

# Chapter 7

## Development of Automated Systems using Proved B Patterns

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### ABSTRACT

*This chapter proposes an approach for reusing specification patterns for the development of automated systems composed of two components: the controller and the controlled parts. The first is a software component controlling the second one that models the physical device and its environment. Specification patterns are design patterns that are expressed in a formal specification language. Reusing a specification pattern means instantiating it and the proofs associated. This chapter shows through a case study how to define specification patterns in Event-B, how to reuse them, and also how to reuse the proofs associated with specification patterns.*

### 1. INTRODUCTION

The idea of design patterns is not restricted to the field of computer science or object oriented software. Design patterns were actually introduced by Christopher Alexander in the field of architecture. In 1977 he spoke of patterns as, “each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a

way that you can use this solution a million times over, without ever doing it the same way twice” (Alexander, 1977). Related to Event-B, by design patterns we understand former developments that can be reused in the current development. Of course not every development is a good choice for reuse. What we are interested in are generic solutions of common problems. Although reusability is a good reason for having patterns, in Event-B, there is another important point. We

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aspire the reuse of proofs. A substantial part of the work when developing in Event-B is proving the correctness of the models. When reusing an already proved development, why should one do the same proofs again? The goal of design patterns in Event-B is therefore: *The reuse of already proved solutions, to refine the problem at hand, without doing any proofs.*

In our research work, we are interested in the formal development of automated systems. These systems are composed of two components: the controlled (operative part) and the controller (control part). The behavior of the first is continuous and modeled by a discrete model, whereas the second is software which has discrete behavior by nature and its goal is to restrict the controlled component behavior. Controller and controlled interact to form the automated system (Figure 1) as a closed-loop control one in which control actions are dependent on its outputs. Modeling continuous processes can be performed in design patterns. Indeed, formal specifications are increasingly used in industry and it becomes interesting to use some of these specifications in new projects. Reuse a formal specification means first defines a formal specification pattern and also the way to combine these patterns in the construction of a new application. B is a powerful notation that can

make it hard for the newcomer to decide how to structure and develop a B specification, and hard for a reviewer or implementer to comprehend a specification written in an unfamiliar style.

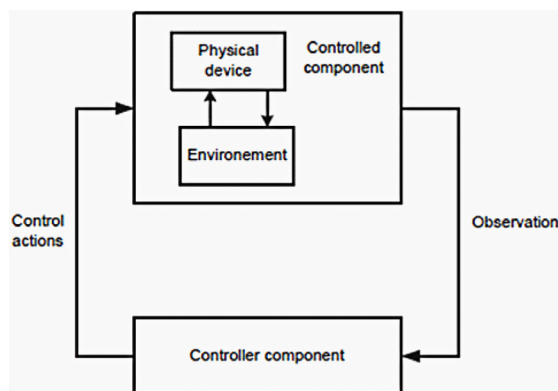
Our motivation is a desire to make B more usable by commercial non specialist developers and our reason for investigating patterns comes from experience in the industrial use of B. B textbooks introduce the mathematical bases of B, the notation, and essential elements of the use of B. However, few books provide advice on how to “do” B in practice. Illustrations clearly show how a feature was used by the author, but context and intent are implicit, and there is rarely any advice on how to reuse or adapt the B text. The work in this paper is a new presentation of the concept of pattern applied to enhance the “semantic structure” of B, thereby helping the writing; reading and presentation of B. Formalisms such as B have a role to play in general software development. So the patterns should enable:

- Writing of formal texts by generalists, because the patterns present formal solutions to common problems,
- Development of tools to support the use of formal methods by generalists, by recognizing and assisting in the application of patterns, and by breaking down the formal concepts into merchandisable or tool-supportable components.

We have chosen in this paper the B language to formally specify the notion of specification pattern for the following reasons:

- Where B is already being used, then there is no need to learn a new formalism to define and reuse specification patterns,
- B is supported by tools that validate the specification. We will use them to validate the definition of specification patterns and

Figure 1. Automated system in a closed loop



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