

The process of developing a VRL-KCiP network ontology continues based on the expertise tree. This work should be completed by the end of this year and will include, among other activities, creating a profile for each instance in the tree.

2.2 *Developing the Expertise Tree*

The process of developing the expertise tree began with a face-to-face brainstorming session. At this meeting the participants contributed their fields of research and built a preliminary structure that incorporated all of these contributions. Next, the task of developing a stable structure for the tree began.

Based on the input from the brainstorming session, a preliminary form was developed to validate the proposed structure and content and gather further instances. This structure (form) was distributed to all the network labs. A number of key lab members were requested to (a) comment on the structure of the tree and (b) complete the form regarding their specific lab expertise. The goal of this information-gathering was to collect further instances and to force each lab to confront the problems in expertise definition within the evolving structure.

Eighteen member labs responded to this preliminary evaluation. The main input from the feedback was that the proposed structure was not consistent and that this would be problematic both for knowledge management and for expertise location. In addition, a large number of new instances and research topics were added that could not be intuitively added to the existing structure.

It was then decided to implement a combined top-down/bottom-up approach.

A top-down approach was applied to define the tree structure and determine its highest levels. For example, it was decided that at the highest level, member expertise would be divided into (a) lifecycle-related knowledge and (b) product-specific knowledge. At the next level, the lifecycle-related knowledge was further detailed to specific lifecycle stages (Design, Manufacture, Service, and EOL). These lifecycle stages were then further divided into sub-stages. Next, emphasis was placed on collecting (i) approaches, (ii) methods and (iii) tools.

A bottom-up approach was then applied to explicate further levels of detail and to gather instances and documents with respect to each type of expertise.

The changes in the tree structure from the first to the second distribution were based upon two major considerations: a) greater emphasis on the **product lifecycle** and on relevant topics and research; and b) creation of a more consistent structure, to be implemented in the VRL KMS.

The hierarchical tree – both structure and content – was then further developed by iterative steps of collecting, analyzing, brainstorming, revising and redistributing for further feedback. This process continued until a relatively stable structure and content were formulated, similar to the process described in Van Heijst, et al. [5].

3 Collecting VRL Competence Profiles

Once the map coordinates were more or less defined and stabilized, a questionnaire in the form of the expertise tree was once again distributed. This time all network members were requested to fill in the form regarding their own personal expertise. To date, 250 responses have been received and entered into a collective knowledge base. These responses made it possible to map the expertise of the individual members of the network as well as to combine the input from individuals belonging to each separate lab for the purpose of analyzing the fields of expertise available in each lab.

Incorporating the expertise mapping data in the VRL KMS knowledge base was carried out in two phases. For those members who responded quickly to the expertise-gathering form, all expertise areas were automatically updated in the knowledge base. Subsequently, members entered their expertise profiles manually by means of the "My Expertise" wizard developed for building and updating user expertise (Fig. 1). Each user is authorized to update his or her own expertise only. The "My Expertise" wizard creates a link between the users and the relevant fields of expertise to accommodate user searches.

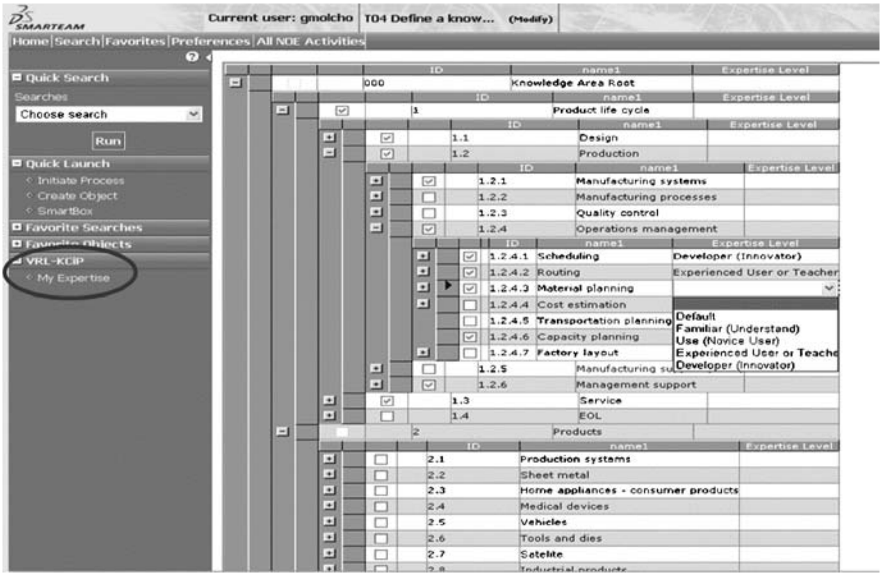

Fig. 1 Implementation of the VRL KMS expertise wizard

As a result of this feedback, many new instances were added to the basic expertise tree structure, as members sought to define their personal expertise and current research fields. These additional instances were easily incorporated into the existing expertise tree structure.

It is important to emphasize that in this first stage of expertise mapping, differential rating of personal expertise was not incorporated.

4 Analyzing the VRL Competence Profile

Once the expertise data was available in the knowledge management system database, four expertise maps were developed: a) individual expertise range, b) individual expertise, c) lab expertise strengths, and d) lab expertise. The expertise map was built by assigning the value ‘1’ to all expertise fields relevant to each network member.

The expertise maps were then analyzed. A number of findings are presented in the following section to illustrate the type of analyses enabled by these expertise maps. Missing competencies and network strengths are immediately evident in the expertise maps.

4.1 Individual Expertise Range

The first map indicates range of expertise for each individual in the network. The map was created using the hierarchical ontology tree. The cells to which the value ‘1’ was assigned (indicating personal expertise in a particular area) were repeatedly summed up to the relevant parent level until two final sums were calculated:

a. *Range of expertise in the product lifecycle*: the number of different expertise fields in the product lifecycle section selected by each member.
b. *Range of expertise in specific products*: the number of different expertise fields in the products section selected by each member.

Figure 2 illustrates a partial map for 15 network members. The level of detail in this figure is low (for demonstration purposes); however, the level of detail of each map can be easily modified to consider any specific or general level of expertise for analysis.

This map provides some insight into missing competencies. The empty patches in the map provide a (visual) representation of areas receiving less attention in the network. They also provide insight into the range of expertise.

For example, in Fig. 2, Member 103 has a subtotal of 48 for the field of ‘design’ in the product lifecycle, whereas Member 104 has a subtotal of 5. It is clear from these findings that Member 103 has a broader under-standing of and more experience in design issues. This map, however, gives no indication of the level of expertise of a particular member. For example, Member 104 may be a world-

	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
Product life cycle	**4**	**66**	**11**	**31**	**34**	**15**	**2**	**60**	**39**	**34**	**8**	**50**	**127**	**56**	**21**	**27**
Design	***4***	***42***	***11***	***16***	***19***	***6***	***1***	***37***	***29***	***23***	***7***	***30***	***99***	***48***	***5***	***17***
Conceptual design		18	4	4	5			18	9	7		5	15	2		8
Detailed design	4	11	3	10	7	2	1	10	19	9	7	23	69	39		4
Support		13	4	2	7	4		9	1	7		2	15	7	5	5
Production		***18***		***12***	***10***	***9***	***1***	***11***	***4***	***11***	***1***	***20***	***23***	***8***	***5***	***10***
Manufacturing system		2							1	1		3	2			
Manufacturing process				8	2	3		5	1	4	1	4	7	8		3
Quality control		2			2	1							8			
Operations management		14		1	2					2		3				4
Manufacturing support					1		1		2			4	6			1
Management support				3	3	5		6		4		6			5	2
Service				***2***									***5***		***6***	
Monitoring/control													2			
Diagnosis								6					2			
e-service															1	
Maintenance													1			
Support				2				6							5	
EOL		***6***		***1***	***5***				***6***						***5***	
Recycling		1						5	2							
Refurbishing		1							1							
Disposal		1														
Support				1				12							5	
Products				**1**	**2**	**3**		**7**	**1**			**6**	**2**			**2**

Fig. 2 Partial ‘Individual expertise range’ map

renowned expert in his limited topics of research. Therefore, expertise level differentiation was determined to be a requirement.

- *Initial analysis insight into individual expertise range*

Because the number of unique instances differs for each field of expertise, the sum total in a particular expertise branch on this map cannot be used to conclude that the research emphasis of a particular member is in a particular lifecycle phase. However, members can be rated according to these sub-totals in order to evaluate the range of knowledge in a given field of research. For example, when analyzing experts in manufacturing processes, we cannot conclude that a member who has marked more instances in cutting than in primary shaping is more of an expert in cutting than in primary shaping, since the absolute number of processes differs for each. However, we can conclude that a member who is an expert in 12 different cutting processes has a much broader understanding of cutting processes than a member who is an expert in only one cutting process. Once again, note that this map gives no indication of the level of expertise of a particular member because a member with expertise in only one type of cutting process may be a world-renowned expert in his limited topic of research.

4.2 Individual Expertise

The individual expertise map does not consider the number of positive answers on each level. Rather, if any instance in the group was marked as expertise, the parent

	#	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Product life cycle	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Design	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Conceptual design	1	1		1	1	1	1	1				1			1	1	1	1	1	1	1		1	1	1		1
Detailed design	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1
Support		1		1	1	1	1	1		1		1	1		1	1		1	1	1	1		1	1	1		
Production		1	1			1	1	1	1	1		1		1	1	1	1	1	1	1	1	1		1		1	1
Manufacturing systems						1		1		1		1			1		1	1	1		1			1			1
Manufacturing processe			1			1	1		1								1	1	1			1				1	1
Quality control								1						1			1		1		1						
Operations managemen		1				1		1		1		1						1	1	1	1						
Manufacturing support (		1	1					1						1				1	1		1	1		1			1
Management support		1				1		1		1		1			1	1		1		1				1			
Service						1	1	1		1		1	1	1	1	1	1	1	1	1	1		1		1		
Monitoring/control																	1										
Diagnosis													1	1				1	1		1						
e-service							1																				
Maintenance						1												1		1			1		1		
Support							1	1		1		1			1	1		1		1					1		
EOL						1						1			1	1			1		1		1		1		
Sorting						1													1				1				
Recycling																							1				
Refurbishing																					1						
Disposal																							1				
Support												1			1	1							1		1		
Products		1		1	1													1	1	1	1		1	1			

Fig. 3 A partial 'Individual expertise map'

level was also marked as expertise, receiving the value '1' regardless of the number of expertise fields in the relevant group. This allowed us to rapidly identify those areas where expertise is missing. Figure 3 illustrates the responses of 27 network members at a very low level of detail.

- *Initial analysis insight into individual expertise*

Figure 3 allows easy identification of existing expertise or lack of expertise in different fields of expertise in life cycle engineering. It is evident from the figure that a higher percentage of members have expertise in design and manufacturing than in service and EOL (indicated by the empty white patches). The VRL-KCiP leaders need to identify strengths and weaknesses and decide what needs to be reinforced and what should be marketed as the core network capabilities.

4.3 Lab Expertise Strengths

It was decided that lab expertise would be collected from the bottom up and not in a top-down centralized manner. Therefore, as the expertise of the individual members of the labs was collected, it was assigned to and summarized in the associated lab entity. This can be accomplished in two ways: (a) not taking duplication into consideration – to analyze coverage; and (b) including duplication (numerous experts for a single expertise area) – to analyze the strengths of the particular lab.

All the inputs of the individual members were summed up for each instance in the ontology tree structure to generate a map of lab expertise strengths. These numbers were then summed up, similar to the process used in devising the 'individual expertise range' map. It is important to note that the numbers calculated cannot stand alone and must be considered relative to the number of responses received from each lab. Nevertheless, the map provides insight into the major focus of the different network labs.

Figure 4 illustrates a partial 'Lab expertise strength' map.

- *Initial analysis insight into lab expertise strengths*

One use of this type of lab expertise map is to rate or compare the range of expertise in different labs. For example, if we compare Lab A and Lab D (both returned eight expertise forms), we can see that Lab A has indicated approximately four times as many instances in design than Lab D. This indicates that Lab A has a broader spectrum of understanding of design processes, methods, and tools, while Lab D has more focused research in the product design field. Note that this provides no indication of the level of expertise but rather points to the range or spectrum of insight in a field.

LAB no. of members	Lab A 8	Lab B 10	Lab C 14	Lab D 8	Lab E 3	Lab F 8	Lab G 11	Lab H 11	Lab I 7	Lab J 6	Lab K 21
Product life cycle	**481**	**246**	**425**	**147**	**111**	**143**	**276**	**41**	**228**	**90**	**534**
Design	***325***	***231***	***286***	***100***	***66***	***107***	***200***	***28***	***139***	***64***	***384***
Conceptual design	50	55	49	28	13	32	29	14	50	17	99
Detailed design	225	139	189	67	45	62	147	7	53	25	201
Support	50	37	48	5	8	13	24	7	36	22	84
Production	***124***	***15***	***102***	***42***	***38***	***22***	***66***	***8***	***68***	***16***	***115***
Manufacturing systems	8		15	5	3	4	4		13		7
Manufacturing processes	41	5	10	23	9	7	23		6	6	33
Quality control	10		4	5	2			8	1	5	6
Operations management	38	5	38	3	6	2	13		9		22
Manufacturing support (to	5	4	4	5	16	6	16		8	1	13
Management support	22	1	31	1	2	3	10		31	4	34
Service	***11***		***30***	***5***	***5***	***5***	***6***	***5***	***16***	***6***	***8***
Monitoring/control				2				3			
Diagnosis			2	1	2				2		
e-service			1								
Maintenance			1	1	1	2		2			
Support	11		26	1	2	3	6		14	6	8
EOL	***21***		***7***		***2***	***9***	***4***		***5***	***4***	***27***
Sorting	5		1		1	3	1				13
Recycling	2					1					3
Refurbishing	1				1						2
Disposal	2					1					1
Support	11		6			4	3		5	4	8
Products	**16**	**19**	**1**	**5**	**12**	**3**	**12**		**8**		**33**

Fig. 4 A partial 'Lab expertise strength' map

4.4 *Lab Expertise*

An additional map was created to reflect lab expertise. In this map, we did not sum up the responses. Rather, similar to the 'Individual expertise map', if any member of a group marked expertise in a particular area, the parent level was also marked as expertise. This again provided an instant map of network coverage of the different fields of lifecycle engineering research.

Figure 5 illustrates a partial 'Lab expertise' map. As in the previous maps, this map may also be expanded to any desired level of detail.

- *Initial analysis insight into lab expertise*

Figure 5 provides a visual analysis of where network members have focused their research activities.

A number of further conclusions can be drawn by analyzing the complete expertise map. For example, although only 23 % of the members have expertise in the EOL phase, these members are distributed over 77 % of the labs. Similarly, the 43 % of members with expertise in service are distributed over 95 % of the labs. Therefore, networking is possible since points of contacts between the labs exist for cooperating on projects.

LAB	Lab A	Lab B	Lab C	Lab D	Lab E	Lab F	Lab G	Lab H	Lab I	Lab J	Lab K
Product life cycle	1	1	1	1	1	1	1	1	1	1	1
Design	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
Conceptual design	1	1	1	1	1	1	1	1	1	1	1
Detailed design	1	1	1	1	1	1	1	1	1	1	1
Support	1	1	1	1	1	1	1	1	1	1	1
Production	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
Manufacturing systems	1		1	1	1	1	1		1		1
Manufacturing processes	1	1	1	1	1	1	1		1	1	1
Quality control	1		1	1	1			1	1	1	1
Operations management	1	1	1	1	1	1	1		1		1
Manufacturing support (tools)	1	1	1	1	1	1	1		1	1	1
Management support	1	1	1	1	1	1	1		1	1	1
Service	*1*		*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
Monitoring/control				1				1			
Diagnosis			1	1	1				1		
e-service			1								
Maintenance			1	1	1	1		1			
Support	1		1	1	1	1	1		1	1	1
EOL	*1*		*1*		*1*	*1*	*1*		*1*	*1*	*1*
Sorting	1		1		1	1	1				1
Recycling	1					1					1
Refurbishing	1				1						1
Disposal	1					1					1
Support	1		1			1	1		1	1	1
Products	1	1	1	1	1	1	1		1		1

Fig. 5 A partial 'lab expertise' map

Furthermore, we can conclude that the research in the network is both general and product-specific; 46 % of network members have expertise related to a particular product, and they are dispersed over 91 % of the labs.

The network apparently has significant expertise in manufacturing systems and vehicles (cars, planes, trains, ships); 75 % of the labs have expertise in these two fields.

5 Updating the Expertise Tree

Since ultimately there is no correct ontological structure – each proposition has its benefits and drawbacks – and since a platform must be in place to initialize joint ventures and research, we have refrained from major changes in the structure. Nevertheless, the tree will continue to evolve for a number of reasons:

- **The top part of the tree** (product lifecycle): It is apparent from the expertise maps that there is a lack of balance between the level of detail of the *Design* phase, which is the most explicit, and the *Service* and *EOL* phases, which lack detail. This would appear to mirror the fact that the strength of the VRL-KCiP lies in the design phase (design approaches, methods and tools), whereas the network lacks expertise in the service and EOL phases, so that the structure is sparsely populated in these areas. More effort must be invested in further detailing the service and EOL product life cycle stages. For example, the EOL

phase should have approximately the same number of instances as the production stage, since it mirrors the production process. Bottom-up methodologies more commonly applied in ontology development (topic mapping or text mining methodologies) will be applied in the network to identify further detailing of the expertise tree. This work is currently underway in the network, and involves text mining of member CVs and descriptions of member's current areas of research that are being collected on the central KMS.
- **The lower part of the tree** (products section): The products section of the tree will be built applying the bottom-up approach, and branches are likely to be added as new members with new expertise in specific product types join the network.

New instances are added to the ontology as new members join the network and new fields of research evolve and research projects begin. Hence, the bottom-up process of expanding the tree to include new fields of research relevant to the network and new tools or methodologies developed within the labs will continue. The structure will continue to expand both in depth (further detailing of existing branches) and in breadth (by introducing additional fields of expertise not yet included in the structure).

6 Expertise Differentiation

Due to participant personality differences, it appears that on the first competence profile some members filled in only those instances for which they are very highly knowledgeable, whereas others filled in all the instances for which they had any basic knowledge. This obviously does not provide a balanced picture for understanding lab capabilities. Hence, a differential rating was required.

For each direct instance (leaf in the tree structure), the user will be requested to select the appropriate level of expertise (Familiar, Novice User, Experienced User or Teacher, and Innovator or Developer). These levels will provide insight into the level of expertise of the user in each field.

In a pilot test, the members of one lab were requested to enter the VRL KMS and, based upon their previous input, indicate the level of expertise for each marked instance. Two types of analyses were then carried out:

1. *The user was requested to remark on the process. These remarks were analyzed, and changes will be implemented where required.*

Numerous attempts were made to initiate the process of collecting the level of expertise, but due to software bugs and communication interrupts on SmarTeam, these attempts were not successful. Consequently, results could not be saved correctly and therefore could not be analyzed. We have finally overcome these difficulties and have collected a number of inputs for an initial analysis.

In addition, members pointed out that even when using the expertise wizard in SmarTeam, the task of expertise definition is tedious. Two different solutions were proposed. One solution was to send a form to each member that included only his/her particular expertise; this form would include a drop-down menu next to each selected area for completing the level of expertise.

This solution was not chosen for it would remove one of the benefits of this process: expanding the spectrum of member expertise by offering the option of selecting fields of expertise in which a person is not an "expert" but is knowledgeable, as discussed in point (b) below.

The second solution was to invest efforts in improving (shortening) the process of completing this task in SmarTeam.

The most significant request by users was to enable the tree to expand to the most detailed level at once, instead of the current situation where the tree expands level by level and branch by branch. This expansion takes time due to web performance issues and is also confusing with respect to which branches have already been completed. This change is currently being implemented.

2. *The added value of the insight provided by the added information was analyzed.*

Including level of expertise makes the following contributions: (a) It offers a broader spectrum of member and lab expertise, since on average 16 % more instances were selected by members in this process (Table 1). (b) It offers insight into the expertise profile of each individual member. For example, a particular member may have only a few fields of expertise, but all of them are at level '3' or '4', indicating that he is an innovator and leader in these areas. This profile is very different from that of a member who also has only a few fields of expertise but at an expertise level of '1', '2', probably indicating this member is a student or is new to the fields of research relevant to the network.

Based on these results, the process of expertise differentiation will continue lab by lab, until the level of expertise is mapped as well. This process should take at least one year if reliable and meaningful results are to be obtained.

Table 1 Increase in number of instances selected due to expertise level differentiation

Member	Number of instances selected to date	Number of instances previously selected	Increase in the number of instances selected
1	65	49	33 %
2	93	74	26 %
3	63	58	9 %
4	53	52	2 %
5	40	29	38 %
6	41	39	5 %
7	93	93	0 %
8	53	40	33 %
9	65	65	0 %
AVERAGE			16 %

7 An Implementation – Project Team Formulation

To cope successfully in today's competitive atmosphere, partners and teams in geographically distributed locations must collaborate. A group consisting of various expert teams from different locations must be created for every new network project.

Selecting the appropriate teams for a particula cooperative project in order to achieve the desired expertise coverage is known to be a difficult, nonpolynomial problem. Such a problem can become almost intractable very fast, and can be particularly problematic when the number of labs grows. One way to cope with the coverage problem is to use AI-based algorithms. A genetic-algorithm based tool has been developed [6] to solve the problem of building an optimal team for multiple projects within a given time frame, based on the expertise maps both at the level of the labs and the level of the individual member.

8 Conclusion

This chapter has discussed the construction of an expertise tree and expertise map for the virtual research network VRL-KCiP with a collaborative environment.

To date the expertise tree is being applied (a) as a reference for a common understanding of terms in the fields of research relevant to the VRL-KCiP; (b) for collaboration definition and initiation; (c) as one of the indexes for the dual-index KMS; (d) as the coordinates for the VRL-KCiP knowledge map describing the current expertise of each member in the network, thus representing its intellectual capability; and (e) as the database for the project team formulation expert system.

Implementation of (c) and (d) in the VRL KMS has created a "Yellow Pages" capability that enables members to locate experts in all the fields of life cycle engineering. This capability also allows cross-referencing by enabling location of members with multiple fields of expertise.

The expertise maps, which were developed based on the expertise tree and implemented in the VRL KMS, are used for enhancing structural integration among the partners in the virtual organization and for providing the organizations with a competitive advantage. Such knowledge sharing can only be achieved if the members of the group are convinced that the group is stronger than the individual.

Much effort has been invested in the network to complete the mapping of the entire team (approx 320 researchers) and work continues to enhance and upgrade the maps and to build further implementations upon them.

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