

GUEST EDITORIAL PREFACE

Engineering Middleware for Service-Oriented Computing

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This special issue of the *International Journal of Systems and Service-Oriented Engineering* (IJSSOE) contains five peer-reviewed research papers with recent advances on middleware for service-oriented computing. After revisiting the importance of middleware for service-oriented computing, the authors give a brief overview of the review process and the papers accepted for this special issue. Finally, the authors discuss some open challenges for future research, with an emphasis on increasingly popular mobile service-oriented systems and cloud computing. The editorial note is followed by lists of review board members and additional reviewers for this special issue.

INTRODUCTION

Welcome to this special issue of the *International Journal of Systems and Service-Oriented Engineering* (IJSSOE). In this issue, scholarly contributions under the topic “Engineering Middleware for Service-Oriented Computing” are presented.

Middleware on one hand, placed between the network operating system and the applica-

tion layer, simplifies the task of programming and managing distributed applications by providing programming abstractions and run-time tools. Service-oriented computing (SOC) on the other hand is an architectural style and a paradigm focusing on business integration. It abstracts software constituents as services that can be dynamically discovered, composed, and reused in different contexts.

Apparently the role of middleware is integral to service-oriented computing, in that greater flexibility and implementation independence of service implementations are supported (or even enabled) by middleware solutions, such as abstract programming models, quality-of-service provisions, transactions, monitoring and management, and so on.

In fact, middleware for service-oriented computing is becoming more important, as the environments to which the services are applied are increasingly diverse. The traditional environment of service-oriented computing systems has been in business-to-business (B2B) and/or enterprise application integration (EAI) scenarios. Today, we are experiencing the rapid development of SOC into new and emerging areas, such as Software-as-a-Service (SaaS),

utility computing, cloud platforms, mobile computing and embedded systems. As middleware plays an essential role in managing and provisioning services in these diverse environments, this trend obviously creates challenges and innovation opportunities for middleware technology.

CONTENT OF THE SPECIAL ISSUE

In this special issue, we present recent research findings on middleware concerns for supporting service systems in diverse environments which aim at better understanding and advancement of the discussion on middleware for service-oriented computing.

The inaugural editorial preface of the *International Journal of Systems and Service-Oriented Engineering* (Chiu, 2010) clearly lays out the challenges and opportunities in Service-oriented computing driven by the globalised service-oriented economy. As mentioned before, the middleware technology is at the core of many of the open issues (e.g., scalability using cloud platforms, system quality control and provisioning, service matchmaking) in this emerging field. Thus, examining the recent research developments in middleware for service-oriented computing is a timely exercise, highly relevant to the readers of this journal.

This special issue is a result of collaboration between the organizers of the Middleware for Web Services (MWS) and Middleware for Service Oriented Computing (MW4SOC) workshops. The Middleware for Web Services (MWS) workshops were organized at the IEEE Enterprise Computing Conference (EDOC) from 2005-2009. The Middleware for Service Oriented Computing (MW4SOC) workshops were organized as part of the ACM International Middleware Conference since 2006. The workshops provided successful venues for researchers and developers interested in service-oriented computing and middleware technology to gain insights into the latest developments in the field. These efforts enabled exchanges of

new ideas, advancement of the understanding of open research issues and possible approaches towards their solution. This special issue further extends the achievements of all these past workshops and facilitates scientific growth of this important area.

The call for papers for this special issue attracted 21 submissions from 18 countries. The formal review process was supported by the review board of international area experts, many of whom also served as program committee member for the MWS and MW4SOC workshops for many years. Each paper was peer reviewed by three to five reviewers, who remained anonymous to the authors. The rigorous reviewing process also included a rebuttal phase from the authors and further discussions among the reviewers. Finally, we selected the five best papers for publication in the special issue. We sincerely thank the members of the review board (listed at the end of this editorial note) for their time and support throughout the review period.

Here is a brief summary of the papers presented in this issue. The first paper is “ODACE SLA: Ontology Driven Approach for Automatic Establishment of Service Level Agreements” by Kaouthar Fakhfakh, Tarak Chaari, Said Tazi, Mohamed Jmaiel, and Khalil Drira from the University of Toulouse in France, LAAS CNRS in France, and/or the National Engineers School of Sfax in Tunisia. Service level agreements (SLAs) are contracts between service providers and service clients/consumers, describing quality of service (e.g., expected response time and availability) and pricing aspects. One of the frequent problems in establishment (particularly automatically, with minimal human intervention) of service level agreements is the syntactic and semantic incompatibility between descriptions of client intentions and provider offers. An ontology is a formal representation of concepts from a particular domain, as well as their relationships. Ontologies are frequently used for resolving terminological incompatibilities. This paper presents a novel four-step approach to automatically generate a draft version of a service level agreement compatible

both with client intentions and provider offers.

The second paper is “A Service Oriented SLA Management Framework for Grid Environments” by Vassiliki Pouli, Constantinos Marinos, Mary Grammatikou, Symeon Papavassiliou and Vasilis Maglaris from the National Technical University of Athens in Greece. This paper is also related to service level agreements in a multi-domain environment. However, the authors examine SLAs in Grid computing systems that combine computing resources from multiple administrative domains. The authors provide a set of Web services for automatic creation of end-to-end SLAs by merging per-domain SLAs, as well as for management (particularly monitoring) of these SLAs. The authors’ solution has been deployed in the European Research & Education Networks (NRENs) Advanced Multi-domain Provisioning System (AMPS).

The third paper is “Execution Management for Mobile Service-Oriented Environments” by Kleopatra Konstanteli, Tom Kirkham, Julian Gallop, Brian Matthews, Ian Johnson, Magdalini Kardara and Theodora Varvarigou from the National Technical University of Athens in Greece, Nottingham University in the UK and/or the STFC Rutherford Appleton Laboratory in the UK. This paper is also related to management of Grid computing systems, but with the added complexity that that Grid services can reside on mobile devices. Since the rate of various changes (e.g., related to connectivity and underlying network quality of service) experienced in mobile environments is significantly higher than in stationary (non-mobile) environments, management of service-oriented computing systems in these environments requires additional capabilities to support reliability and dependability of composite applications. The authors present their Execution Management System (EMS) that builds upon industry standards to seamlessly manage mobile and other services across multiple domains to create a mobile dynamic virtual organization (MDVO).

This Execution Management System has been implemented and tested within the European Akogrimo project.

The fourth paper is “SLIM: Service Location and Invocation Middleware for Mobile Wireless Sensor and Actuator Networks” by Gianpaolo Cugola and Alessandro Margara from Politecnico di Milano in Italy. The authors of this paper studied how to make programming of wireless sensor and actuator networks (WSANs) easier and chose the service-oriented computing paradigm. The paper presents the SLIM middleware that supports service-oriented programming in mobile WSANs. Mobility significantly complicates management of wireless sensor and actuator networks. Therefore, SLIM adopts an advanced routing protocol designed for reliable discovery and invocation of services in mobile scenarios. It also supports efficient multicast invocations, invoking at once all services satisfying a given query. The authors’ simulations have shown that the performance achieved by using SLIM is much better compared to alternative approaches.

The fifth and final paper is “A Method to Support Fault Tolerance Design in Service Oriented Computing Systems” by Domenico Cotroneo, Antonio Pecchia, Roberto Pietrantuono, and Stefano Russo from the University of Napoli Federico II and/or Laboratory CINI-ITEM “Carlo Savy”, both in Italy. Various faults can occur during operation of service-oriented computing systems and not all of these faults can be discovered during testing. This requires making SOC systems able to tolerate faults that can occur. The real challenge is gaining knowledge about system behavior when various faults occur. This paper presents a novel method that supports design of fault tolerance in SOC systems by determining where to place fault tolerance code and what functionality this code should provide. The authors have applied their method to the Apache Web server and the TAO Open Data Distribution Service (DDS).

SOME OPEN CHALLENGES FOR FUTURE RESEARCH

Service-oriented computing has become an integral part of the way modern organizations (e.g., enterprises) understand their own information technology (IT) architecture, and model, analyze, integrate, and engineer their IT systems. The tools and methodologies from this modern computing paradigm have equipped the organizations with cross-platform compatibility, agility and cost-efficiency in their core operations. The systems and software engineering can greatly benefit from the level of flexibility provided by the service-oriented computing paradigm (e.g., through definition of interfaces that are implementation independent, discoverability, composability, and other features) and the maturity of the industry standards. Therefore, it is not surprising to see new and emerging applications of service-oriented computing transpiring in recent software or infrastructure platforms.

For example, applications on mobile devices can benefit from the flexibility provided by the service-oriented computing technology. Service-oriented computing technology is also having an impact in reducing the complexity in designing and developing embedded systems or wireless sensor networks. These news environments, in which the SOC systems are now expected to operate, raise challenges that need to be addressed by middleware as a supporting technology that will enable management and provisioning of such SOC-based applications. Challenges in running applications on mobile platforms, for example, include balancing communication overhead and power consumption, maintaining uniformly addressable and reachable end-points for the services, enabling heterogeneous devices to discover each other to exchange data and advertise/consume services. Solutions for security and privacy in mobile devices will be important for wider acceptance of the platforms. These topics, still insufficiently explored, are closely related to the middleware technology (Aitenbichler et al., 2007).

Cloud computing is a business model of provisioning IT as a remote service over the Internet, where the provided service can contain different IT elements: infrastructure (Infrastructure as a Service - IaaS) such as memory and processor time, platform (Platform as a Service - PaaS) such as operating system images, and software (Software as a Service - SaaS) such as customer relationship management applications. The flexibility of consumption of cloud services and pay-per-use models (e.g., users might need large memory only in occasional peak periods and cloud services enable users to pay for what they consume) have made cloud computing an attractive option for many organizations, both in the private sector and in the government. The cloud computing provides a vision for an exciting future of IT and the service-oriented computing concepts are often its drivers (particularly in the cloud-based SaaS solutions). However, there are still many open issues to be solved. Due to business reasons, it is not likely for any large organization to move its entire IT systems and infrastructure to the cloud. There will be core systems that will remain on-premises, while public data or business processes will move to a cloud environment. This new enterprise systems architecture requires orchestration of data and process flows that move across cloud and legacy environments. Such capabilities will likely be provided by middleware. Cloud-related middleware should also be able to respond to the key challenges these environments bring about, such as managing service level agreements, effective governance and quality management and supporting collaborative processes over a multitude of clouds. Additionally, since the coupling between systems inside this environment is becoming increasingly looser, there is a higher need for successful accommodation of heterogeneity (e.g., in data models) and fault tolerance.

In the above paragraphs we emphasized some open challenges for future research related to middleware for service-oriented computing systems in mobile or cloud environments,

because of their increasing population. There are certainly many other research challenges in the area of middleware for service-oriented computing. For example, the need for increased support for semantics in SOC middleware has been known for a long time and there are some important results in this area, but here are also many remaining challenges, often related to translation of advanced theoretical results into middleware that is widely used in practice. While the papers in this special issue present some solution to various challenges, further research is needed and can be expected in the area of middleware for service-oriented computing. We hope that the presented papers will inspire you to contribute to this important and exciting area of research.

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