Chapter 1
Decision Models in the Design of Adaptive Educational Hypermedia Systems

Demetrios G. Sampson
University of Piraeus, Greece & Centre for Research and Technology Hellas, Greece

Pythagoras Karampiperis
University of Piraeus, Greece & National Center of Scientific Research “Demokritos”, Greece

ABSTRACT

Several efforts have been reported in literature aiming to support the Adaptation Model (AM) design in Adaptive Educational Hypermedia Systems (AEHS) with either guidance for the direct definition of adaptation rules or semi-automated mechanisms that generate the AM through the implicit definition of such rules. The main drawback of the direct definition of adaptation rules is that there can be cases during the run-time execution of AEHS where no adaptation decision can be made, due to insufficiency and/or inconsistency of the pre-defined adaptation rule sets. The goal of the semi-automated, decision-based approaches is to generate a continuous decision function that estimates the desired AEHS response, aiming to overcome the above mentioned problem. However, such approaches still miss a commonly accepted framework for evaluating their performance. In this chapter, we review the design approaches for the definition of the AM in AEHS and discuss a set of performance evaluation metrics proposed by the literature for validating the use of decision-based approaches.

INTRODUCTION

Adaptive Educational Hypermedia Systems (AEHS) have been proposed as the underlying facilitator for personalized web-based learning with the general aim of generating and providing personalized learning experiences to an individual learner (Brusilovsky, 2001), (De Bra, Aroyo, & Cristea, 2004), (De Bra, 2006), (Knutov, De Bra, & Pechenizkiy, 2009).

Henze and Nejdl (Henze & Nejdl, 2004) provided a logical definition of AEHS introducing
Decision Models in the Design of Adaptive Educational Hypermedia Systems

a quadruple (KS, UM, OBS, AM) with the following notation:

- the Knowledge Space (KS), that contains two sub-spaces. The first one, referred to as, the Media Space contains educational resources and associated descriptive information (e.g. metadata attributes, usage attributes etc.) and the second, referred to as, the Domain Model contains graphs that describe the structure of the domain knowledge in-hand and the associated learning goals.
- the User Model (UM), that describes information and data about an individual learner, such as knowledge status, learning style preferences, etc. The User Model contains two distinct sub-models, one for representing the learner’s state of knowledge, and another one for representing learner’s cognitive characteristics and learning preferences (such as learning style, working memory capacity etc.). This distinction is made due to the fact that the first model (Learner Knowledge Space) can be frequently updated based on the interactions of the learner with the AEHS. On the other hand, learner’s cognitive characteristics and learning preferences are more static, having the same property values during a significant time period.
- the Observations (OBS) which are the result of monitoring learner’s interactions with the AEHS at runtime. Typical examples of such observations are: whether a user has visited a resource, the amount of time spent interacting with a given resource, etc. Observations related with learner’s behavior are used for updating the User Model.
- the Adaptation Model (AM), that contains the rules for describing the runtime behaviour of the AEHS. Typically, these rules include Concept Selection Rules which are used for selecting appropriate concepts from the Domain Model to be covered, Content Selection Rules which are used for selecting appropriate resources from the Media Space, as well as, Sequencing Rules which are used for generating appropriate learning paths (sequences of learning objects) for a given learner.

In order to adaptively select and sequence learning objects in AEHS, the definition of adaptation behaviour, referred to as Adaptation Model, is required (Nejdl & Brusilovsky, 2004). In the literature, there exist different approaches aiming to support the Adaptation Model design by providing AEHS designers with either guidance for the direct definition of adaptation rules, such as ATO (Aroyo & Mizoguchi, 2004), MOT (Cristea, 2004), (Cristea & Stewart, 2005) and ACCT (Dagger, Wade, & Conlan, 2005), or semi-automated mechanisms which generate the AM through the implicit definition of such rules (Karampiperis & Sampson, 2005), (Huang, Chen, Huang, Jeng, & Kuo, 2008), (Ras & Ilin, 2008).

The main drawback of the direct definition of adaptation rules is that there can be cases during the run-time execution of AEHS where no adaptation decision can be made due to insufficiency and/or inconsistency of the defined adaptation rule sets (Wu & De Bra, 2001), (Brusilovsky, Wade, & Conlan, 2007). This is due to the fact that, even if appropriate resources exist in the Media Space, the absence of a required rule (insufficiency problem) or the conflict between two or more rules (inconsistency problem), prevents the AEHS to select and use them in the generated learning resource sequence. As a result, either less appropriate resources are used from the Media Space, or required concepts are not covered at all by the resulting sequence (Wu & De Bra, 2001).

The goal of the semi-automated approaches is to generate a continuous decision function that estimates the desired AEHS response, overcoming the above mentioned problem (Karampiperis &