Performance and Dependability in Service Computing: Concepts, Techniques and Research Directions

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Foundations

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In recent years, extensive research has been conducted in the area of Service Level Agreement (SLA) for utility computing systems. An SLA is a formal contract used to guarantee that consumers' service quality expectation can be achieved. In utility computing systems, the level of customer satisfaction is crucial, making SLA significantly important in these environments. Fundamental issue is the management of SLAs, including SLA autonomy management or trade off among multiple Quality of Service (QoS) parameters. Many SLA languages and frameworks have been developed as solutions; however, there is no overall classification for these extensive works. Therefore, the aim of this chapter is to present a comprehensive survey of how SLAs are created, managed and used in utility computing environment. The authors discuss existing use cases from Grid and Cloud computing systems to identify the level of SLA realization in state-of-art systems and emerging challenges for future research.

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There is a growing trend towards enterprise system integration across organizational and enterprise boundaries on the global Internet platform. The Enterprise Service Computing (ESC) has been adopted by more and more corporations to meet the growing demand from businesses and the global economy. However the ESC as a new distributed computing paradigm poses many challenges and issues of qual-
ity of services. For example, how is ESC compliant with the quality of service (QoS)? How do service providers guarantee services which meet service consumers’ needs as well as wants? How do both service consumers and service providers agree with QoS at runtime? In this chapter, SLA-Aware enterprise service computing is first introduced as a solution to the challenges and issues of ESC. Then, SLA-Aware ESC is defined as new architectural styles which include SLA-Aware Enterprise Service-Oriented Architecture (ESOA-SLA) and SLA-Aware Enterprise Cloud Service Architecture (ECSA-SLA). In addition, the enterprise architectural styles are specified through our extended ESOA and ECSA models. The ECSA-SLA styles include SLA-Aware cloud services, SLA-Aware cloud service consumers, SLA-Aware cloud SOA infrastructure, SLA-Aware cloud SOA management, SLA-Aware cloud SOA process and SLA-Aware SOA quality attributes. The main advantages of viewing and defining SLA-Aware ESC as an architectural style are (1) abstracting the common structure, constraints and behaviors of a family of ESC systems, such as ECSA-SLA style systems and (2) defining general design principles for the family of enterprise architectures. The design principles of ECSA-SLA systems are proposed based on the model of ECSA-SLA. Finally, the authors discuss the challenges of SLA-Aware ESC and suggest that the autonomic service computing, automated service computing, adaptive service computing, real-time SOA, and event-driven architecture can help to address the challenges.

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This chapter presents modeling method and evaluation techniques for computing dependability metrics of systems. The chapter begins providing a summary of seminal works. After presenting the background, the most prominent model types are presented, and the respective methods for computing exact values and bounds. This chapter focuses particularly on combinatorial models although state space models such as Markov models and hierarchical models are also presented. Case studies are then presented in the end of the chapter.

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Service Oriented Architecture (SOA) is changing the way in which software applications are designed, deployed and maintained. A service-oriented application consists of the runtime composition of autonomous services that are typically owned and controlled by different organizations. This decentralization impacts on the dependability of applications that consist of dynamic services agglomerates, and challenges their validation. Different techniques can be used or combined for the verification of dependability aspects, spanning over traditional off-line testing approaches up till monitoring and on-line testing. In this chapter...
the authors discuss issues and opportunities of SOA validation, identify three different stages for validation along the service life-cycle model, and overview some proposed research approaches and tools. The emphasis is on on-line testing, which to us is the most peculiar stage in the SOA validation process. Finally, the authors claim that on-line testing is only possible within an agreed governance framework.

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The ability to rapidly find potential business partners as well as rapidly set up a collaborative business process is desirable in the face of market turbulence. Traditional linking of business processes has a large ad hoc character. Implementing service-oriented business process mashup in an appropriate way will deliver the collaborative business process more flexibility, adaptability and agility. In this chapter, the authors describe new landscape for supporting collaborative business processes. The different solutions and tools for collaborative business process applications are presented. A new approach for supporting situational collaborative business process, process-oriented mashup is introduced. The authors have highlighted the security and scalability challenges of process-oriented mashups. Further, benefits of using process-oriented mashup are discussed.

Section 2
Performance

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The use of Service Oriented Architectures (SOA) enables the existence of a market of service providers delivering functionally equivalent services at different Quality of Service (QoS) and cost levels. The QoS of composite applications can typically be described in terms of metrics such as response time, availability, and throughput of the services that compose the application. A global utility function of the various QoS metrics is the objective function used to determine a near-optimal selection of service providers that support the composite application. This chapter describes the architecture of a QoS Broker that manages the performance of composite applications. The broker continually monitors the utility of the applications and triggers a new service selection when the utility falls below a pre-established threshold or when a service provider fails. A proof-of-concept prototype of the QoS broker demonstrates how it maintains the average utility of the composite application above the threshold in spite of service provider failures and performance degradation.
Chapter 7
High-Quality Business Processes based on Multi-Dimensional QoS
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An important area of services research gathering momentum is the ability to take a generic business process and instantiate it by selecting services that meet both the functional and non-functional requirements of the process owner. These non-functional or quality-of-service (QoS) requirements may describe essential performance and dependability requirements and apply across different logical layers of the application, from business-related details to system infrastructure; i.e., they are cross-cutting and considered multidimensional. Configuring an abstract business process with the "best" services to meet the process owner’s multidimensional end-to-end QoS requirements is a challenging task as there may be many services that match to the functional requirements but provide differentiated QoS characteristics. In this chapter the authors explore an approach to discover services, differentiated by their QoS attributes, to configure an abstract business process by selecting an optimal configuration of the “best” QoS combinations. The approach considered takes into account the optimal choice of multi-dimensional QoS variables. The authors present and compare two solutions based on heuristic algorithms to illustrate how this approach would work practically.

Chapter 8
A Game Theoretic Solution for the Optimal Selection of Services
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This chapter considers the problem of optimally selecting services during run-time with respect to their non-functional attributes and costs. Commercial pressures for reducing the cost of managing complex software systems are changing the way in which systems are designed and built. The reason behind this shift is the need for dealing with changes efficiently and effectively, which may include removing the human operator from the process of decision-making. In service-oriented computing, in particular, the run-time selection and integration of services may soon become a reality since services are readily available. Assuming that each component service has a specific functional and non-functional profile, the challenge now is to define a decision maker that is able to select services that satisfy the system requirements and optimise the quality of services under cost constraints. The approach presented in this chapter describes a game theoretic solution by formulating the problem as a bargaining game.

Chapter 9
A Tool Chain for Constructing QoS-aware Web Services
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Web services play a dominant role in service computing and for realizing service-oriented architectures (SOA), which define the architectural foundation for various kinds of distributed applications. In many business domains, Web services must exhibit quality attributes such as robustness, security, dependability,
performance, scalability and accounting. As a consequence, there is a high demand to develop, deploy and consume Web services equipped with well-defined quality of service (QoS) attributes – so-called QoS-aware Web services. Currently, there is only limited development support for the creation of QoS-aware Web services, though. In this work the authors present a tool chain that facilitates development, deployment and testing of QoS-aware Web services. The tool chain has following features: i) integration of standard components such as widely used IDEs, ii) usage of standards and specifications, and iii) support for various application servers and Web services infrastructures.

Chapter 10
Performance, Availability and Cost of Self-Adaptive Internet Services
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Although distributed services provide a means for supporting scalable Internet applications, their ad-hoc provisioning and configuration pose a difficult tradeoff between service performance and availability. This is made harder as Internet service workloads tend to be heterogeneous, and vary over time in amount of concurrent clients and in mixture of client interactions. This chapter presents an approach for building self-adaptive Internet services through utility-aware capacity planning and provisioning. First, an analytic model is presented to predict Internet service performance, availability and cost. Second, a utility function is defined and a utility-aware capacity planning method is proposed to calculate the optimal service configuration which guarantees SLA performance and availability objectives while minimizing functioning costs. Third, an adaptive control method is proposed to automatically apply the optimal configuration to the Internet service. Finally, the proposed model, capacity planning and control methods are implemented and applied to an online bookstore. The experiments show that the service successfully self-adapts to both workload mix and workload amount variations, and present significant benefits in terms of performance and availability, with a saving of resources underlying the Internet service.

Section 3
Dependability

Chapter 11
Performability Evaluation of Web-Based Services
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The joint evaluation of performance and dependability in a unique approach leads to the notion of performability which usually combines different analytical modeling formalisms (Markov chains, queueing models, etc.) for assessing systems behaviors in the presence of faults. This chapter presents a systematic modeling approach allowing designers of web-based services to evaluate the performability of the service provided to the users. We have developed a multi-level modeling framework for analyzing the user perceived performability. Multiple sources of service unavailability are taken into account, particularly i) hardware and software failures affecting the servers, and ii) performance degradation due to e.g. overload of servers and probability of loss. The main concepts and the feasibility of the proposed
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The chapter investigates the uncertainty of Web Services performance and the instability of their communication medium (the Internet), and shows the influence of these two factors on the overall dependability of SOA. The authors present our practical experience in benchmarking and measuring the behaviour of a number of existing Web Services used in e-science and bio-informatics, provide the results of statistical data analysis and discuss the probability distribution of delays contributing to the Web Services response time. The ratio between delay standard deviation and its average value is introduced to measure the performance uncertainty of a Web Service. Finally, the authors present the results of error and fault injection into Web Services. The authors summarise our experiments with SOA-specific exception handling features provided by two web service development kits and analyse exception propagation and performance as the major factors affecting fault tolerance (in particular, error handling and fault diagnosis) in Web Services.

Chapter 13
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Service composition is a widely accepted method to build service-oriented applications. However, due to the uncertainty of infrastructure environments, service performance and user requests, service composition faces a great challenge to guarantee the dependability of the corresponding composite services. In this chapter, the authors provide an insightful analysis of the dependability issue of composite services. And the authors present a solution based on two-level redundancy: component service redundancy and structural redundancy. With component service redundancy, the authors study how to determine the number of backup services and how to guarantee consistent dependability of a composite service. In addition, structural redundancy aims at further improving dependability at business process level through setting up backup execution paths.

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Developing web services with timing requirements is a difficult task, as existing technology does not provide standard mechanisms to support real-time execution, or even to detect and predict timing violations. However, in business-critical environments, an operation that does not conclude on due time may be completely useless, and may result in service abandonment, reputation, or monetary losses. This chapter presents a framework that allows deploying web services with temporal failure detection and prediction capabilities. Detection is based on timing restrictions defined at execution time and historical data is used for failure prediction according to prediction modules. Additional modules can be added to the framework to provide more advanced failure detection and prediction capabilities. The framework enables providers to easily develop and deploy time-aware web services, with the failure detection code decoupled from the application logic, and allows consumers to express their timeliness requirements.

Chapter 15
Dependability and Security on Wireless Self-Organized Networks: Properties, Requirements, Approaches and Future Directions

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Wireless communication technologies have been improved every day, increasing the dependence of people on distributed systems. Such dependence increases the necessity of guaranteeing dependable and secure services, particularly, for applications related to commercial, financial and medical domains. However, on wireless self-organized network context, providing simultaneously reliability and security is a demanding task due to the network characteristics. This chapter provides an overview of survivability concepts, reviews security threats in wireless self-organized networks (WSONs) and describes existing solutions for survivable service computing on wireless network context. Finally, this chapter presents conclusions and future directions.

Section 4
Security

Chapter 16
Engineering Secure Web Services

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Web services are key components in the implementation of Service Oriented Architectures (SOA), which must satisfy proper security requirements in order to be able to support critical business processes. Research works show that a large number of web services are deployed with significant security flaws, ranging from code vulnerabilities to the incorrect use of security standards and protocols. This chapter discusses state of the art techniques and tools for the deployment of secure web services, including standards and
protocols for the deployment of secure services, and security assessment approaches. The chapter also discusses how relevant security aspects can be correlated into practical engineering approaches.

**Chapter 17**

Approaches to Functional, Structural and Security SOA Testing

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In this chapter, the authors provide an overview of recently proposed approaches and tools for functional and structural testing of SOA services. Typically, these two classes of approaches have been considered separately. However, since they focus on different perspectives, they are generally non-conflicting and could be used in a complementary way. Accordingly, the authors make an attempt at such a combination, briefly showing the approach and some preliminary results of the experimentation. The combined approach provides encouraging results from the point of view of the achievements and the degree of automation obtained. A very important concern in designing and developing web services is security. In the chapter the authors also discuss the security testing challenges and the currently proposed solutions.

**Chapter 18**

Detecting Vulnerabilities in Web Services: Can Developers Rely on Existing Tools?

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Although web services are becoming business-critical components, they are often deployed with software bugs that can be maliciously exploited. Numerous developers are not specialized on security and the common time-to-market constraints limit an in-depth testing for vulnerabilities. In this context, vulnerability detection tools have a very important role helping the developers to produce less vulnerable code. However, developers usually select a tool to use and rely on its results without knowing its real effectiveness. This chapter presents two case studies on the effectiveness of several well-known vulnerability detection tools and discusses their strengths and limitations. Based on lessons learned, the chapter also proposes a benchmarking technique that can be used to select the tool that best fits a specific scenario. The main goal is to provide web service developers with information on how much they can rely on widely used vulnerability detection tools and on how to select the most adequate tool.