Services and Business Process Reengineering

Ajay Kumar Jena
Himansu Das
Durga Prasad Mohapatra *Editors*

Automated Software Testing

Foundations, Applications and Challenges

Springer

Services and Business Process Reengineering

The book series aims at bringing together valuable and novel scientific contributions that address the critical issues of software services and business processes reengineering, providing innovative ideas, methodologies, technologies and platforms that have an impact in this diverse and fast-changing research community in academia and industry.

The areas to be covered are

- Service Design
- Deployment of Services on Cloud and Edge Computing Platform
- Web Services
- IoT Services
- Requirements Engineering for Software Services
- Privacy in Software Services
- Business Process Management
- Business Process Redesign
- Software Design and Process Autonomy
- Security as a Service
- IoT Services and Privacy
- Business Analytics and Autonomic Software Management
- Service Reengineering
- Business Applications and Service Planning
- Policy Based Software Development
- Software Analysis and Verification
- Enterprise Architecture

The series serves as a qualified repository for collecting and promoting state-of-the art research trends in the broad area of software services and business processes reengineering in the context of enterprise scenarios. The series will include monographs, edited volumes and selected proceedings.

More information about this series at http://www.springer.com/series/16135

Ajay Kumar Jena · Himansu Das ·
Durga Prasad Mohapatra
Editors

Automated Software Testing

Foundations, Applications and Challenges

Springer

Editors
Ajay Kumar Jena
School of Computer Engineering
Kalinga Institute of Industrial Technology
(KIIT), Deemed to be University
Bhubaneswar, Odisha, India

Himansu Das
School of Computer Engineering
Kalinga Institute of Industrial Technology
(KIIT), Deemed to be University
Bhubaneswar, Odisha, India

Durga Prasad Mohapatra
Department of Computer Science
and Engineering
National Institute of Technology
(NIT) Rourkela
Rourkela, Odisha, India

ISSN 2524-5503 ISSN 2524-5511 (electronic)
Services and Business Process Reengineering
ISBN 978-981-15-2454-7 ISBN 978-981-15-2455-4 (eBook)
https://doi.org/10.1007/978-981-15-2455-4

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

Nowadays, the society and industry are dependent on software-supported environments that can reduce human efforts and time. This leads to provide fast and precise automated software approach to develop and evolve these systems. In spite of several advanced tools, techniques, and methods are employed in the software development process, software faults may occur at any stage of the development process of the product. These faults must be identified and removed as early as possible to reduce the propagation and verification costs. Software testing is one of the most popular software verification and validation techniques used in the academic research community and software industry. The software testing phase of the software development process is essential before the release of any piece of software. Generally, the number of software fails due to a lack of proper testing for which large economic loss, waste of human resources, and also degrades the quality of life. So, testing plays a major role in the software development process. The traditional testing techniques used somehow solve the need, but testing complex programs like programs written in object-oriented programming, aspect-oriented programming, distributed object-oriented programs, etc. is a quite brainstorming task and time-consuming process. To deal with object-oriented testing, model-based testing helps in testing the runtime system behavior of the software under test. Model-based testing helps detect the flaws in the software under test before its execution in its early stage and reduces the cost and effort. To solve complex real-world problems, different minimization, prioritization, and optimization techniques are also used. Apart from this, a large amount of effort has been made on automation of test-case generation, automation of test-case selection, etc. to develop automated software testing tools. As a result, these automated software testing tools reduce the cost and improve the efficiency and effectiveness of software testing. Although many software test tools have been developed, still many new findings are being discovered by researchers and also used in several real-life applications.

The main intent of this edited book is to cover both the theory and applications in the automation of software testing tools and techniques for different types of software such as object-oriented, aspect-oriented, and web-based software. Many software fails due to a lack of proper and thorough testing. The problem becomes

more acute for object-oriented, aspect-oriented, and web-based software. It becomes more difficult to test distributed and service-oriented architecture (SOA)-based applications. So, there is a pressing need to discuss the recent developments in automated software testing. This book aims at discussing the relevant issues, models, tools, challenges, and applications in automated software testing. It aims at providing an intellectual forum for the researchers in academia, scientists, and engineers from a wide range of industrial application areas to present their latest research findings in these areas and to identify future challenges in this fledgling research area.

Organization of the Book

It includes most recent innovations, trends, practical challenges, and advances in the field of software engineering, especially software testing. To achieve the objectives, this book includes eight chapters, contributed by promising authors, as follows:

Chapter "Object-Oriented Modeling of Multifaceted Service Delivery System Using Connected Governance"

This chapter focuses on object-oriented modeling of multifaceted service delivery system using connected governance. The digital identity of the user is established uniquely before initiating any electronic transaction using an authentic instrument. A case study of the citizen in India is considered with uniquely identified documents of Aadhaar card, voter ID card, ration card, PAN card, etc. To resolve the issue of validating the fake documents, the author proposed a cloud-based multifaceted service delivery model, whose object-oriented modeling (OOM) is performed in this chapter.

Chapter "Automated Requirements Extraction and Product Configuration Verification for Software Product Line"

This chapter presents an automated requirements extraction and product configuration verification for the software product line. The authors presented an automated approach where a customized product configuration, which is derived from the extracted features from the product description, is validated giving immediate feedback to users. The product descriptions are collected from users, machine learning techniques are applied to examine the text and identify the domain of the product, and domain-specific features are then extracted. From the extracted features, a product configuration is derived and validated by using a developed tool.

Chapter "Test-Case Generation for Model-Based Testing of Object-Oriented Programs"

The authors have proposed a new method of test-case generation for model-based testing with the help of object-oriented programs. The authors have included the

application of UML diagrams in model-based testing. Here, the authors have covered various model-based and search-based testing approaches and methodologies used by researchers in the last 25 years to generate test cases and test data for functional as well as system-level testing of object-oriented programs.

Chapter "New Metrics for Predicting the Reliability of Individual Component Based on Software Design Metrics

This chapter focuses on new metrics for predicting the reliability of individual components based on software design metrics. For predicting the reliability of components, in component-based software, the authors identified the standard quality metrics like coupling, cohesion, and cyclomatic complexity using principal component analysis (PCA). To validate the newly proposed metrics statistically, a t-test is applied to it.

Chapter "Prediction Priority of Defective Modules for Testing Resource Allocation"

This chapter provides a detailed analysis of the prediction priority of defective modules for testing resource allocation. In this study, the prioritization of faulty modules in low, medium, and high categories for software defect dataset is performed. A new infrastructure, software defect prediction model, based on categorized data is developed, and extensive study with benchmark machine learning algorithms is designed and conducted for different software fault datasets.

Chapter "Early Reliability Prediction Model Integrating Halstead's Metrics and Fuzzy Usage"

This chapter describes the concepts of the early reliability prediction model, integrating Halstead's metrics and fuzzy usage. The authors observed the faults of each component independently and errors occurred for six months in a contiguous go and proposed the model. The proposed model was validated statistically by comparing the predicted and estimated values of reliability.

Chapter "Investigation and Analysis of Power System Faults with Soft Computational Techniques"

This chapter discusses the investigation and analysis of power system faults using soft computational techniques. The authors used feature extraction, subsequently analyzed various methods for determination of the faulty phase, and estimated its location. The authors used the artificial neural network, fuzzy logic, the combination of fuzzy-neuro technique, decision-tree-based classifier, and support vector machine to achieve this task.

Chapter "Decision Making on Critical Component Using Combined Approach"

This chapter focuses on decision making on critical components using a combined approach of Bayes hypothesis and fuzzy TOPSIS. A medium-size, component-based system is considered, and an integrated approach using Bayes hypothesis is applied to it to find out the critical component, so that refactoring effort should be applied to the critical components. Integrated weights involve

weights from different approaches, namely subjective approach which has been evaluated with fuzzy TOPSIS, and objective weights are evaluated by the entropy approach.

Topics presented in each chapter of this book are unique to this book and are based on unpublished work of contributed authors. In editing this book, we attempted to bring into the discussion all the new trends and experiments that have made on automated software testing. We believe this book is ready to serve as a reference for larger audiences such as system architects, practitioners, developers, and researchers.

Bhubaneswar, India Ajay Kumar Jena
Bhubaneswar, India Himansu Das
Rourkela, India Durga Prasad Mohapatra

Acknowledgements

The preparation of this edited book was like a journey that we had undertaken for several months. We wish to express our heartfelt gratitude to our families, friends, colleagues, and well-wishers for their constant support throughout this journey. We express our gratitude to all the chapter contributors, who allowed us to quote their remarks and work in this book. In particular, we would like to acknowledge the hard work of authors and their cooperation during the revisions of their chapters. We would also like to acknowledge the valuable comments of the reviewers which have enabled us to select these chapters out of so many chapters we received and also improve the quality of the chapters. We wish to acknowledge and appreciate the Springer team for their continuous support throughout the entire process of publication. Our gratitude is extended to the readers, who gave us their trust, and we hope this work guides and inspires them.

Contents

About the Editors

Ajay Kumar Jena is currently working as an Assistant Professor at the School of Computer Engineering, KIIT Deemed to be University, Bhubaneswar, Odisha, India. He received his Ph.D. in Software Engineering from KIIT Deemed to be University in 2016. His main teaching areas are software engineering, programming languages, OS, data mining, and cryptography. He has published more than 15 papers in international journals and conference proceedings, and two book chapters. He has also edited one book of international repute. He is an editorial/reviewer board member for various journals and conferences.

Himansu Das is currently working as an as Assistant Professor in the School of Computer Engineering, Kalinga Institute of Industrial Technology (KIIT), Deemed to be University, Bhubaneswar, India. He has received his B.Tech. degree from Institute of Technical Education and Research, India and M.Tech. degree in Computer Science and Engineering from National Institute of Science and Technology, India. He has published more than 50 research papers in various international journals and conferences. He has also edited more than 12 books of international repute such as IGI Global, Springer and Elsevier. He is also serving many journals and conferences as editorial or reviewer board member. He is also serving as member or advisory board member of several national and international journals and conferences. He is proficient in the field of Computer Science Engineering and served as an organizing chair, publicity chair and act as member of technical program committees of many national and international conferences. He is also associated with various educational and research societies. His research interest includes in the field of Data Mining, Soft Computing and Machine Learning. He has also more than 12 years of teaching and research experience in several engineering colleges and universities.

Durga Prasad Mohapatra received his Ph.D. from the Indian Institute of Technology Kharagpur and is presently serving as a Professor at NIT Rourkela, Odisha. His research interests include software engineering, realtime systems, discrete mathematics, and distributed computing. He has published more than 80

research papers in these fields in various international journals and conference proceedings. He has received several project grants from the DST and UGC, Government of India. He received the Young Scientist Award for the year 2006 from Orissa Bigyan Academy. He also received the Prof. K. Arumugam National Award and the Maharashtra State National Award for outstanding research work in Software Engineering from the Indian Society for Technical Education (ISTE), New Delhi, for the years 2009 and 2010, respectively. He is the author of two books and also edited several books of international repute.

Object-Oriented Modeling of Multifaceted Service Delivery System Using Connected Governance

Abhishek Roy

1 Introduction

Advancements of Information and Communication Technology (ICT) have facilitated faster communication among its user. This approach helps to deliver citizen-centric services to doorstep of populace, which is very much beneficial for the remotely located users. In earlier occasion, conventional form of governance delivered services to its citizen through manual mode with the direct involvement of human resource, which encountered performance issues during its operation. For instance, occurrence of human errors during record management, loss, damage or misplacement of official records during operations, delayed delivery of services due to physical constraints of message communication, engagement of huge manpower thereby leading to recurring expenses over the state, chances of favoritism (i.e., biasness) during delivery of services, etc., may be mentioned as few. Though connected governance can successfully overcome these drawbacks of conventional governance, it has its own issues which should be addressed properly. This is due to the usage of public communication channel like Internet, which is susceptible to infringement attempts of adversaries. Hence, for delivery of electronic services to doorstep of citizen within affordable budget, neither we can completely ignore the usage of Internet as fastest communication medium, nor we can completely rely on it for secured transmission of sensitive information.

Member: International Association of Engineers (Number# 111299), Hong Kong. Cryptology Research Society of India (No# L/0509), ISI Kolkata 700108, India.

A. Roy (✉)
Department of Computer Science and Engineering, School of Engineering and Technology, Adamas University, Kolkata 700126, India
URL: http://adamasuniversity.ac.in/

A. K. Jena et al. (eds.), *Automated Software Testing*,
Services and Business Process Reengineering,
https://doi.org/10.1007/978-981-15-2455-4_1

As a motivation of research work, these security lapses should be neutralized for secured transmission of **SERVICE REQUEST** and **SERVICE RESPONSE** between the communicating parties during electronic message communication.

To achieve this objective, the digital identity of user should be established uniquely before initiating any electronic transaction. This strict verification of user identity from the initial stage of electronic transaction will help to perform transaction under a controlled environment, which will reduce the scope of infringement attempts of adversaries.

In India, though citizen is claimed to be uniquely identified using Aadhaar Card, Voter Card, Ration Card, PAN Card, etc., the mere existence of all these multiple identity instruments is sufficient to establish their inability to uniquely identify an individual. Furthermore, recent initiative of government to interlink these instruments implicitly acknowledges the necessity of integrated environment for the delivery of multifaceted services to citizen. To be precise, interlinking of these already existing multiple identity instruments is making the entire system susceptible to threats of adversary due to inclusion (i.e., linking) and subsequent validation of fake identity instruments thereby leading to the collapse of complete system.

As a solution, a single digital identity instrument of user (i.e., Citizen) should be newly introduced, which will serve the purpose of all the existing instruments and also act as single window interface to deliver multifaceted electronic services under a controlled and connected environment. This step will effectively promote national security by identifying intruders and also help citizen to access multivariate electronic services within an affordable budget.

To fulfill this objective, author have already proposed a citizen-centric smart card, i.e., Multipurpose Electronic Card (MEC) [1, 2, 11–15]-based Electronic Governance [3–5, 16–18] model, which will uniquely identifies citizen and facilitates them to access multivariate electronic services [7, 8] under an integrated environment. As this proposed model has to perform in real-world scenario, its efficiency should be measured accordingly to establish its mechanism. In similar situation, researchers have applied object-oriented (OO) [6, 9, 10, 19–50] approach to validate their research work. Object-oriented (OO) approach defines a specific set of rules to study the dynamic nature of a software system in real-world scenario. For this purpose, Unified Modeling Language (UML)-based diagrams like class diagram, use case diagram, sequence diagram, inheritance diagram, deployment diagram, etc., are used for pictorial representation of the internal mechanism. Object-oriented (OO) approach demonstrates the following features of software system.

1. Identify primary entities or actors of the system.
2. Identify attribute (i.e., parameter) and behavior (i.e., member method) of these entities. Since an entity or actor contains various types of attributes, depending upon its sensitivity, they can be broadly categorized as private, protected and public. As these entities or actors interact among themselves through their behaviors, it is usually represented as public in type.
3. Identify sequence of operations, i.e., message passing among the entities or actors.

4. Furthermore, the efficiency of these object-oriented (OO) concepts may be measured using object-oriented metrics [48].

Researchers have applied object-oriented (OO) concept to measure their research model, which is usually application-specific in type. Whereas, in this case, author have used object-oriented (OO) approach to measure efficiency of citizen-centric electronic service delivery model, which intends to deliver multivariate electronic service to citizen through a connected and integrated environment. Each service sector like cloud banking, cloud health care, cloud education, etc., will further develop its complete system which will be measured using object-oriented (OO) concept to study its dynamic nature.

As the origin of work, a smart card-based service delivery model is described in Sect. 2. Since this proposed model has to handle a huge amount of data due to mutlifaceted SERVICE REQUEST and corresponding SERVICE RESPONSE of user, its enhanced version of C-Governance model [2] is also explained in the same section. To simulate the operations of this cloud service delivery model, its object-oriented modeling is shown in Sect. 3. As this model has to deliver multifaceted electronic services in real-world scenario like cloud banking, cloud health care, cloud education, etc., an object-oriented modeling of cloud banking transaction is shown in Sect. 4 of this chapter. The conclusion drawn from this work is stated in Sect. 5, which also includes the limitation of this work. Finally, the future scope of this work is explored in Sect. 6.

2 Origin of Work

2.1 E-Governance Model

In this section, Fig. 1 shows the smart card-based E-governance model [7, 11–15] which was proposed to bring all the electronic services under an unified system. The stepwise operation of this citizen-centric E-governance system is mentioned below:

1. Citizen uses proposed Multipurpose Electronic Card (MEC) to initiate electronic transaction and provides all necessary information for validation, which is shown through path - 1 of Fig. 1.
2. This information is passed to E-governance system through public communication channel, i.e, Internet.
3. E-governance interface being the first component of E-governance system receives the SERVICE REQUEST and sends it for the verification of user.
   (a) Scenario - I: Validation failure leads to operation abort. User is intimated about SERVICE RESPONSE (i.e., negative acknowledgment, timeout, etc.) through path - 2 of Fig. 1.
   (b) Scenario - II: Validation success.

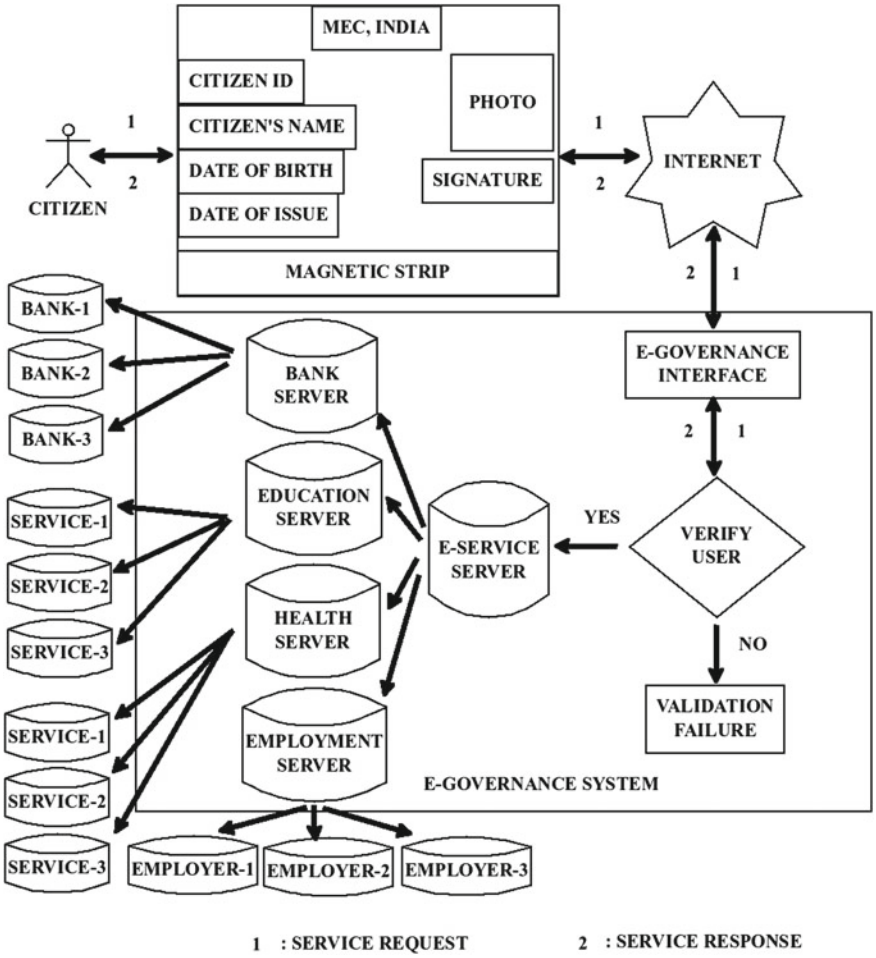

Fig. 1 Multifaceted service-oriented electronic governance model

4. SERVICE REQUEST of user is processed toward E-Service Server of E-governance system. E-Service Server, being the repository of multifaceted electronic services, will analyze the SERVICE REQUEST and forward it to service-specific server of the system.
5. The service-specific server like bank server, education server, health server, employment server, etc., analyzes the SERVICE REQUEST and processes it to the third-party service provider for its final execution.

With the increasing load of SERVICE REQUEST and corresponding SERVICE RESPONSE of user, the proposed system has to securely handle all the sensitive information through cloud, which is discussed in Sect. 2.2.

2.2 C-Governance Model

In this section, Fig. 2 shows the citizen-centric enhanced cloud governance system [2], whose stepwise operation is mentioned below:

1. Citizen initiates electronic transaction using Multipurpose Electronic Card (MEC) through hybrid cloud of the proposed system. This information mainly contains SERVICE REQUEST along with necessary parameters for verification of user, which is shown through path - 1 of Fig. 2.
2. As the first component of proposed C-governance system, C-governance interface receives SERVICE REQUEST of user through Firewall of the system. In this stage, network-based intrusion detection system (NIDS) may be considered as the future scope of research for early detection and sanitization of intruders.
3. C-governance interface filters the received information for verification of user.
   (a) Scenario - I: Validation failure leads to operation abort. User is intimated about SERVICE RESPONSE (i.e., negative acknowledgment, timeout, etc.) through path - 2 of Fig. 2.
   (b) Scenario - II: Validation success.
4. SERVICE REQUEST of user is processed toward C-Service Server of proposed C-governance system. C-Service Server, being the repository of multifaceted electronic services, analyzes the SERVICE REQUEST and forwards it to data center through private cloud to perform corresponding READ and WRITE operations. Intrusion detection system (IDS) may be considered as the future scope to prevent intruders from the data center.
5. After READ and WRITE operations over data center, SERVICE REQUEST is forwarded to service-specific server like bank server, education server, health server, employment server, etc., of C-governance system.
6. The service-specific server of C-governance system transmits the SERVICE REQUEST of user to the third-party service provider through hybrid cloud for its final execution.

As this proposed cloud governance system has to perform in real-world scenario (which will incur huge operational cost), the SERVICE REQUEST generated by user (i.e., Citizen) is simulated and studied thoroughly in this chapter, whose object-oriented modeling [21] is explained in Sect. 3.

3 Object-Oriented Modeling of C-Governance System

To achieve optimum utilization of resources, software engineering approaches are used to perform feasibility study of any software system before its actual implementation. This approach is very much essential particularly for developing nation like India, which have to strive hard for mobilization of resources. As the proposed