
Preface

Collaborative Research Center (Sonderforschungsbereich) 476, “Information Technology Support for Collaborative and Distributed Design Processes in Chemical Engineering” (IMPROVE), is a large joint project of research institutions at RWTH Aachen University, including different groups in engineering, in particular process systems engineering, plastics processing, labor research, and different groups in informatics, namely, communication, information systems, and software engineering. It is funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG), with more than 20 scientists collaborating continuously in a long-term research effort since 1997.

In this volume we summarize the results of IMPROVE after 9 years of cooperative research work. Together with master’s theses and the contribution of technical personnel we report on the total effort of more than 200 person years of scientific work. This includes research work done in dissertation projects.

The 9-year period of the CRC has been and will be continued by technology transfer activities from mid 2006 to mid 2009 (Transfer Center 61 “New Concepts and Tools for Chemical Engineering Practice”), also mostly funded by the DFG. The main activities of this transfer center are also described in this volume.

The focus of IMPROVE is on understanding, formalizing, evaluating, and, consequently, improving *design processes* in chemical engineering. In particular, IMPROVE focuses on conceptual design and basic engineering, where the fundamental decisions concerning the design or redesign of a chemical plant are undertaken. Design processes are analyzed and evaluated in collaboration with industrial partners.

The design of a plant for producing Polyamide-6 is used as the *reference scenario* within IMPROVE. Based on this scenario, novel concepts, models, and tools for supporting integrated forms of design processes in chemical engineering have been developed.

The kernel of the approach is a *formal process/product model* for design, which is regarded on different levels, covering domain models on the top to internal models used for the realization of tools at the bottom. Infrastruc-

ture projects introduce research results on distributed platforms for computer processes and data integration as part of the architecture of the overall environment of supporting tools. The formal product/process model has already gained a certain degree of maturity. However, further research work will be needed to present it in a formalized way. We invite other research groups to join our activities and to contribute to this challenging task.

The IMPROVE approach in particular deals with *collaborative* and *distributed* design *processes* across different organizations. Cross-company collaboration takes place every day. It is still a big problem for all engineering disciplines with respect to in-depth understanding and a suitable tool support. In order to improve the state of the art, not only organizational boundaries have to be considered. Rather, knowledge across different specific domains and design disciplines is needed and, therefore, has to be uniformly presented.

The goal of IMPROVE can also be seen from the *tool integration perspective*. There, we follow an approach which is based on existing tools and aims at enriching their functionality (bottom-up or a-posteriori strategy). Hence, integration does not only refer to system integration in the sense that all existing tools work coherently on top of a distributed platform. In contrast, new tool functionality is added to support and, therefore, improve distributed design across different persons, roles, disciplines, or companies. For this purpose, new informatics concepts are introduced to facilitate the design process, e.g., by reusing developers' experience, controlling consistency on a fine-grained level, direct multimedial communication of results, and by reactive project management. Furthermore, the combination of these new functionalities is studied providing further synergistic functionalities. This comprehensive tool integration approach is unique and not yet covered by any available book on tool integration.

Another unique feature is the derivation of new *tool functionality* from explicit *models* of the *chemical engineering domain* including the organization of design processes, thereby embedding existing design support tools. The analysis of industrial design processes is the basis of the formalization. The new tool integration functionality is derived from the resulting formal models. Thus, we do not build a new integrated environment and check afterwards whether it matches the needs of the design processes of interest. Rather, the functionality is derived from validated practical models. This vertical and formalized integration aspect demonstrates the close cooperation between chemical engineering and informatics within IMPROVE.

Although chemical engineering is the application domain for which we produced conceptual and practical results in the form of models and software, a substantial part of the research results contained in this volume hold true for other engineering domains as well. Some results are directly valid in other domains, others relate to approaches which can be carried over to other domains without revision. Hence, this book can also be seen as dealing with *engineering design processes* and their *integrated support in general*.

The results of IMPROVE have been reviewed four times by peers at the beginning and after every 3 years. Furthermore, evaluation by the industry has been implemented by affiliating a number of industrial partners with the CRC. Transfer activities will strengthen the relations between IMPROVE and the industry in the next few years. Both peer reviews and cooperation with the industry imply a *spiral research approach*: Goals have been checked and revised after a period of 3 years. Finally, the progress of one period is based on the results of the preceding period.

This book intends to summarize the results of 10 years of interdisciplinary research and future plans for an additional 2 years to present them to the international community. The results are applicable to different design processes including chemical engineering, mechanical engineering, electrical engineering, or computer science. Thus, the book addresses the whole community of people involved in the improvement of design processes in different engineering disciplines, either in academia or in industry.

Hence, a specific goal of this book is to broadcast our results across different disciplines. As informatics is the main focus, publication in the *Lecture Notes in Computer Science* series is an obvious objective. However, engineers from many disciplines are addressed as well.

There is no interdisciplinary joint project on design process modeling and support of a comparable breadth and depth known to the editors. Therefore, the approach and the results of the CRC received broad international recognition in both the chemical engineering and informatics communities.

Results of IMPROVE have been published in many scientific journals or conference and workshop proceedings, as compiled in the bibliography. The aim of this book is to give a complete and uniform description of the corresponding results with a quality of coherence which comes close to that of a monograph.

Our thanks go to different institutions: The German Research Foundation has given and will give us remarkable support during the last 10 years and the 2 years to come. RWTH Aachen University and the Ministry of Science and Research of the State North-Rhine Westphalia have also provided us with additional funding. The funding sums to about 11 million euro. Without these generous donations IMPROVE could not have been started. Section 1.3 gives more detailed figures. Additional grants have been given to the research groups participating in IMPROVE by the DFG, the Federal Ministry of Research in Germany, or by the European Community for other and related projects. Their results have been the basis for IMPROVE or they will continue the research described in this book.

We are also indebted to several persons: Peers have visited us four times to evaluate our proposals and to make remarks for improving the project. Their engagement is especially acknowledged. Members of IMPROVE (see Appendix A.2) have worked hard to achieve the results described in this book. Furthermore, many master's degree students contributed to the project during their thesis work.

Finally, Mrs. Fleck and Mr. Haase spent a lot of effort and time getting the layout of this book in shape.

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