Chapter 4
Intelligent Tutoring System Architecture Rebuilt: A Pattern Approach

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ABSTRACT
In this chapter, an approach to support the development of ITS based on patterns and pattern catalogues is described. Patterns are means to facilitate inter-project communication. As such, they provide for a clear terminology in an application domain. They support the development process itself by encapsulating information at different levels (e.g. using underlying concepts and tools, adding and integrating new concepts and tools, and fundamentally changing the structure of an existing piece of software). The approach described in this chapter shows two examples of how a catalogue of patterns collected from existing ITS architectures can be used and re-used in different settings. Those settings span the field of plugin frameworks for ITS (i.e. JaBiN), a concrete “proof of concept” ITS (i.e. ChemNom and CoChemEx) using a collaboration script approach.

INTRODUCTION
Projects which aim at the development of Intelligent Tutoring Systems (ITSs) are usually interdisciplinary projects. Some ITSs are developed based on psychological theories (e.g. (Anderson et.al., 1990), (Künzel & Hämeer, 2006)), some are tailored for specific application domains (Bergin & Fors, 2003), some are developed as “playground” for ideas of computer scientists (Martens & Himelspach, 2005). Often, these fields overlap in one and the same project (IlIlmann et.al., 2000).

However, ITSs projects are cost intensive when it comes to development time and man power (Murray, 1999). Thus, approaches to allow re-usage of ideas or even of components, system parts, databases, training content, and the like are highly desirable. Other research fields under the e-Learning umbrella have identified re-usability, especially of content, as one major contribution a computer system can have in educational settings (e.g. (Forte et. al., 1999)).

DOI: 10.4018/978-1-61692-008-1.ch004
This article is based on research described in (Harrer & Martens, 2006), where a generic pattern catalogue for ITSs has been introduced. We want to clarify some fundamental concepts and terms, we will show how patterns can be used by different ITS developers (given their different research background), and we will show examples, how we have used the pattern language in the last two years.

AN ARCHITECTURE AND THE PROBLEM OF INTERDISCIPLINARITY

Having its roots in the Greek term “arkitekton” (αρχιτεκτων), an architect is etymologically spoken the “leader” or “chief” of the “builders”. The architecture, being related to the Latin term “architectura”, denotes something which is man-made. Traditionally, it is related with built environment, which means man-made surroundings, buildings, and the like. Nowadays, the term’s meaning has been extended and is used in additional areas, e.g. mathematics, computer science, but also biology (e.g. architecture of cells). The core of today’s usage of the term is that an architecture is a structure plan of something, which is either man-made or found in nature.

In the context of computer science, the notion of architecture is often related to the abstract structural description of the underlying software system. The architecture describes the fundamental structural organization of the system. An architecture pattern thus sketches established solutions regarding the development of software. Moreover, the architecture pattern usually provides structure but no details (Buschmann et al., 1996). The notion of design patterns and architecture patterns has been proposed for the field of ITS early (e.g. Devedžić; 1999). Surprisingly, patterns still have not been taken up as a major method for systematic ITS development.

One possible reason for this is that, when it comes to concepts and terms in an interdisciplinary field like teaching and training systems, the computer science perspective is only one among several other perspectives. The history of ITS development is an interdisciplinary history: ITS have been developed by psychologists (e.g. (Anderson et.al., 1990)), by application domain experts, and by computer scientists (e.g. (Illmann et.al., 2000)). They sometimes work hand in hand with experts from pedagogy and design. Each of these groups of people developed their system with a different scientific background, and, moreover, based on different ideas about the finally resulting system (see Figure 1). For example, a psychologist might want to investigate hypotheses or teach a theory (Künzel & Hämmer, 2006) - however, usually his main interest will not lie in the design of the underlying software system. The computer scientist might be interested in the re-usability of components or in formal system descriptions (e.g. (Harrer, 2003)), but in most cases his knowledge about the learning theory which shall be realized with the system, or his knowledge about the training content might be comparably low. The same situation arises when it comes to content development. Usually, the developer of teaching and training content has not much knowledge about software engineering processes - and vice versa, the computer scientist does not need to have knowledge of the teaching and training domain. All these different needs and interests have to be merged and integrated productively to create mature and maintainable ITS, otherwise only specific aspects of the field can be explored with little perspective to use the synergy of the knowledge of the different stakeholders in the ITS area.

Summarizing, in ITSs development, psychologists, computer scientists, training domain experts, and designers have to communicate about the intended resulting system - which naturally has “an architecture”, in the sense that it has a fundamental structural organization. To find this underlying
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