Chapter 2

TOWARDS KNOWLEDGE LOGISTICS IN AGILE SME NETWORKS

A Technological and Organisational Concept

Kurt Sandkuhl, Alexander Smirnov, Bengt Henoch

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 pro-actively 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.

2.2 Technological Aspects

Knowledge supply has to be more than simply installing a search engine or providing a joint repository for all partners. Our approach is to use semantic modeling in order to improve knowledge capturing, knowledge reuse and knowledge transfer. Semantic modeling means in this context that the semantics of all relevant concepts of the industry sector or domain will be modeled in a semantic net by capturing the associations between the concepts. This semantic net, which is a pre-stage for an ontology, defines a "common understanding" for the application area and helps to identify and find the most relevant information for a user by reflecting the meaning of the concepts.

The most important relationship amongst concepts is the so-called *subsumes* relationship. This expresses a hierarchical order and sums up the aggregation and generalization / specialization relationship. In addition, associations can be made, placing various concepts in a named relationship.

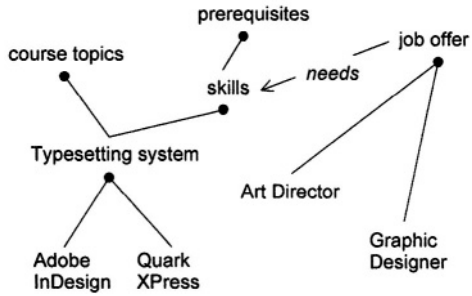

Figure 2-1. Extract of a semantic net from the domain "print & media"

Let us take the field of qualification and job offers in the area of print & media as an example. The depicted extract of the semantic net (see Figure 2-1) lists various concepts and their relationships[1]:

Semantic nets are not only used for stating classical relationships like „Adobe InDesign *is a* typesetting system" or „art director *is a* job offer" but also for stating the so-called *context* relationship, e.g. „Quark Xpress in context of typesetting".

Based on a semantic net especially developed for the agile SME-network in question, the existing knowledge is captured by using *concept paths.* For every knowledge object, a set of paths in the semantic net is identified. One path consists of a number of connected concepts in the semantic net, describing the characteristics of the knowledge object. These concept paths

1 The edge with the filled-in circle depicts the "subsumes" relationship, while the arrow shows the named and specified association.

serve as meta-data in the KSNet when identifying and transferring the right knowledge with respect to a users' need. The concept paths and other meta-data of the knowledge object are stored in a *knowledge source repository.*

As modeling of all competence aspects for a large number of SMEs is time and cost intensive, we differentiate competence models and short competence profiles.

Competence models are prepared for an SME with the assistance of student ambassadors. The student uses an enterprise modeling tool (e.g. METIS toolset[2]) and templates prepared for the relevant industry sector. Modeling includes all aspects introduced in Section 2.1 and is done in close cooperation with the personnel of the enterprise. For the resulting competence model concept paths within the semantic net are generated serving as meta-data for knowledge selection and supply.

Competence profiles can easily be entered by the SMEs themselves via the Internet by using functionality of the knowledge source repository. The repository provides a profile entry form, which consists of properties, references to resources and concept paths in the semantic net. Properties are structured data types and used for representing meta-information on the enterprise, e.g. general contact information, available production capacities and personnel, etc. Resource reference provide the possibility to include additional material on the enterprise, e.g. text documents or product information. The most important part of the competence profiles is the identification of concept paths within the semantic net. These paths reflect the competences of the enterprise with respect to skills and product structure. The repository supports this task by providing a browser for semantic nets.

3. KSNET APPROACH

The term KSNet has its origin in the concept of virtual organization / enterprises [13, 16] based on the synergetic use of knowledge from multiple sources [8, 12, 14]. A KSNet can be defined as a flexible connection of appropriate knowledge sources at different locations with the target to fulfill a concrete task, e.g. the decision making of a task in a determined volume, cost frame and time. In the context of agile SME-network, the consortium exists for a period of time, with formation, integration and operation phase. The network becomes operational when a concrete realization takes place or at least the necessary budget is endorsed. During the planning phase until the offer is ratified the KSNet represents a planning task in order to design and evaluate potential scenario solutions for the decision making of task. Figure 2-2 explains roughly the basic concept of the KSNet.

2 http://www.computas.no

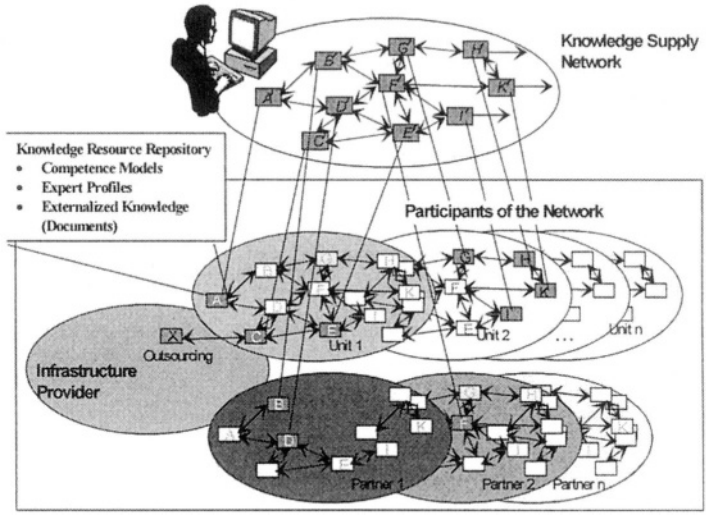

Figure 2-2. Distributed multi-level KSNet

In agile SME-networks, the knowledge sources interlinked and integrated by KSNet are expert profiles, externalized knowledge (electron. stored) or competence models (see Section 2). The semantic net supports navigation and knowledge supply.

Analysis of some existing systems/projects for knowledge source integration has shown several multi-agent approaches. Some examples are [1,9,12]:

- KRAFT (Knowledge Reuse and Fusion / Transformation) – multi-agent system for integration of heterogeneous information systems. The main aim of this project is to enable sharing and reuse of constraints embedded in heterogeneous databases and knowledge systems.
- InfoSleuth – multi-agent system for retrieving and processing information in a network of heterogeneous information sources.
- OBSERVER (Ontology Based System Enhanced with Relationship for Vocabulary heterogeneity Resolution) – system for information retrieving from repositories. The main aim is to retrieve information from heterogeneous knowledge sources without having knowledge of their structure, location and existence of the requested information.

An effective KSNet is characterized by (i) increased connectivity between its units, (ii) alignment of its inter-organization support systems, and (iii) sharing of information resources among its units.

Major KSNet functions could be determined as (i) communication, (ii) co-ordination, (iii) collaboration, and (iv) common/shared memory. This set of functions could be realized by using the following technologies [14]:

- Direct knowledge entry by domain experts (based on GUI, complex object cloning, and object-oriented template library),
- Knowledge repository parallel development by distributed teams (based on automatic change propagation and conflict negotiation),
- Knowledge sharing by knowledge maps (based on reusable ontology theory and distributed constraint satisfaction technology), and
- Distributed uncertain knowledge management (based on object-oriented fuzzy dynamic constraint networks as a shared ontology paradigm).

The multi-agent approach is much more suited for scalability than the conventional approach due to its, (a) orientation towards object-oriented modelling for encapsulation, and (b) suitability for unstructured knowledge problem domains. Therefore, a multi-agent approach based on a contract net protocol model has been adopted for our approach. The contract net protocol is a classic co-ordination technique that is used for task and resource allocation between agents. In this protocol agents can play two different roles: a manager and a contractor.

According to FIPA it is necessary to develop the following technological agents: *Facilitator, Mediator, Wrapper* [4]. Furthermore, application-oriented agents have to be implemented. In our approach we see four types of agents:

- *Translation agent* and *Knowledge Fusion (KF) Agent* provide operation performance for KF. *KF* is defined as integration of knowledge from different sources (probably heterogeneous) into a combined resource in order to complement insufficient knowledge and obtain new knowledge.
- *Configuration Agent* supports effective use of knowledge source network, e.g. for integration of knowledge source repositories.
- *Semantic Net Management Agent* provides semantic net operation performance.
- *Monitoring Agent.* Life cycle of rapid knowledge fusion systems consists of forming problem domain (preparation phase) and utilizing it with possible modification (operation phase). During the operation stage rapid knowledge fusion systems work in real-time mode. Accessibility and consistency of knowledge sources are the critical factors for them. Monitoring Agent reduces system failure probability by knowledge source verifications.

Figure 2-3 summarizes the conceptual approach for KSNets in agile SME-networks based on multi-agent technology.

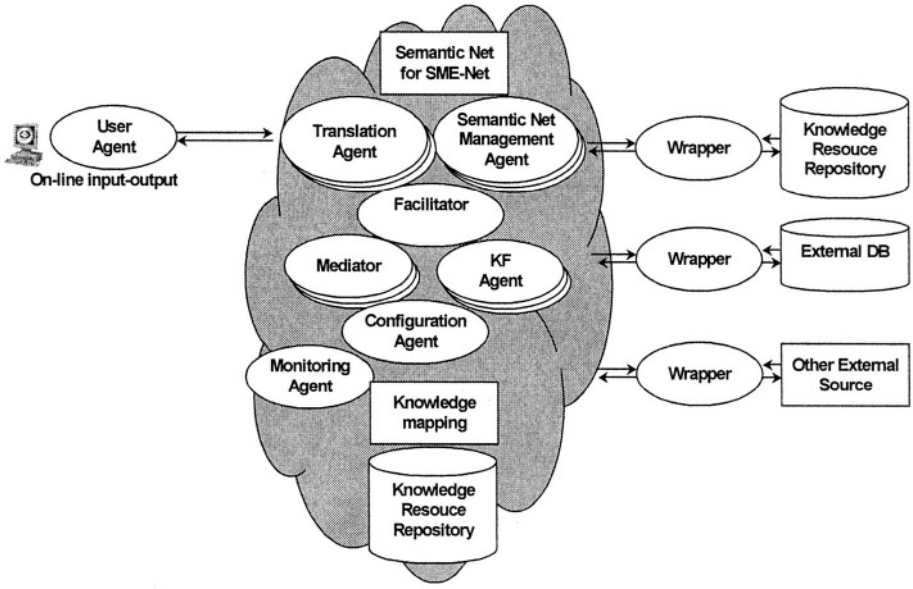

Figure 2-3. General multi-agent framework for KSNet in agile SME-Networks

4. CONCLUSIONS

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. We introduce organizational and technological aspects of our approach including university – SME cooperation, semantic nets and multi-agent framework. Although implementation of the complete approach is still work in progress, first experiences with some parts of the approach have been made.

With respect to the organizational support of SMEs for competence modeling, some early experience was gained in 1991-94 when the ESTPID program [5] was active based on existing and extended cooperation between the electronics departments of the Royal Institute of Technology Stockholm and Tallinn Technical University as a catalyst for developing Estonian Electronic Industry. The results of this project are approx. 30 new jobs in Estonian Electronics Industry, establishing of one new company and creation of different industrial joints.

Furthermore, the approach to competence modeling presented is closely related to the R&D project "SME-Chains" funded by the European Union within the ALFA program. In SME-Chains, four universities from Europe

(Sweden, Norway, Germany, Spain) and five partners from South America (Chile, Argentina, Uruguay, Columbia) establish regional networks of SMEs in their countries in the field of software production. Formation of SME-networks in SME-Chains is based on competence modeling [6]. As a cooperation basis, an Internet-based Web-Portal [2] including competence base has been set up which can serve as a basis for knowledge source repositories.

Experience in multi-agent environments and KSNets has been gathered in several areas, e.g. profile-based configuration of KSNets [15]. Implementation of KSNets is planned for automotive supplier and wood-related industries.

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