Supporting Cooperative Learning of Process Knowledge on the World Wide Web

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Abstract

The WWW makes learning materials widely accessible and provides an environment where people can learn across time and space. However, the simple read-only information structure on the Web provides little or very limited guidance to learners, especially when they want to learn how to do something through interaction with computers and other people. We suggest overcoming the problem by introducing a graphical hypermedia-based process representation and a cooperative process enactment support. The hypermedia-based process structure is accessible on the WWW. It contains a rich set of associated materials with which people can seamlessly interact while they are systematically carrying out the process they are learning under the guidance of computers or tutors. A hypermedia based process support system and a use case are presented. The use case shows that such a system can not only provide traditional learning support, but also offers novel cooperative hypermedia based support for the learning of process knowledge.

1. Introduction

In today's global economy, organizations are becoming increasingly distributed. Furthermore, new forms of virtual organizations are emerging. As a consequence, teams carrying out business processes in a collaborative way are increasingly distributed and constantly changing. In addition, the business processes to be executed are changing in our global economy. Together, these trends require those teams

(1) learn what business processes they shall execute collaboratively,

(2) learn how they can execute these processes effectively in a distributed team,

(3) carry out the work collaboratively following the intended process, and

(4) adapt the process to the needs of the team and the actual situation. Thus, a platform is needed which supports teams in the description and definition of processes, the learning of these processes, and the adaptation and execution of these processes.

The Internet and the WWW make information widely accessible and provide an environment within which people can learn and perform work whenever they want and wherever they are. However, the simple read-only information structure of the Web creates several problems: Firstly, it provides learners with little or very limited guidance, especially when they want to learn how to do something through interaction with computers and other people. The simple HTML-based information structure can not represent a process structure graphically. Therefore, it is difficult for learners to get an overview of the process they are learning. Secondly, the read-only restriction prevents team members from changing a process description, either individually or cooperatively, based on the changing situation and what they have previously learnt. This restriction also prevents learners from getting interactive support from computers and other learners or tutors.

In this paper, we describe how to use and augment the WWW to overcome the above problems. Our approach to supporting teams in the description and definition of processes, the learning of these processes, and the adaptation and execution of these processes can be outlined as follows:

- Use advanced hypermedia structures, i.e., extended links and composite nodes, to enrich the information structure of the current Web, as is required for process modeling;
- Integrate process support into the advanced hypermedia structure that is superimposed on the current Web, as is required for supporting collaborative process execution;
- Use the authoring and cooperation capabilities of a cooperative hypermedia system to support cooperative modeling, changing, and execution of both learning processes as well as the business processes to be learnt;
- Make the cooperative hypermedia-based process support accessible on the Web; and
- Provide traditional plus cooperative hypermedia-based process support for the learning of process knowledge.

The remainder of the paper is organized as follows: In section 2, our enabling technology, the cooperative hypermedia-based approach to process supports, is presented. Section 2.1 describes the principle of our flexible cooperative hypermedia based process support. Section 2.2 presents a cooperative process support system (XCHIPS) implemented with the approach. After these technical descriptions, section 3 uses a use case scenario to describe how the support for the learning of process knowledge is provided by XCHIPS. In section 3.1, a use case scenario is described. In section 3.2, the learning process for process knowledge and our support for the learning process are described. Section 3.3 presents our support for traditional learning skills (or teaching resources) on process knowledge learning. This section also reveals how the cooperative learning support can enrich the traditional means for the learning of process knowledge. Section 4 discusses related work. The paper concludes with a summary and plans for future work. For a quick grasp of the cooperative learning aspects of the paper, readers may also go through section 3 before the more technical oriented section 2.

2. Cooperative hypermedia approach to process support

In this section, the concepts of cooperative hypermedia and the principle of cooperative hypermedia based process support are presented. Then, a prototype system implemented with the cooperative hypermedia based approach is described.

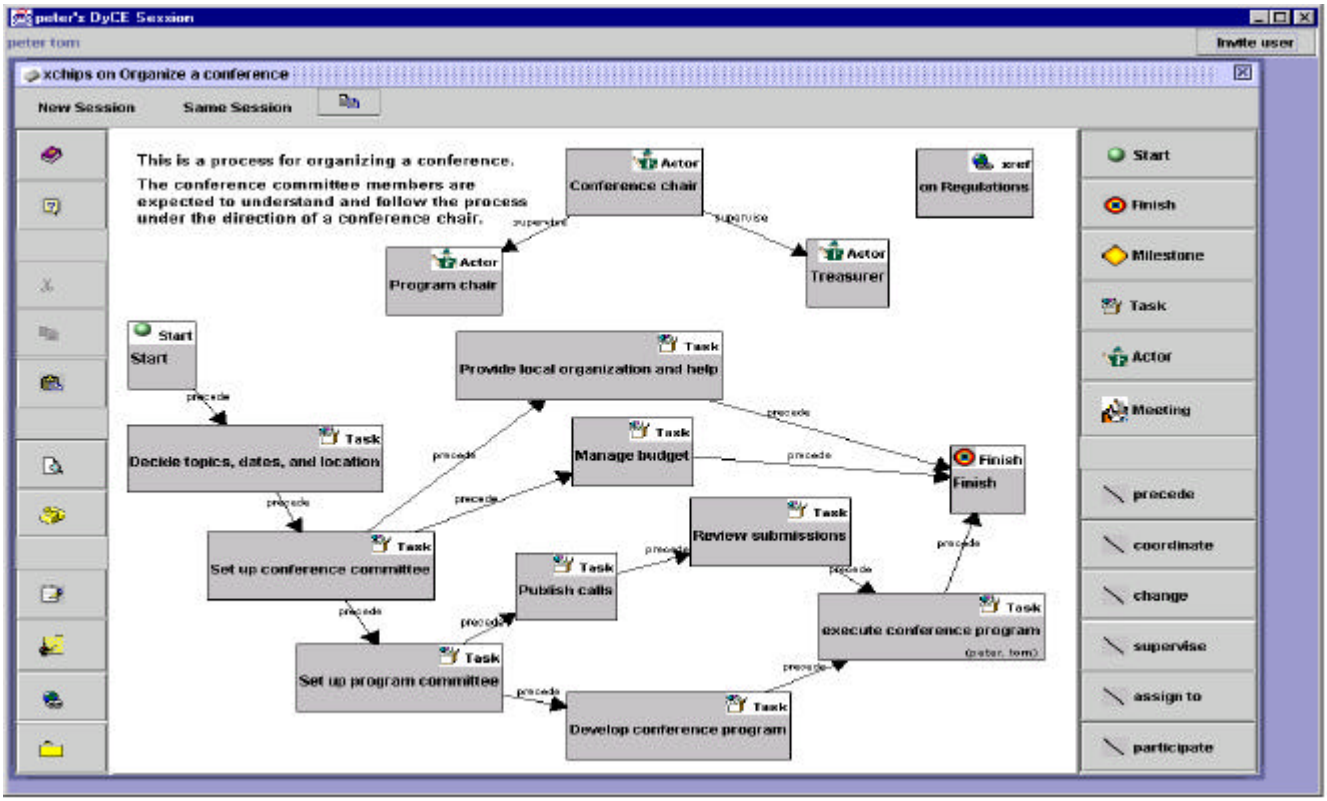
2.1. Flexible, cooperative, hypermedia-based process support

A work procedure in a workflow system is defined by a workflow model composed of a set of discrete work steps with explicit specifications of how a unit of work flows among the different steps [2]. In general, a workflow coordination model can be defined as a directed graph, (N, L), with a node set N representing individual steps in the procedure and an edge set L representing the coordination structure among the tasks [8].

The hypertext concept distinguishes information components (nodes) which are connected by relationships (links) [13]. Using links, linear as well as nonlinear network structures can be formed. In addition to the basic notion of nodes and links, one can introduce types of nodes and types of links. These types can be used to capture application or domain semantics, e.g., by determining allowed types of nodes as link end points of specific types of links. In addition to simple nodes, many hypertext systems introduced composite nodes (composites) that can contain other nodes and links. Thus, they can be used to form aggregated subnets within the hyperdocument, which lead to the possibility of layered graphs or networks. Hypermedia extends the hypertext concept by allowing any kind of multimedia information to be the content of nodes. Collaborative hypermedia now adds to the hypermedia concept the possibility of sharing a hypermedia workspace among many people.

Both the logical structures of a workflow process and a hypermedia network can be seen as a directed graph. This makes the correspondence between many workflow concepts and hypermedia concepts straightforward. For instance, tasks correspond to nodes. Control and data flow connectors between tasks correspond to links. Process execution corresponds to guided tours through a hypertext graph. The key difference between these worlds is that process structures have their own computational semantics, such as task state transitions and flow dependencies, while hypermedia structures usually have no such semantics.

Our approach to modeling processes is to incorporate task-related attributes, such as state and time, into hypertext nodes, and incorporate control flow and data flow semantics into hypertext links [5, 10]. Thus, a



process is represented as a set of hypermedia task nodes connected by process links. Ordinary hypermedia links, nodes, and media objects are application-specific. They are usually not directly accessible to a workflow system. However, in this model they are represented in a unified hypertext model and therefore accessible by our system. Such a hypermedia-based process support system can provide support for a wide range of processes from very informal ones that guide people to perform their tasks to very formal workflow processes with automatic execution support. The composite structure of nested nodes of different types can provide different coordination support for differently structured subtasks. Such a hypermedia-based process description can contain a rich set of associated materials with which people can seamlessly interact while they are carrying out the primary task. More technical details on the cooperative hypermedia based process support can be found in [5, 10, and 11].

Figure 1. Process structure for organizing a conference in an XCHIPS browser

2.2. The XCHIPS system

Based on the hypermedia-based process support approach, we have developed XCHIPS. XCHIPS stands for eXtensible Cooperative Hypermedia Integrated with Process Support. The XCHIPS system contains a set of tools (components) for people to create and use hypermedia objects cooperatively. It is implemented using Java and a Java-based Dynamic Collaboration Environment (DyCE) [12]. DyCE is a framework for creating mobile groupware components that are loaded on demand. It provides dynamically replicated-shared data as well as transactional support for access to and modification of this shared data. Additionally, DyCE provides dynamic extension of the working environment in the sense of adding groupware components at runtime.

2.2.1. Components and shared objects. The XCHIPS collaborative components developed on DyCE can be registered to a server and transferred across the Internet. These components may work as Java applications or Java

applets that are executable in standard WWW browsers. In the XCHIPS system, both the hypermedia-based process structure and its associated information are represented in object-oriented shared data models of the collaborative components. These data models are stored on one or more DyCE servers and replicated to client applications when needed. They can also be imported from and exported to documents in XML.

2.2.2. Process structure representation. In XCHIPS, the process structure is represented by composite nodes and extended XML links. Composite nodes are graphically presented as labeled icons and the extended links are graphically presented as labeled arrow lines between the node icons. The common WWW embedded links (i.e. the HTML links or simple XML links) can be used to point to the content information of a task or associated reference materials. They are presented as link markers with a special icon image. Composite nodes may contain other nodes, links, and information objects. An XCHIPS browser has been developed to present and edit the graphical process structure, its associated content objects and HTML links. The state information of task nodes is color-coded in their iconified views (white for inactive, yellow for enabled, green for active and brown for completed). Tasks are performed by menu operations activated on the task nodes. For the common WWW embedded links, when activated, their content pages will be presented in standard Web browsers (i.e., Netscape and IE).

2.2.3. The XCHIPS browser. There are two object palettes on the XCHIPS browser: a tool palette on the left-hand side and an object palette on right-hand side of the browser (see Figure 1). The tool palette contains groupware tools and information organization tools. The groupware tools include a User Guide Browser, an Example Browser, a Paste tool, a Search tool, a Chat tool, and a Whiteboard tool. The information organization tools include hypermedia objects for creating Notepads, Embedded Links and Folders. The object palette on the right-hand side contains hypermedia objects used to represent workflow processes. These objects are "Start", "Finish", "Milestone", "Task", "Actor", and "Meeting" nodes, and "precede", "coordinate", "change", "supervise", "assign to", and "participate" links.

2.2.4. Sessions. The XCHIPS browser is itself a groupware tool. In addition, all tools activated from its tool palette or its content pane are also groupware tools. These groupware tools are used in sessions. A session is formed of a collection of people, tools, and content objects. The groupware tools can be activated in the same session (thus becoming accessible to all users within this session) or in a new session (providing a simple transition between coupled cooperative and individual work). Users can invite other users to join their working session by activating the *Invite user* button at the upper right corner of the session browser. Users can also use the query tool to search for all the active sessions and request to join selected sessions.

2.2.5. Working modes. The XCHIPS browser can be launched in private, loosely coupled or tightly coupled working modes, and users may switch among these modes within a collaborative working process. In these working modes, some aspects of shared objects, such as the current node and the position of the scrollbar of the content pane, are coupled in different ways. For instance, in a loosely coupled cooperation mode, the navigation action of a user does not affect the browsers of other cooperating users. However, if users work in a tightly coupled cooperation mode, all users follow the navigational actions of other group members in the same session.

3. Supporting cooperative learning of process knowledge in XCHIPS

In this section, we first introduce a use case scenario. Then we use this scenario throughout all the subsections to show

- how the process for learning how to do something (i.e., the learning process) and the process on doing something (i.e., the business process to be learnt) is supported, and
- how both traditional support and newer flexible, cooperative hypermedia based process support for the learning of the process knowledge is provided by the XCHIPS system.

3.1. Use case scenario

Peter is a distinguished scientist. He is invited to serve as the next conference chair of a conference series. He has had no such experience before. Therefore, he wants to learn how to organize a conference, as conference chair. Peter's friend John, who lives in another country, has served as conference chair for this conference series. Therefore, Peter contacts John for

advice. Coincidentally, John has documented the process for organizing the conference in the XCHIPS system, so he simply sends a URL to Peter. The scenario is continued in the following sections in italic font.

3.2. Support for the learning process and the business process to be learnt

There are a number of different types of learning, such as learning to remember something, learning to understand something, learning a skill and learning how to do something. The learning process for learning how to do something is a simple process involving three steps [1]:

(1) determine the purpose,

(2) identify the procedures involved, and

(3) practice the task.

The following sub sections provide more details on these steps and describe how they can be supported by the XCHIPS system.

3.2.1. Determining the purpose. A clear understanding of the purpose of what we are trying to learn may motivate us to learn. The XCHIPS system supports the explicit formulation of goals and allows learners to access this information for facilitating a better understanding. A hypermedia-based process structure may contain the process definition and other relevant information resources; the goals can be expressed as textual annotations to the process structure. *After receiving the URL from John, Peter types it into the URL field of the Web browser on his computer desktop. An XCHIPS browser appears and its content page contains a graphical representation of the process structure for organizing a conference (see Figure 1). On the top of the content pane, there is a textual annotation that says, "This is a process for organizing a conference. The conference committee members are expected to understand and follow the process under the direction of a conference chair ". Peter is very happy, as this is just what he wants.*

3.2.2. Identifying the procedures. There are many ways to identify the procedures of how to do something. One way is to extract them from written instructions. Another way is to examine documented examples. The third way is to watch someone else doing it or interview someone who knows how to do it. The identified procedures on how to do something can be externalized in a graphical process representation, maybe first on paper and then in computer using the hypermedia-based process representation. In the XCHIPS system, the identified procedures on how to do something can be externalized in a graphical hypermedia-based process structure, in which tasks are represented as task nodes and precedence relationships between tasks are represented as process links. Other associated information, such as team and role based organization structure and referential materials can be represented using ordinary hypermedia nodes, links, and other content objects. *When John was to serve as a conference chair for the first time, he had the same learning need. He spent a lot of time reading texts on how to organize conferences, examining various conference Web pages, and talking to experienced people. When he finally figured out how to organize a conference, he documented the process in the XCHIPS system and used the process structure as a systematic guidance for learning and execution support.*

3.2.3. Practicing. We will learn how to do something successfully only by practicing it. We can practice the tasks in a process following the identified procedures. *As described in the next section, Peter has studied the process structure and practiced it virtually using both traditional learning support and cooperative hypermedia based support provided by XCHIPS.*

3.3. Traditional plus new kind of support

The headings of the following subsections are named after the widely used learning skills or teaching resources for learning how to do something [1]. In each subsection, we first briefly introduce one or two such traditional learning skills. Then, we describe how they are supported in the XCHIPS system. Finally, we continue the scenario to further highlight such support, especially the newer ingredients for cooperative learning.

3.3.1. Written instruction and examples. One way of learning how to do something is by following written instructions. These instructions summarize the main points to be learnt and provide us with background reference material. In the XCHIPS system, such instructions are provided as annotations and referential links at the side of the graphical process structure (see the “xref” on the upper right corner of the content pane in Figure 1. This “xref” contains an URL, which points a Web page describing the established regulations of the conference series). Additional information about how to use the process structure is provided in hyperlinked on-

line documentation. This can also be referenced from within the hypermedia-based process structure.

Another way of learning how to do something is to examine and follow good examples. The hypermedia-based process structure can serve as an example. Learners can navigate through the process structure to get an overall picture of how to do something. They can also simulate the process execution to see how it proceeds when the actual execution starts.

Peter glances at the process structure and quickly gets an overview over how to organize a conference. He then has a look at the on-line help information of the system, and starts to navigate through the process structure to examine the content of the tasks and the sub process structures, such as the sub process for "develop conference program". He also reads the instructions and reference materials attached to the process. After the first go, he returns to the root task node of the process structure, and triggers the process execution animation. The root task node first turns to "yellow" (for ready), and then to "green" (for active), then its containing process structure appears. The start task in the process structure turns to "yellow" and then to "green", and finally to "brown" (for completion). Then the following tasks of the start task turn to "yellow", "green", and "brown". The animation continues until all sub tasks of the tasks are completed. Peter gets a feeling that a conference has been going smoothly towards its successful completion.

3.3.2. Demonstration and practice in a guided tour. One of the best ways of learning how to do something is to watch someone else doing it. A demonstration by a tutor is useful in that learners can see a model of correct behavior provided by the tutor, which they can then imitate. With demonstrations, the tutor is also available to answer any questions that the learners might have.

Peter has some questions to ask. He invites John into his working session in the XCHIPS system. John volunteers to give a guided tour for Peter. As they work in a tightly coupled mode, the navigation performed by John also affects Peter's browse. They use the Chat tool provided by the system in the same session as their XCHIPS browser, so that they can see both the process structure and the Chat window at the same time. John explains what he has done for each task during the tour and answers many questions asked by Peter.

3.3.3. Role-play and record-keeping. One of the most efficient ways of learning how to do something is to practice it. Role-play exercise is a situation in which one acts out, or performs certain skills and behaviors in a simulated situation. Each learner is given a certain role to perform and he or she is free to develop his or her role at wish, or according to guidelines that are provided. Role-play exercise is a valuable learning strategy in that it allows learners to practice new skills in a controlled, safe setting, before they are used in real environment.

Record-keeping of the role-play exercises should greatly improve our learning of skills because the records provide feedback of how we have performed and how others see us. Because all the information attached to a process is kept in the shared hypermedia space, newcomers can navigate the hyperspace to examine the process structures and the contents used or created in the process. Also, the process structure can be reused for performing similar tasks. In the XCHIPS system, the actors of a process take roles named with specified responsibilities. These roles are visualized and assigned to specific tasks at the proper levels where they are involved in the nested process structure.

Peter makes a clone of the process structure, does some more practice, and makes some tailoring to his needs. He introduces the process structure and the XCHIPS system to his will-be program chair Tom. They work together on-line in the system, taking the conference chair and program chair roles. Peter works on many tasks, but only at a high level. Tom takes responsibility for developing a conference program. Peter also tries the Treasurer role. They edit the "execute conference program" task jointly (Figure 1 shows an awareness indicator that Peter and Tom are working on this task). They split the task into two tasks: one for "Refine conference program" and another for "Execute conference program". They agree that it is a good idea to have the system used by all their conference and program committee members. Peter feels that he is well prepared to organize and chair the coming conference.

4. Related work

Cooperative learning can improve several cognitive and social aspects of the learning process [6]. In a distributed cooperative learning setting, learners need some means to communicate and coordinate their learning activities. In the CSILE system, a certain cooperative learning method is modeled, and learners are guided through the process by specific rules [9]. Work in

[6] and [7] provide some scripted learning support as learning protocols. The scripts are implemented procedures that can be executed automatically or on demand. The scripted learning support is some form of formal process support. Comparing to scripted procedures, the hypermedia based process support provided by XCHIPS is more flexible. The XCHIPS system can support a wide range of coordination means; from very informal shared artifact-based means to very formal processes that are suitable for different cooperative learning settings.

Process support is primarily provided by workflow systems. However, most workflow systems are not hypermedia-based and they often only provide users with a work list. It is not always easy to figure out the overview of a process structure and the current states of its containing tasks. Some workflow systems also provide a graphical process editor. However, the editor is mainly for process designers, rather than end users of the processes. The same is true for most scripting and agent based workflow systems. Our hypermedia based approach leads to a system dealing with processes and information structures (as the subject of processes) as two views on a unified data model. This permits smooth transitions between these two views, and supports cooperative work on defining and manipulating process and information structures. Unlike those workflow systems, which still maintain the strict separation between process and document data, the XCHIPS system can provide much more flexibility.

The user interface provided by most Web-based workflow systems uses the simple HTML-based pages, in which only few components, such as Forms, provide some interaction support. Compared with HTML, Java is a full-fledged programming language, its development kit provides a rich set of interface components for creating application user interface. Therefore, we have implemented our user interface in Java. Java and XML have provided our system with a better accessibility and visualization support. In our approach, we still use HTML links to refer to our exported XML documents and other Web pages, and use Web browsers to invoke the XCHIPS system so that we can take advantage of the wide accessibility of the WWW.

A few previous hypertext systems have provided some form of process support. For example, Anecdote [4] provides support for a storyboarding process and the work in [3] provides an automaton-based hypertext for hypertext browsing and software engineering processes. However, their focus is not on cooperative modeling and execution of user-defined processes. The CHIPS system, a predecessor of XCHIPS, provides hypermedia-based support for cooperative process definition and execution [5, 10, and 11]. However, in the past it had not been applied to the learning of process knowledge and as many systems in this category, it is not accessible on the web. Other XCHIPS extensions to CHIPS include the XML importing/exporting facilities and the dynamic software component extensibility, which allows the newly developed groupware components to be added to the system and made available to all its distributed users at run time. The advanced hypertext links and composition structure in XCHIPS enrich and complement the current Web information organization structure. They provide a process enabled, graphically presented semantic network that is superimposed on web pages. Moreover, XCHIPS enables synchronous as well as asynchronous collaborative editing of shared processes and their associated information.

5. Conclusions

In this paper, we described XCHIPS, which provides cooperative hypermedia-based process definition and enactment support for modeling, disseminating, and evolving process knowledge, and how it can be used for supporting cooperative learning of process knowledge on the WWW. XCHIPS presents the hypermedia-based process structure in a graphical form over the WWW. In addition, the hypermedia-based process structure contains a rich set of associated materials with which people can interact while they are carrying out the business process they are learning. The processes can be executed automatically, under the control of computer, or manually, under the control of the process performers. The explicit process representation and enactment support can be used to guide people to practice and carry out the process they are learning. A prototype system based on the approach has been implemented. The use case presented in this paper shows that the system can not only provide traditional learning support, but also offers novel cooperative hypermedia based support for the learning of process knowledge.

This paper focuses on the support for the learning of process knowledge in general, and the type of learning on how to doing something in particular. Our experience suggests that such cooperative hypermedia-based process support is also helpful for other types of learning, such as learning to memorize something and learning to

understand something. The XCHIPS system is one of the tools we will bring into and extend in the EXTERNAL project (IST1999-10091) funded by the CEC. EXTERNAL focuses on the engineering and operation of networked organizations, and the management of process knowledge. Next, we will broaden and apply our approach to process knowledge management, integrate it with other EXTERNAL tools, apply it to other types of learning, and evaluate this approach in three real-world use cases.

Acknowledgments

We thank Martin Wessner for his helpful comments on a previous version of this document.

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