Dynamic Generation of Adaptive Web-Based Collaborative Courses

Rosa M. Carro[1], Alvaro Ortigosa[1], Estefanía Martín[1], and Johann Schlichter[2]

[1] Escuela Politécnica Superior, Universidad Autónoma de Madrid
28049 Madrid, Spain
{Rosa.Carro,Alvaro.Ortigosa,Estefania.Martin}@ii.uam.es
[2] Fakultät für Informatik, Technische Universität München
85748 Munich, Germany
Schlichter@in.tum.de

Abstract. In this paper we present the use of adaptation techniques to dynamically generate adaptive collaborative Web-based courses. These courses are generated at runtime by selecting, at every step and for each student, the most suitable collaborative tasks to be proposed, the time at which they are presented, the specific problems to be solved, the most suitable partners to cooperate with and the collaborative tools to support the group cooperation. This selection is based on the users' personal features, preferences, knowledge and behavior while interacting with the course. The advantages of this approach and the peculiarities of combining individual adaptation with collaboration seamlessly are also presented.

1 Introduction

Adaptive hypermedia has been widely used for the development of adaptive Web-based courses [3]. In these courses the students are personally guided during the learning process. They usually interact with the courses alone, in their own time frame, and learn at their own pace. On the other hand, collaboration tools have been used in educational contexts [6] for supporting communication among students, discussions about topics [9], cooperative problem resolution [10], knowledge sharing, and collaborative knowledge construction [8]. A proper use of these tools reduces student isolation and facilitates the development of reasoning skills such as making ideas explicit, arguing, interacting with other students to build a common solution, etc. [1].

Our approach deals with the integration of collaboration capabilities in adaptive Web-based courses and the use of adaptation methods and techniques for the personalization not only of the course contents and navigational options, but also of the collaboration aspects. It consists not just of putting adaptive courses and collaborative tools together, but of integrating adaptation and collaboration in a seamless way.

[1] This work has been partially supported by the German DAAD and the Spanish Inter-ministerial Commission of Sc. and Tech., projects TIC2001-0685-C02-01, TIC2002-01948

J. Favela and D. Decouchant (Eds.): CRIWG 2003, LNCS 2806, pp. 191–198, 2003.

Therefore, the users can benefit not only from adaptation and collaboration, but also from a combination of both of them.

This paper is structured as follows: In section 2 the main features of adaptive collaborative courses are described. Section 3 presents the mechanism for generating these courses dynamically. Section 4 contains a discussion about the advantages and open issues concerning this work. Finally, in section 5 the future work is presented.

2 Adaptive Collaborative Courses

While interacting with an adaptive collaborative course the students will be guided individually through the course contents. They will also be invited to cooperate with other students in the resolution of certain problems at specific points of the course. In addition, they will be able to share ideas, contact other students, and ask/answer questions about the whole course.

In these courses, features such as the most suitable topics to be learned at each time, the multimedia contents to be used for page generation, the navigational options available at every step, and/or the collaboration activities, among others, are adapted to each user by taking into account his personal features, preferences, behaviors and achievements while taking the course. Concerning the collaboration activities, aspects such as the convenience of performing collaborative tasks at certain points of the course, the suitability of a collaborative task itself, the tools supporting the user's interactions, the partners who a student will interact with, and the type of collaboration, among others, will be adapted. In order to support this personalized guidance, adaptive collaborative courses are described by means of:

- *Tasks*: represent the activities to be performed while interacting with the course, and can be atomic or composed. Atomic tasks represent theory to be learned, examples to be observed, self-assessment tests or exercises to be solved collaboratively. Composed tasks are decomposed in atomic and/or other composed tasks.
- *Content fragments*: can contain texts, images, videos, simulations, animations, etc., and are used for page generation. Several versions of the same contents (a topic explanation, an example about a certain topic, or a problem statement) can be associated to the same task, each of them intended for a different type of student.
- *Course-structure rules*: describe the organization of tasks in the course, i.e., which subtasks are part of a composed task, the order in which subtasks must be performed, if any, and the requirements for a task to be performed, if they exist. Each of these aspects can be different for different types of students. The requirements for a rule to be activated, that is, for its information to be used for the course structure generation for a particular student, are expressed in the rule activation conditions. These conditions can be related to the student's features, preferences, actions or behaviors while interacting with the course.
- *Collaborative-workspace rules*: describe the way in which problem statements and sets of collaborative tools are combined to compose specific collaborative workspaces. The sets of tools can be different for different collaborative tasks. Both the statements and the sets of tools can be different for dissimilar types of students,

even if performing the same task. The features of the students a workspace is intended for are stated in the respective rule activation conditions.

- *Problem statements*: describe the problems to be solved, including the goals and expected results. Different problems can be associated to the same task, so that the most suitable one for each group of students can be selected at runtime.
- *Collaborative-tool rules*: describe the way in which collaborative tools are integrated in the interface. Normally, the set of tools for each workspace has a subset of main tools and a subset of additional tools. The former compose the main interface, while the later are accessed from it. Different combinations for the same set of tools can be described in order to satisfy the user's needs. For example, generally, students with a textual learning style prefer to propose solutions and discuss by writing texts, while those with a visual learning style usually prefer to create diagrams and draw their proposals. The most suitable tools for each group of students will compose the main interface, while the other tools will be accessible from it. There exist a set of collaborative-tool rules by default, so that if there is no special need, it is not necessary to describe them. A more complete description of collaborative-workspace rules and collaborative-tool rules can be consulted at [4].
- *Global collaboration tools*: the course designer can specify which collaborative tools (email, forum, chat) will be available to support the communication and cooperation among all the users that are interacting with the same course. A set of global collaboration tools is provided by default.
- *Rules for student grouping*: are taken into consideration during the group formation. Rules to be used by default are provided; they indicate that students with similar features and preferences will be grouped. The course designer can define rules with different criteria to form the groups, either specifically for certain collaborative tasks or for the whole course.

An adaptive collaborative course can be completely described by tasks, course-structure rules, collaborative-workspaces rules, content fragments and problem statements. The course designer must also specify the user features to be considered with either individual or collaborative adaptation purposes. These features are attributes whose values can be discrete values or ranges of values; the designer will be able to select among those proposed in the authoring tool and/or to specify new ones, if needed. He will be able to provide a pattern (with background, headers, etc.) to be used to generate all the pages related to the same course, as well as to indicate if he offers himself to be consulted during the course execution by e-mail.

The description of adaptive collaborative courses will be supported by an authoring tool that is also being developed. In this tool, collaborative editors, forums, chats, file sharing and e-mail programs are available, so that the course designers will only have to select the specific ones to be offered for each collaborative task.

3 Dynamic Course Generation

Once the course components have been described, the course itself is dynamically generated for each student at runtime. In order to support this process, a system has been developed starting from the TANGOW system [5] and including functionality

for supporting collaboration among users [2]. This new system interprets the course descriptions, triggers the corresponding rules and generates the pages to be presented to the students dynamically, step by step, by selecting the most appropriate course components (tasks, contents, problems, collaborative tools, etc.) depending on the student's features, preferences and actions during the course execution. It stores all the actions performed by the students and uses them to adapt the course in the following steps. The whole process is illustrated in Fig. 1 and is explained next.

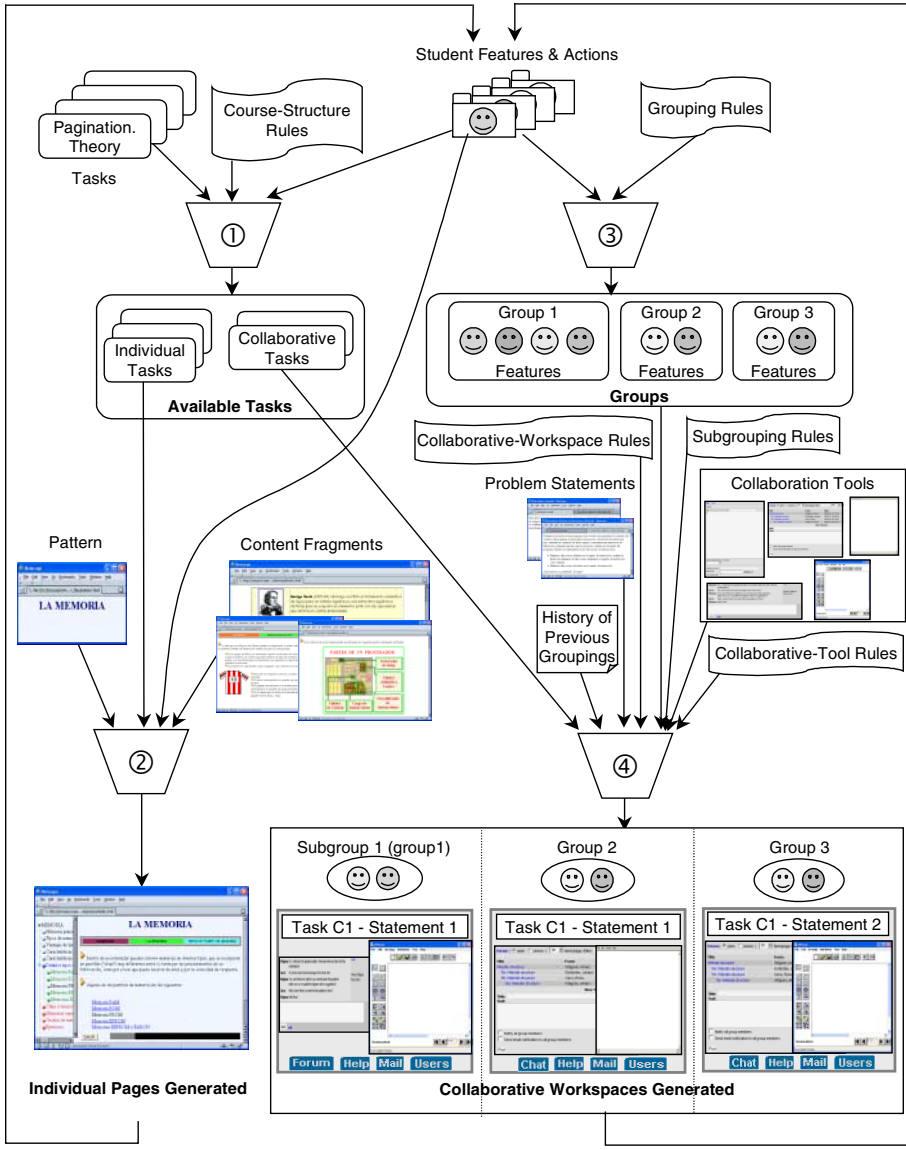

Fig. 1. Dynamic Generation of Adaptive Collaborative Web-Based Courses

When a student starts taking a course, the course-structure rules are analyzed in order to select one that describes the decomposition of the main task of the course, and whose activation conditions are satisfied by the student. The rule is triggered, and, depending on the rule sequencing-mode and the subtask prerequisites (if any), all the subtasks, only some of them, or a single task are made available to the student. During the course execution, the most suitable tasks for the student to perform are selected in a similar way at every step, by taking into account the course-structure rules and the student's features and previous achievements (see ① in Fig.1).

The next step concerns the generation of the page to be presented to the student. Depending on the number of available tasks, the student is presented with a selection menu or with a page of contents. In the first case, the menu is built starting from the tasks descriptions. In the second case, if the task is not collaborative, the system selects the most suitable content fragments to build the page. These fragments are selected among the set of fragment variants associated to the task, by comparing the student's features with the ones each variant is intended for. In addition, an annotated table of contents is generated, so that the students can know which tasks are (not) available at each time and which ones they have already performed. A progress bar and a button bar are also generated. If a common pattern has been provided, it is used to generate the page (② in Fig. 1).

When the student is ready to perform a collaborative task (the task is included in the set of available tasks), the system checks if it is possible for him to collaborate with other students. The first step concerns the group formation. Groups are formed, at a first stage (③ in Fig. 1), by taking into account the user's personal features and preferences (including aspects such as the learning style and background, among others) and their interaction style (such as the frequency of interactions with the course). In a second stage, for each collaboration task, as soon as it is available to more than one user belonging to the same group, subgroups start to be formed, so that users can initiate the cooperation. During this phase, their opinions and preferences based on previous collaboration experiences are also considered (i.e., other users they do not wish to interact with again). The teacher could specify different criteria for subgroup forming, such as mixing novice and advanced users, or active with passive ones, if desired. Default grouping rules can also be specified (i.e., the maximum size of a group). Once a subgroup is formed, its members' features constitute the group profile, which will be enriched with other attributes concerning the users' interactions.

When a subgroup is ready to perform a collaborative task, the corresponding students are informed (the link to this task is activated). The collaborative workspace is build as soon as one of the students starts performing the task. Firstly, the collaborative-workspace rules that describe the potential workspaces to support the execution of the task are evaluated. The one whose activation conditions are satisfied by the students in the subgroup is triggered, and the most suitable problem and set of tools for the subgroup are selected. Secondly, the collaborative-tool rules are evaluated and the corresponding one is triggered to get information about the collaborative tools that will be used to support the students working on the task and also about their layout.

Finally, the page is built by joining the problem statement, the set of tools described above, the access to the additional tools and other supplementary tools, such as a buddy list, in an integrated interface (④ in Fig. 1). If several partners are interacting at the same time, it is possible to enable the access to synchronous tools. The students in a subgroup can organize themselves for the task execution: they can divide the task, provide partial solutions, discuss and join them in a complete one; they can

solve the problem altogether; or they can provide complete independent solutions to be discussed until they agree the best one. Their actions are stored to get information about the task execution. If we want to analyze not only when and who used a tool or provided a solution, but also the meaning of their interactions with the different tools, it is necessary to add semantic information, which we are currently considering.

During the whole learning process, the student progress while interacting with the course individually is considered not only with individual adaptation purposes but also to decide about collaborative aspects such as the presence or absence of collaborative tasks or the group formation, among others. The subgroup actions while performing collaborative tasks can also affect the remaining course evolution, both for each of its members while working alone and for the subgroup in subsequent interactions. The actions performed by students and subgroups, such as the pages visited, the exercises done (individually and collaboratively), the contributions to collaborative tasks and the obtained results, among others, are stored to be used with adaptation purposes during the course execution.

4 Discussion

The use of the approach presented allows the creation of Web-based courses in which adaptation and collaboration are seamlessly integrated. In these courses, it is possible to adapt not only the presentation of a course to individual students but also the collaboration issues, by considering each student's personal features, preferences, behaviors and achievements. Starting from a unique course description provided by the course designers, personalized courses are dynamically generated by including and/or removing components or groups of components, and by setting their sorting and compulsoriness. Concerning the adaptation of collaboration aspects, different students can be presented with the same collaborative task at different times. The requirements for a task to be available can be different depending on the student taking the course. Furthermore, collaborative tasks can be proposed only to certain type of students.

For each collaborative task, the specific problem to be solved can be selected for each particular subgroup, among those related to the task. It can also be different for distinct subgroups, although related to the same task. For example, it is possible to consider the difficulty of the problems associated to a task, to select the most suitable one for a group of students, according to the knowledge they have acquired previously. The selection of the problem statement depends on the problem characteristics and on the group features and achievements while learning the involved subjects. The tools to support the interactions among students while working on a collaborative task can be dependant on the specific problem to be solved and can also be adapted to the features of each group, even if solving the same problem. The main goal is to create collaborative workspaces in which each group can feel comfortable.

The only requirement to exploit these adaptation capabilities is to define the corresponding course-structure rules, collaborative-workspace rules and, optionally, collaborative-tool rules, indicating the types of users each rule is intended for. An advantage of this approach is that the teacher does not need to define/create specific workspaces for each collaborative task. In the simplest case, he only needs to provide the problem statements and select among the workspace configurations offered by

default. In this case, when a given task requires the utilization of specific tools, the workspace configuration can be specified for this particular task.

The separation of course contents, structure, problem statements and collaborative tools facilitate the reuse and maintenance of components. It is easy to add, remove or modify a collaborative task, a set of tools to be used in a workspace or a problem to be solved collaboratively. In the same way, collaborative tasks can be easily moved from one point of the course to another, and prerequisites for a task to be proposed can be simply changed. It is also easy to modify a course according to new needs detected. In general, new adaptation requirements can be implemented adding or modifying rules. Courses are dynamically generated at runtime. Therefore, when a change is made, the consequences are reflected in the course, being unnecessary to check for possible inconsistencies (course descriptions are checked at design time).

Concerning the student grouping, the dynamic formation of groups offers the possibility of grouping students which are ready to perform certain tasks, avoiding situations in which a student is waiting for the others to learn the required topics to solve the problem.

However, integrating adaptation and collaboration is not an easy task. On the one hand, adaptation is oriented, a priori, to the personalization of courses to individual students, focusing on their personal features, so that they can learn at their own pace. On the other hand, collaboration must be addressed from both the cognitive perspective and the social perspective. The users are required to acquire a compromise with their partners, and it is important for each member to feel comfortable with the others to take advantage of the experience. Therefore, it is necessary to use proper criteria to manage the social aspects of the collaboration and to support the whole experience.

Many decisions concerning the user grouping depend on the context in which an adaptive collaborative course is used. For example, if it is widely offered for long-life learning, it is probable for the students to be very different. Moreover, they may connect to the courses at completely different moments. Even it is possible for some users to access to the course only with consultation purposes. On the contrary, if the course is used as an additional support to traditional classes, it is very probable that the users take the whole course in a delimited time frame. The number of students participating in a course and the course duration may also determine collaboration issues such as the need of establishing deadlines for collaborative task resolution or the minimum/maximum number of students for each group.

The context must also be considered in order to take decisions about the way of solving or avoiding undesirable situations such as: students waiting too long for their partners to participate (When should the system send a warning to the students? What is “too long” in each context?), students waiting too long to be grouped (How long should they wait, as maximum? Should they be incorporated to recently formed groups? Should new groups be formed with several of these students, although the new groups do not satisfy all the criteria for student grouping?), students whose partners have left the course (Should they wait for other students to be ready to join them? If yes, how long? It is better for them to join recently formed groups?). In order to satisfy the users’ needs while interacting with others in different contexts it would be convenient to implement a mechanism for changing the criteria used for student grouping dynamically, depending on the context in which the adaptive course is used.

In order to get the best answers to all these questions and the best criteria for adaptive group formation depending on the context, it is necessary for us to experiment with adaptive collaborative courses with different real students in different contexts.

5 Future Work

As it has been concluded in the previous section, this approach needs to be tested with real students in order to get feedback about the effectiveness of integrating adaptation and collaboration in different contexts, and also about the criteria to be used to adapt collaboration aspects such as the student grouping or the solutions to undesired situations. We will create new adaptive collaborative courses and design the corresponding experiments. These experiments could also provide us information about how students work and learn [7], especially if we include semantic information to support the internal analysis of the student interactions, which we are considering. We are developing an authoring tool to support the description of adaptive collaborative courses and we plan to develop a monitoring tool for the teachers to get information about the course evolution, including individual and collaborative aspects.

References

1. Barros, B., Verdejo, M.F.: Designing Workspaces to support collaborative learning. In: Pobil, A.P., Mira, J., Moonis, A. (eds.): Tasks and Methods in Applied Artificial Intelligence. LNAI, Vol. 1416. Springer-Verlag (1998) 668–677
2. Borghoff, U., Schlichter, J.: Computer-Supported Cooperative Work – Introduction to Distributed Applications. Springer (2000)
3. Brusilovsky, P. Adaptive hypermedia. User Modeling and User-Adapted Interaction, 11 (2001) Kluwer Academic Publishers, 87–110.
4. Carro, R.M., Ortigosa, A., Schlichter, J.: A Rule-based Formalism for Describing Collaborative Adaptive Courses. In: Palade, V., Howlett, R., Jai, L. (eds.): KES 2003. LNCS/LNAI. Springer-Verlag (2003). In press.
5. Carro, R.M., Pulido, E., Rodríguez, P.: Dynamic generation of adaptive Internet-based courses. In: Journal of Network and Computer Applications 22 (1999) Academic Press, 249–257
6. Dillembourg, P. Collaborative learning: cognitive and computational approaches. Elsevier, Oxford, 1999
7. Muehlenbrock, M., Hoppe, U.: Computer supported interaction analysis of group problem solving. In: Proceedings of the Computer Support for Collaborative Learning (CSCL) Conference. Palo Alto. Stanford University (1999) 398–405
8. Schlichter, J. Lecture 2000: More than a course across wires. Teleconference – The Business Communications Magazine (1997) 18–21
9. Suthers, D., Xu J.: Kukakuka: An Online Environment for Artifact-Centered Discourse. Education Track of the Eleventh World Wide Web Conference. Honolulu (2002) 472–480
10. Vizcaíno, A., Contreras, J., Favela, J., Prieto, M.: An Adaptive, Collaborative Environment to Develop Good Habits in Programming. In: Gauthier, G., Frasson, C., VanLehn, K. (eds.): Intelligent Tutoring Systems 2000. LNCS 1839. Springer (2000) 262–271