
Preface

To cope with new characteristics of software for the Internet computing environment, existing software paradigms need to be evolved to be a new one. Such a new software paradigm should be able to systematically support the development, deployment, operation, and quality assurance of software on the Internet. Around 2000, we coined a word *Internetware* from the two words “Internet” and “Software”, to denote our visions of a new paradigm for software systems that are constructed, executed, used, and evolved in the open and dynamic Internet environment. Elaborately, these systems often need to be

Autonomous. Software entities are usually distributed, relatively self-contained, and independent. Software entities perform according to the composition or deployment strategies defined by their providers, and continuously satisfy the providers’ requirements. A software entity can adapt itself when necessary, by sensing and collecting information on environment changes.

Cooperative. A set of software entities can collaborate with each other for the purpose of business or management. Often the collaborations are rather dynamic than static, to adapt to the user requirements and environments in an on-demand way. The collaboration mechanisms between software entities can be of various types, and can be changed if necessary.

Situational. Software applications can be aware of the runtime contexts and scenarios, including the underlying devices, operating platforms, networking conditions, application contexts, or the changes of other dependent applications, etc. Hence, both software entities (included in a software application) and their operating platforms might be capable of exposing their runtime states and behaviors in some way.

Evolvable. The structures and behaviors of software applications might dynamically change. Software applications usually consist of autonomous entities over the Internet, and provide online and continuous (e.g., 24 h * 7 days) services for a large number of users. Hence, software applications cannot be shut down during evolution. Software applications have to perform online evolution to accommodate new user requirements and environments. Possible evolutions can include addition/removal of software entities, changes of functionalities on-the-fly and just-in-time, changes of interaction styles between entities, change of topologies among entities, etc.

Emergent. Software applications can exhibit undesigned behaviors or undesired effects on runtime instances or interactions. Such nature might iteratively result in more and more changes of software application structures and behaviors to accommodate such emergences.

Trustworthy. Software applications should promise comprehensive tradeoffs among various quality attributes. As software applications serve a number of online users, the trustworthiness of the software applications should cover a wide spectrum, including reliability, security, performance, user experience, etc. Quality assurance can be relevant to various aspects, including autonomous entities, interaction styles, network environments, usage patterns, malicious attacks, software evolution, etc.

Since then, substantial efforts have been made on Internetware research and practices. Especially, two national projects have been carried out consecutively: the project *Research on Theory and Methodology of Agent-based Middleware on Internet Platform* (2002–2008) and the project *Research on Networked Complex Software: Quality and Confidence Assurance, Development Method, and Runtime Mechanism* (2009–2013). About 80 researchers from Chinese universities and institutes have participated in the projects, including researchers from Peking University, Nanjing University, Tsinghua University, Institute of Software of the Chinese Academy Sciences, the Academy of Mathematics and Systems Science of Chinese Academy Sciences, East China Normal University, and IBM China Research Laboratory. Since 2009, the Asia-Pacific Symposium on Internetware (<http://sei.pku.edu.cn/~internetware>), in cooperation with ACM SIGSOFT, has been held annually, attracting authors and attendees from China, USA, Europe, Australia, Japan, and Korea.

Internetware research gets funding support from various China's national research and development programs in the past 15 years. The preceding two projects are first sponsored by the Chinese National Basic Research Program (known as 973), which is one of the five major national programs in the national R&D program of China. After the first five years, some research topics identified for Internetware, are sponsored by the National Natural Science Foundation of China and the National High Technology Research and Development Program (known as 863). Some prototypes of Internetware operating platforms and development tools have been successfully transferred to commercial products and solutions under the support of the National Science and Technology Major Projects. In 2014, the *Research on Internetware: Theory, Approaches, and Technologies* was awarded by the *Top 10 Grand Progress of Science and Technology* awarded by the Ministry of Education of the PRC. In a word, the Internetware research community has been established and keeps increasing in the past a few years.

Book Overview

This book is organized to summarize and share the state-of-the-art efforts of Internetware research. More specifically, this book presents the efforts that address the challenges of software technologies in Internet computing

environment, including the fundamental aspects of programming model, engineering approach, runtime operational platform, and quality measurements and assurance. In addition, this book also includes a number of real-world applications, experiences, and practices of Internetware. The book consists of five parts.

- *Part 1* gives an overview of a technical framework for Internetware. It takes a software architecture-centric viewpoint and organizes the framework as three connected aspects: system modeling, middleware support, and engineering method.
- *Part 2* presents a software model featuring environment driven adaptation for Internetware applications. Enabling techniques for the model, especially the modeling, management and utilization of environment information are discussed. An architecture-centric framework has also been built to prove the concepts and evaluate the techniques.
- *Part 3* focuses on the runtime support for Internetware application systems. The support covers various aspects of the execution and adaptation of software situated in the open and dynamic Internet environment.
- *Part 4* introduces the Internetware engineering approach. It essentially follows the core and underlying principle of software architecture throughout a whole-life cycle. This software architecture serves as a blueprint, and suggests or controls each phase in lifecycle for developing Internetware applications.
- *Part 5* describes how the Internetware paradigm is applied to real-world cloud and client applications. At the client side, applications on smartphones connect to the physical world and Internet by their built-in sensors and networking chips, respectively. At the cloud side, numerous computing platforms like virtual machines and middleware infrastructures are managed to run user tasks in a cost-effective way. We discuss how the Internetware paradigm is realized on the two sides, as well as how the two sides are connected and how applications can be diagnosed for energy efficiency.

Organizations of the Book

The book stems from a set of high-quality research papers that have been published on premier computer science conferences or journals. Indeed, there have been numerous efforts contributed to Internetware research in the past 15 years. Due to space limit, we have to select only some representative efforts that cover some typical Internet-based applications such as cloud/grid computing, services computing, mobile computing, Web, Internet of Things, and so on. These efforts are organized by the research framework of Internetware paradigm. When having acquired the copyrights of original publishers, the authors further make great efforts to revise and expand the original contents to better fit the goal of this book.

As mentioned previously, the Internetware research is a long-term and open study that involves hundreds of researchers with different background. Meanwhile, the understanding, synthesis, and scope of Internetware paradigm keep improving during our 15-year course of study. The selected efforts in this book were actually made at different time and from different perspectives. As a result, this book cannot comprehensively enforce the consistent understanding and representation of some aspects in Internetware. Indeed, it can reflect the history that we made substantive headway towards the essence of Internetware paradigm.

Audiences and Readers of the Book

This book can be a reference book to researchers and practitioners of software engineering, operating/network systems, programming languages, and so on. It can be also used as a textbook for graduate students and junior/senior undergraduate students who major in computer science.

Beijing, China
June 2016

Hong Mei
Jian Lü

Internetware

A New Software Paradigm for Internet Computing

Mei, H.; Lü, J.

2016, XXVIII, 442 p. 191 illus., 117 illus. in color.,

Hardcover

ISBN: 978-981-10-2545-7