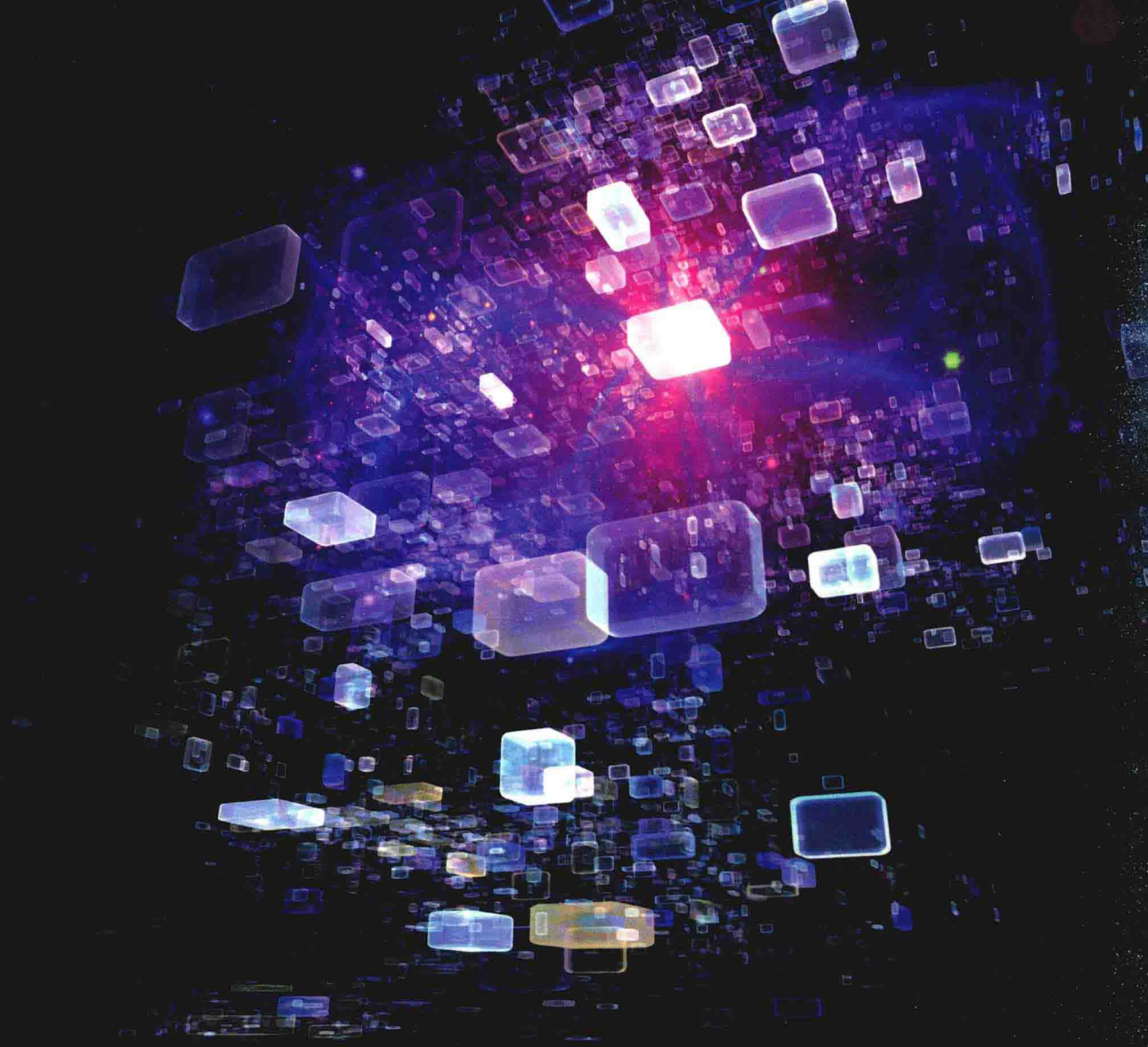

CLOUD DATA CENTERS AND COST MODELING

A complete guide to planning, designing and building a cloud data center

Caesar Wu
Rajkumar Buyya

MORGAN KAUFMANN

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Preface

How can we measure the sky? This question sometimes refers to how to measure the cost of cloud computing. For many people, it is a very challenging and tough question. And yet, many C-class senior executives (CEO, CFO, and CIO), stakeholders, and cloud investors would not only want to know "how" (cost model assumptions and calculations), but also want to know "why" (logic behind these assumptions).

Why is this so important? The simple answer is it is too big to be ignored. We have heard many stories about how some decision makers just throw big money into cloud projects without proper understanding of cloud technology and expect to catch up to the "wind" (win). This book will lay out the basic concepts and foundation of cloud computing and data center facilities and then provide tools and practical approaches for decision makers to make the right strategic investment decisions. It will help the decision maker to not only rely on "gut feelings" or previous experiences but also count on the scientific method.

One of the goals of this book is to establish a practical framework to enable IT executives to make a rational choice when they are facing a multimillion-dollar investment decision for a cloud project, which is to determine whether IT workloads should stay local or fly to a cloud. (inhouse or cloud computing).

Almost five years ago, this challenging task was assigned to us because a senior IT executive wanted to justify a multimillion investment decision that he had already made but he was not sure whether the decision was a rational choice or not. The original idea of this exercise was to check his intuition, estimate the strategic value, communicate with all the stakeholders, and change the scope of the cloud investment project if necessary.

At that time, many trial projects of cloud computing, server virtualization, and software multitenancy had just taken off. Various companies made different investment decisions in order to test the water or get a foothold on the cloud market.

With these intentions in our mind plus many years' practical experience in cost modeling of utilities and grid computing, hosting services management, network design, construction, operation, lifecycles, and service delivery, we elicited eight basic questions about this cost modeling exercise:

- What is the ultimate goal of measuring the sky?
- How many cost models are there?
- How can we make a logical and rational comparison with different models?
- Why is the TCO/ROI model is so popular? If we use TCO/ROI, would it be the right choice?
- What are the assumptions of these models?
- How can I select the right model to fit a particular business need?
- How can we establish both revenue- and nonrevenue-based cost models?
- What are the risks of keeping the IT workload in house versus migrating to the cloud?

We believe that most people, whether they are cloud service providers or cloud service consumers, will also face similar questions if they are asked to measure "the sky" or to prepare a business case for a cloud investment project. From this perspective, this book is also targeted for IT business analysts and MBA students as reference material.

In essence, the core objective of this book is to demonstrate how to build a cloud cost model. It will illustrate the process of establishing the cost framework and calculating the costs. One of the main reasons to address the cloud cost modeling issue is that many ordinary people have two popular misconceptions:

1. The cloud is free.
2. My data is stored anyway up in the air.

If this is so, why should we bother to measure the sky? The answer is dependent on who you are. If you are just an individual consumer and require very limited cloud resources, it is quite clear that you can obtain nearly free cloud resources. However, if you are a business consumer, especially for medium- and large-scale businesses, there will be no free lunch. You have to pay for what you have consumed. This leads to the issue of how to make the rational investment decision for the usage of IT resources.

For most small or medium size companies, the investment decision would be relatively simple. The decision criteria could be mainly based on financial or economic returns plus a decision maker's intuition or personal satisfaction. However, for a large enterprise, the strategic investment decision (very often involving millions of dollars) is not a simple intellectual exercise but rather than process of negotiation and compromise among different Line of Business (LoB) units.

However, to some degree, all models are subjective because cost modeling involves many subjective assumptions and selection of raw data and material. It would be impossible to avoid subjective assumptions and personal opinions. Strictly speaking, any data selected and assumption made are subjective. It is based on personal experiences and intuition or perhaps, a gut feeling.

Many people think a gut feeling is negative or nonscientific. As a matter of fact, a gut feeling is kind of a super-logic or sixth sense or recognition of a subconscious pattern. It gives us a shortcut to quickly reach a solution. Sometimes, this shortcut serves us quite well, especially if we do not have enough time to analyze the circumstances surrounding us or do not have enough information available. In this case, the sixth sense would be the only choice for us to reach a self-satisfactory conclusion. It is not purely arbitrary or an illogical guess but rather meta–knowledge built upon the subconscious mind. Actually, people's minds are always searching for a recognised pattern based on available information, knowledge, experiences and most importantly, wisdom. Perhaps that is why a gut feeling is very often called an "educated guess," self-learning, working experience, or armchair thinking.

Many strategic investment decisions made by IT legends such as Steve Jobs and Marc R. Benioff [1] led to great success for their companies. Why did they achieve what most people cannot achieve? Is it because they not only have years of working experiences and cumulative knowledge, but also have "gut feelings" or wisdom? People speculate that they may have absorbed wisdom from Eastern philosophy and religion because they both went to India for enlightenment. In Steve Jobs' own words, "Trust in destiny" and "Follow your heart." Walter Isaacson, the exclusive biographer of Steve Jobs, wrote it this way:

> Jobs's interest in Eastern spirituality, Hinduism (Krishna/God Consciousness), Zen Buddhism, and the search for enlightenment was not merely the passing phase of a nineteen-year-old. Throughout his life he would seek to follow many of the basic precepts of Eastern religions, such as the emphasis on experiential prajñā, wisdom or cognitive understanding that is intuitively experienced through concentration of the mind. Years later, sitting in his Palo Alto garden, he reflected on the lasting influence of his trip to India [2].

For the East, it is the soul. The soul did not come with body nor die with the body. The body is just a temporary home for the soul. The soul can be enlightened by many sophisticated methodologies and practices that have been developed by Eastern philosophy, religion, and culture for many thousands of years or by messages delivered by the Supreme God personally (e.g., Lord Krishna's teachings compiled as Bhagavad Gita) or his incarnations.

For the West, it is subconsciousness. In Sigmund Freud's teachings, it is the unconscious mind beneath consciousness and awareness. It is a repository of idea, desire, memories, and emotion. It consists of any information and data the mind collects from five senses but cannot consciously process to make meaningful sense of. However, it can be retrieved or recalled to consciousness by the simple direction of attention.

In order to make the right decision at the right time, the spiritual mind constantly needs not only information and knowledge but also wisdom. Without that, a strategic decision may just be a tactical one. Long-term success would be dependent on pure luck rather than a strategy. Here, wisdom means abstract pattern recognition at hierarchical level. It is the experience of cumulative knowledge. Cumulative knowledge has four different levels:

- Level 1: You do not know what you do not know (ignorance).
- Level 2: You know what you do not know (know unknowns).
- Level 3: You know what you know and what you do not know (know your boundaries).
- Level 4: You know all – knowledge of knowledge or meta-knowledge, wisdom (wizard).

For many people and under many circumstances, they are just wandering around atknowledge level 1. If we borrow the Indian philosophy term, it is so-called "ignorance." There are two different scenarios when people face the unknown. One is either leaving to chance or pretending to know. The other is to wonder about the unknown and continuously search for knowledge and wisdom. That is why people often say wondering is the beginning of wisdom.

Unfortunately, we have witnessed many IT strategic decisions made by some wayward people subject to purely static analysis, shallow observation, personal opinion, preference, taste and prejudice and, above all, ignorance. The results of these decisions often led to great fiascos or disaster.

Certainly, this book does not intend to tell readers how to make a particular decision or to enlighten readers on how to search for wisdom, but rather to share some common experiences that we have learned from previous lessons of cloud investment projects. By Buddhist philosophy, enlightenment depends only on oneself. Wisdom cannot be taught or demonstrated but one can only be shown the path to be followed.

This book will provide analytic tools and some practical processes of decision making for people to follow. It will not only provide readers with knowledge and analytic methods to establish a cost framework for strategic decision making but also will help readers to understand the logic behind the strategic decision making for cloud computing investment in practice.

We think it is important because not all decisions can be made by "gutfeelings," especially for a multimillion-dollar strategic investment decision that is made in a complex and dynamically changing environment. It requires hard mental work and comprehensive analysis. Gut feelings and educated guesses may add some value but not enough. Perhaps we can summarize the main point by altering the old English proverb "Look before you jump" as "Analyze before you decide."

ORGANISATION OF THE BOOK

This book is organized into five major parts:

I. Cloud Computing Foundations and Business Requirements (Introduction)
II. Cloud Data Center Facility (Below the Floor)
III. Cloud Infrastructure and Management (Above the Floor)
IV. Cloud Computing Cost Models and Framework (Framework)
V. Cloud Strategy and Critical Decisions with Real Option Theory (Example)

The structure of this book is similar to a five-paragraph essay. Actually, the structure of the entire book can be loosely considered a recursive five-paragraph essay.

Part I is made up of three chapters (Chapter 1–3) that offer an introduction to cloud computing, define related computing paradigms such as parallel computing, identify business requirements through a five-phase process for defining business needs, and conclude with a case study.

Part II consists of seven chapters (Chapters 4–10) that cover issues related to data center architecture and key components and elements of data centers including space, power, cooling, fire suppression, and physical security.

Part III consists of three chapters (Chapter 11–13) that focus on cloud physical infrastructure elements namely servers, storage, and networking.

Part IV is made up of three chapters (Chapters 14–16). They cover topics related to the cost modeling framework and associated challenges. They also offer a detailed review of literature on cost modeling and key classifications, and how these concepts are put into practice in the real world.

Part V consists of two chapters (Chapters 17 and 18), which discuss the application of cost modeling to a real-life case scenario and present real option theory as one of the effective strategic methodologies for a decision maker to steer the business based on three basic elements: planning, opportunities, and decision making.

Caesar Wu and Rajkumar Buyya
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