Economic Models for Managing Cloud Services

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To my parents, Sunil and Mili, and my wife, Pragga, and my daughter, Aapti.

Sajib Mistry

To my wife and best companion and friend, Malika.

Athman Bouguettaya

To my parents, Jianwen Dong and Aiying Yang.

Hai Dong

Foreword

Cloud computing is inexorably making large inroads to becoming the technology of choice among small and large businesses via provisioning IT infrastructure resources and hosting applications. A significant advantage of cloud computing is its economic benefits to both service consumers and providers. From a consumer's perspective, cloud computing is a model for providing computing resources as a location-independent and highly scalable service that is acquired on demand with little or no fixed capital investment. Cloud is ideal for those organizations with fluctuating computational resource demands. It is able to fulfill those demands with dynamically provisioned resources. From a provider's perspective, cloud computing provides economies of scale through a distribution of costs among a large pool of consumers, centralization of infrastructures in locations with lower costs, and improved resource utilization.

Cloud service management is a critical aspect of cloud computing. In cloud computing, a complex business process can be realized by outsourcing its involved tasks to the cloud and then composing the resulting component cloud services against each of these outsourced tasks. The cloud service management from the consumers' perspective aims to select the optimal provider for each component cloud service to minimize consumers' total cost while meeting consumers' Quality of Service (QoS) requirements. Similarly, cloud providers require an effective cloud service management process to achieve their business goals, e.g., specific revenue or profit expectations. In this regard, the cloud service management process can be realized by selecting and composing more profitable services to fulfill consumers' demands while ensuring delivery of the promised QoS. From here, we can see that cloud computing management is mainly driven by economic factors. Employing economic models to design the cloud service management framework is a right way, as it perfectly fits the way in which business is conducted.

There are a variety of books on the market that cover many interesting issues related to cloud computing. However, none but this book provide a comprehensive analysis of economic models in the long-term cloud service management from the providers' perspective. This book is a first attempt to design quantitative and qualitative economic models for an Infrastructure as a Service (IaaS) provider. It provides an efficient, market-driven, and competitive environment for cloud providers and consumers to maximize their profit and minimize their costs, respectively, while meeting their long-term QoS requests. This is crucial if we want to unlock the full potential of cloud computing which has largely remained closed and proprietary. This book also covers fundamental technical details concerning optimization, prediction, and machine learning models in the cloud service management. The state-of-the-art technologies described and the references included in this book will also help the interested readers gain knowledge on these topics.

This book can be utilized as a useful reference to anyone who is interested in theory, practice, and application of economic models in cloud computing. This book will be an invaluable guide for small and medium entrepreneurs who have invested or plan to invest in cloud infrastructures and services. Overall, this book is suitable for a wide audience that includes students, researchers, and practitioners studying or working in service-oriented computing and cloud computing.

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Preface

Cloud computing is increasingly becoming the technology of choice as the next-generation platform for conducting businesses. Cloud solutions are represented as services, i.e., a higher level abstraction of computing resources. An effective cloud service management framework has the potential of creating a sustainable cloud service market. It enables the wider adoption of the cloud at a greater scale and faster pace by considering economic perspectives of service consumers and providers. The long-term cloud service composition is an essential element to designing an effective management framework. The composition from the consumer's perspective aims to minimize total costs while meeting Quality of Service (QoS) requirements by selecting the best set of cloud providers. The composition from the provider's perspective aims to maximize profit for a long-term period by selecting an optimal set of service requests. Developing an efficient and long-term cloud service composition framework from the provider's perspective is very important to sustaining and growing demand from a large number of service consumers in the market.

In this book, we develop an economic model-driven long-term cloud service composition framework from the Infrastructure as a Service (IaaS) provider's perspective. The provider-consumer relationships in a cloud market are usually long term and economically driven. In this regard, using economic models to optimize the composition of service requests fits perfectly well with the way in which business is usually conducted. First, a new quantitative economic model is developed that maximizes the provider's long-term revenue and profit by selecting an optimal set of IaaS requests in a dynamic economic environment. We propose a new multivariate Hidden Markov and Autoregressive Integrated Moving Average (HMM-ARIMA) model to predict various patterns of runtime resource utilization. A heuristic-based Integer Linear Programming (ILP) optimization approach is proposed to maximize the runtime resource utilization. We deploy a Dynamic Bayesian Network (DBN) to model the dynamic pricing and long-term operation cost. A new Hybrid Adaptive Genetic Algorithm (HAGA) is developed that optimizes a nonlinear profit function periodically to address the stochastic arrival of requests. Next, we develop a qualitative economic model which is a preference-driven approach to enact on high-level business strategies, such as service menu creation and pricing. We propose the Temporal Conditional Preference Network (TempCP-Net) to represent the high-level IaaS business strategies. The temporal qualitative preferences are indexed in a multidimensional *k*-d tree to efficiently compute the preference ranking in runtime. A three-dimensional Q-learning approach is proposed to find an optimal qualitative composition using statistical analysis on historical request patterns. Finally, we propose a new multivariate approach to predict future Quality of Service (QoS) performances of peer service providers to efficiently configure a TempCP-Net.

We have evaluated the efficiency of the proposed framework using Google Cluster data, real-world QoS data, and synthetic data. Experimental results show that the proposed composition framework efficiently maximizes the provider's long-term economic goals in runtime. The proposed models in this book are expected to play a significant role in creating an economically viable and stable cloud market.

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Sydney, NSW, Australia Sajib Mistry

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Sydney, NSW, Australia Athman Bouguettaya

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Melbourne, VIC, Australia Hai Dong

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