Journal of Universal Computer Science, vol. 9, no. 12 (2003), 1398-1409
submitted: 29/8/03, accepted: 18/9/03, appeared: 28/12/03 © J.UCS

A Practical Knowledge-based Approach to Skill Management and Personal Development[1]

Wolfgang Hiermann
(BEKO, Austria
wolfgang.hiermann@beko.at)

Max Höfferer
(BEKO, Austria
max.hoefferer@beko.at)

Abstract: BEKO-SMS is a knowledge-based skill management system that combines project planning and human resource management. Application and system functions model specific skills and relationships used in a particular project. The definition of skills, skill trees, skill updating and other processes form the basis for the success factors of the SMS. We conclude that efficient project resource planning would not be possible without SMS and the skill manager.

Keywords: skills, skill database, skill management, skill updating, project planning, human resource planning
Categories: K.6.1, J.1

1 Introduction

The development of practice-relevant models for knowledge management that are of practical relevance [Probst et al. 1997] is imperative for companies that wish to operate successfully on the market. IT service and consulting companies like BEKO only make profit when they sell a certain share of the working time of their employees to the customers. Therefore the knowledge and skills of employees are key factors for consulting companies to become competitive. Companies well informed of the skills and the knowledge of their employees will be able to fulfil the following items:

- find the right single employee for a specific task or project
- retrieval and assembling of flexible project teams [Lucas and Weber 2000]
- develop and update employees skills
- explore the employees future career paths and
- speed up innovation management

The employment of skill management systems [Schürholz 2001] can prove to be very efficient for service providers particularly when changing project requirements

[1] A short version of this article was presented at I-Know'03 (Graz, Austria, July 2-4, 2003)

and the flexible roles of the employees necessitate short reaction times in time-critical projects. Objectives of skill management systems (SMS) vary according to the target group [Deiters et al. 2000]:

Employees:

- help in finding a suitable knowledge for solving a specific problem
- career planning: development of own skills in a most focused way

Management (in addition to the items above):

- staffing: search of suitable employees for positions
- skill gap analysis: identify the skills employee need in order to succeed in their current or planned projects
- bridging the gap between personal administration, recruiting and human resource development.

The human resource management processes like personal planning, recruiting, selection or development benefit from a successfully implemented skill management system.

In this paper we shall be focussing on BEKO-SMS, a tried and tested skill management system of BEKO Ing. P. Kotauczek GmbH (over 700 employees) which combines the advantages of knowledge and skill management.

BEKO-SMS aims to localise company and employee-related know-how in the company, to deploy and, in the final analysis, commit employees in an optimal manner.

2 BEKO-SMS

In many companies skill management systems are driven, developed and managed by the human resource department [Wöls et al. 2003], [Beck 2003]. At BEKO skill management is an integral business process and over a period of 10 years BEKO has developed a knowledge-based skill management system (SMS) for work preparation and project resource scheduling so as to enhance its capacity to operate as a technology service and solution provider. The SMS administrates the evaluated skills of the employees and records their knowledge in the form of application reports which document each environment in which the skill was used.

In this paper we will describe the main SMS processes assessing, storing and updating of skills as presented in [Deiters et al. 2000]. These Processes were implemented at BEKO over a period of several years. At BEKO the term project team is used for a group of employees who work together on a contemporary project and do not stay together (in most cases) after the project is completed. Individual training programs for skill updating are carried out at the BEKO academy.

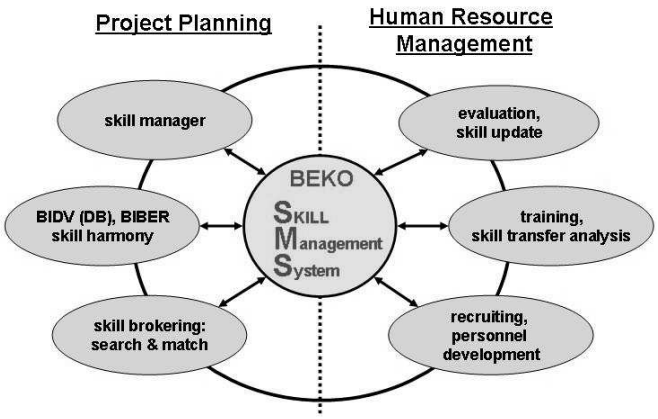

Figure 1: BEKO-SMS

BEKO-SMS combines project planning and human resource management and defines the interfaces to other fields and processes such as resource scheduling, skill update, transfer controlling [Hiermann 2002] or recruiting (see Figure 1). Like a Knowledge Broker the SMS employs an ontology to model specific skills and relationships used in a particular project.

2.1 The underlying model

The BEKO-SMS is founded on the following model which describes the mapping between project items and employee skills based on a knowledge function.

The skill manager will master a search problem if a candidate possesses a set of skills necessary for a project to be planned.

We define a relation between project items and skills.

Let I be a set of project items and $S \neq \emptyset$ a set of skills. A mapping $\lambda : I \to 2^S \setminus \{\emptyset\}$ which assigns to each project item $i \in I$ a subset $\lambda(i)$ of skills is called a *skill function* for *I*. The set $\lambda(i) \subseteq S$ is called the set of skills associated with *i*. To each project item $i \in I$ a set of latent skills $\lambda(i)$ necessary to solve i is associated.

Given a skill function λ, let $K \subseteq S$.

A mapping $\mu : 2^S \to s^I, K \to \mu(K) := \{i \in I \mid \lambda(i) \cap K \neq \emptyset\}$ which assigns a subset of *I* to each subset *K* of *S* is called a *knowledge function*.

A project item set $I = \{i_1, i_2, i_3, i_4\}$ and a skill set $S = \{s_1, s_2, s_3, s_4\}$ with the skill function $\lambda : I \to 2^S$ are defined by the table:

$i \in I$	i_1	i_2	i_3	i_4
$\lambda(i)$	$\{s_1,s_2\}$	$\{s_2,s_3\}$	$\{s_1\}$	$\{s_1,s_3\}$

The corresponding knowledge function $\mu : 2^S \rightarrow 2^I$ is given by the table:

$K \subseteq S$	Ø	$\{s_1\}$	$\{s_2\}$	$\{s_3\}$	$\{s_1,s_2\}$	$\{s_2,s_3\}$	$\{s_1,s_3\}$	$\{s_1,s_2,s_3\}$
$\mu(k)$	Ø	$\{i_1,i_3,i_4\}$	$\{i_1,i_2\}$	$\{i_2,i_4\}$	$\{i_1,i_2,i_3,i_4\}$	$\{i_1,i_2,i_4\}$	$\{i_1,i_2,i_3,i_4\}$	$\{i_1,i_2,i_3,i_4\}$

$\mu(K)$ is defined as a knowledge space [Doignon and Falmagne 1998]. The union of any two knowledge states is again a knowledge state. With this knowledge function more than one subset of skills can be assigned to one set of project items.

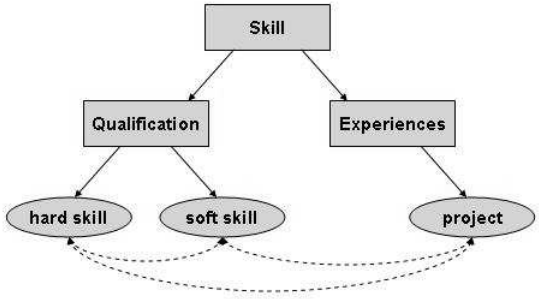

Figure 2: skill model

The Figure above gives a simplified picture of our definition of skills. Skills consist of a set of experiences and qualifications that are divided into hard skills (data bases like DB2, SQL-Server, Progress, Oracle; programming languages like COBOL, PL/1, CICS, JAVA, C++, SmalTalk, XML; computer systems like MVS, Microsoft, Linux, …) and soft skills (leadership, motivation, teamwork, …).

The functions that are listed below apply primarily in the fields of project planning and resource scheduling where teams that have to create solutions for complex IT projects have to be put together in a fast and flexible manner. The result of the search is to find a balanced project team, that focuses four competencies: professional, technical, social and management competence [Patzak and Rattay 1998]; [Deiters et al. 2000].

2.2 Skill Attributes

The storage of different skill attributes is important for the quality of the search result.

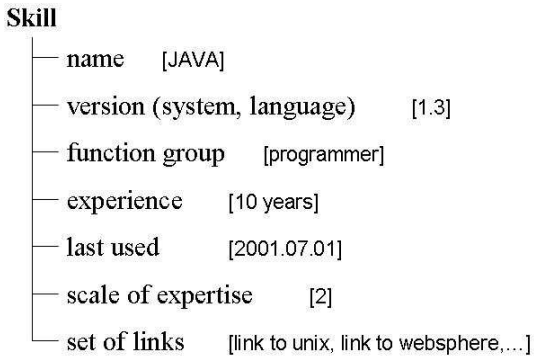

Figure 3: skill attributes

The figure above illustrates the information stored for one skill in the skill profile of an employee. "Name" is a unique name for one skill in the skill database. "Version" is the specification for name that stores for example the version of a computer system or a computer language. The "function group" contains the data in which function the skill was used (for example: programmer, consultant, user, etc.). The attribute "experience" collects how long the employee has experience in that specific skill (for example: 10 years). The item "last used" provides the information when the skill was utilised for the last time. It is a time stamp to indicate if the employee needs a skill update. With the period over which the skill was used and the last time of utilisation a judgement can be made with regard to the employee's current command of this skill. In the attribute "Scale of expertise" BEKO uses a four-part scale whereby the evaluation is primarily based on a self-appraisal of the employee. "Set of links" is a link-up possibilities between skills. We combine professional and technical skills, if for example an employee has professional knowledge in the test field but has only implemented this knowledge with a specific tool. With this important information the skill manager knows the environment, where the skill is primary used.

2.3 System functionality

To carry on an efficient skill management system it is essential that the following technical and organisational requirements be met:

2.3.1 Administration of skill maps

Definition of skill maps in the form of hierarchic structures the depth and width of which can be extended as required. Classification of the hierarchies on the basis of specific criteria such as: expertise, languages, operating systems, programming languages, etc. The hierarchic structures are represented like trees with branches,

trunks and leaves. Like real trees they can grow in some fields, or they can die, if a skill field is no longer necessary.

More than 2,500 different skills are entered in the BEKO-SMS database.

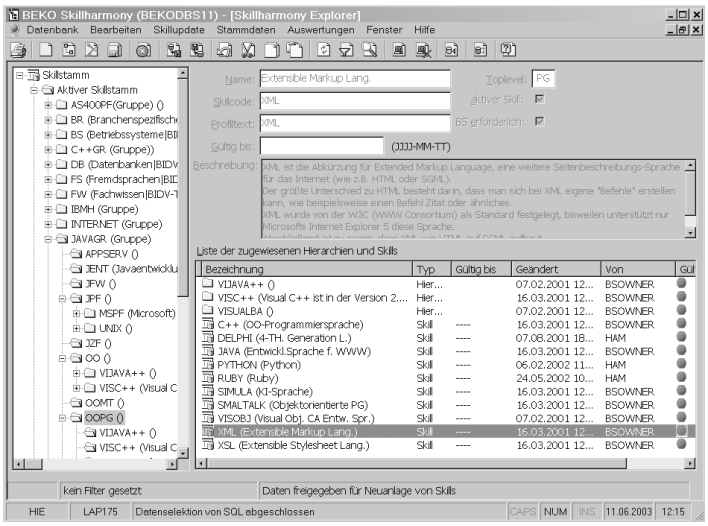

Figure 4: skill database mask

2.3.2 Matching

The primary function for a service and solution provider like BEKO is (1) to find the right specialist team member for project tasks and (2) assembling of project teams. The complex search process, matching of project requirements and skill database, is divided into four steps:

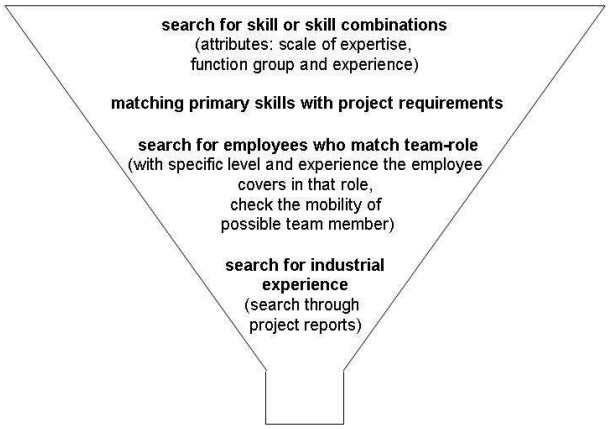

Figure 5: skill funnel - how to find the perfect team member(s)
Default skill matching steps:

1. selection of those employees whose skills best match the project requirements. The search engine runs through the skill profiles of the employees.
2. selection of those employees who dispose of the primary skills that are required for the project and have already implemented these skills on several occasions. In view of professional development and practical application a distinction is made between standard skills and primary skills. The primary skills are the skills in which the employee has gathered the most experience and the skills with which he "feels most comfortable" when developing his personal career. A programmer for example has a command of ten different programming languages but normally only uses two of these languages because he takes a greater interest in these languages and uses these skills primarily in projects. Our experience is that the differentiation between skills and primary skills helps to find out the specialisation of the employees (for example: one employee has over 400 skills in his skill profile). The employee has the possibility to change the primary skills to focus his next career step.
3. selection of those employees whose experience in that specific role best matches with the needed project role. In this case the search engine runs through (1) skill profiles, (2) project reports and (3) role (job description).
4. selection of those employees who have already used the required skills in the same branch or environment. The search engine walks through the project reports.

Complex skill matching steps:

1. Search possibilities on a skill basis: in this way, various professional and technical skills can, for example, be put together and queried for a skill profile.
2. Search possibilities at experience report level. This provides an unrestricted search possibility in texts that describe the customer environment.
3. Linking of various search results to identify the ideal candidate for the task on hand.

The steps above describe the technical process for finding the employee with the best technical skills. Nevertheless for the project manager and the skill manager it is very important to identify soft skills of the team members. In order to successfully accomplish this task the BEKO Skill managers have experience for many years, apply intuition and act from the belly.

2.3.3 Visualisation

Visualisation and input possibilities for the skills and the experience reports for various persons such as: employees, superiors, skill manager, project planning and academy.

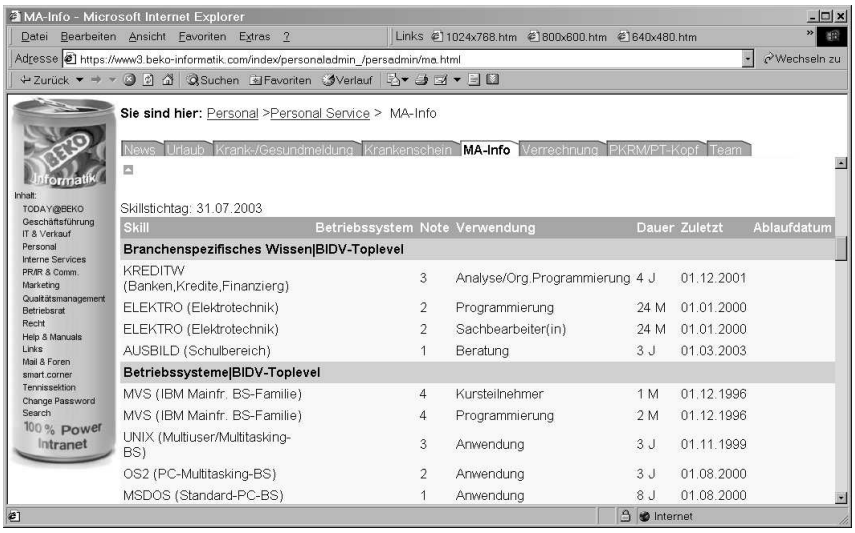

Figure 6: One of the personal info pages of an employee. Every employee is able to see his skill sheet, project reports and his role via intranet.

2.4 Organisational factors for BEKO-SMS

2.4.1 Staff

The internal position "Skill Manager" in the project management business unit was established to manage the catalogue system and ensure that the same definitions are used throughout the company. The skill manager is responsible for adding new skills in the skill database. He gets input from the project reports or the employees. For finally definition of a new skill, he coordinates the definition with the responsible department. A second way is the strategic definition of a new skill, if e.g. a new service is introduced.

2.4.2 Defining skills and skill trees

In the first phase of the skill management system, the skill data grew up to 5000 skills and more. The reason was that each business unit described skills on their own. Therefore we developed the skill harmony tool, which is a catalogue system for the skill keywords. With the tool we define new skills, delete (or deactivate) old skills and update employee skill maps. Skill harmony is the explorer for skills.

2.4.3 Skill updating

One of the problems with skill management systems is timeliness. Therefore BEKO-SMS has three ways for updating the skill profile of an employee. (1) practical skills in projects: updating the skills at the end of the project and two times a year. After each project the employee reports the project goals, his tasks in the project, the project environment, his role in the project and the skills used. So he is drawing up of

experience and application reports which allow a link to the skills but also facilitate a description of the application field by means of indexing and free text input. (2) strategic: updating after finishing a training/course. (3) own activity (self motivated): the employee is able to see his skill profile via intranet and meet his manager for updating his skills.

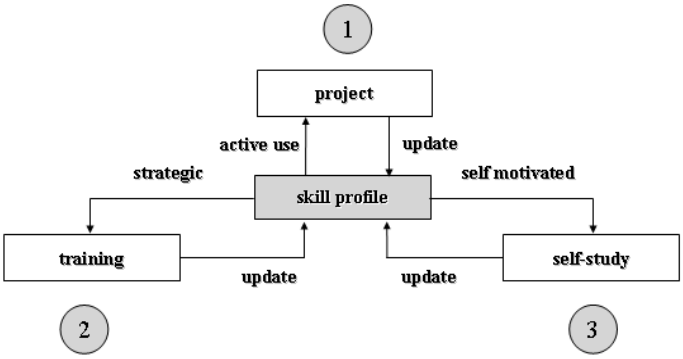

Figure 7: three different ways for updating skill profiles

2.4.4 Skill development

All skill requirements are market-oriented. The problem is not to create new skills at the BEKO academy but to engage the high technical personnel to the company by the implementation of career models. BEKO offers three different career paths for all employees:

(1) The technical career path focuses in a very deep technical knowledge and a specialising in at least one technical field. For example "Java Developer".
(2) The competence career offers a wide technical understanding in different fields (for example the "e-Solution-Consultant").
(3) The management career offers a combination between executive and professional. For example the "Competence Team Leader".

Each career path defines the role type and the role. A role type describes the global definition for a career path. One career path is the "software developer". A role is a specialisation for the role type. For the role type "software developer" specified roles are "Java-Developer" or "Oracle-Developer". In these role specifications we define different levels of the role. These levels define the career path for that role. In one level we define soft and hard skills and the project experiences or certifications the employee needs for this role. This specification for a role level is visible for everyone in the company and so every employee is able to find out his skill requirements for the next level.

A role defines: (1) requisites; (2) professional qualification/professional skill; (3) technical qualification/technical skill; (4) social qualification/social skill.

2.4.5 Costs

The development of the SMS resulted from the necessity to remain competitive, so the question of cost-benefit calculation was not of relevance. The going concern of the SMS results from the personnel expenditure for one fulltime Skill Manager, line management (5% of their yearly work time) and employees (2% of their yearly work time).

2.4.6 Works council

Consultation with works council relating to data collection. Compliance with the data protection regulation. Prevention of data abuse.

3 Success factors of BEKO-SMS

1. Quality of skill matching (human resource project planning): The first success factor of BEKO-SMS is the fast and easy way to find the right people for a project.
2. Quality of skills: Our system has more than 2500 business relevant skills in the database. So we know which skill everyone of our employees has to fulfil his tasks in a project. The actuality of the skill profiles is in maximum a half year old.
3. Quality of services: To show the relation between the SMS and contentedly customers, we use a process for the measurement of the customer feedback to check and control the quality of an employee's services.
4. BEKO-SMS is not a stand-alone application but is integrated into a comprehensive human resource management system.
5. The BEKO Intranet provides an effective information and communication infrastructure for the SMS. For the employees the transparency of their skills and roles is very important. So they know which skills, project reports and other information is stored in the database.

4 Lessons learned

Lessons learned during the implementation and day-to-day operation of BEKO-SMS:

1. Top management commitment: the implementation of the project would not have been possible without management approval and support.
2. The skill requirements for the project can change dramatically between the resource scheduling phase and the actual start of the project.
3. The requirements and specifications embraced in the project inquiries are becoming more complex. For this reason, a flexible expansion of skills must be possible at all times. Furthermore, it must be possible to deactivate complete branches on the skill map so that clarity can be maintained at all times.
4. The know-how of the employee can never be fully reproduced in a system.

5. Some of the applicants got a shock when confronted with the extensive application form – they felt as if they were obliged to fill out such a detailed questionnaire.
6. Over the years, various designations were used to describe one skill in the skill database. The skills were harmonised, i.e. standardised, in the course of the skill harmony process. This made the development of the hierarchies more transparent and drastically improved the quality of the results of the query.
7. Necessity of a skill manager. The skill manager coordinates the skill database and focuses different ontologies of the service departments to one company skill ontology. Today the skill ontology is operative and imperative throughout the company.

5 Conclusion and ongoing research

BEKO-SMS not only facilitates the formation of an optimal project team but also supports the human resource management processes in the sense of personnel selection and career development (see Figure 1). On the one hand, we view knowledge brokering in a project planning context as being the utilisation of skills and, on the other hand, as being the development of skills in the human resources field.

The outlined approach describes the functions and processes that are needed for the implementation and integration of a knowledge-based skill management system. Fundamental to an effective SMS is an objective skill assessment process providing enterprise-wide standards and insights. We conclude that skill management playes a central role in knowledge-based companies with more than a hundred employees.

The BEKO-SMS can never exchange our skill manager and competence team leader but it is a well-proved tool for supporting their tasks.
BEKO-SMS is a continuously growing system which has developed over the years to become the “lifeblood” of the company. We now know that efficient project resource scheduling would not be possible without BEKO-SMS.

In the personnel development field work is continuing on the definition of role models and role validation. This project aims to combine soft and hard skills for modelling in BEKO-SMS.

References

[Beck 2003] Beck, S.: "Skill and Competence Management as a Base of an Integrated Personnel Development (IPD) - A Pilot Project in the Putzmeister, Inc./Germany"; Journal of Universal Computer Science, 9, 12 (2003), 1381-1387.

[Deiters et al. 2000] Deiters, W.; Lucas, R.; Weber, T.: "Skill-Management: ein Baustein für das Management flexibler Teams"; Information Management & Consulting, 15, 3 (2000), p. 54-60.

[Doignon and Falmagne 1998] Doignon J.-P.; Falmagne J.-C., "Knowledge Spaces"; New York, Springer (1998).

[Hiermann 2002], Hiermann, W.: "Methoden und Modelle zur Einführung von Bildungscontrolling-Maßnahmen in einem Softwareentwicklungs-Unternehmen", Masters Thesis, Technical University Vienna (2002)

[Lucas and Weber 2000] Lucas R., Weber T., Skill-Management: Building Block for Project Management with Flexible Teams, 4th IEEE International Baltic Workshop on databases and information systems, Vilnius, Litauen, Mai 2000.

[Nonaka and Takeuchi 1997] Nonaka, I.; Takeuchi, H.: "Die Organisation des Wissens: wie japanische Unternehmen eine brachliegende Ressource nutzbar machen"; Campus Verlag GmbH (1997)

[Patzak and Rattay 1998], Patzak, G; Rattay, G.: "Projekt Management" (1998)

[Probst et. al. 1997], Probst, G., Raub, S., Romhardt, K.: "Wissen managen", FAZ/Gabler, Frankfurt/Wiesbaden (1997)

[Schürholz 2001], Schürholz, D.: "Skill Management zur Unterstützung der dispositiven Aufgaben des Personalwesens", Masters Thesis, University Köln (2001)

[Wöls et al. 2003] Wöls K., Kirchpal S., Ley T.: "Skills Management – an "all-purpose" Tool?"; in: Tochtermann, K.; Maurer, H.: "Proceedings of the 3rd International Conference on Knowledge Management (I-KNOW 03)", Graz, Austria, July 2003.