



Chapter X

Modelling and Analysis of Web-Based Courseware Systems¹

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Designing reliable Web-based courseware systems is not trivial. Courseware authors need to allow as much flexibility in navigating through the system as possible on the one hand, and to ensure the satisfaction of properties and constraints in the system on the other. The problem is aggravated with facilities like Java applets which incorporate dynamic behaviour into the information structure. These issues motivate the need for designing such systems through rigorous modelling and analysis. We propose a scheme using a formal method called the Calculus of Communicating Systems (CCS) to unify the modelling of the courseware based on its navigational structure, semantics and dynamic components. Properties like ordering constraint, reachability and coverage constraint can be answered after a model is extracted from the implementation. Besides, our approach can be extended to assist in the design phase of the construction process, just like what computer-aided software engineering (CASE) tools do. A hypothetical example is used throughout the chapter as an illustration.

Internet banking, digital library, electronic commerce—applications of the World Wide Web (WWW), also known as *Web-based information systems*—are real and of widespread use. A typical Web-based information system has three dimensions:

- *Semantics* refers to the combination of the semantics of individual information elements (such as Web pages), which in turn captures the main theme of the element.
- *Navigational structure* is the connections among different information elements, i.e. hyperlinks.
- *Dynamic behaviour* of the system is exemplified when resources like CGI-scripts

receive input from users and cause a change in the semantics and/or structure of the system.

In the education domain, Web-based teaching is becoming a hot topic among educators. Courseware systems on the market can be grouped into categories like assignment collection and course delivery; we are more interested in the actual teaching/learning process. Listed in Figure 1 are some of the features of the Web and the respective benefits when WWW is used as a teaching medium.

While these features introduce several benefits as to adopting Web-based learning scheme over traditional classroom learning, the same features bring a big challenge to Web-based course designers and authors. On the one hand, learners should experience *flexibility* in navigating through the courseware, as promised by any Web-based system; on the other hand, course designers need to impose certain *constraints* to ensure that materials are presented in a “right” way. For instance, advanced materials should only be learned after fundamental topics are covered.

This problem may be easily solved by manual effort when the scale is very small (say, less than 10 independent pages). However, think of the following scenario: a high-school mathematics course (requiring 2 years of teaching) is to be transformed as a Web-based equivalent, involving a couple of developers. With such a medium-sized project, the navigational structure and semantics of the system are not trivial. It is a hard job maintaining the highest possible browsing flexibility while simultaneously ensuring the satisfaction of the required properties and constraints.

This challenge becomes more complicated when dynamic components like Java applets are involved since the navigational structure, semantics and dynamic behaviour of web pages are then interrelated. As an example, some interactive web pages lead learners to different pages based on their submitted answer. This may alter the reachability of other pages.

Figure 1: A summary of how teaching over the Web enhances the learning process by exploiting the unique features of the World Wide Web

Feature	Explanation	Benefit
<i>Ubiquitous</i>	Users can refer to the materials as long as Internet access is provided on a computer.	Learners can progress according to their own pace.
<i>Non-linear</i>	Traditional printed documents usually suggest a linear order of reading; the provision of hyperlinks in Web pages allows users to navigate through the same document in more than one way.	It is especially advantageous for learners to acquire concepts that are highly related to one another.
<i>Dynamic</i>	The Web is not merely the combination of semantics (text, images, sound, etc.) and hyperlinks. Java applets, Java-Scripts and Common Gateway Interface (CGI) programs bring dynamic behaviour to Web pages.	Both material scope and depth can be adjusted in response to learners' feedback through their performance in answering questions.

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