

# Emerging Web Services

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FROM a technology foundation perspective, services computing has become the default discipline in today's services industry. As a major implementation technology for modernizing the services industry, Web Services are Internet-based programmable application components that are published using standard interface description languages and that are universally available via standard communication protocols.

At their inception, Web Services were based on the SOAP, XML, WSDL and UDDI standards. Subsequently, further standards such as Web Services Atomic Transactions and Web Services Business Activities were developed, and Restful Web Services (which depend on HTTP rather than SOAP) also came to be used in practice. Concurrently, much research related to Web Services was undertaken on topics such as composition, recommendation, etc. However, there are still many unresolved research issues related to Web Services, as they are still a relatively young technology.

This IEEE TSC special issue on emerging Web Services includes six articles that address the latest advances in Web Services selection, discovery and recommendation. These advances consider context awareness, quality of service, quality of experience, service usage history and evolution, and cost effectiveness.

The first article titled, "Automatic reuse of user inputs to services among end-users in service composition," by Wang et al. investigates how to leverage inputs from an end-user and from similar end-users to reduce repetitive typing for end-users. The authors develop a method that propagates user inputs across services by linking similar input and output parameters. They also report empirical results from real-world services.

The second article, "Time-aware service recommendation for mashup creation," by Zhong et al. leverages the evolution of the service ecosystem to improve the performance of service recommendations. The authors present a method that extracts service evolution patterns by exploiting Latent Dirichlet Allocation (LDA) and time series prediction. Experiments that are based on a real-world service repository are reported.

The third article, "CCCloud: Context-aware and credible cloud service selection based on subjective assessment and objective assessment," by Qu et al. addresses the cloud service selection problem, considering the diversity and dynamic nature of cloud services. The authors present a selection model based on the comparison and aggregation of subjective assessments extracted from ordinary cloud consumers

and objective assessments from quantitative performance testing parties. Experimental results are also presented.

The fourth article, "A partial selection methodology for efficient QoS-aware service composition," by Chen et al. addresses the multi-objective optimization problem for service selection. The authors model QoS-aware service composition using a Pareto set model. They also present a service composition algorithm that uses partial selection techniques.

The fifth article, "Towards operational cost minimization in hybrid clouds for dynamic resource provisioning with delay-aware optimization," by Li et al. analyzes the cost minimization problem using a Lyapunov optimization framework. The authors present an online dynamic provisioning algorithm that addresses the challenge, where no *a priori* information of public cloud renting prices is available and the probability distribution of future user requests is unknown. The results of an experimental study are also presented.

The sixth article, "Quality of experience: User's perception about Web Services," by Upadhyaya et al. advocates incorporating the perceived quality from the user's perspective for service selection and composition, i.e., quality of experience (QoE) in addition to quality of service (QoS). The authors develop a method that automatically mines and identifies QoE attributes from the Web. Evaluations using empirical studies are also reported.

These six articles not only present the latest advances in Web Services but also suggest directions for future research on Web Services. We hope that you find these articles on emerging Web Services both interesting and thought provoking.

In future research, you might consider Web Services as they relate to cloud computing, mobile computing, big data and the Web of Things. There are still many Web Services research opportunities to undertake and application areas to explore. We encourage you to pursue these topics and contribute to the Web Services of the future.

## GUEST EDITORS OF THIS SPECIAL ISSUE



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