Knowledge Transfer Processes in a Modern WBT System

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Abstract: The paper offers a general view of Web-based Training (WBT) as a number of knowledge transfer processes utilizing current and advanced Internet technology to facilitate and speed the flow of knowledge from people possessing that knowledge to people who need to acquire it. The key here is in the use of both conventional and innovative tools compatible with current Internet standards to transfer the knowledge. Thus, the paper introduces an innovative application of Internet technology to acquire, store, structure and transfer different types of human knowledge in a working environment. It starts with a number of typical training scenarios and shows that traditional WBT systems support only most rudimentary ones. It demonstrates a number of concepts and tools necessary in the real training situations. Those tools are bringing together a number of disparate areas, encompassing more than what was traditionally considered simply "Web-based training". The following knowledge transfer processes are discussed: Web-based training, Web-based tutoring, Web-based mentoring as well as Web-based knowledge mining, Web-based knowledge profiling and Web-based knowledge delivery. These processes were implemented as a number of typical knowledge transfer scenarios (http://coronet.iicm.edu). The scenarios were practically tested and evaluated with hundreds of users in a real industrial environment.

1 Introduction

It is our experience that many Web-based Training (WBT) [Andrews, 95][Helic et al, 2000][Dietinger et al. 1997] systems do not take into account the latest advances in teaching paradigms – they simply reflect Internet technology. We have developed an application called WBT-Master. It is a set of tools that facilitates the flow of knowledge from experts/mentors to learners in a highly personalized, on-demand fashion. The key here is the use of both conventional and innovative tools compatible with the current Internet standards, to facilitate the flow of knowledge. As we shall see, WBT-Master brings together a number of disparate areas, certainly encompassing more than what was traditionally considered simply "training".

We believe that WBT-Master is not simply yet another Web-based Training system for delivery of online training materials [Gaines et al. 1996]. It rather applies well-tested teaching paradigms to Internet situations enabling the acquisition, storing, structuring and transferring of human knowledge in working environments.

Generally speaking, WBT-Master tools work with so-called Corporate Memory. The Corporate Memory is made up of the knowledge that is found within the company. It includes huge collections of documents residing on the WBT-Master server, portals (i.e. references to information resources available from the Internet), on-the-fly material (i.e. annotations to documents, contributions to discussions, question-answer dialogues, etc.) as well as the personal knowledge of organizational members.

Since we consider training as a primary application area, all such knowledge elements are called Basic Training Resources. Basic Training Resources may be organized into composite structures, combining resources needed to accomplish a particular training task. These training resources when combined into a composite structure may be seen as a new training resource. In other words, training resources may be reused by inclusion into other collections. In this way training resources can be collected, managed, organized and made easily accessible to all members of the organization.

Corporate Memory may be seen as a combination of training resources and operations that are applicable to such training resources. The operations allow users to access and create new training resources, or to add an additional value to existing training resources.

To illustrate the concepts introduced above, a simple example might be helpful. A typical Web-Based Training (WBT) system utilizes HTML documents as learning resources [Dietinger et al. 1998]. Ordinary Internet hyperlinks (references) are used to create navigable data structures such as courses, chapters, books, etc [Berners-Lee et al. 1994][Cailliau 1995]. Different WBT tools such as annotation, email, discussion forums, personal bookmarks are used, as normal, to add additional value to the basic documents [Helic et al 2000][Dietinger and Maurer 1997][Shaw and Gaines 1996]. However, WBT-Master can improve knowledge flow by introducing composite training resources such as reusable Learning Units, Learning Goals, Knowledge Cards, Mentoring Sessions, and Knowledge Domains.

In addition to specially prepared training materials, anything that is part of the enterprise knowledge, such as technical documents, presentations, or the personal experiences of employees can be used as learning resources via the Internet or Intranet. Note that the system essentially supports addressing human subject matter experts as learning resources. Since all information services operate with unified data structures, the result of any collaboration (discussion sessions, brainstorming sessions, annotations, question-answer dialogs, etc) can be seen as new training material and can be reused by others.

In addition to this WBT-Master also enables synchronous and asynchronous communication among distributed teams and team members. This includes discussion forums, brainstorming sessions, chats, annotation facilities etc. Communication tools such as these will, of course, support collaboration between different users.

In the following sections, several knowledge transfer processes are presented since they cover a part of the core elements of the WBT-Master methodology. The WBT-Master methodology represents a fundamental paradigm shift from the conventional "online course" model, in that it tries to capture the best elements of what works so well in classroom learning. It uses Internet technologies to transfer human knowledge in a much more general sense by incorporating Web-based tutoring, Web-based mentoring, knowledge mining and knowledge profiling. Thus, the methodology bridges the gap between the initial possessors of the knowledge (which often does not exist in an electronic form) to the ultimate ability of a learner to apply that knowledge in a practical situation. In this way it encompasses the entire Knowledge Life Cycle from authoring or capturing, through to integration and delivery, and finally to application of that knowledge.

2 Web-based Training

This process utilizes the classical “online course model” [Dietinger and Maurer 1997] and may be presented with the following typical situation: an experienced employee (i.e. tutor) is supposed to conduct training sessions on a regular basis. The tutor in collaboration with a courseware author develops a special Internet course and makes a special announcement on the WBT-Master server. Potential learners may access the announcement board and subscribe themselves for a particular training session. Before starting the training session the tutor defines a user group and user accounts for all members of the group. During the timeslot allocated for the training session, the learners work through the courseware material and communicate with the tutor and with other group members.

Courseware authors experience basically the same problems as other WWW authors. Firstly, in WWW there is no possibility to define document attributes, i.e., data about data or meta-data, such as document author, keywords, document topic, expiration date of document, etc. Such attributes are often very useful in search procedures, where users can search for documents that have certain attributes. Thus, WWW authors experience the well-known problem of *lack of metadata*. Recently, initiatives such as Dublin Core Metadata Initiative [DCMI, 2003], Learning Object Metadata Standard [IEEE LTSC, 2003], Resource Description Framework [W3C RDF, 2003] and the Semantic Web [Berners-Lee et al., 2001] try to address this issue. Secondly, authors in WWW have no possibilities to define bi-directional links, typed links, or links pointing to or emanating from other types of media than text and graphics, i.e., WWW offers only a *limiting link philosophy* [Hardmann et al., 1994][Halsz, 1991][Helic et al., 2000]. Further the *inadequate authoring support* results in tedious and time-consuming authoring process. Thus, many of the links that WWW requires to be introduced manually could be generated by the system. For example, inserting a new document into a linear list of documents provided with a table of content (data structure which is rather often used to present educational material), requires editing of at least four documents instead of a single operation [Duval et al., 1995][Kappe et al., 1993]. Last but not least, *unsatisfactory reuse of materials* leads to a huge amount of redundant work in developing educational material. For example, an author wishes to reuse material that has been created by another person. The author might be able to refer to those documents in the documents he creates, but has no control over the references from and appearance of documents being referred to. To adjust the referred documents the author needs to make local copies of the referred documents and additionally edit those copies [Garzotto et al., 1991].

Authoring in WBT-Master is supported through the concept of so-called Learning Units. Generally speaking, Learning Unit is a special type of Hypermedia Composite. Thus, *Learning unit* is a collection of documents and other Learning units; all of them are called members. A Learning unit is treated (i.e. accessed, stored, deleted) as one entity.

Consider a WBT system that contains educational material. A set of documents presenting information on a certain topic (say, “X”), can be joined together to form a conceptual group - a Learning Unit "Topic X". The Learning unit in question would contain HTML documents (members) - "title page", "abstract", "referential material", etc. Moreover, it might contain even other Learning units presenting an explanation of other related topics.

Additionally, each Learning unit encapsulates a special navigational paradigm, i.e. computer-navigable links between members of the Learning unit. As can be expected of a hypermedia system, whenever a user accesses such Learning unit with an ordinary WEB browser, it is visualized in the form of interrelated HTML pages.

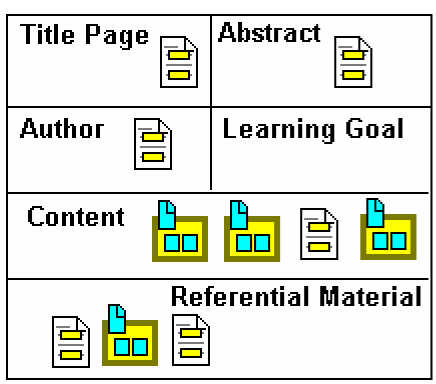

Figure 1: Learning Unit

There are a number of predefined templates (Learning unit types) where users can simply insert existing pages or other Learning units to define sophisticated navigable structures.

The system works with two internal presentations of Learning Units: HM-Data Model S-Collections [Helic et al., 1998] and SCORM packages [Advance Distributed Learning, 2001].

Learning Course is a special status of a previously created Learning Unit. If a Learning Unit gets a status of Learning Course, it gets also the following properties:

- Learners are provided with additional navigational tools including context-dependent search functions and graphical course structure overview.
- Tutors may control access to the course (courses may be public, restricted and private). Tutors may also administer learners having different rights for the course (some courses may be previewed by anonymous users, registered users may subscribe to the course themselves or via the tutor, etc.).
- Statistic and progress tracking information is automatically gathered for each learner subscribed for a particular course, and may be presented to the learner and/or to the tutor in different forms.
- Learners can add and change the material by annotating it for themselves or others: and others can again annotate notes made for others. Annotations can also take the form of links, i.e. material can be linked together by learners for their own benefit or the benefit of a whole group. Thus, learners themselves contribute to the course on the fly.
- An innovative collaborative environment supports synchronous or asynchronous communication between learners, human tutors and user groups. A structured discussion forum is provided for each course.

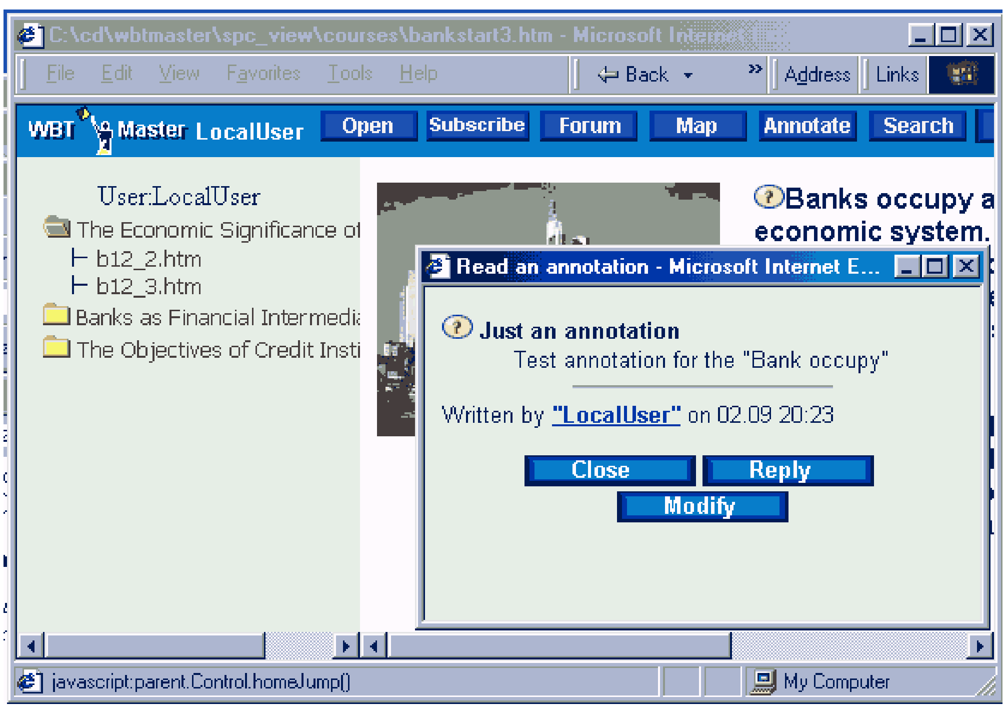

Figure 2: Working with a Learning Course

3 Web-based Tutoring

Basically, Web-based tutoring repeats the situation of Web-based training. The principal difference is that after having analyzed the problem, the tutor cannot develop the courseware, but he has a number of heterogeneous documents (Textual files, WinWord files, PowerPoint Presentations, Simulations, etc.) that can be used for training sessions. The tutor uploads the documents to the WBT-Master server and defines a special training schedule prescribing which document should be accessed at each particular stage and what actions are expected from a learner working with the document. For example, learners may be requested to read a document, work through test questions, work with a simulation package, etc. During the time slot allocated for the training session, the learners work through the training schedule and communicate with the tutor and with other group members.

WBT-Master supports such training schedules through the concept of so-called Learning Goals. The Learning Goal may be seen as an alternative to a Leaning Course. The concept of Learning Courses in WBT has a very serious default precondition: learners are basically supposed to get knowledge from courseware that is available anytime and everywhere. Tutors simply monitor and assist the process of knowledge acquisition that is carried out via "mouse-clicking", i.e. via browsing the courseware material. In the case where the tutor does not want to develop a learning course, but has a number of training resources that can be used to define a training schedule, WBT-Master provides a convenient tool to *prescribe* a set of so-called Learning Actions leading eventually to a designated Learning Goal without just pointing to a Learning Course.

This approach has a number of advantages in comparison with Learning Courses. First, a Learning Action is a much more interactive concept than just reading information chunks. A particular Learning Action may be: a reading session, communication with a tutor or another expert, passing a test, publishing a learner's own material, solving a training problem, etc.

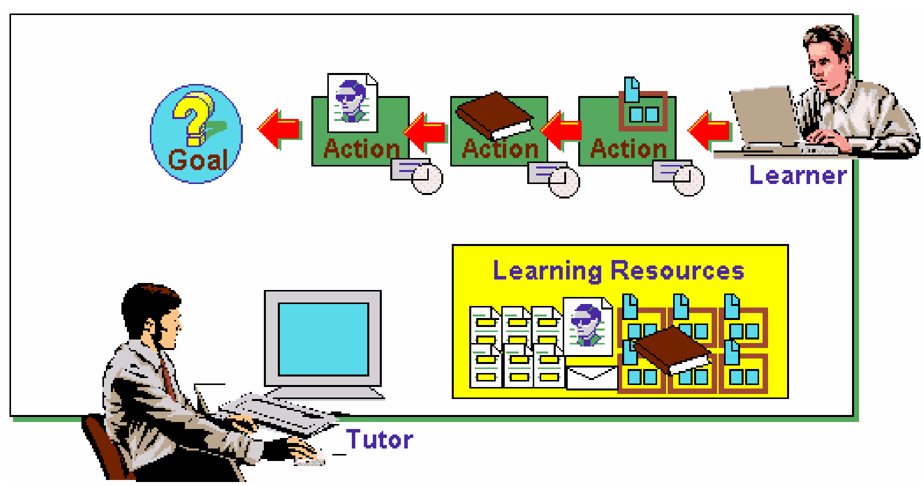

Figure 3: Authoring a Learning Goal

Another important aspect is that tutors can assess the Learning Actions carried out by learners during on-line sessions and, thus, communicate with the learners, track their activity and certify their results. Technically speaking, Learning Goals are defined by tutors in the form of structured collections of *Learning Actions*. Actions may be simple or complex. A complex Learning Action is a collection of other Learning Actions. A simple Learning Action is a request to carry out a particular action to move a user one step closer to the Learning Goal. A simple Learning Action is accompanied with a number of so-called *Learning Resources*. A Learning Resource is a WBT-Master object, i.e. a course, document, learning unit, discussion forum, brainstorming session, etc.

There may be the following simple Learning Actions (see Figure 4):

- Reading: a request to read (i.e. to access) one or more Learning Resources
- Questionnaire: a request to fill out one or more Test Questionnaires.
- Publication: a request to publish a document presenting the result of some work carried out by the student.
- Practical Work: a request to work with a real application.

Each Learning Action may have a particular time slot allocated to it that indicates when the action at issue has to be carried out. In other words, a Learning Goal may be described by a sequence of Learning Actions.

Each Learning Goal is defined by a *short name* (just one word without blank spaces) and by a *descriptive name* (a text defining the Learning Goal itself). The designated tutor for the users working with that particular goal creates a Learning Goal. The tutor gets additional rights, for example, the tutor may see user statistics, comment on a particular user actions, subscribe users for the Learning Goal, etc. Each Learning Goal has one or more user groups associated with it. All members of such associated user groups are *subscribed* to the Learning Goal.

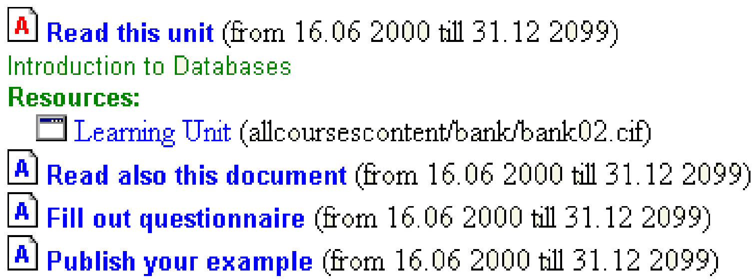

Figure 4: Defining Learning Actions

Learning Goals may be public, restricted or private. Any user may access a *public* Learning Goal and any registered user may subscribe to a public Learning Goal. *Restricted* and *private* Learning Goals are available only for *subscribed* users.

4 Web-based Mentoring

Web Based Mentoring may be explained with the following typical situation. A learner (or learning group) needs to solve a particular problem and he/she has an ongoing partnership with a mentor. The mentor is supposed to help the less experienced students acquire new knowledge in a topic area. The mentor accesses the server to initiate a special one-to-many synchronous communicational session with the learners. In the rest of this paper, this kind of communication will be called a "mentoring session".
The mentor explains the problem solution by guiding the mentoring session. Thus, the mentor may:

- Select a document which is automatically visualised on the learner's screen (share a document)
- Provide an explanation (text, voice and/or drawings) attached to the document
- Request the learner to perform an action, which may be monitored from the mentor's screen.

Similarly, the learner may:

- Provide comments (text, voice) to the shared document
- Ask questions (text, voice) in the context of the shared document.

WBT-Master provides tools that support conducting of mentoring sessions online. Additionally, the mentor may record an online mentoring session in order to reuse it later as a learning resource. Thus, Mentoring Sessions may be seen as:

- Special form of synchronous communication (online mentoring sessions)
- Special method of structuring and presenting to users existing learning resources (recorded mentoring sessions).

An online mentoring session is carried out as a data exchange between a mentor's client (so-called, leading client) and a number of learners' clients (so-called, led clients). A recorded mentoring session is prepared by means of a mentor's client and can be viewed anytime by means of a learner's client. The main idea is that the leading client is provided with a number of special tools to control the data displayed by the led clients to learners. Thus, a mentor initiates a mentoring session and defines restrictions for learners to join the session. Selected learners are automatically notified about the session and can join it (i.e. can activate their led clients). The mentor is informed about learners joining the session. The mentor selects and browses learning resources by means of the leading client. The leading client may be seen as a monitor controlling other WBT-Master tools and sharing the resource with led clients. The leading client simply passes the selected resource to the led screens.

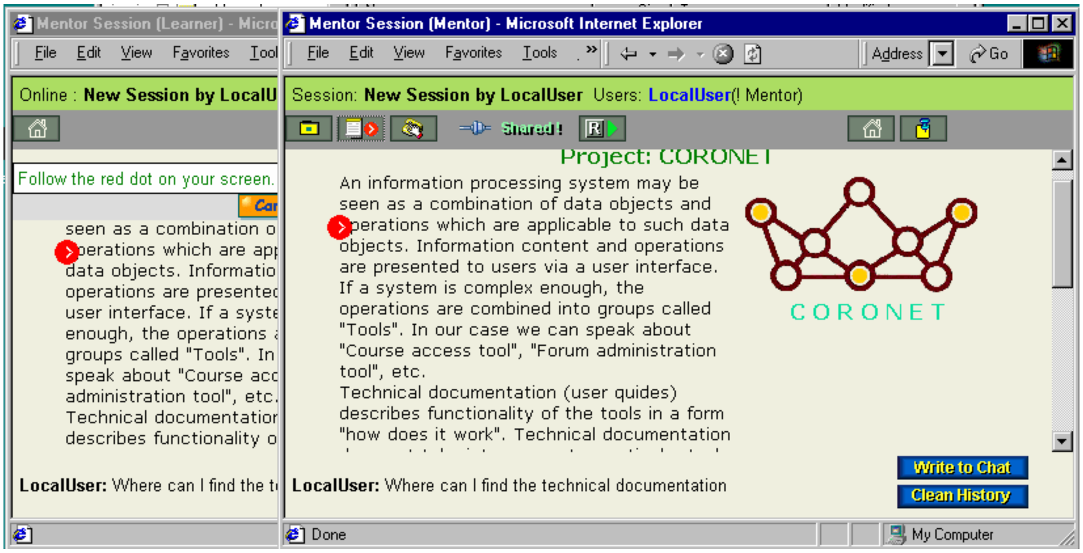

Figure 5: Running a mentoring session

Additionally, the mentor can attach an explanation (text, voice and/or live pointer) to such a shared resource. The explanations can take form of a chat session or a special transparent layer on the leading screen where pointer and texts may be put on top of a current picture. The explanatory layer is also automatically displayed on the led screens.
The leading client also can accept data from led clients. Thus, the mentor can request learners to perform an action (say, to write a short article), and they can then monitor the process from the leading client.

Learners are allowed to provide comments to a shared resource by means of special chat facilities. The same mechanism can be used to ask questions in the context of a shared resource.

5 Web-based Knowledge Mining

A typical situation involving the process of the knowledge mining may be as follows. A Learner needs training in a particular subject to acquire additional knowledge, and is aware that the WBT-Master server contains relevant information. The learner accesses the server to find most relevant material. They work through the material and communicate with subject experts as well as other learners working on similar materials.

Finding relevant learning resources in a WBT environment containing very many objects of different types (i.e. many courses, learning units, forums, learning goals, etc.) may constitute a serious problem. A search function often does not help because it analyses the document content as opposed to the knowledge that can be acquired from the learning resource. Moreover, accessing learning materials should also take into consideration a preferable learning style, preferable tutor, available certification facilities, etc.WBT-Master provides an alternative way of accessing preferred learning resources based on so-called Knowledge Cards (see Figure 4). The idea behind this concept is rather simple: Knowledge Cards allow the definition of a conceptual view of the server in the form of a collection of knowledge cards. A *Knowledge Card* is a description of particular concept (i.e. *semantic entity*). For example, a semantic entity "Database technology" may be seen as a knowledge card. In WBT-Master, knowledge cards may be combined into a *semantic network* [Lambiotte et al. 1984][Nosek and Roth 1990] using just one type of relationship: "is a part of". Inverse relationships may be called "consists of". For example, the knowledge card "Relational Data Model" may be related as "is a part of" to the knowledge card "Database Technology".

Thus, a knowledge card associated with some particular concept (e.g. "Database Technology") contains information on learning resources for this concept and can be related to other knowledge cards using the semantic relationship "is-a-part-of". The semantic relationships essentially define a graph structure (as opposed to just a hierarchical one). For example, the same knowledge card "Relational Data Model" may be defined as a part of "Introduction to Oracle", "Information Systems", etc. Moreover, there may be Knowledge Cards defining areas of personal interest: say "Personal Knowledge of H. Maurer" which may also refer to the previously mentioned card "Relational Data Model", etc. To be more concrete, each Knowledge Card may provide access to a number of associated Learning Resources. For example, a Learning Course "Relational Data Model" may be associated with the Knowledge Card "Relational Data Model". In addition, some other Learning Units, Learning Goals, Discussion Forums, Documents, etc. may be associated with the same Knowledge Card. Moreover, WBT-Master considers users to be Learning Resources (so called "Peer Helpers") as well. Thus, Peer Helpers may also be associated with a Knowledge Card.

Whenever a content provider contributes to the server with new material, he/she is supposed to associate it with one or more Knowledge Cards or create a new Knowledge card and place it into a proper position within the semantic network. Of course, a specially designated member of the server administration team (Knowledge engineer) may also do it.

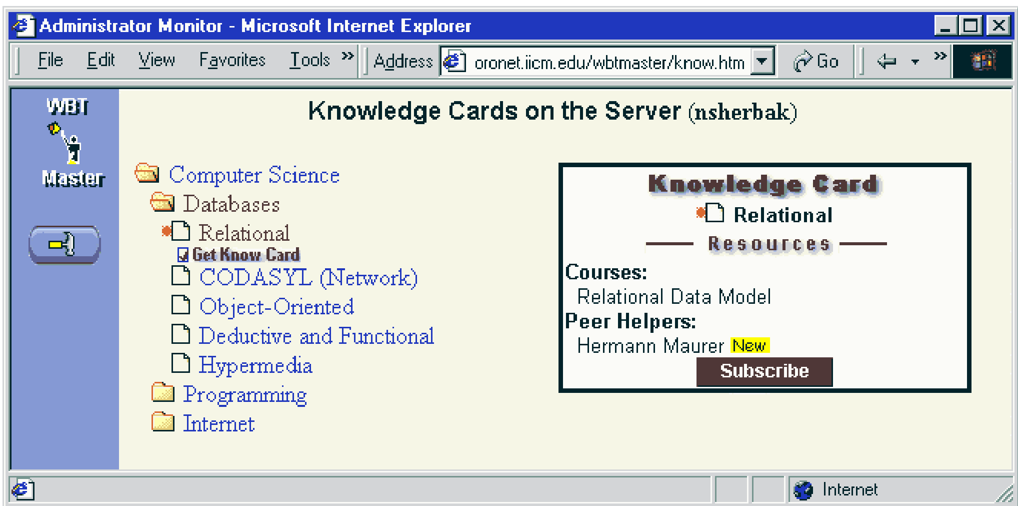

Figure 6: Resources attached to a Knowledge Card

Instead of browsing through countless learning resources new users are supposed, in the simplest case, to browse the semantic net consisting of previously defined Knowledge Cards (see Figure 6). We should especially mention the most important property of the semantic network - the possibility of inferring Learning Resources using semantic relationships. Whenever a user accesses a knowledge card, the system infers all Learning Resources that are associated with this particular Knowledge Card and with the Knowledge Cards related to this one. Thus, for example, suppose that there were no resources associated with the knowledge card "Computer Science", but a number of other cards (say, Databases, Programming, etc.) were defined as "is a part of" Computer Science. Accessing the "Computer Science" knowledge card will result in the resources inferred from other related cards.

The situation discussed above, leads us to a number of very important conclusions:

- Content providers do not need to search for a precise "knowledge card" to associate their resources with. They can simply define their own field of interest (say, "Personal Knowledge of H. Maurer" and associate all their resources with this card automatically). Other users may decide that "Personal Knowledge of H. Maurer" is an important contribution to the "Hypermedia" concept, and create a relationship between these two knowledge cards. Of course, "Personal Knowledge of H. Maurer" may be further structured as a number of knowledge cards (say, "Maurer & Theory", "Maurer & Hypermedia", etc.) that are related "as a part of" to "Personal Knowledge of H. Maurer".
- Learners do not need to browse the whole semantic net. They might be interested in defining a personal knowledge card related to the most important previously defined concepts of interest. In

this case, whenever a user accesses such a personal knowledge card all relevant resources will be inferred automatically.

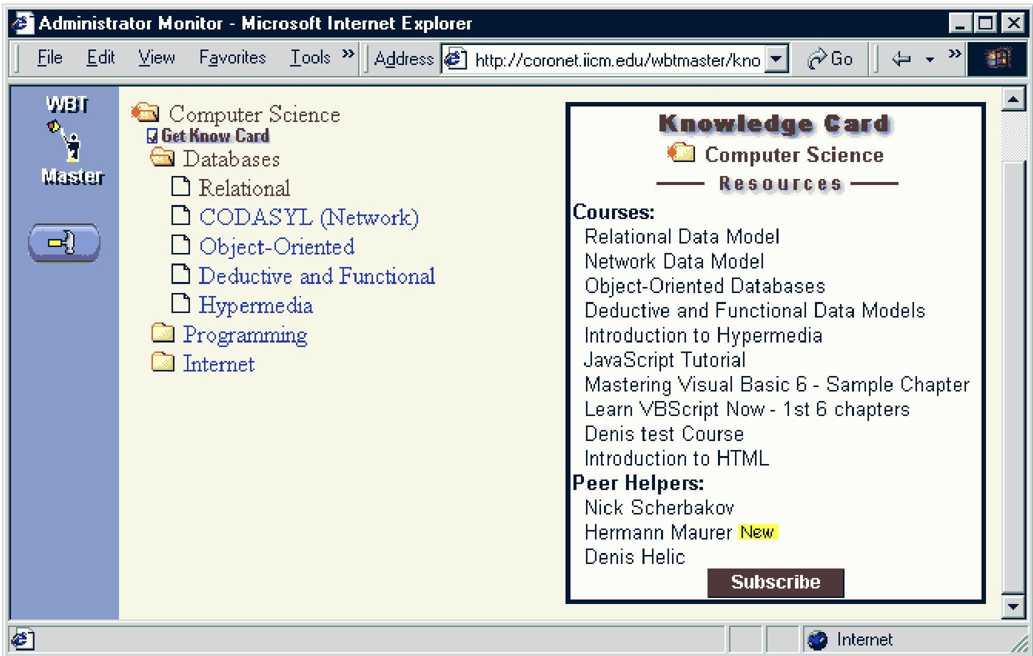

Figure 7: Resources automatically inferred for a Knowledge Card

A personal knowledge card may serve as a "customized" entry point to the server resources. The server may also automatically notify the learner about new resources that might be of interest.

6 Web-based Knowledge Profiling

The process of knowledge profiling may be explained through the following typical situation. Suppose a company needs to install knowledge profiles for each of its employment positions. The process may be seen as defining a position and providing descriptions of the knowledge components required for this position. Moreover, the knowledge components may be further associated with training resources which provide such knowledge. On joining the company an employee will need to be initiated into the practices and procedures of the organization. This will probably be achieved by them taking part in Web-based training sessions. So, they must be able see what knowledge is needed (i.e. they should be able to browse the position profile) and automatically access the training resources.

WBT-Master supports such knowledge profiling of learning resources in the form of Knowledge Domains. Each Knowledge Domain is a set of documents belonging to a number of predefined semantic categories. For the previously discussed example, we could speak about three semantic categories: Position, Resource and Know Component. For instance, we can also say that a document "Project Manager" (describing this position within the company) is an instance of the category "Position", a training course "Sub-contract management process" is an instance of the category "Resource" and a document "Sub-contracting" is an instance of the category "Know Component". Speaking in general terms, we can say that each semantic category is linked to a set of Learning Resources that are called instances of the category.

A *knowledge domain schema* may be seen as a definition of all categories and all possible semantic relationships between them.

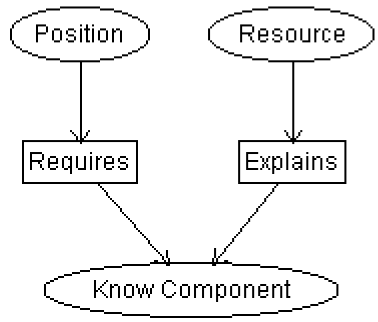

Figure 8: Schema of a Knowledge Domain

The definition of a Semantic Category includes the definition of a number of attributes, which are properties of instances of the Semantic Category. An attribute is a standard key-value pair. The value of an attribute is defined to be of a specified type, i.e., a value may be a string, a number or a selection from a list of possible values. For example, the category "Position" may have two associated attributes: name (string) and department (string). Similarly, the category "Know Component" may have just one associated attribute – name of the component.

Figure 9: Browsing a Knowledge Domain

The knowledge domain schema defines common properties of all the category instances. Any resource may be inserted (stored) into a particular knowledge domain as an instance of a predefined category. Thus, a responsible author simply selects an existing Knowledge Domain and a predefined category for a new resource and the system guides the author through the process of defining attributes and necessary relationships. For example, if a new instance of the category "Know Component" is created, the system automatically requests the selection of a name (an attribute predefined for the category). It also provides references to the resource where that "Know Component" is described and a certain position within the company (relationships predefined for the category). This, of course, facilitates the creation of well-structured repositories.

The concept of well-structured Knowledge Domains facilitates also browsing and searching the resources reused as instances of semantic categories. Thus, for example, whenever a user access the document "Sub-contract", the system automatically provides information on attributes attached to this document, references to instances of other knowledge categories which are related to this one, next/prior navigational tools, etc.

7 Web-based Knowledge Delivery

As we already saw, WBT-Master is a rather complex system, which supports dozens of different tools, utilizes many different data structuring facilities and provides access to thousands of different training resources. At the same time, a typical user works just with a few tools and resources and is mainly interested in:

- The most relevant and up-to-date training material, which can be automatically delivered to his/her personal desktop.
- A profiled schema of all relevant learning resources depicting relationships between resources.
- He/she is automatically notified about such new materials.
- Communication with the subject experts and other learners working on similar materials is possible via the desktop.
- A simple, unifying and intuitive user interface solution combining all relevant resources and tools.

Summarizing, learners are mainly interested in the process of obtaining the most relevant, up-to-date, and semantically described learning resources through a simple and intuitive user interface. We call this process the Web-based knowledge delivery.

WBT-Master supports such process through the concept of so-called Personal Desktop. At the first, Personal Desktop was developed as a simple WBT-Master user interface solution. Thus, a special customization mechanism was needed to adjust the rich system functionality to personal needs of a particular user or a group of users.

Moreover, the system was supposed to be used by learners who had no special knowledge on the system functionality and just needed to access especially designated training resources. Hence, the customization concept was extended in the sense that a tutor may decide on preferable user interface for such group of learners and on training resources, which are needed to accomplish a particular training task.

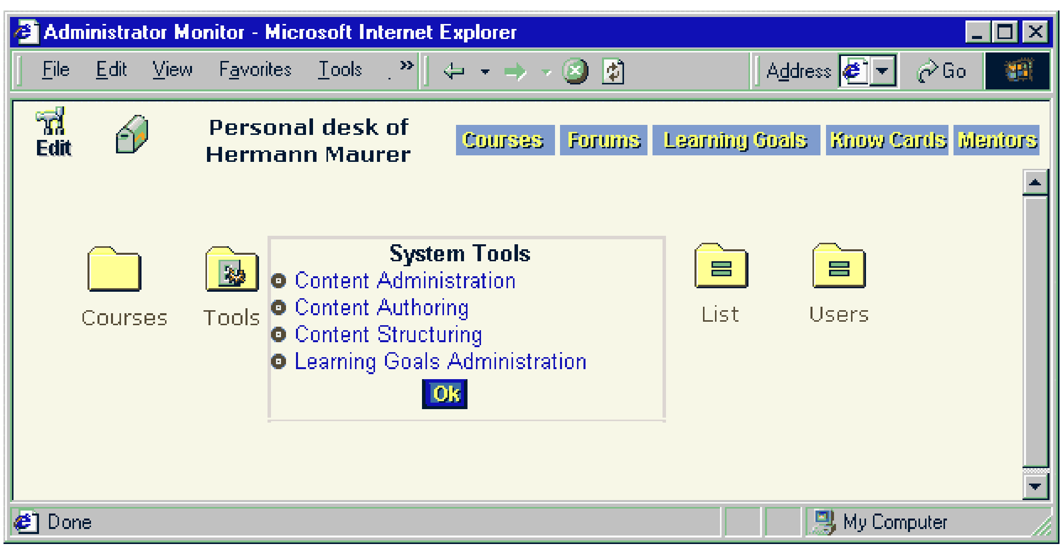

Figure 10: Personal Desktop

Conceptually, a Personal Desktop is just a set of folders containing references to designated learning resources and WBT-Master tools.

Another important aspect of the Desktop Concept is collaboration facilities, which are provided by so-called shared folders and internal messaging system. For example, a user group may share a certain folder to put all contributions of the group members into it. In this way, the contributions may be easily accessed by group members and discussed by attaching messages to such contributions.

Extending the functionality of Personal Desktop from a simple user interface solution to a knowledge delivery solution was rather simple. Such an extension of the personal desktop concept treats knowledge cards and knowledge domains as training objects that might be added to a personal desktop folder.

By adding a knowledge card as a training object in a personal desktop folder we achieve the following. Whenever users access a knowledge card from a personal desktop folder the system automatically infers all related and to that particular concept relevant training objects.

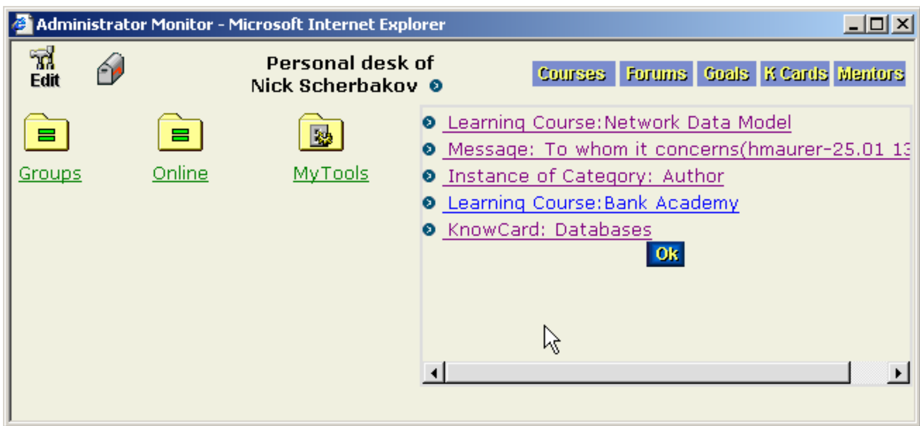

Figure 11: Adding a knowledge card to a personal desktop folder

If a new training object is associated with this knowledge card, the system automatically captures that change by inferring the newly added training object the next time we access the personal desktop folder. Thus, this mechanism is a rather robust one to changes in the underlying repository of training objects. On the other hand, by adding a knowledge domain to a personal desktop folder users are provided with possibility of browsing semantic overviews of training objects residing in the system. Again, if a new training object is added to such an overview, the system automatically updates the overview the next time when we access it. Thus, changes in the system's repository of training objects are captured again. Hence, by incorporating these two simple knowledge-processing mechanisms into the concept of personal desktop we were able to enhance personal desktop from a general user interface solution to a simple knowledge delivery tool.

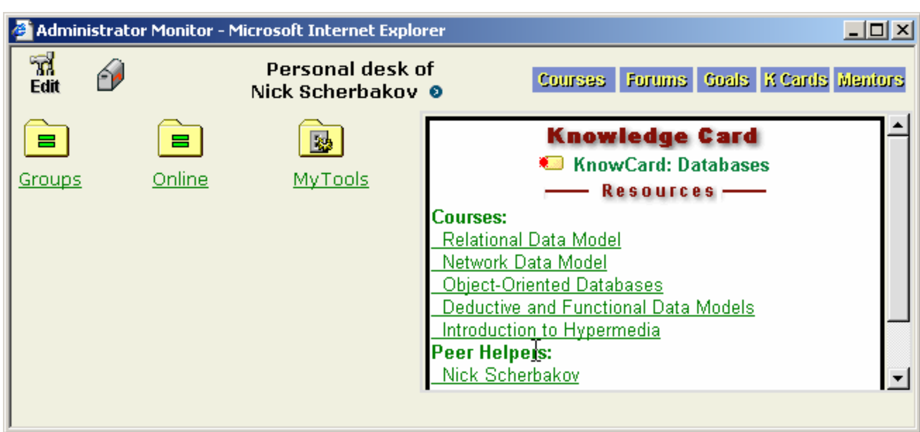

Figure 12: Accessing a knowledge card from a personal desktop folder

8 Evaluation of WBT-Master Concepts

WBT-Master was developed within the scope of CORONET (Corporate Software Engineering Knowledge Networks for Improved Training of the Work Force) project funded by the European Union. The CORONET project was running from Mai 2000 until Mai 2002. The project consortium consisted of:

- Center for Advanced Empirical Software Research, the University of New South Wales, Sydney, Australia
- Atlante, Madrid, Spain
- DaimlerChrysler, Ulm, Germany
- Fraunhofer Institute for Experimental Software Engineering (IESE), Kaiserslautern, Germany
- Fraunhofer Institut for Computer Graphics (IGD), Darmstadt, Germany
- Highware, Paris, France
- Institute for Information Processing and Computer Supported New Media (IICM), the University of Technology, Graz, Austria
- Centro de Computacao Grafica, Coimbra, Portugal

WBT-Master was mainly developed by IICM. The application partners in the project were DaimlerChrysler, both Fraunhofer institutes, and Highware. These institutions deployed WBT-Master and evaluated it in a wide range of possible applications.

8.1 The CORONET Project Evaluation Approach

The CORONET project evaluation activities were performed through the following 3 phases [CORONET, 2002]:

- Phase 1 (June – August 2001): In-depth assessment of the first WBT-Master prototype. The results from this evaluation were the main input for the enhancement of the CORONET methodology and infrastructure during the 2nd cycle of the CORONET project.
- Phase 2 (September 2001 – April 2002): Continuous evaluation studies performed with the WBT-Master prototype in parallel with incremental enhancements of the product.
- Phase 3 (February – April 2002): In-depth assessment of the improved WBT-Master prototype.

The three phases were performed in a systematic way during the project according to a detailed evaluation plan developed during cycle 1 of the CORONET project. The evaluation approach was fine tuned with the contribution of software and learning evaluation experts involved as member of the CORONET Pedagogic Advisory Board. Furthermore, the evaluation activities during phase 2 and 3 were monitored by additional requests derived from phase 1 results and from the comments of the 2nd and 3rd CEC in-depth project reviews in Paris (June 2001) and Madrid (March 2002).

General goals for WBT-Master evaluation were:

- Analysis of learning effectiveness: Evaluating the effectiveness of WBT-Master system in supporting knowledge sharing and collaborative learning.
- Usability analysis: Evaluating the perceived ease of use and the perceived usefulness of WBT-Master system, i.e. documentation and WBT-Master functionality.
- Cost-Benefit Analysis (CBA): Evaluating the cost-benefit ratio of using WBT-Master system.

In order to evaluate WBT-Master, the four partners that conducted the evaluation chose a "mixed evaluation" approach, where not each partner focused on all of the goals, but selected one or more focus areas in which individually tailored evaluation processes were applied.

To analyze learning effectiveness DaimlerChrysler, consistent with its role of software development organization, focused on evaluating the effectiveness of WBT-Master in supporting continuing, self-directed, collaborative learning. The evaluation process was based upon the cognitive load theory and relied on a series of specifically designed evaluation sessions that were conducted in a specifically established evaluation laboratory setting, involving members of the research group as well as members of a business unit. Fraunhofer IESE, consistent with its role of research institute, focused on evaluating the effectiveness of WBT-Master in supporting collaboration and knowledge sharing. This was done by conducting two quasi experiments that compared the efficiency and effectiveness of conducting similar tasks with and without using WBT-Master. Highware, consistent with its role of training service provider, focused on evaluating the effectiveness of WBT-Master in supporting web-based learning by training and web-based experience sharing. Evaluation data was collected with the help of specifically designed questionnaires.

To perform usability analysis Perceived Ease of Use (PEU) and Perceived Usefulness (PU) of WBT-Master from the point of view of end users was estimated. In order to analyze the PEU and PU end users were requested to answer related sets of questions. For data collection, specifically designed questionnaires were distributed to end users of WBT-Master at the end of running a particular learning scenario. In order to test the reliability of their analysis results Fraunhofer IESE calculated and interpreted Cohen's Kappa coefficient. DaimlerChrysler used the questionnaire ISONORM 9241/10, which was evaluated with respect to validity and reliability. The ISONORM questionnaire was derived from the software ergonomic standard DIN EN ISO 9241.

Finally, Fraunhofer IESE designed and guided the cost-benefit analysis. Cost-benefit data was collected by DaimlerChrysler and Highware with the help of specifically designed data collection forms. The cost-benefit analysis was based on a 3-phase learning reference model. The purpose of this model is to provide a common basis for comparing different learning and training approaches in one common framework. The reference model consists of the following main phases:

- Pre-Learning Phase: comprising all relevant activities before learning is performed.
- Learning Phase: comprising all relevant activities during learning.
- Post-Learning Phase: comprising all activities happening after learning is finished.

For each of the phases, during the evaluation studies conducted by the application partners DaimlerChrysler and Highware, associated cost and benefit data was collected.

8.2 Evaluation Results

The first evaluation goal focused on the effectiveness of learning with WBT-Master from the perspective of software organizations, software engineering research organization, and software training service providers, i.e. DaimlerChrysler, Fraunhofer IESE, and Highware. In accordance with the findings related to the first goal, all partners appreciated the innovative concepts offered by WBT-Master.

Nevertheless, the results of the evaluation studies related to learning effectiveness were not fully consistent. The data reported by scientists, software engineers, and software trainers at Fraunhofer IESE, Highware, and Highware's partner and customer organizations generally indicated improved learning effectiveness when using WBT-Master. The analysis of learning effectiveness conducted by DaimlerChrysler was partly influenced by negative judgment of the usability of the WBT-Master platform. This was reflected by the data received from DaimlerChrysler system users who expressed the feeling that the cognitive load associated with tool usage prevented them from learning in the proper sense.

In addition to the evaluation studies conducted by DaimlerChrysler, Fraunhofer IESE and Highware within the scope of the CORONET project, a large number of students (more than 100) at the Technical University of Graz have been using WBT-Master extensively since mid-2001 without major problems, thus confirming that the system can be considered a helpful instrument for collaborative learning and knowledge sharing.

As a by-product of the analysis of learning effectiveness, some observations and conclusions on cultural and organizational aspects could be drawn from the associated evaluation studies. The analysis of WBT-Master user profiles clearly showed that there was a positive predisposition to work with a web-based learning environment as most of the users had been familiar with ICT for more than two years. However, some cultural factors were detected as being critical. They should be taken into account when introducing and operating WBT-Master.

First, shifting to e-learning clearly requests changes in the behavior of nearly all the roles involved. The changes are mainly related to:

- Learning approach: shifting from the conventional presence learning mode to using the internet is not obvious for learners who have not yet had experience with or have not been prepared to using the new learning and knowledge transfer processes offered by a web-based learning environment.
- Pedagogical approach: replacing interpersonal relations typically occurring in conventional classroom settings by interactions between the learner and the web-based learning environment requires new competence on the part of trainers, tutors, and authors of learning materials.

Using a learning environment like WBT-Master is not a one-shot experience: it is highly recommended to properly introduce both the methodology and the infrastructure to all types of users in order to facilitate the adequate use of the learning environment. It clearly appeared from all evaluation studies that system users need some time to handle the new environment before focusing on any specific learning activity.

Here are some highlights from the evaluation at DaimlerChrysler. In total, forty individuals were involved in DaimlerChrysler's evaluation studies. Twelve of them actively participated in thirty-four in-depth evaluation sessions. The qualitative analyses applied to the "think-aloud protocols" and recorded video tapes of the evaluation sessions indicated that the concepts offered by WBT-Master (e.g. to combine collaboration and document work) were generally appreciated by system users. The following functionalities were considered most beneficial for the specific setting of DaimlerChrysler's evaluation study:

- Knowledge cards for self-paced worker's knowledge mining,
- Mentoring session for the experts to give advice, and
- Various collaboration tools, i.e. forums and virtual rooms, to collaborative problem-solving with peer learners, and collaborative knowledge building.

The positive impression, however, was negatively influenced by the subjective perception that the current version of the learning prototype platform WBT-Master was too difficult to use. In particular, the various options for communication/collaboration were perceived as too numerous, too spread out, and too hard to differentiate. One possible explanation for these partly negative results is that DaimlerChrysler's software engineers have to cope with extremely high pressure to continuously upgrade their knowledge on-the-job, possibly without spending any effort other than the project-related effort to learning. Hence, this highly specialized clientele is used to (and needs to) work with a software environment that perfectly matches their specific expectations and does not require any introduction and learning curve. Thus, the tolerance level towards deviations between expectations and actual behavior of a new learning environment is rather low. This might explain why WBT-Master, having the maturity of a research prototype, had problems to meet the high expectations of DaimlerChrysler's trial users.

Some highlights of the Fraunhofer IESE's evaluation are as follows. In total, seven individuals actively participated in Fraunhofer IESE's evaluation studies. The results of the evaluation studies show that knowledge sharing activities in a research department setting can be performed more efficiently and more effectively with using the knowledge transfer functionality offered by WBT-Master.

Finally, some of the results of the evaluation at Highware are as follows. In total, thirty-two individuals actively participated in Highware's evaluation studies. The results of the evaluation studies were in its majority positive. The main findings can be summarized as follows:

- The concepts contained in the learning methodology of WBT-Master are presented in a clear and concise style so that learners, trainers, tutors, and authors can easily identify the right learning scenario for their particular learning/training needs. This was particularly true for the scenario web-based training, which was one focus of Highware's evaluation studies.
- The Mentoring Session functionality provided by WBT-Master offers a viable alternative to classical in-class training settings. The effectiveness of virtual classes was judged of being at least as effective as conventional in-class sessions.
- Regarding the effective support of web-based experience sharing, the second focus of Highware's evaluation studies, WBT-Master successfully helped establish a network of geographically distributed learners. From the point of view of the management, the establishment of such a

network, facilitating learning at the workplace by connecting people to a network of distributed learning resources (documents, courseware, peers and experts) was considered as one of the main strengths of the CORONET system.
- Since the main focus of the CORONET project was to develop innovative solutions to support collaborative web-based learning, it was not surprising that evaluation results judged WBT-Master being acceptable as a training management system, but several proposals for future enhancements were made.

It was interesting to observe that the results of the evaluation studies conducted within Highware and in collaboration with Highware's partner and customer organizations in real business cases were more positive than the results of DaimlerChrysler, the other industrial partner in the CORONET consortium. One possible explanation is the following: Since the use cases defined by Highware were more focused, relatively less effort for introducing WBT-Master to their own staff and to their customers was needed. This helped avoid misunderstandings of the concepts and paved the way for better tool acceptance. It also meant that both Highware staff members (who used the system internally) and end users of Highware's partners and customers were more tolerant towards a prototype system that obviously is not yet perfect (and thus imposes an initial learning curve) but delivers innovative functionality. Another explanation might be the differences between organizational cultures involved in DaimlerChrysler's and Highware's evaluation studies. Both DaimlerChrysler and Highware (and its partners and customers) are highly professional and successful in their respective businesses, but the individuals involved in DaimlerChrysler's evaluation sessions mainly work in complex team-oriented organizational settings with a strong product focus, whereas the individuals involved in Highware's evaluation sessions mainly work in small to medium sized network-like organizational settings with a strong service focus. Whether cultural differences induced by the different geo-political settings of the studies could also account for the different findings was not investigated.

Case studies to analyze perceived ease of use (PEU) and perceived usefulness (PU) of WBT-Master were conducted by DaimlerChrysler, Fraunhofer IESE, Fraunhofer IGD, and Highware. The data analyses of the various evaluation studies did not result in a consistent view. While subjective user acceptance of WBT-Master by individuals involved in DaimlerChrysler's evaluation studies turned out to be insufficient in its majority, evaluation data provided by WBT-Master users at Fraunhofer IESE, Fraunhofer IGD, and Highware (including their partner and customer organizations) showed positive PEU and PU ratings.

An explanation for this inconsistent result could be the different approaches that were chosen to conduct the evaluation studies. DaimlerChrysler based their analysis on very complex use cases that require a relatively high usability of the tool environment in order to avoid that system users resign from trial experiments. Given that WBT-Master is a prototype platform – and not a fully developed product – time constraints coupled with high expectations of the system users and their low level of tolerance towards initial learning curves resulted in low usability ratings. Hence, the partial non-acceptance of the system by DaimlerChrysler users might be perceived as a confirmation of the project intention to develop a usable prototype, but not an "off-the-shelf" software product. Due to the different nature of their use cases and the associated learning scenarios it was less difficult for the other partners (Highware, Fraunhofer IESE and Fraunhofer IGD) to introduce the system as a working prototype to their respective end users. As a consequence, in their evaluation studies these partners better managed to focus on innovative functionality and to invest into providing additional learning and user support (which would not be needed for a software product). This led to the positive results of the usability studies of these partners, reconfirming the overall project success.

The results of the Cost-Benefit Analysis (CBA) were gained from data collected by DaimlerChrysler and Highware in seven evaluation studies conducted across two evaluation cycles. The majority of the results showed that using WBT-Master is – in addition to the non-monetary benefits generated by the innovative methodology and infrastructure – beneficial from the monetary perspective. The CBA showed that:
- For Highware, a training provider, using WBT-Master increases the Net Present Value (NPV) and thus can be considered as being monetarily beneficial.

- For DaimlerChrysler, which is not a training provider, using WBT-Master does not generate a positive NPV in a short term. However, using WBT-Master over a period of more than three years is expected to result in a positive monetary effect.

Generalizing the CBA results, it can be expected that:

- Training providers can be advised to buy and apply WBT-Master "as-is" because cost savings along with a profit increase caused by travel cost reduction, reuse of training materials, and additional (new) customer services (based on the CORONET features) that generate additional revenue can be expected.
- Customers of training providers will experience – besides the non-monetary benefits of CORONET – a cost reduction through reduced inter-location travel of the employees attending to the CORONET-based training.
- Non-training providers, i.e. software development organizations, can reach a positive NPV in the training and learning cost by using CORONET for a few years.

9 Conclusions

In summary, the following features of the WBT-Master distinguish it from other existing WBT systems:

- In addition to existing data structures based on hypermedia links, it introduces such new innovative composite training resources as reusable Learning Units, Learning Goals, Knowledge Cards, Mentoring Sessions, Knowledge Domains and more.
- WBT-Master enables synchronous and asynchronous communication among distributed teams and team members. This includes discussion forums, brain storming sessions, chats, annotation facilities etc. The variety of communicational tools supports collaboration between different users working together.
- In addition to especially prepared training materials, anything that is part of the stored enterprise knowledge, such as e.g. technical documents, presentations, or the personal experiences of employees can be used as learning resources via the Internet or Intranet. Note that the system essentially supports addressing human subject matter experts as learning resources.
- Since all information services operate with unified data structures, results of any collaboration (discussion sessions, brainstorming sessions, annotations, question-answer dialogs, etc) can be seen as new training material and can be reused by others
- The WBT-Master methodology represents a fundamental shift from a classical "online course" model of a standard WBT system. Usually, the standard WBT system reflects Internet technology providing access to courseware "anytime anywhere". On the contrary, WBT-Master tries to use Internet technologies to capture the best elements of what works so well in a classic classroom training. This methodology provides possibilities to transfer human knowledge in a much more general sense by incorporating the knowledge transfer processes such as Web-based tutoring, Web-based mentoring, knowledge mining and knowledge profiling.

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