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AUTHOR	Lyardet, Fernando; Rossi, Gustavo; Schwabe, Daniel
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ABSTRACT

This paper shows how to use design patterns for building educational multimedia applications. The first section summarizes design issues related to organizing the information, the organization of the interface, and implementation. Navigating through information is covered in the second section, including problems, motivations, and solutions, and relevance to EMS (Educational Multimedia Systems) related to navigational context and information factoring. The third section describes the organization of the interface in terms of problems, motivations, and solutions related to information-interaction decoupling, behavioral grouping, behavioral anticipation, and process feedback. It is concluded that, through the use of patterns, authors are able to identify common design problems and express solutions in a methodology-independent manner; the set of patterns also provides authors with a common language and access to the ideas behind successful EMS. Six figures present examples from current educational multimedia software. Contains 10 references. (DLS)

Using Design Patterns in Educational Multimedia applications

Fernando Lyardet (*), Gustavo Rossi(**),
(*)(**)LIFIA, Fac. De Ciencias Exactas, UNLP, Argentina
(**) is also at CONICET and UNLM. Email: [fer, gustavo]@sol.info.unlp.edu.ar

Daniel Schwabe,
Departamento de Informática. PUC-RIO, Brasil. Email: schwabe@inf.puc-rio.br

Abstract:

Designing and implementing Educational Multimedia Systems (EMS) is hard; even when design methods may help in this task, most critical design decisions remain undocumented making reuse a difficult task

In this paper we show how to use design patterns while building Educational Multimedia Applications. We first present the idea of design patterns and then discuss some simple though effective design patterns addressing different concerns in this kind of applications. Each one of them is exemplified with successful educational applications.

1. Introduction

In the past four years there has been a growing interest in hypermedia design techniques. The different problems an educational hypermedia author has to deal with are complex, since the combination of navigation through an intricate information space with the unstructured nature of multimedia data poses new challenges. There are some well-established notions of good hypermedia development, outlining three groups of design issues:

- The first group comprises the problem of organizing the information:
  - *How do we organize the information space to let the user navigate following meaningful links established between information units, and let the users understand?*
- The second group of design issues explores the organization of the interface:
  - *Which objects the user will perceive and how these objects relate to the navigation objects*?
  - *How will the interface behave as the user exercises it?*
- The third group of design issues has to do with implementation:
  - *How these information units mapped into pages?*
  - *How are navigation operations and interface objects implemented?*

Design Methodologies help the software designer to express an idea with an appropriate language, and the way it has to be implemented. Unfortunately, there is an important issue that no existing methodology addresses and that is: how to make good, effective designs.

This is the barrier that separates successful experienced hypermedia authors from the rest. Having reached a certain maturity in the process of designing hypermedia applications it was, until now, hard to talk about effective design solutions and convey experience to other people, mostly due to the lack of an abstraction mechanism.

Such a mechanism allows to express design strategies to face common design problems and to record design experience; it is a language to talk about how things must be designed rather than how they are written under any given methodology. If we are not capable of transmitting the experience gained through the years, how will we develop and enhance the next generation of Educational Multimedia Systems?

Though originated in architecture [Alexander77] design patterns are being increasingly used in software design [Gamma95]. Design patterns are a good means for recording design experience as they systematically name, explain and evaluate important and recurrent designs in software systems. They describe problems that occur repeatedly, and describe the core of the solution to that problem, in such a way that we can use this solution many times in different contexts and applications. Looking at known uses of a particular pattern, we can see how successful designers solve recurrent problems.

In some cases, it is possible to give structure to simple patterns to develop a pattern language: a partially ordered set of related patterns that work together in the context of certain application domain. Design Patterns complement methodologies in that they address problems at a higher level of abstraction. Many design decisions that cannot be recorded through the uses of the primitives of a method can be described using patterns.

We next present a set of simple design patterns that address usual concerns in Educational Applications; though it is not our objective in this paper to show how they interact with each other, it will be clear from each example that they can be used together in a synergistic way.

2. Navigating through information

The patterns presented in this section, face common problems in the organization and access to the information. There is an underlying idea connecting the patterns presented here that stressed the importance of a clean separation between interface and. Some methodologies such as OOHDM [Schwabe96] propose an architectural model that follows this principle. Similar separations can be found in other methodologies such as RMM [Isakowitz95] and HDM [Garzotto93].

We next present some patterns discovered and used in the context of developing educational multimedia applications. We describe them using a single template describing the problem that originates the patterns, the motivation, the solution and an example in the context of Educational Multimedia Systems (EMS). This template allows expressing solutions in a "methodology-independent" way and so they can be used with different Hypermedia design methods, such as OOHDM, RMM or W3DT [Bichler97]. For each pattern we add a short comment explaining why it is relevant to EMS.

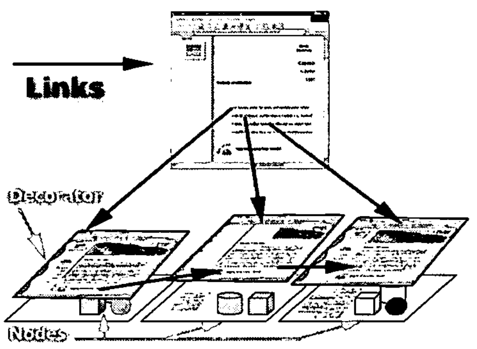
2.1 Navigational Context

Problem: How to organize the EMS navigational structure, providing guidelines, information and relationships that depend on the current state of navigation, in such a way that information can be better presented and comprehended?

Motivation: EIS usually involve dealing with collections (e.g. Concepts, Paintings, Cities, Persons, etc) These Collections may be explored in different ways, according to the task the user is performing. For example, we may want to explore Books of an author, Books on a certain period of time or literary movement, etc., and it is desirable to give the user different kinds of feed-back in different contexts, while allowing him to move easily from node to node.

Suppose for example that in an EMS about inventors and inventions, we reach Thomas A. Edison and then we arrive to the Light Bulb invention. However, we can also reach the Light Bulb while exploring inventions during a specific period of time, following a history of the most famous inventions, or while visiting another invention such as the "Fluorescent Light" and we follow the link to related inventions. It is clear that we will explore the same object under three different perspectives: as a Thomas A. Edison's invention, as an invention of the past century, and as an invention related to others such as the Fluorescent Lamp.

Solution: Decouple the navigational Objects from the context in which they are to be explored, and define objects' peculiarities as Decorators [Gamma95], that enrich the navigational interface when the object is visited in that context. Navigational contexts are composed of a set of Nodes (like Books or Inventions) and Context Links (links that connect objects in a context).



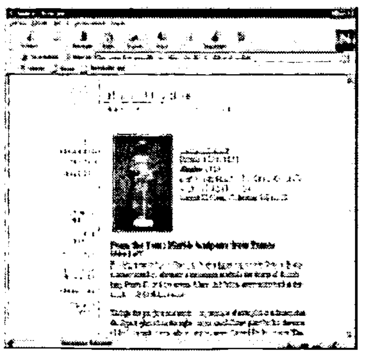


Figure **Error! Unknown switch argument.** :Diagram of "Navigational Context" pattern and a working example

Relevance to EMS: It is usual in EMS that the same concept may be reached from different "learning paths"; in each one of them we want to help the learner to explore other related concepts conforming with the actual context. The navigational context navigation pattern helps to group nodes in meaningful sets that can be easily explored. It also address the problem that arises when the same node belongs to more than a set by indicating that in each case the node must be decorated according to the context.

2.2 Information Factoring

Problem: How can we present information needed by the reader to understand a given topic/Information unit?

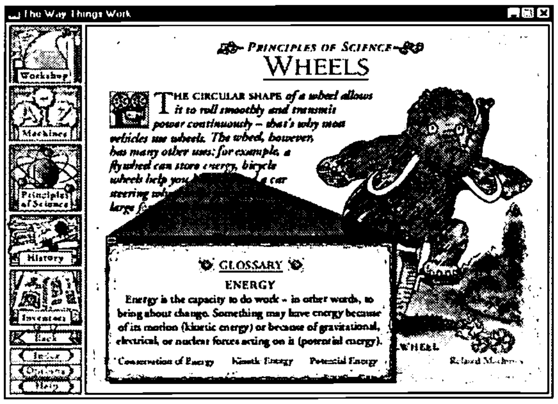
Motivation: This problem is of a particular interest in EMS. Many times, for example when introducing a new topic, it is necessary to refer to related concepts. The author has the possibility of adding links to the nodes of the referred concepts. But, if the reader is forced to navigate back and forth the original topic to read about complementary ones, the navigation overhead is high and the users' focus desagregated through a number of nodes, instead of concentrating in one topic at time. Thus the effectiveness of having links with related information is reduced by the distraction penalty it imposes over the reader.

Solution: This problem has been devised in hypertext systems from the early days. The usual technique is to activate those nodes of related information inside the current node. The user sees this "in-place activation" as a pop-up window that generally can be easily dismissed with an escape keystroke. In this way, the reader does not have to navigate to other nodes avoiding the inherent context switch and cognitive overhead.

Known Uses: In the "The Way Things Works", complementary concepts are shown in this way in figure 3, where the concept of "energy" is mentioned in both topics, and a reference to a node containing its definition is given. Notice that the definition of energy is not a part of the topics but rather an independent node that is activated as a pop-up window. Also, the MS-Windows Help System [Win95], provides different ways of specifying anchors, depending whether the result of activating the anchor is navigation or in-place activation of the target node (these are called: jump-anchors and popup-anchors).

Related Pattern: Information on demand [Rossi 97], since additional information enriches the contents by activating other nodes in pop-up windows. The difference with Information On Demand relies in that information is not part of the current node, that is, it is not part of the node's attributes and might be accessed from other ways, not only from the current node. The user activates simultaneously other nodes of information.

Relevance to EMS: This pattern address a common concern in EMS; how to provide background information to the reader without distracting his attention.



PRINCIPLES OF SCIENCE

WHEELS

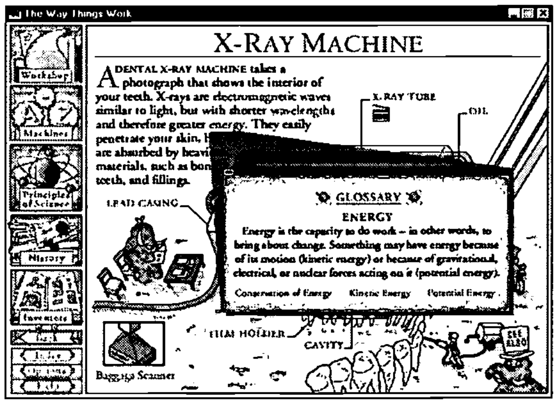
THE CIRCULAR SHAPE *of a wheel allows it to roll smoothly and transmit power continuously – that's why most vehicles use wheels. The wheel, however, has many other uses: for example, a flywheel can store energy, bicycle wheels help you* [illegible] *a car steering* [illegible] *large* [illegible]

GLOSSARY

ENERGY

Energy is the capacity to do work – in other words, to bring about change. Something may have energy because of its motion (kinetic energy) or because of gravitational, electrical, or nuclear forces acting on it (potential energy).

Conservation of Energy Kinetic Energy Potential Energy



X-RAY MACHINE

A DENTAL X-RAY MACHINE takes a photograph that shows the interior of your teeth. X-rays are electromagnetic waves similar to light, but with shorter wavelengths and therefore greater *energy*. They easily penetrate your skin, [illegible] are absorbed by heavi[illegible] materials, such as bon[illegible] teeth, and fillings.

GLOSSARY

ENERGY

Energy is the capacity to do work – in other words, to bring about change. Something may have energy because of its motion (kinetic energy) or because of gravitational, electrical, or nuclear forces acting on it (potential energy).

Conservation of Energy Kinetic Energy Potential Energy

Figure **Error! Unknown switch argument.**:An Example of "Information Factoring" from the "The Way Things Work" CD.

3. Organization of the interface

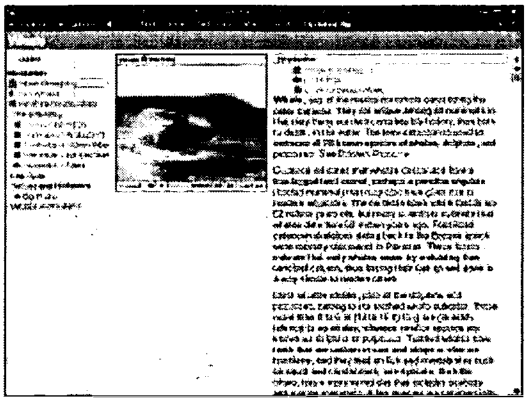
3.1 Information-Interaction Decoupling

Problem: How do you differentiate contents and various types of controls in the interface?

Motivation: A page of a complex application display different contents, and is related to many other pages, thus providing many anchors. Moreover, if the page supplies means of control activation other than navigation (such as triggering some query), the user may experience cognitive overhead. It is well known that when too many anchors are provided in a text, the reader is distracted and cannot take profit of all of them.

Solution: Separate the input communication channels from the output channels, by grouping both sets separately. Allow the "input interaction group" to remain fixed while "the output group" reacts dynamically to the control activation. Within the output group, it is also convenient to differentiate the "substantive information" (i.e. content) from the "status information". This solution not only improves the perception of a node's interface, but also the efficiency of the implementation.

Example: in figure 3, all links to related information on the current topic are displayed on the left. The graphics/video relevant to the current topic is displayed in the middle. Notice there are no links in the text itself.



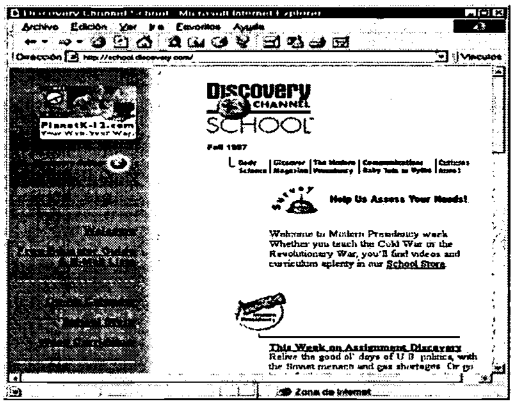

Archivo Edición Ver Ir a Favoritos Ayuda
Dirección http://school.discovery.com/
Discovery Channel School
Help Us Assess Your Needs!
Zona de Internet

Figure **Error! Unknown switch argument.**:Two examples of "Information-Interaction Decoupling" from the MS-Encarta97 CD-ROM and the Discovery Channel's educational web page (http://school.discovery.com/)

3.2 Behavioral Grouping

Problem: How to recognize the different types of controls in the interface so that the user can easily understand them?

Motivation: A problem we usually face when building the interface of a EIS is how to organize control Objects (such as anchors, buttons, etc.) to produce a meaningful interface. In a typical EIS there are different kinds of active interface objects: those that provide "general" navigation, such as "back" button, or anchors for returning to indexes, objects that provide navigation inside a context; objects that control the interface, etc. Even when applying Information-Interaction decoupling, there may be a lot of different kinds of control objects.

Solution: Group control interface objects according to their functionality in global, contextual, structural and application objects, and make each group to enhance comprehension.

Example: in figure 4, the first picture is taken from MindQ's CD-Rom "An introduction to Java Applets" groups the navigation controls at the left and the current topic playing controls at the bottom.

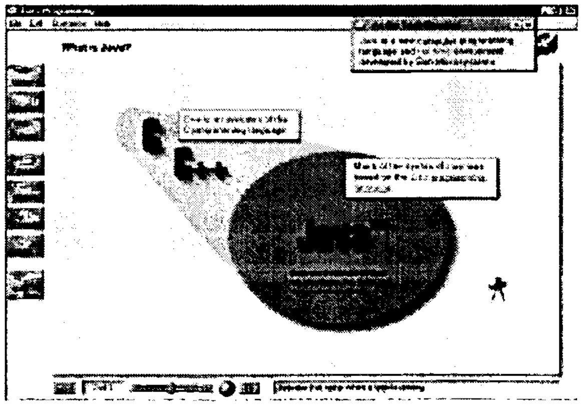


Figure **Error! Unknown switch argument.**: An example of "Behavioural Grouping" from the MindQ's CD-ROM "An introduction to Java Applets".

3.3 Behaviour Anticipation

Problem: How do you tell the user the effect or consequence of activating an interface object?

Motivation: Many times, when building an interface, it is necessary to combine different interface elements such as buttons, hotwords, media controls or even custom-designed controls. It is usual to find readers wondering what has happened after activating a control, and the exact consequence of the action performed.

Solution: Provide feedback about the effect of activating each interface element. Choose the kind of feedback to be non-ambiguous and complete: different cursor shapes, highlighting, small text-based explanations called "tool tips". Also, these elements can be combined with sound and animations. If we are using the behavioural Grouping interface pattern we can select different kinds of feed-back according the kind of behaviour provided; when the interface controls refer to a particular media such as animation, we could use a small status field for that family.

Example: In figure 5, there is an example from the Microsoft Atlas Encarta97. Each time the user positions the cursor over an interface element, a tool tip pops up with an explanation about the effect of activating the control.

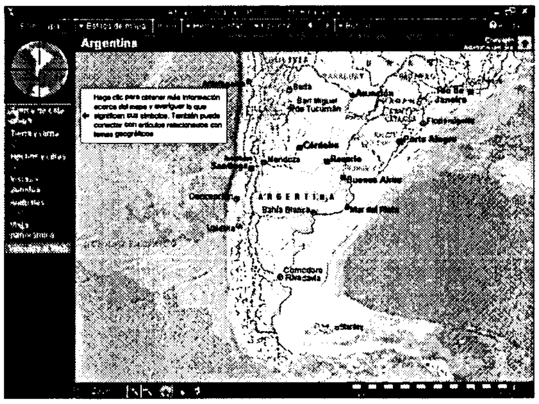


Figure **Error! Unknown switch argument.**: Example of "Behaviour Anticipation".

3.4 Process Feed-Back

Problem: How do we keep the user informed about the status of the interaction in such a way the he knows what to expect?

Motivation: When the user interacts with a hypermedia application, it may happen that many options result in non-atomic operations, such as getting information from the database, loading an image, or contacting another machine (in the case of the web browsers). In these cases, the user may feel the system didn't receive the order or simple is not working fine. As the user looses his patience without any positive feedback from the system but a silent screen, he may start retrying the last action or even any other action no matter whether it is connected or not with the sole target of getting some response. At this point, the user may have already lost the orientation and the task to be performed has been left in a second place.

Solution: Provide a constant perceivable feedback about the status of the operation that is being carried out, indicating progress in the case of non-atomic operations. Analyze which operations are atomic and do not need to be tracked. For non-atomic operations, give information about the current status: beginning, progression and ending of the operation. The kind of feedback depends on what kind of operation is involved: network connection, file loading or database search.

Related Patterns: Both process-feedback and behaviour anticipation address a similar problem: giving prompt feedback to the user about the actions he is performing.

Known Uses: In Web Browsers like Netscape Navigator and MS-Explorer, process feedback is given through a status bar showing the state of the http connection. On many CDs, the feedback given to the user is to set the cursor to the OS busy-hourglass. However, there are others that explicitly implements such feed to the user, as the example shown below.

Example: In figure 6, we can see an example of "Process Feedback", from the "Programming Java Applets" CD. The slider bar tells the user about the amount of information that remains for a given topic, and the rolling knob tells that animation is taking place.

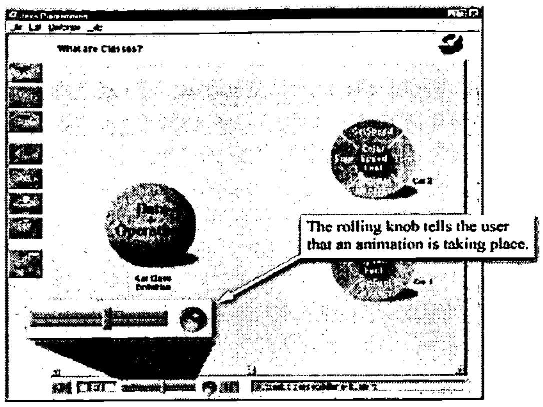

What are Classes?
The rolling knob tells the user that an animation is taking place.

Figure **Error! Unknown switch argument.**:A "Process Feedback" example from Mind Q's CD-ROM "

4. Conclusion

The process of designing and building educational hypermedia applications is far from being a simple task. There are several methodologies that already provide the necessary constructs and support for the different design tasks, though none the means to record the author experience and knowledge in the field.

We claim that through the use of patterns, authors are now able to identify common design problems and express solutions in a methodology-independent manner. Furthermore, now authors can talk about their designs with a common language and learn which were the ideas behind successful educational hypermedia systems.

In this paper we have presented some patterns we have found in different educational hypermedia systems on CD-ROMs and WWW. These patterns address important concerns in EMS and they can be used together to build complex but effective systems. Our aim is to define a pattern system containing a rich set of patterns dealing with most relevant issues in EMS.

It is our hope that, once a rich set of patterns is available, authors will be able to learn and work on multimedia systems at a higher levels of abstraction and with better results, since their work will be based on proven successful techniques.

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