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Software Architecture

With 161 figures

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Preface

Building software nowadays is far more difficult than it can be done several decades ago. At that time, software engineers focused on how to manipulate the computer to work and then solve problems correctly. The organization of data and implementation of algorithm were the crucial process of software designing then. However, more and more tasks in low level, such as memory management and network communication, have been automatized or at least can be reused with little effort and cost. Programmers and designers, with the help of high level programming languages and wieldy development tools, can pay more attention to problems, rather than bury themselves into the machine code manuals. However, the side effect of these utilities is that more complicated problems are given according to the requirements from military, enterprise and so on, in which the complexity grows rapidly day by day. We believe that software architecture is a key to deal with it.

Many people become aware of the existence of software architecture just recently. Nevertheless, it in fact has a long history, which may surprise you. Before the invention of C++or even C, some computer scientists had begun to notice the concept of software structure and its influence to software development. In the 1990s, software architecture started its journey of bloom, when several communities, workshops and conferences were hold with a great amount of published articles, books and tools. Today, software architect, the job of taking software designing, analysis and dealing with different concerns and requirements from different stakeholders, is considered as the center of development team.

But there is an ironical problem that most existing architects in fact do not take any study or training in this field, some of whom even do not realize that software architecture is a kind of realm requiring academic effort, just as artificial intelligence or data mining. The reason is that software architecture has no widely-accepted definitions and standards of basic theories and practical methods, which leads to that there are almost no universal course about this subject. Meanwhile, the rapid growth and division of software architecture result in too many branches and sub-fields, most of which still keep non-dominant and unified. These changes aggregate the trouble in learning even a subset of software architecture area. In this book, we will provide an overview among the classic theories and some latest progresses of software architecture and try to touch the software architecture's essence.

This book is a collaboration of three authors: Zheng Qin, Jiankuan Xing and Xiang Zheng. More particularly, Professor Qin is the primary author who decides the contents and issues what you can see in this book. And Jiankuan Xing organizes the work of writing, and facilitates the cooperation with authors and other contributers.

Targets

This book aims to give an introduction to the theory foundations, various sub-fields, current research status and practical methods of software architecture. In this book, readers can acquire the basic knowledge of software architecture, including why software architecture is necessary, how we can describe a system's architecture by formal language, what architecture styles are popular for practice use and how we can apply software architecture into the development of systems. Study cases, data, illustrations and other materials which are released in the recent years will be used to show the latest development of software architecture. This book can be used as the learning material for touching software architecture.

How to Read This Book

We target to give readers an inside-out understanding of software architecture, therefore this book is divided into two parts (not shown explicitly in content):

- Basic Theories: Chapter 1—Chapter 5
- Advance Topics: Chapter 6—Chapter 9

In detail, we give the overview descriptions for each chapter as follows:

Chapter 1: Introduction. The theme of this chapter is the basic introduction to software architecture, where readers will see why we need it, how it emerged and what its definitions look like. We hope to give readers a clear vision on it, considering a great many misunderstanding and arguments' presence. In addition, with the development of research, concerns and usage of software architecture have become different, which we will mention at the last section of this chapter.

Chapter 2: Architectural Styles and Patterns. Initially, the research on software architecture emphasized the categorization of software in architectural level. Some systems share the common structure and properties are classified into one set in which the same vocabulary and similar models for representing these systems can be used. Each vocabulary and models specified for a category is called "architectural style". What's more, we abstract and represent some representative structure and reuse them with style. Each structure is called an "architectural pattern". Architecture styles and patterns are very precise utilities for constructing complex systems. In Chapter 2, we provide descriptions, study cases and comparison of them.

Chapter 3: Application and Analysis of Architectural Styles. After characterizing several popular styles, we continue to offer a few study cases, each of which combines more than one architectural style. Academically, this is called "heterogeneous style constructing". As a matter of fact, applied software always uses multiple styles simultaneously, no matter how simple they are. The goal of this chapter is to tie the abstract styles to practice use.

Chapter 4: Software Architecture Description. How to describe software architecture is the centric subject of architecture realm, because it is the foundation to represent software's design, perform effective communications among stakeholders and measure systems' behaviors according to requirements. In this chapter, we pay attention to architectural formal description, which stands on the mathematic basis. However, for UML, the language widely used as architecture representation in practice, you can find excessive materials about it.

Chapter 5: Design Strategies in Architecture Level. This chapter gives you a chance to touch the concept of architectural design with formal foundation. In contrast to practical software development processes, such as RUP (Rational Unified Process), formal architectural design strategies stress the relationship and calculus of function space and structure space, both of which abstract the development process performed in the real world. To get through with this chapter, a fair capability of set theory and automata theory is required.

Chapter 6: Software Architecture IDE. Although software architecture is useful for software development, using it with pure handwork incurs too much overhead, and then time and cost, to the development process, which may obliterate its benefits. That's the key why software architecture was not popularly accepted in the 1990s. Now, we have the handy assist, software architecture IDE. The purpose of IDE is to enable an organization to manage its software architecture and other related actions and processes in a way that meets business needs by providing a foundational utility upon which design, communication, framework code generation and validation can be carried out automatically.

Chapter 7: Evaluating Software Architecture. After the initial architectural design is finished, any stakeholder would finger out whether this design is good or not, whether it will contribute to a successful development and then output the satisfying production or doom to crush resulting from the design defects. That's the evaluation's task. In this chapter, currently widely-used evaluation methods are discussed and compared. However, evaluation methods still lack the formal foundation, and more focus on the experience and capability of participators. Therefore, the description here will bring you the practical architectural methods and technologies, based on which evaluation is performed.

Chapter 8: Flexible Software Architecture. Flexible software architecture means the structure of a system which can metamorphose during runtime according to users' instructions, executing environment's changes or other requirements and the related actions and processes. That's crucial for systems' needs of self-healing and self-adaptation abilities. The systems with these needs before normally mix the structure metamorphosis code and application code, which insults more trouble in maintaining and improving procedures. What's more, failing to divide this confusion causes the system as conceived and the system as built to diverge over time. In this chapter, we give an introduction to what flexible software in architecture level looks like and what the principles and organization patterns of constructing it are.

Chapter 9: A Vision on Software Architecture. This is a chapter far away from theories, methods and technologies, in which the applications of software architecture in current software industry and in other fields, such as medicine, electronic engineering and military are presented in general. After that, we will provide several future research directions of software architecture at the end of this book.

Considering the relative independence of each chapter, readers can choose several chapters they are interested in. But we recommend Chapter 1 should be read carefully since it can help you understand other chapters easier and better. In addition, you can find more detail and deeper description about some topics through the reference materials we give.

Who Should Read This Book

The graduates and undergraduates whose majors are elated to software design and development will benefit much from this book. Also, other people who are interested in software architecture would be guided to this field by reading this book. Then, experienced software designers and project leaders who want to adopt architecture as the centric concerns and utility of their software development process are our target readers, too. But they may suffer pain for a moment when converting their original mind to the new world, from which they will at last benefit. We assume our readers should have simple experience as follows. (Each capability may only be involved in several chapters rather than the whole book)

- Programming using C++, Java or C#
- Software design (even a simple project would be fine)
- Software project management

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For the current years I have been considering the problems of software

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