

Adaptive Patterns in Authoring of Educational Adaptive Hypermedia

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Pre-Discussion Paper

Problem issues

One of the main problems with e-learning environments is their lack of personalization (or adaptivity). They cannot offer customisation for the student; they can only offer identical contents to all the consumers.

Educational Adaptive Hypermedia (EAH) environments should be the answer to this problem. Adaptive Hypermedia is a relatively new field (starting around the early 1990s), but it already has reached some maturity and already features some good applications.

Imagine, for instance, that, instead of showing all students an example of a painting by Rembrandt and then show them the description of the chiaroscuro technique, one could write a rule:

```
IF student.chiaroscuroTechnique.motivation='non-existent' THEN show.paintingRembrandt;  
Show.chiaroscuroTechnique;
```

So, show the painting only to students without motivation in studying the chiaroscuro technique (with the hope that seeing such a great painting will motivate them), and skip this step if the motivation is already there (give direct information for motivated students). This very simple rule already offers some customisation, dependent on a student model variable called 'motivation'.

At the Eindhoven University of Technology, for instance, a few courses are given already for a couple of years on-line, in adaptive hypermedia environments (featuring student models and automatic adaptation to student's computed 'knowledge level': e.g., <http://www.wis.win.tue.nl/2L690/>).

However, such EAH environments are not yet as spread as we would have expected, and not many educators even know about the opportunities offered by such automatic personalization, let alone make use of it.

Our opinion about those issues

The major drawback that we have found is that, at present, there are no good authoring tools for educational adaptive hypermedia, and creating EAHs from scratch without such tools becomes actually a programmer's job – and not that of an author (e.g., teacher).

Therefore, we embarked on the quest of *designing appropriate authoring tools for EAHs*.

Please note that such authoring tools as we envision do not try to compete with commercial tools such as Blackboard, WebCT, etc. What we want is to complement these tools with what they lack: the possibility of expressing the automatic personalization elements for the student.

Please also note that such authoring is normally more difficult than authoring of a sequential course: alternatives have to be designed, linked and annotated (i.e., the *static descriptions*). The rules of when and how to take the alternative routes have to be specified (i.e., the *dynamics description*).

In order to make authoring efficient, such an authoring system should propose to the author a lot of methods of reuse, both of contents (static description) as well as of contents dynamics.

The static contents description reuse has been discussed and researched more thoroughly, and it can be based on the learning object model (LOM), on the emerging SCORM standard, as well as on work on hypermedia patterns as developed by the team of Franca Garzotto (<http://www.elet.polimi.it/upload/baresi/pub/papers/SCI02.pdf>) and on our own work on course domain structuring (<http://www.wis.win.tue.nl/cheetah/~acristea/HTML/Minerva/papers/WWW03-cristea-mooij.doc>) [4].

Therefore, our main focus is to research and work on the re-usage of the dynamics, i.e., on the *re-usage of adaptation features*. Please note that the IMS ADL simple sequencing protocol, although a step in the right direction, cannot provide all the features of adaptation that adaptive hypermedia can offer.

Suggested solutions

We are running a European Community project, ADAPT, whose main goal is to *extract adaptive patterns of educational adaptive hypermedia, and to use these in authoring*:

<http://www.wis.win.tue.nl/cheetah/~acristea/HTML/Minerva/>

Our purpose is to find these more general patterns of adaptive behaviour, and then make them reusable via an authoring environment that offers these patterns, or even groups of patterns (adaptation strategies), as we shall see. To go back to the adaptation example above, the IF-THEN rule described there cannot be reused: it is too specific, binding two specific instances, `paintingRembrandt` and `chiaroscuroTechnique`. Moreover, if we would want to make a similar connection between Picasso and the collage technique, we would have to actually write a new rule:

```
IF student.collageTechnique.motivation='non-existent' THEN show.paintingPicasso;  
Show.chiaroscuroTechnique;
```

Obviously, the two rules have much in common, and it is natural to expect that an author would want to use a similar structure for the Picasso case, which s/he can reapply instead of writing a new rule. To make this rule reusable, we should be allowed to write higher (schema) level constructs such as:

```
IF student.Technique.motivation='non-existent' THEN show.painting;  
Show.Technique;
```

The advantage of the rule above is not only that it summarizes the rules for Picasso's and Rembrandt's paintings, but that it can connect any other painter and the technique s/he invented. This is just a very simple example how generalization of the content structure can lead to reusable components, even for adaptation rules. However, we can go even further than that, and notice that the two higher level constructs, `technique` and `painting`, can be seen as representing some **theory** and its corresponding **example**, and that they could be both belonging to a concept that binds the theoretical part with its practical part. As we can then define a relation that connects this theoretical part of the concept with its practical part, by marking the example as a **specialization** of the theory (and, vice versa, the theory as a **generalization** of the example), we can replace the previous rule with a higher-level language rule, as follows:

```
IF student.Concept.motivation='non-existent' THEN specialize;  
generalize;
```

From these kinds of considerations the first constructs of an adaptation language emerged, as described more systematically in [1]:

<http://www.wis.win.tue.nl/~acristea/HTML/Minerva/papers/UM03-cristea-calvi-accepted.doc>

The idea behind it was, as mentioned above, to let the author of adaptive educational hypermedia work on a higher semantic level, instead of struggling with the 'assembly language of adaptation'. Furthermore, these patterns should represent the first level of reusable elements of adaptation, as shown in the examples above.

However, reusability can go further than that. Even this *adaptation language*, we are aware, might still be difficult to handle for some authors (teachers). So, as mentioned in the paper above ([1]), reuse should be strived at even at the level of *adaptation strategies* (that correspond to cognitive/ learning strategies). In this paper we show how the four cognitive styles identified by Kolb (converger, diverge, assimilator, accomodator) can be

written in adaptation language (as well as in adaptation assembly language) and transformed into adaptation strategies, ready to be reused. Below (table 1) is an extract example from the paper with the implementation for the cognitive style converger, using the **specialize** and **generalize** adaptation language constructs, as described previously, but also some other special construct, such as **enough**. The latter is a more relaxed way to specify preconditions, without precisely defining them. In this case, enough (result) means, e.g., having a passing average for at least two of the tests, but other definitions are also possible.

Table 1. Adaptation strategy for cognitive style: converger (abstract, active)

medium increase() : <i>generate adaptive presentation with (obviously) increasing difficulty</i>
1. Explanation: Convergencers are <i>abstract</i> and <i>active</i> ; they like to feel in control; start with course for intermediates at medium adaptivity level, repeat for a number of times: - evaluate state of learner and start increasing difficulty & decreasing adaptivity level if result=good - evaluate state of learner and start decreasing level if result=bad
2. Translation at medium level: (ENOUGH shows here that the result is above an average result) AdaptLevel= 5; N=AskUser(); # this is to let user feel and be in control; levels: (1=min to 10=max) FOR <I=1..N> DO { SPECIALIZE (ENOUGH(Result)); IF (AdaptLevel>1) AdaptLevel--; GENERALIZE (NOT(ENOUGH(Result))); IF (AdaptLevel<5) AdaptLevel++; } # Note that adaptation level is not allowed to increase too much
3. Translation at low level: (the average can be implemented but takes more space) DiffLevel = 3; AdaptLevel= 5; # note that here there is no predefined number of repetitions IF <ACTION> THEN # Note that above we don't need the action of the user for triggering; { IF (Result1 +Result2)/2>5 AND DiffLevel<10 THEN # Note that 'enough' and specialize { DiffLevel++; IF (AdaptLevel>1) AdaptLevel--;} # must be redefined each time IF (Result1 +Result2)/2<5 AND DiffLevel>1 THEN {DiffLevel--; IF (AdaptLevel<5) AdaptLevel++;} }

In discussions resulting at the User Modelling conference, other cognitive styles that should be implemented were suggested, such as *field dependence* versus *field independence*.

Questions for the members to respond to

1. *What other cognitive/learning strategies would be appropriate to experiment with for e-learning in particular?* (i.e., to transform them into adaptation strategies) The main target we are envisioning are university students, but extensions towards other categories of pupils are also important, especially in the context of life-long learning.
2. *Are the patterns described so far enough for describing the cognitive/ learning strategy you would like to implement?*
3. *What other patterns would be necessary, and for what cognitive/ learning strategies?*
4. *Would you opt for reusing directly adaptation strategies, or would you prefer to write your own?*
5. *If you would write your own adaptation strategies, what would you need in the adaptation language?*
6. *What criteria/ constraints should the adaptation language fulfil?*

Papers produced by this research

- [1] Cristea, A. I., & Calvi, L. (2003). The three Layers of Adaptation Granularity. UM'03. User Modelling - June 2003. Springer.
- [2] Cristea, A. I. (in press). Automatic Authoring in the LAOS AHS Authoring Model. HT'03. Hypertext workshop on AH. ACM.
- [3] Cristea, A.I., & Kinshuk (2003). Considerations on LAOS, LAG and their Integration in MOT. ED-MEDIA '03.
- [4] Cristea, A., & De Mooij, A. (2003). LAOS: Layered WWW AHS Authoring Model and its corresponding Algebraic Operators. In Proceedings of WWW'03, Alternate Education track. (Budapest, Hungary 20-24 May 2003). ACM.
- [5] Cristea, A., & De Mooij, A. (2003). Designer Adaptation in Adaptive Hypermedia. In Proceedings of ITCC'03 (Las Vegas, US 28-30 April 2003), Los Alamitos: IEEE Computer Society.

- [6] Cristea, A. I., & De Bra, P. (2002). Towards Adaptable and Adaptive ODL Environments. In Proceedings of AACE E-Learn'02 (Montreal, Canada, October 2002), 232-239.
- [7] Cristea, A. I., Okamoto, T., & Kayama, M. (2002). Considerations for Building a Common Platform for Cooperative & Collaborative Authoring Environments. In Proceedings of AACE E-Learn'02 (Montreal, Canada, October 2002), 224-231.
- [8] Calvi, L., & Cristea, A. I. (2002). Towards Generic Adaptive Systems Analysis of a Case Study. In Proceedings of AH'02 (Malaga, Spain, May 2002) Adaptive Hypermedia and Adaptive Web-Based Systems, LNCS 2347, Springer, 79-89.
- [9] Cristea, A. I., & Aroyo, L. (2002). Adaptive Authoring of Adaptive Educational Hypermedia, In Proceedings of AH 2002, Adaptive Hypermedia and Adaptive Web-Based Systems, LNCS 2347, Springer, 122-132.
- [10] Cristea, A., & De Mooij, A. (2003). Adaptive Course Authoring: MOT, My Online Teacher. In Proceedings of ICT-2003, IEEE International Conference on Telecommunications, "Telecommunications + Education" Workshop (Feb 23 - March 1, 2003 Tahiti Island in Papetee - French Polynesia).
- [11] <http://www.wis.win.tue.nl/cheetah/~acristea/HTML/Minerva/papers/>

Post-discussion Summary

This is a summary of what has been discussed within the IFETS discussion group on the topic of adaptive patterns in authoring of educational adaptive hypermedia (EAH).

Initial goal

The INITIAL GOAL of the discussion was to find out what can be reused from the dynamics of the EAHs (so what are the ADAPTIVE PATTERNS), in order to complement the research on what can be reused from the static EAH data. A 3-layer structure of adaptation was proposed, with at the lowest level IF-THEN rules traditionally used in EAH, but which cannot be reused. The next layer contains ADAPTATION LANGUAGE constructs, such as Generalize, Specialize, Repeat, While, Break. This layer already represents a higher semantic level as compared to the traditional first one. The last layer is made of ADAPTATION STRATEGIES, such as the ones proposed based on the Kolb model of cognitive style characterization.

Main questions

The main questions were grouped around finding out the appropriateness of this division from an educator's (and author's) perspective on one hand, and finding suitable suggestions for populating the 2nd and 3rd layer with respective new adaptation language constructs or new adaptation strategies, which would correspond to a specific teaching style/ theory.

Reactions

Reactions to the above proposal and questions were as follows:

Robert Valian suggested that the Annehurst Curriculum Classification System (ACCS) developed by Jack Frymier at the Ohio State University in the '70 for student classification might be a good source to look at; unfortunately, this is out of print - and might be outdated (?). It is surely a good starting point, but we have to look at more up-to-date opportunities.

José M Parente de Oliveira noted that adaptation strategies might be grouped around instructional/ learning theory in conjunction with cognitive styles and learner preferences; this could be a good direction to develop adaptive strategies on; here, the question is what would be the typical instructional strategies that should be translated into adaptation strategies, and if it seems feasible with the few adaptation language constructs that we have proposed (Generalize, Specialize, Repeat, While, Break + low level If-Then-Else) or if more would be needed?

Clark Quinn and others pointed with their comments to the fact that adaptation strategies could be directly inferred from a specific domain structure (such as in automatically smoothing the transition from one topic to another by inserting introductory/ explanatory information, if this exists and is appropriately tagged in the domain description); the same idea has been brought up by José M Parente de Oliveira and also mentioned by Simos Retalis in the form of using generic relationships between resources to generate adaptive patterns (for learning or assessment of learning); this is another proof of the inter-relatedness of the static representation and the adaptation dynamics (same as re-iterated below).

Clark Quinn also stressed the fact that for a good adaptation model in general a rich and specific tagging system is necessary; although this represents the static part of the EAH, it is a necessary precondition for a good development of the dynamics; the adaptation language and adaptation strategies should have as base a rich model of the domain or learning content, of learner characteristics (knowledge + others: compendium of potential standards: Jonassen & Grabowski, eds., 1992? + emotional data - D.A. Norman, A. Ortony), context or presentation platform characteristics (PDA, mobile phones, web, etc.), pedagogical constraints and goal model (Jeroen J.G. Van Merriënboer). These different aspects of the elements of learning can be decomposed, as proposed in a 5-layer model in: <http://www.wis.win.tue.nl/~acristea/HTML/Minerva/papers/WWW03-cristea-mooij.doc>. The question then remains: given a representation, what are the adaptive patterns that can be applied?

Can these patterns be used to author new adaptive strategies?

Eric Flescher had an interesting proposal regarding adaptation strategies: adaptation strategies should be able to be written that allow for meta-cognition and incubation, for slow, methodical work; this issue also raises the question of what specific patterns of adaptation language would be appropriate to represent such adaptation strategies?

Conclusions

The main conclusion of the discussion on adaptive strategies and adaptive patterns for educational adaptive hypermedia is that, although the discussion is closed, there are many questions that remain open.

In this way we have just made the research -, as well as the educational practitioner community attentive to the possibilities that can be opened by our line of research.

Hopefully, we will be able to reiterate this discussion at some other time, with new results, as the topic is by no means exhausted.

Clear from the discussion is that adaptive patterns for adaptive educational hypermedia should rely heavily on patterns of the static description of the elements involved, such as the domain model, user model, etc. Adaptation can only describe 'intelligent' dynamics if the basic tagging and meta-data is present in the model on which it is applied. Therefore, any attempt to describe adaptive patterns for educational adaptive hypermedia has to also be paired with the respective description of the static elements. This leads, obviously, to a multi-dimensional view. The exact number of dimensions is still a matter of discussion and research, but some are clearly needed, such as the domain -, user - and adaptation model.

Moreover, the discussion pointed out that the focus should not be only on the cognitive strategies, but also embrace learning theories. The question then remains: how these can be translated into adaptive strategies.

Important open questions that remain are the different granulation levels that are needed for creating appropriate adaptive patterns for educational adaptive hypermedia, as well as the proper adaptive language that has to be used. It is important to keep in mind that this language has to be used by authors and designers of on-line courseware, so by teachers, so it has to be at a level that is comprehensible for them.

As already mentioned in the introductory paper, we are now running a project that has as one of the main goals finding an answer to these open questions: "ADAPT: Adaptivity and adaptability in ODL based on ICT": <http://www.wis.win.tue.nl/~alex/HTML/Minerva/index.html>.