



SERVICE COMPUTING

CONCEPTS, METHODS AND TECHNOLOGY

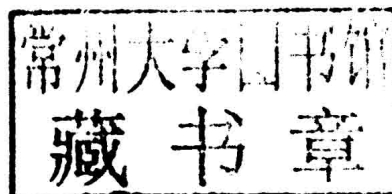
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Service Computing

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Service Computing

Preface

Service computing is a cross-discipline that covers the science and technology and represents the promising direction of distributed computing and software development methodology. It aims to bridge the gap between business services and information technology services by supporting the whole life cycle of services innovation. The last 10 years has witness the progress and success from both academic research and industry application.

This book compiles some recent work from the E-service research group of the CCNT (advanCed Computing aNd sysTem) laboratory at Zhejiang University, China. It presents the concept of service computing and proposed a multilayered technical framework for service computing, which divided the main issues of service computing research into four layers from bottom to up: service resource layer, service convergence layer, service application layer, and service system layer. And then it briefly introduces two underneath technologies, i.e., Web services and service-oriented architecture. After that, it presents the research group's latest research findings in the hot topics such as Web service QoS prediction, Web service discovery, service selection, service recommendation, composition, and verification. Some new models and methods are proposed including collaborative filtering-based QoS prediction, behavior-based service discovery, skyline-based service discovery, Bayes-based service recommendation, top-k service composition, type theory-based service formalization and verification, and so on. And also, it discussed three challenging issues of complex service computing, i.e., service computing with big data, with complex mobile environment, and with service pattern model. At last, this book introduces JTang, an underneath platform supporting service computing, which has been widely used in more than seven different areas such as e-business, e-government, public services, and financial industry. This book presents the architecture and components of JTang and gives the details on its core systems such as distributed storage system for big data and distributed service enterprise bus for service integration.

This book would not have been possible without many contributors whose names did not make it to the cover. We would like to give our special thanks to Prof. Jianwei Yin and Prof. Ying Li in our research group, Prof. Li Kuang and Prof. Yuyu Yin who had been affiliated to the CCNT laboratory of Zhejiang University, as well as some Ph.D. candidates in our group including Mr Liang Chen, Mr Longtao Huang, Mr Yuesheng Xu, Mr Wei Luo, Mr Zhiling Luo, and Mr Hongyue Wu. For a long time already, it has been our pleasure to do research with them in service computing. They have devoted their energy and enthusiasm to this area and relevant research projects.

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Introduction

Chapter Outline

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Throughout the history of the software industry, each birth of new software development technology and design ideas has triggered a major revolution in the software industry. In the 1960s, the emergence of object-oriented technology was a substantive revolution for structured programming design and analysis. It greatly reduced the complexity and improved the efficiency of software development. In the 1980s, the flourish of software component technology initiated the transformation of the software production mode from workshop production to industrial production. It fundamentally changed the traditional software production mode and brought the software industry into an unprecedented rapid developmental track. Today, with services as the basic elements, service-oriented architecture (SOA) as the guiding principle, and service reuse and service composition as the software design methods, service-oriented computing has become the latest developmental direction in current distributed computing. It is undeniable that service computing is leading the new round wave in software industry development. This chapter mainly focuses on the concept and research framework of service computing, as well as state-of-the-art of service computing both from the industrial and academic perspective.

1.1 Overview

With the development of computer and network technology, modern enterprise is entering an era when enterprise forms are continuously changing, enterprise extensions are being

continuously expanded, enterprise environments are continuously changing, and enterprise businesses are being continuously adjusted. The traditional software development concepts and methods, characterized by “once development” and “continuous usage,” are becoming increasingly stale and outdated. How to solve the problem of “on-demand” for enterprise application systems has become an increasing critical issue for the modern software industry. Moreover, it has been the stumbling block that hinders the rapid development of the software industry. Under such circumstances, service computing technology is proposed, as a new kind of computing schema, to resolve this problem.

1.1.1 The Origin of Service Computing

From the time service computing was first proposed, it took only three years' time for service computing to be established as an independent computing discipline. The concept of service computing can be traced back to the International Conference on Internet Computing held in June 2002. In the web service computing track of this conference, service and computing were combined for the first time. The important role that web service played in distributed computing and dynamic business integration was emphasized and widely approved by all experts and scholars at the conference, which laid the foundation for the future promotion of service computing. From that time, service computing has continuously attracted the interests of researchers and industrial giants and has become regarded as the latest development direction of distributed computing. In November 2003, the Technical Community for Service Computing was established by the Institute of Electrical and Electronics Engineers (IEEE). In May 2004, it was renamed the Technical Steering Committee for Service Computing, dedicated to promoting the development of service computing disciplines and creating related standards. This marked the point at which service computing became an independent computing discipline. In September 2004, the first session of the IEEE International Conference on Service Computing was held by the Technical Steering Committee for Service Computing in Shanghai. It was the first global event on service computing. A large number of scholars and experts were attracted, and a large number of research results emerged from this conference. The successful holding of this conference drew wide attention from both academia and industry, greatly promoted the development of service computing discipline, and made service computing become a popular computing discipline.

The reason service computing could rapidly grow and develop in only three years lies in the continuously evolving computing environments. The computing environment consists of a group of computers, software platforms, protocols, and interconnected networks. In this environment, computers and software platforms can exchange data and process information through the network according to the established protocols. The computing environment has transformed from an early centralization mode to a current distribution

mode. In this process, it has gone through four stages: mainframe computing environment, client/server computing environment, multilayer distributed computing environment, and service computing environment.

The mainframe computing environment in the 1960s was a completely centralized computing environment, in which the majority of the computing devices and resources were concentrated on the expensive and bulky mainframe. Users could use it only through their dumb terminals, which contained only a display and a keyboard.

In the early 1980s, with the development of hardware technology, especially the large-scale integrated circuit technology, small personal computers began to enter households. Computing devices and resources had been transferred from the central machine rooms with mainframes to households, while the computing environment was still limited to the signal-machine environment. In the middle and late 1980s, with the development of computer networks and the growing popularization of personal computers, the computing environment entered the distributed era. Interoperability and sharing were achieved in this distributed but interconnected computing environment. During this period, the client/server computing environment emerged, in which client computers and server computers were separated. The former are always personal computers or workstations, while the latter are always mainframes, minicomputers, personal computers, and workstations, which provide clients with functions including large-scale data storage, file sharing, printing, key business processing, etc.

In the 1990s, to provide better performance, flexibility, and scalability, a multilayer distributed computing environment was derived from the client/server environment. It realized the separation of the presentation layer, business layer, data layer, etc. However, the computing environments were still built on relatively closed protocols, so they lacked general standardization support. Owing to the more open Internet, especially the continuous application and development of XML and web services technology, the computing environment had evolved into an Internet-oriented service computing environment, which is based on open standards and protocols. In the service computing environment, computing devices and software resources also evolved by showing necessary trends, including both standardization and transparency. This new computing environment needed a new computing technology to support, which led to the environmental foundation for service computing.

The formation of the service computing environment brought new requirements for software architecture and software-development methods. Software architecture refers to the software elements that constitute the software system, the external visible properties of these software elements, and the relationships between these software elements [1]. The ever-changing computing environment that made up the centralized software architecture in the early era of mainframe computing gradually developed into service-oriented

software architecture. In the service computing environment, all kinds of computing devices and software resources are highly distributed and autonomous. Variation becomes the essential innate characteristic of this environment. Software systems are facing unprecedented challenges brought about by dynamic elements, the changing environment, and complexity. Service-oriented software architecture is a loose, flexible, scalable, distributed software architecture scheme that is formed to be adapted to the dynamic, distributed, autonomous, and transparent service-computing environment. The formation of service-oriented software architecture lays the most important technical foundation for the formation of a service computing discipline.

Meanwhile, with the variations in the service computing environment and software architecture, the concepts, principles, and methods of a service-oriented software system design and development emerge as required. Every variation in software development methodology had brought significant changes to the software industry. As we know, the birth of component-oriented software development technology initiated the transformation of the software production mode from traditional workshop production to industrial production. Service-oriented software system design and the development approach is the real source power to further promote this transformation and the critical theory and method to complete this transformation. Therefore, the concepts, principles, and methods for service-oriented software system design and development, continuously developed and improved with service-oriented software architecture, provide the basis for the most important methodology foundation for the formation of service computing discipline.

In conclusion, the birth of service computing is the result of the continuously evolving computing environment, software system architecture, and software development methods. It is the inevitable result of further enhanced and accelerated development of the software industry.

1.1.2 The Concept of Service Computing

Although service computing has become a new research hotspot both in current academia and industry, it has not a unified concept. Besides, as it is in a continuously developing process, its definition and connotation are also constantly changing. Experts and scholars have different understandings from different perspectives.

Mike P. Papazoglou, who is from the software system design and development perspective, thinks that “Service computing is a way of developing application systems with services as the basic elements” [2].

Munindar P. Singh and Michael N. Huhns, who are from the application of service technology, think that “Service computing is the set of technologies that combine service