First, this thesis presents an analysis of diversity of component-based software engineering (CBSE) concepts and approaches, and provides a summary of selected runtime-aware component models structured according to newly proposed criteria. As a result of the analysis, hierarchical component models are identified as a CBSE domain still not sufficiently explored in the current research with respect to their lacking penetration into regular industrial use. The major part of the thesis consequently almost exclusively focuses on problems related to application of hierarchical component models to real-life applications development.

The motivations for hierarchical structuring of application architectures are presented in the thesis and key advantages of hierarchical component models are thoroughly discussed and shown on examples from commercial software development. To verify the claims, two major case-studies are presented in the thesis and the Fractal component model is successfully applied to model and implement them focusing on formal verifiability of correctness of resulting component-based applications. The thesis proposes novel approaches to model dynamic architectures changing at runtime, to deal with complex error traces and a novel specification language for component environments, all resulting from our evaluation of the case-studies.