

# Report on the PhD Thesis: Hierarchical Component Models – “A True Story”

*Doctoral Candidate:*

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## **Background and Motivation for the Work**

Component-based Software Engineering (CBSE) is an established approach in research and practice and many elements from CBSE have been integrated into other design and development approaches. Still CBSE meets some challenges, and one of them is ability to build systems in a hierarchical manner, from primitive and composable components. The hierarchy principle is very powerful and very desired in building complex (software) systems, but also due to many challenges and problems (both theoretical and practical, both general and specific for CBSE) not fully exploited – neither in research nor in the practice. For this reason the topic “hierarchical component models” (i.e. component models that allow hierarchical component compositions) is of great interest in software development in general, and in particular for component-based systems, for both research and practice.

## **The thesis outline**

Contents-wise the thesis consists of four parts. The first part includes two chapters that discuss the general principles of CBSE and the definitions of components and component models. In this part some new characteristics of component models are emphasized, mostly related to run-time aspects and to a management of hierarchical component compositions. The component models that provide support for run-time are considered. The second part includes one chapter that gives a comprehensive overview of the following chapters. The third part includes five chapters (chapter 4 – chapter 8) and it provides the core of the contributions: Building and evaluation systems built from hierarchical components. Chapter 4 provides a method for compositional behavior verification, and Chapter 5 presents a case study with verification implementation for Fractal component model. The chapter that follows presents another case study and the limitations of the approach presented in the previous chapter. The problem is further discussed in chapters 6 and 7 in which the challenge with dynamic architecture (where components can be updated or replaced), and new approach sc. “proto-binding” was introduced in order to solve dynamic binding (i.e. binding not known at configuration time). Chapter 8 is somewhat out of the main scope (the hierarchical component model), but related to behavioral verification. It describes a language to model MS Windows kernel environment and its use for verification of MS Windows drivers. The last

part of the thesis, chapter 9 and 10 give a short overview of the related work and conclude the thesis.

### **Main contribution of the research**

The thesis contains several contributions: (i) a valuable discussion about component models and component specifications, (ii) analysis of key features of hierarchical component models, (iii) two case studies demonstrating design of component-based systems using a hierarchical component model, (iv) demonstrating verification methods for system behavior when using hierarchical component models, (iv) capturing and managing dynamic architectural changes by component updates, and (v) development and demonstration of use of a specification environment language used in a verification process. While there are many different contributions with a different level of deepness, the main contribution is a thorough verification of system's behavior, including the dynamic architecture management.

### **The thesis presentation**

The outline of the thesis is carefully and well designed. In particular the summaries of the problems and contributions are valuable for a reader to get an overall understanding of the thesis. English is in general good, with some occasional small grammatical errors.

### **Issues and questions for the thesis defense**

Although the thesis is well written with good arguments, there are some issues that would be useful for further clarifications.

(I) In your focus on hierarchical component model and discussion of the difficulties of their use you primarily focus on behavior and its verification. This is reasonable, but that should be clearly stated in the work. There are many other issues related to hierarchical component compositions. For example non-functional properties are hardly mentioned, and these are very important and the most challenging in compositions, and in particular in hierarchical composition. For this reason it would be useful to define the hierarchy property in a more formal way and by this precisely define the scope of the research.

(II) Of the desired properties of hierarchical component models that you have listed, not all elements are addressed later in the thesis. For example you identified "performance prediction" yet it seems that the term "performance" is referred only in this list, and never elaborated later. Again a precise specification of "performance" is missing. Maybe you thought on behavior in your specification when you wrote performance, but a performance includes more sub-characteristics. In addition, all these properties (except the first one, the hierarchical component run-time architecture), are the properties desired for any component model, and not specifically for hierarchical component models. A discussion why these properties are more important or are more challenging (or maybe easier to be obtained) for hierarchical component models is missing.

(III) The discussion of benefits in using hierarchical component models in industry (in particular ABB) is somewhat speculative. A more thorough discussion would imply a more detailed description of the problems and the current solutions that exist in the industry that are actually beyond of a problem

of using hierarchical models. An interesting question is how far the principles be can used on different abstraction levels. In the concrete example (ABB), layered and distributed architectures are used, since the (physical and process) objects managed are on quite different abstraction level.

(IV) The thesis lists the publications, and from some of them the text was copied to the thesis. This is not a problem, but it would be nice if you have specified in the thesis your concrete contribution in each publication.

### **Judgment**

The candidate has shown ability to conduct a research work, with a clear novel and relevant research contribution. By his publications and in particular by this thesis work the candidate has proved a scientific maturity of a PhD. I recommend the thesis for a defense, and judge the candidate worthy of the degree of PhD. In my view the thesis can be graded as "A".

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