
SUPPLY CHAIN OPTIMISATION

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SUPPLY CHAIN OPTIMISATION

Product/Process Design, Facility
Location and Flow Control

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Preface

The idea of this book came to us in October 2002 at the international conference “Production systems design, supply chain management and logistics” (Miedzzydroje, Poland). This conference was organized by an initiative group from certain French and Polish Universities with the objective to find a new synergy and to develop a Pan European (West – East) cooperation in the areas of:

Design of production systems

Supply and inventory management

Production planning and scheduling

Facility location, transportation and logistics

Supply chain optimisation via simulation

The conference was focused on a wide spectrum of optimisation problems taking into account Supply Chain paradigms, which create a pivotal idea to increase the productivity of modern production systems.

The editors proposed to the group members, to present their results for this book. Some well-known scientists agreed also to participate in this work and sent us their contribution.

The main idea of this book is that now, it is necessary to consider all the stages of product life cycle in an integrated approach, from the product/process design to the customer delivering. For example at the product design stage, we need to analyse and to optimise all the supply chain.

The book is composed of 20 chapters divided into three parts.

The first part of the book presents a set of modelling techniques taking into account the enterprise integration problem (K. Kosanke), the knowledge management in the SME networks (K. Sandkuhl *et al.*), and the human resources in business process engineering (J. Worley *et al.*). It deals with advanced demand forecasting methods (J. Petuhova and Y. Merkuriev;

M. Pashkevich and A. Dolgui), deadlock avoiding in utilisation of common resources (Z. Banaszak and M. Polak), sizing and plant control using dioid algebra (S. Amari *et al.*) and queueing modelling of resources allocation for distributed e-production (O. Zaikin *et al.*).

The second part is dedicated to advanced optimisation methods. The assembly line balancing problem (load balancing) is explored in two ways: mathematical analysis of stability of optimal solutions (Yu. Sotskov *et al.*) and search for an optimal solution using meta-heuristics techniques (C. Boutevin *et al.*). New analytical approaches to facility allocation (Z. Lu *et al.*), supply chain design (J. Lamothe *et al.*), sales and operations planning (P. Genin *et al.*) and delivery cost optimisation (S. Chauhan *et al.*) are also presented. These are completed by an interesting optimisation technique which is based on simulation and response surface methods (G. Merkurieva).

In this domain, the research activities are directly linked to real industrial problems. Therefore, it is necessary to develop applied decision aid tools. The third part of this book deals with some examples of these tools. A special tool for supply chain simulation (H. Ding *et al.*), a Web-based tool for product/ process integration (A. Bargelis and R. Mankute), a chemical plant scheduling tool (N. Sotskova *et al.*), maintenance planning optimisation tools (Pashkevich *et al.*) and a multi-agent tool and a software platform architecture for distributed industrial systems analysis (S. Galland *et al.*) are presented.

We acknowledge all the reviewers and the authors for their contribution to this book. We hope that this book will be useful to the whole community of scientists in Computer Science and Industrial Engineering.

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PART I: MODELLING TECHNIQUES

Chapter 1

AN INITIATIVE FOR INTERNATIONAL CONSENSUS ON ENTERPRISE INTER- AND INTRA-ORGANISATIONAL INTEGRATION

Kurt Kosanke

Abstract: The initiative is aimed on building international consensus on enterprise integration and is carried out in five-year intervals. The third initiative focused on virtual enterprises and in particular on aspects of enterprise engineering, relations between knowledge management and business process modelling, the issue of interoperability of business processes and models and the needs of common model representation. The roles of ontology and agent technologies have been addressed as potential solutions for the current issues in enterprise integration. Four workshops with international experts discussed the different issues and developed proposals for solutions of the issues identified. Workshop results were presented at the International Conference on Enterprise Integration and Modelling Technologies (ICEIMT'02) and are published in the proceedings of the initiative. The paper summarises the results of the initiative including some details from the four workshops and provides an outlook on future activities resulting from the initiative.

Key words: business process modelling, enterprise integration, enterprise interoperability, enterprise modelling, knowledge management.

1. INTRODUCTION

Virtual Enterprises (VE) and Business to Business (B2B) type applications of electronic commerce are new ways - especially for Small and Medium Enterprises (SME) - to unite forces, increase their competitiveness, meet today's market needs and jointly behave as one producer towards the customer. However, the main concern in the required collaborations is the

need for trust between the partners, which can certainly be enhanced by sufficient information on partner capabilities. Those capabilities can best be described through models of the relevant business processes and their associated information and resources. Linking compatible business process models from the different collaborators into an overall business process model will allow evaluating the collaboration prior to its real implementation through a priori simulation of the intended operation. Up to now application of relevant Information and Communication Technology support has been hampered by a lack of business justification, by a plethora of seemingly conflicting solutions and confusing terminology [2,6], and by an insufficient understanding of the technology by the end-user community.

The third international initiative had again the objective to increase both international consensus and public awareness on enterprise integration [1,3]. Following the two previous initiatives in 1992 and 1997 [7,4], the focus of the third initiative was on Enterprise Inter- and Intra-Organisational Integration. Drivers, barriers and enablers for electronic commerce in general and B2B applications in particular, as well as potential benefits from the application of integration supporting information and communication technology have been addressed.

Up to 25 selected experts in the fields of engineering, business administration, and computer science participated in each of the four workshops. About 75 persons from 18 countries on 5 continents attended the ICEIMT'02, coming from academic institutions, government, industry, and consortia. The conference proceedings [3] provide about 40 papers offering a very comprehensive overview of the state-of-the-art in of enterprise integration as well as providing directions for further research in the 9 working group reports, which present the different workshop results.

2. METHODOLOGY AND ACTIVITIES

The international initiative on Enterprise Inter- and Intra-Organisational Integration (EI3-IC) has provided a basis for an international discourse on the subject of enterprise inter- and intra-organisational co-operation. Inviting experts in the field has enabled pulling in insights and results from other projects hence enabling a consolidation of this fragmented know-how, and thereby contributing to an international consensus in the field. Therefore, it enables the presentation of both current status and potential developments in inter- and intra-organisational integration for electronic commerce with focus on B2B applications.

The EI3-IC initiative consists of two parts:

1. Four workshops with international experts reviewing and consolidating a set of issues in enterprise inter and intra-organisational integration.

2. The ICEIMT'02 (International Conference on Enterprise Integration and Modelling Technologies) aimed on state of the art overview and presentation of the workshop results.

A scientific committee guided and supported the initiative. It acted as advisory committee helping to identify the experts to be invited to the workshops and reviewing workshop and conference agendas and papers.

The 3-day workshops have been organised with plenary sessions for all participants and a number of parallel working group sessions. The first plenary session held in all workshops provided time for the participants to present their own work as it relates to the predefined set of issues. This methodology has led again to very good results. It enables the members of the working group to have a common understanding of each other's position leading to a much better focusing on the issues to be discussed.

During the first plenary session the experts will usually amend the set of predefined issues. Working groups have then worked on subsets of the issues of the particular workshop. Presentation of working group results and discussions of the topic with all working groups have been done during subsequent plenary sessions.

Papers on workshop results were prepared co-operatively by the working groups and presented at the ICEIMT'02 by a group member. Information dissemination activities will further increase awareness and consensus within academia and industry about enterprise inter- and intra-organisational integration.

2.1 Workshops and Conference

Four thematic workshops with international experts in the field have been organised. The workshop themes have been selected according to their importance for the management of business collaborations. The following workshops have been held:

- Workshop 1, Knowledge management in inter- and intra-organisation environments (EADS, Paris, France, 2001-12-05/06)
- Workshop 2, Enterprise inter- and intra-organisation engineering and integration (Gintic, Singapore, 2002-01-23/25)
- Workshop 3, Interoperability of business processes and enterprise models (NIST, Gaithersburg, MD, USA, 2002-02-06/08)
- Workshop 4, Common representation of enterprise models (IPK, Berlin, Germany, 2002-02-20/22)

The ICEIMT'02 was held at the Polytechnic University of Valencia, Spain, on 2002-04 24/26. It was structured according to the themes of the workshops. In addition to an opening session with keynote papers, a special session on international projects provided information on actual work done on an international level.

3. RESULTS

As stated in [5] the results from all four workshops indicate the important role of business processes in the area of e-commerce and virtual enterprises. Sharing relevant knowledge between co-operating partners and making it available for decision support at all levels of management and across organisational boundaries will significantly enhance the trust between the partners on the different levels of partner operations (strategy, policy, operation and transaction). Clearly business process modelling can significantly enhance establishment, operation and decommissioning of the required collaboration. However, interoperability between partner processes and common understanding of their model semantics is a prerequisite for successful collaborations.

Agent technology has been a subject in all four workshops as well and several proposals for further work have been made. The same is true for the concept of ontology, which will play an important role in solving the interoperability issues and provide for common understanding through the harmonisation of business knowledge semantics.

More specific results from the four workshops are presented in the following sections. Tables 1-1 to 1-4 (derived from the different working group reports in [3]) identify major issues discussed and results obtained from the working groups.

3.1 Knowledge Management and Business Process Modelling in Inter- and Intra-Organisational Environments (Workshop 1)

Knowledge management has gained significant momentum within enterprise organisations and is considered an important success factor in its operation. However, there exist wide differences in the understanding of what a knowledge management system is and does. The perception of knowledge management ranges from using enterprise-wide databases or expert systems to enterprise modelling and integrated communication systems, which are to be supported by Internet technology. Generally accepted guidelines or standards to support the design and implementation of a knowledge management system in an organisation or between organisations are missing. Capturing knowledge and using it across organisational boundaries with a satisfactory acceptance of the human user is another major challenge.

Table 1-1. Issues and Results from Workshop 1

Major problems and issues:	Results and future work needed:
Working Group 1	
<ul style="list-style-type: none"> - Awareness and education at all organisational levels - KM metrics for cost-benefit analyses - Auditability of intellectual property - Softness of many KM topics - Lack of enterprise-wide continuity in KM systems - Diverse corporate culture in virtual and merged enterprises 	<ul style="list-style-type: none"> - Knowledge exists only in human minds-stuff stored electronically is information - No new techniques are needed to model information relating to knowledge - <i>Methods for representing information about "soft" enterprise activities (strategic planning and decision making)</i> - <i>Methodology to define what we know, need to know, do not know, cannot know and what to forget at what time.</i>
Working Group 2	
<ul style="list-style-type: none"> - Creation and exploitation of synergy between KM and BPM - Integration of general knowledge into business process models - Identification of critical knowledge in business processes? - Role of ontologies in KM and BPM? 	<ul style="list-style-type: none"> - KM and BPM have common objectives (capture, structure and provide knowledge for decision making) - Proposal for mapping KM onto BPM - <i>Establish a formal base for enterprise ontologies</i> - <i>Analyse the potential contributions of semantic web technologies</i>
Working Group 3	
<ul style="list-style-type: none"> - Lack of a common understanding and barriers for KM in industry - Scope and goal of KM to enable growth with the (system) life cycle and adaptation to evolving infrastructures - Use of existing standards - Guidelines for implementation and use of KM systems especially in SMEs 	<ul style="list-style-type: none"> - Definition of Requirements for KM system infrastructures - Synthesis from examples of Process and KM applications - <i>Methodologies for scalable KM systems</i> - <i>Investigation of dependencies and interoperation of (process) model management and KM</i> - <i>Development of an infrastructure consisting of IT and non-IT services to support KM across organisational borders</i>

Merging Knowledge Management (KM) and Business Process Modelling (BPM) will provide synergy and improve efficiency of enterprise collaborations. During the workshop, three working groups addressed the relations between knowledge management and business process modelling concluding that joining both in some form could be possible and synergy would bring additional benefits (see also Table 1-1). The focus of the first working group was on possible combined futures and the research roadmap these futures require. Three different levels of potential work have been identified: near term, medium term and longer term oriented. Problems and limits at each level have been identified and potential solutions are proposed.

Discussing the mapping of BPM concepts onto KM concepts similarities and differences as well as solutions have been identified by the second working group. Ontology will play an important role in this mapping. This will become intensified even more with the move towards inter-organisational collaboration. The working group has started to map the two concepts into a common methodology.

Concentrating on guidelines for business process modelling to cover scope and goals, architectures, infrastructures and approaches to implementation, the third working group looked at examples of industrial solutions and tool strategies. Potential synergies and solutions have been identified with emphasis on the human role in future environments.

However, the benefits of knowledge sharing between collaborators can only be exploited if interoperability of business processes and business-process models can be assured. This is especially important during the virtual enterprise establishment phase where the required and provided capabilities have to be matched under the time constraints of the market window.

3.2 Enterprise Inter- and Intra-Organisational Engineering and Integration (Workshop 2)

Collaboration is not only a technical issue, but also a social and organisational one, as well as a matter of trust. That means enterprise engineering has to cover both of these aspects equally well. But there is a significant difference for the two subjects in the degree of understanding of the problems and of the potential solutions. Whereas technology behaviour is to a large extent predictable and technical issues are usually understood and mostly appear solvable, human behaviour is non-deterministic and solving human related so-called soft issues requires different methodologies.

This workshop addressed both of these topics focussing on infrastructures and on planning of virtual enterprises. The first working group proposes the exploitation of agent technology to obtain solutions applicable for advanced virtual enterprises. Such concept includes the use of agent-model pairs applying ontology and thereby addressing the issue of model semantics and its impact on model complexity and costs.

The second working group identified a set of common VE business planning activities and the degree of concurrency between planning processes at different planning levels. The concept of team building and the related human issues has been a special topic recognised in the working group discussions and in the proposed planning activities.

Table 1-2. Issues and Results from Workshop 2

Major problems and issues:	Results and <i>future work</i> needed:
Working Group 1	
<ul style="list-style-type: none"> – Employ new technologies (agents, models and their combinations) in inter-organisational enterprises – Determine if special modelling techniques are required to support enterprises driven by agents, actors and their models 	<ul style="list-style-type: none"> – Agents using enterprise models are the triggers that enable model-driven enterprises to work – <i>Extend Process Specification Language to be more agent friendly and to include state mechanics</i> – <i>Develop index systems for existing self-organising model frameworks</i>
Working Group 2	
<ul style="list-style-type: none"> – Increase efficiency in the collaborations in virtual environments? – Define languages and methods to describe business strategies and business models in relations to the life cycle phases of the GERAM modelling framework 	<ul style="list-style-type: none"> – Identification of a set of common VE business planning activities – Identification of degree of concurrency between planning processes at different planning levels – <i>Test concept in real practical applications</i> – <i>Investigate concept relations to concepts in human and management science</i> – <i>Investigate communication and negotiation needs with emphasis on human relations</i>

3.3 Interoperability of Business Processes and Enterprise Models (Workshop 3)

Integration is the timely and meaningful exchange of information among software applications. It requires the error-free transfer of information, a total agreement on its syntax, and the correct understanding of its semantics. The Internet and its associated standards have addressed successfully the first of these requirements. Syntax and semantics, on the other hand, remain as elusive today as they were ten years ago. These issues are resolved typically by proprietary, de facto, or standard-interface specifications, which, in theory, should have solved the problem, but have not because the costs of development and custom implementation remain prohibitively high.

Two working groups addressed the issues of systems requirements and the role of ontology from a business process integration point of view (see also Table 1-3). Discussions in the first group were on life-cycle-based system engineering and how to interoperate across the different engineering life-cycle phases and between their different processes in the enterprise. Emphasis was on product development and production processes development.

The second group addressed the barriers of enterprise integration and examined the new leverage that ontology might provide. The group agreed that such an approach could overcome the most severe of these barriers - the

lacking common semantics. A number of actions and proposals have been outlined by the group, which may be taken up especially in NIST (National Institute of Standards and Technology) activities. But interoperability has not only an information technology aspect, but a human aspect as well. Only if the business-process model representation is commonly understood, will the people involved in the collaboration be able to build and maintain the needed trust in each other’s capabilities.

Table 1-3. Issues and Results from Workshop 3

Major problems and issues:	Results and <i>future work</i> needed:
Working Group 1	
– Interoperability of processes and models	– Interoperability: on-time transfer of understood information between processes.
– Model of interactions between all life cycle activities of both production- and product processes	– Metrics for interoperation quality: number of conversations needed--not needed
– Concurrent use of product design and production system engineering data	– <i>Define relevant processes to support design optimisation and production decision.</i>
– Synthesis of data dictionaries	– <i>Emphasise human-oriented information exchange</i>
	– <i>Define set of required standards</i>
Working Group 2	
– High and unpredictable cost of enterprise modelling.	– Model complexity is due to the semantic content that overloads models.
– Models are often too complex to use.	– <i>Evaluate ontologies for their ability to:</i>
– How to use ontology for more efficient modelling	– <i>Improve cost versus benefits by adding formal rigor to ontologies</i>
	– <i>Separate semantic aspects of models from non-semantic ones</i>
	– <i>Improve agent's use of knowledge</i>
	– <i>Improve security in information sharing by assigning a context code to each shared parcel of information.</i>

3.4 Common Representation of Enterprise Models (Workshop 4)

Many industrial users think of models as a blueprint of the enterprise. As this has been the case originally, it is not true any more. Enterprise models or business-process models nowadays not only provide an understanding about the enterprise operation, but also are actively used for knowledge management, decision support through simulation of operation alternatives and even for model-based operation control and monitoring.

Whereas before model creation was a skill left to experts, it will become a need for many people in the enterprise to be able to evaluate process alternatives for decision support. That means we need executable models as

well as a common representation of the models for the model users to enable understanding and easy manipulation of the models. However, common representation does not imply an Esperanto like language, but rather a set of dialects aimed at the different user groups, but based on a common set of modelling language constructs.

Table 1-4. Issues and Results from Workshop 4

Major problems and issues:	Results and future work needed:
Working Group 1	
<ul style="list-style-type: none"> – Convince users of the value of EM – Gap between user expectations towards EM and modelling expert results – Faithfulness of models to the reality and the maintainability of models – EM to enable model based decision support – Guide the user in modelling and evaluating process alternatives? – Link business process models to the actual operational data bases of the enterprise 	<ul style="list-style-type: none"> – Business process model to be the blueprint of the enterprise – Outline of user enabled business process modelling directed towards model based decision support – <i>Identify the common set of modelling language constructs (e.g. UEML) from which the representations needed by the different users can be derived</i> – <i>Develop the methodologies to support the users in modelling and evaluating business alternatives</i>
Working Group 2	
<ul style="list-style-type: none"> – EM encompasses local and global views with different terminology, modelling methods, and ontologies; and occupies different space in virtual enterprises – Globally modelled things tend to be "soft" and non-deterministic – The infinity of tacit knowledge needs to be classifiable into apropos chunks 	<ul style="list-style-type: none"> – <i>Develop methodologies to support:</i> <ul style="list-style-type: none"> – <i>Soft modelling: uncertainty, non-determinism, social and cultural dynamics, and tacit knowledge</i> – <i>Introspective modelling: models to control other models</i> – <i>Multi-world modelling: legal, financial, and production domains contain conceptual discontinuities.</i> – <i>Multi-level modelling: interaction between process models and enterprise models</i> – <i>Meta-tools for modelling to support multi-level and multi-world models</i>

The two working groups addressed the user orientation and new support technologies for enterprise integration (see also Table 1-4). Emphasis has been placed in working group 1 on the need for user oriented business process modelling, which is seen as a prerequisite for model based decision support. Critical issues discussed include the role of the user and his requirements in the modelling process. Especially emphasis was on the use of current process information needed to evaluate proposed solutions and the use of formal methods for semantic mappings between different tools and

models. The working group explored methodologies needed to support user-enabled business process modelling for model based decision support.

The second working group focused on radical but practical strategies for greatly improving process modelling in an enterprise context. The group's work centred on improving user benefits in the context of common models, enterprise context and enterprise views. Major problems addressed were: multi-world views, soft modelling and meta-modelling theories. Several discrete research projects are proposed.

4. CONCLUSIONS

Considering the results from the workshops as identified in the different working group reports several conclusions can be drawn:

- On Knowledge Management: merging knowledge management and business process modelling will significantly improve decision support at all levels of the enterprise by providing more relevant knowledge structured according to the business processes of the enterprise.
- On Enterprise Engineering and Interoperability: the current issue of process semantics should be addressed by employing ontologies both for improving both human and machine understandability and inter-organisational interoperability.
- On Model Representation: focus has to be on the industrial user and his need for model based decision support.

All working group identified the need for further enhancements of the state of the art by identifying significant subject for further research and development. Some of the efforts identified will be taken up by research projects, other still need the critical mass to be assembled.

International consensus on the contents of enterprise intra- and inter-organisation integration is a prerequisite for real industry acceptance and application of the technology. With its particular focus on e-commerce the third initiative identified major players in this field both in industry and academia and thereby has continued to build the community on enterprise integration. A community that will continue the drive for consensus beyond this initiative and towards a follow-on ICEIMT and will continue as an international forum to further identify and eliminate barriers to utilisation of inter- and intra-organisational integration technology [5].

The next international conference on Enterprise Integration and Modelling Technology (ICEIMT) will breakout of the five year interval of the previous conferences and will already be held on 2004-10-09/11 at the University of Toronto. The conference will again focus on the subject of inter and intra-organisational integration, with emphasis on enterprise

knowledge, modelling languages and ontologies and the potential support by the semantic web as well as supporting infrastructures. International standards and common terminology are further subjects to be addressed in the next ICEIMT.

However, significant efforts are still needed to gain awareness and acceptance in the industry. Large-scale demonstrations of pilot applications as well as professional training of potential users would be means to convince the user community of the benefits of the technology. Standardisation as well has to play an important role in this international consensus building and awareness and acceptance tasks. Only with relevant standards can the inter-organisational collaboration in the e-business environment be achieved that the new organisation paradigms like virtual enterprise predict. Such standards are needed in the area of supporting tools and languages as well as in the operational infrastructures for knowledge sharing and information exchange.

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Chapter 2

TOWARDS KNOWLEDGE LOGISTICS IN AGILE SME NETWORKS

A Technological and Organisational Concept

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Abstract: Due to globalization and increased competition, the future market position of small and medium-sized enterprises (SME) is closely related to the ability of cooperating with partners and of reusing existing knowledge. Solutions for efficient knowledge logistics will form a key success factor for distributed and networked enterprises. In our approach, we consider competence models as a knowledge source in SME networks and we use knowledge supply networks as an infrastructure for knowledge logistics. The chapter introduces organizational and technological aspects of our approach including university – SME cooperation, semantic nets and multi-agent framework. Application area is the field of agile SME-networks which are typically temporary, dynamical with respect to their members, geographically distributed, and flexible to market demands.

Key words: knowledge supply net, competence model, agile SME-network, semantic net.

1. BACKGROUND

Due to globalization and increased competition, the future market position and competitiveness of small and medium-sized enterprises (SME) is closely related to the ability of cooperating with partners. In several industry fields (e.g. automotive, aerospace, print & media) this is reflected in a trend to virtual supplier organizations loosely integrating enterprises based on their contribution to the value chain [7]. Other examples for SME-networks include temporary project-oriented co-operations (e.g. in product development or construction projects), trade organizations, and associations for joint marketing activities.

In our research work, we are especially interested in agile SME-networks. Agile SME networks are communities or associations of SMEs based on common economical and value-creation objectives. They proactively form co-operations for joint product development or project work. These co-operations typically are temporary, dynamical with respect to their members, geographically distributed, flexible and quick responsive to market demands.

Due to geographic distribution and dynamics with respect to network members, optimized knowledge supply and efficient re-use of existing knowledge is a critical success factor for agile SME-networks. Usually it is not fully transparent to the network members, which knowledge is available in which intensity at which partners site to which costs and how to access it. One of the major constraints to the success of SME-networks is the difficulty of collectively bringing together many disparate enterprises, consultants, and other participants, and ensuring a common level of knowledge, understanding, and commitment. SME-networks require cooperation and an open exchange of information among all participants.

As a consequence, we propose to implement a cost-effective Knowledge Source Network (KSNet) for intra-network knowledge exchange and supply. In our approach, we consider competence models of SMEs, electronically stored information and personnel resources in enterprises as knowledge sources, which are integrated into a joint infrastructure based on a KSNet.

Section 2 introduces organizational and technological concepts for competence modeling of our approach. Section 3 afterwards investigates concepts of KSNet. As competence modeling has been used in the "SME-Chains" project, first experiences and conclusions are presented in Section 4.

2. COMPETENCE MODELLING

2.1 Organizational Aspects

Identification of potential sources for knowledge in SMEs results in three main categories:

(1) Most of the knowledge exists as *competences of employees*, who very often exercise several roles in the enterprise simultaneously. Personal skill profiles can serve as a description of this knowledge. This field has been investigated in several research projects, e.g. [3, 10] and is not subject of this work.

(2) *Externalized knowledge* stored electronically in documents, databases or information systems. These knowledge objects can be office documents

(e.g. design rules from manufacturer for product development at supplier), CAD drawings of parts or sub-parts, executable routines for simulation of processes or machinery, or formal requirement specifications from the customer.

(3) *Corporate knowledge* represented in work processes, organizational structures, standard operation procedures, or best practices. In most SMEs, this knowledge has not been documented and externalized.

In this section we focus on the latter knowledge category. We consider competence models in SMEs as promising way to capture this knowledge and will introduce organizational aspects of our approach. To our understanding, competence information ideally has to encompass all technical and organizational capabilities of an enterprise. This includes

- Skill profiles of the personnel of the enterprise,
- Technical equipment and production capacity,
- Business processes with focus on value creation and management processes,
- Organizational capabilities,
- Technical and service-oriented products with their features and parameters.

Competence modeling therefore is closely related to enterprise modeling [11]. Competence modeling is a non-trivial task requiring solid competences in information modeling which cannot be taken for granted in SMEs. Organizational support for competence modeling of SMEs therefore is of crucial importance and has to take into account regional and cultural aspects and the individual needs of SMEs. Our concept for organizational support of SMEs is to integrate universities as partner organizations into regional SME-networks and to use student ambassadors as contact partners and assistants to SMEs.

On the regional level each SME participating in the SME-network will have close contacts with the students and receive visits from a team of two students from the regional university. This visiting student team assists in modeling the enterprises competences and generating the meta-data in accordance to the semantic net (see Section 2.2), integrating the competence model as a knowledge source into the KSNet. An SME can also be host for a pair of students during their study time. These students will work on an individual “mini-project” for the host SME, which will be integrated into his or her studies at the university. The regional university, which from the SMEs viewpoint is considered as competent and trustworthy partner, supports the students by offering courses in relevant engineering methods and in project management.

This type of university – SME cooperation generates benefits for all partners: The students benefit by gathering practical experience from their project. The SMEs get individual support in their projects and – as a side effect – close contacts to well educated potential future employees. The university has benefits by learning the everyday needs of SMEs in the region.