

Mastering AWS Cloud

*Cloud adoption using the AWS
cloud computing ecosystem*

Paulo H. Leocadio



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Dedicated to

*My beloved wife Lucy
Our five children and Lily
the next generation*

About the Author

Paulo H. Leocadio is a seasoned technologist, author, and international advisor with over four decades of experience spanning software engineering, cloud infrastructure, **artificial intelligence (AI)**, and enterprise architecture. A Microsoft alumnus with a legacy of leading global transformation projects, Paulo has designed and delivered digital infrastructure strategies across 30+ countries, working with governments, multinationals, and startups alike.

Paulo holds a foundational degree in electronic and computer science engineering, postgraduate qualifications in solid state physics and data science, and a master's in international business. His work reflects a rare blend of theoretical expertise with practical application—from co-authoring public sector cloud modernization blueprints to developing AI-powered cybersecurity frameworks using Hugging Face Diffusers and AWS.

Beyond his consulting and engineering work, Paulo is a prolific academic contributor and peer reviewer for international AI journals. His published works reflect a commitment to bridging frontier science with real-world implementation, often grounded in speculative and philosophical views on the future of intelligent systems.

Currently, he leads Zinnia AI software engineering and digital design—a research-driven enterprise under Zinnia holdings—and mentors emerging AI professionals worldwide. Mastering AWS Cloud is his key contribution to the cloud-native community: a thorough, structured, and highly technical reference for professionals building the next generation of intelligent, scalable systems.

About the Reviewer

Baron Ntambwe is a Canadian professional software engineer. Most of his work focuses on AI, big data, and distributed systems. He holds a bachelor of engineering in computer systems, a bachelor of technology in software engineering, and a master of science degree in AI. With a strong educational foundation, Baron embarked on a successful career in software engineering. He has held various leadership roles, including engineering manager III at Amazon AWS and senior engineering manager at Walmart Global Tech, based in Silicon Valley, San Francisco. His professional journey is marked by a commitment to excellence and a drive to push the boundaries of technological advancements. Beyond his professional accomplishments, Baron is a member of the Baha'i Faith, whose principles of the Oneness of Mankind have prompted him to dedicate himself to giving back to his community. He actively participates in community-building activities initiated by his local Baha'i community, spending most of his weekends engaged in service and youth empowerment work. Through his endeavors, Baron strives to make a positive impact in the world around him.

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Finally, I dedicate this work to my family. In their constant presence, I found stability; in their patience, the rhythm; and in their belief, the strength to cross the invisible line between knowing and starting anew.

Preface

This book is motivated by a long-standing commitment to understanding how complex systems operate, from information theory and distributed infrastructure to human learning and scientific research. It reflects years of experience in both academic and practical aspects of computing, aiming to synthesize a deep, organized, and technically rigorous understanding of cloud computing from the perspective of **Amazon Web Services (AWS)**.

At its core, the motivation for this work is twofold: to provide meaningful insights into the scientific literature on cloud architecture and operations, and to serve as a practical guide for those navigating the rapidly expanding AWS ecosystem. Cloud computing is no longer a niche tool; it has become the foundation of contemporary innovation. This book aims to frame that transformation with both technical accuracy and clear teaching.

Chapter 1: AWS Architecture- Introduces the core concepts of AWS, including its worldwide data center network, Availability Zones, and service regions. It gives readers a basic understanding of how AWS functions globally and prepares them to explore services built on this solid infrastructure.

Chapter 2: Compute- Explores AWS **Identity and Access Management (IAM)**, service control policies, permission boundaries, and governance strategies. The chapter outlines best practices for securely managing users, roles, and resources on scale.

Chapter 3: Storage- Covers **Elastic Compute Cloud (EC2)** and AWS Lambda, comparing traditional and serverless compute models. Readers will gain insight into provisioning, configuring, and managing compute resources for various use cases.

Chapter 4: Content Delivery Network- Explores AWS container services, such as Amazon ECS, EKS, and AWS Fargate. The chapter emphasizes container deployment, orchestration, and infrastructure abstraction for modern microservices architectures.

Chapter 5: Security, Identity, and Compliance- Details AWS storage options such as S3, EBS, EFS, and Glacier. This chapter explains storage classes, performance optimization, lifecycle policies, and how they integrate into distributed application workflows.

Chapter 6: Database- Explores the **Virtual Private Cloud (VPC)** model, including subnets, routing, gateways, NAT, peering, and security groups. Readers learn how to design secure and scalable network environments.

Chapter 7: Developer Tools and DevOps: Part 1- Introduces managed database services such as RDS, DynamoDB, Aurora, and Redshift, along with analytics tools like Athena and Glue. Readers explore use cases and configurations for both real-time and batch processing.

Chapter 8: Developer Tools and DevOps: Part 2- Focuses on decoupling services and integrating them via SNS, SQS, EventBridge, and Step Functions. The chapter emphasizes designing loosely coupled architecture and event-driven workflows.

Chapter 9: End-user, Front-end, and Mobile- Covers security tools like AWS Shield, WAF, Config, and Inspector, along with observability solutions such as CloudWatch, CloudTrail, and X-Ray to ensure system resilience and auditability.

Chapter 10: Applications for Business- Guides readers through infrastructure automation using AWS CloudFormation, CDK, and the integration of CI/CD pipelines with CodePipeline, CodeBuild, and GitOps practices.

Chapter 11: Analytics and Machine Learning- Introduces AWS AI/ML services including SageMaker, Comprehend, Rekognition, and the broader ML stack. Readers learn how to integrate intelligent services into cloud-native applications.

Chapter 12: Management and Governance- Covers AWS Greengrass, IoT Core, and hybrid environments, including Outposts and Snowball. This chapter helps readers connect cloud and edge deployments for low-latency applications.

Chapter 13: Migration and Transfer- Focuses on AWS Budgets, Cost Explorer, Savings Plans, and governance policies for cost management. The chapter teaches how to align financial accountability with scalable cloud expansion.

Chapter 14: AWS Well-Architected Framework- Concludes with advanced architectural patterns, Well-Architected Framework pillars, and compliance considerations. This final chapter prepares readers to design resilient, secure, and regulation-compliant workloads.

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Prologue

In the architecture of a cloud system, the silent elegance lies not in any one service or script, but in the orchestration of parts—how communication, computation, and control converge in reproducible patterns that scale. It is, in many ways, the modern blueprint of systems thinking, echoing disciplines far beyond computer science.

However, behind every system lies a human system: intent, constraint, error, and learning. This book does not merely describe services; it follows the arc of decisions—technical and otherwise—that define how digital infrastructures evolve. It speaks to the engineer, the scientist, and the architect not as discrete identities, but as converging roles in the present technological epoch.

The impetus for writing this volume was not born in a vacuum of abstraction but shaped over decades of lived technical work. From navigating enterprise architecture in the corridors of global corporations to revisiting first principles under a different kind of light—one shaped by inquiry rather than delivery—cloud systems came to be viewed not as tools, but as environments in which reasoning, optimization, and resilience become visible.

And it was in that crossing—from execution to inquiry, from systems of deployment to systems of explanation—that this book began to take form.

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CHAPTER 1

AWS Architecture

Introduction

In the constantly changing world of cloud computing, **Amazon Web Services (AWS)** remains a leading symbol of innovation and change. As we begin our exploration of AWS architecture in the first chapter of this book, we enter a space where cloud technology transforms what is possible. Founded by Amazon.com in 2006, AWS has grown into the world's most extensive and widely used cloud platform, supporting millions of customers worldwide [1]. This chapter acts as our guide to understanding the essential architectural foundations that support this digital giant.

Structure

In this chapter, we will discuss the following topics:

- Introduction to AWS
- Global Infrastructure
- Regions and Availability Zones
- Amazon Web Services
- Compute services

- Storage services
- Networking in AWS
- Security and identity
- Scalability and elasticity
- AWS Well-Architected Framework
- Cost optimization

Objectives

By the end of this chapter, you will gain a basic understanding of AWS's architectural principles and its role as a catalyst for digital innovation. These principles will form the foundation for a deeper exploration of AWS in the upcoming chapters of the book.

Introduction to AWS

In the vast landscape of cloud computing, AWS stands as a formidable titan, shaping the digital evolution of businesses and individuals alike. To embark on our journey into AWS architecture in this book chapter, it is crucial to contextualize its emergence and ascendancy. Founded by **Amazon.com** in 2006, AWS swiftly transcended its initial identity as a humble cloud computing experiment to become the unrivaled leader in cloud technology [2]. Its meteoric rise was propelled by the visionary leadership of Amazon's CEO *Jeff Bezos*, who recognized the potential for providing businesses with scalable computing resources, transforming IT infrastructure into a utility accessible to anyone, anywhere [3].

AWS's influence is worldwide, with a strong presence on multiple continents. Its infrastructure is a feat of engineering, comprising a network of data centers carefully placed across regions and **Availability Zones (AZs)**. This extensive reach not only offers low-latency service access but also ensures redundancy and fault-tolerance, which are essential in today's digital world [4]. With a customer base that includes startups, enterprises, governments, and individuals, AWS has made access to cutting-edge technology widely available. It serves as the foundation for many innovations, from web startups to scientific research, demonstrating its flexibility across a wide range of use cases [2].

Understanding AWS's historical development and the vast scale of its customer base and infrastructure is crucial when examining AWS architecture. These fundamental elements lay the groundwork for grasping the technical details and architectural principles discussed in later sections of this chapter.

Global Infrastructure

In the ever-expanding world of cloud computing, the foundation on which a cloud provider's services are built is critical. AWS, in its effort to provide unmatched performance, resilience,

and scalability, has carefully designed a Global Infrastructure that exemplifies technological innovation. In this section, we explore the details of AWS Global Infrastructure, highlighting the strategic placement of data centers around the world, the concept of regions and AZs, and the significant impact this architecture has on ensuring reliability and low-latency access vital in today's digital age.

AWS's Global Infrastructure forms the backbone of its service offerings, carefully designed to meet customers' various needs worldwide. Key to this infrastructure are AWS Regions, geographic areas made up of multiple AZs. Each region is built to be isolated from others, ensuring redundancy and failover capabilities. This geographic distribution helps reduce the risk of service disruptions caused by natural disasters or other unexpected events. Within each region, there are several AZs, which are essentially data centers with independent power, cooling, and network connectivity. These AZs are connected through low-latency, high-throughput links, enabling synchronous data replication and high availability. This setup is vital for providing the resiliency and fault-tolerance necessary for modern applications [4]. Refer to the following figure:

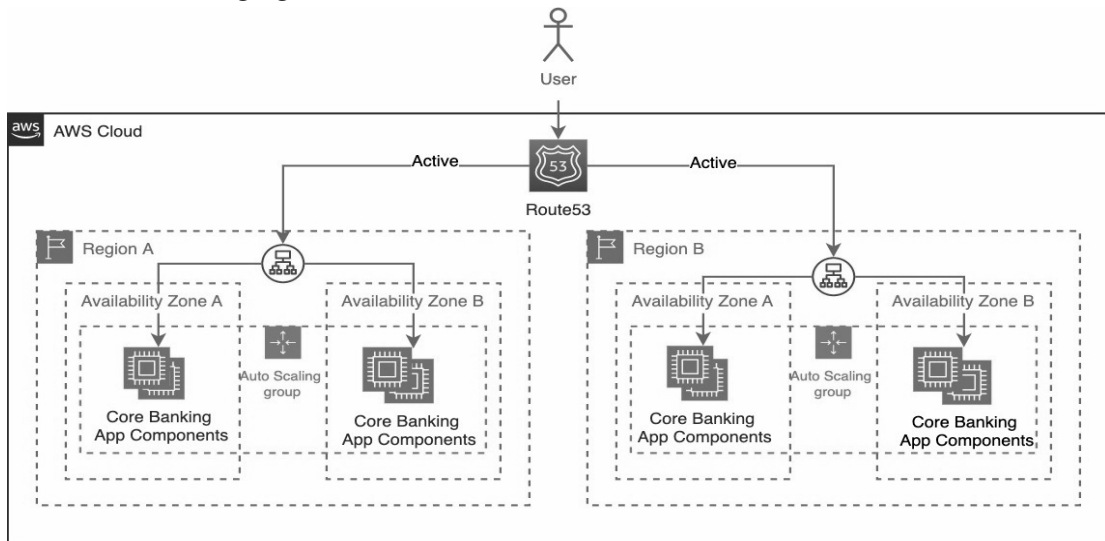


Figure 1.1: AWS commitment to resiliency, multi-region active-active pattern (P5)

Furthermore, AWS's careful approach includes selecting data center locations. These centers are strategically positioned across various regions worldwide to serve a global customer base. By providing regions across multiple continents, AWS ensures that users can deploy their applications and services near their end-users, thereby reducing latency and enhancing the user experience. This strategic placement of data centers is not just about proximity but also about regulatory compliance. It helps organizations meet data sovereignty requirements by keeping data within specific geographic boundaries. Whether you are a startup targeting local markets or a multinational corporation with a global reach, AWS's Global Infrastructure supports reliability, scalability, and low-latency access, making it a key part of modern cloud architecture [5].

Regions and Availability Zones

In the intricately woven tapestry of AWS architecture, the concepts of regions and AZs are essential threads, crucial for creating high availability and fault-tolerance. In this section, we thoroughly examine these fundamental building blocks that support AWS's infrastructure. By the end, you will understand their importance and how they form the foundation of AWS's commitment to keeping your applications and data resilient, available, and high performing. Refer to the following figure:



Figure 1.2: AWS Regions and AZs

AWS defines a region as a geographically distinct area with available AWS resources. Each region operates independently [5], encompassing multiple data centers, which makes it highly resistant to regional disruptions. For example, the AWS US East (N. Virginia) region is separate from the AWS EU (Ireland) region. These regions are strategically located around the world, allowing AWS users to deploy resources close to their target audience or to meet data residency and compliance requirements. This geographical diversity enables organizations to design their systems for redundancy, failover, and low-latency access, all while leveraging AWS's extensive global network infrastructure [4].

Within each AWS Region, the concept of AZs comes into play. It is essentially a data center, but AWS goes the extra mile by ensuring that these AZs are isolated from one another. They have power, cooling, and network connectivity, minimizing the risk of correlated failures. These AZs are interconnected through a network designed for low-latency, high-throughput communication, allowing for synchronous data replication and providing the foundation for high availability. By distributing resources across multiple AZs, AWS users can architect their

applications and systems to withstand failures, ensuring that services remain available even in the face of unexpected events and data remains secure. The combination of regions and AZs exemplifies AWS's commitment to delivering robust and resilient cloud infrastructure [5]. Refer to the following figure:



Figure 1.3: Map of AWS AZs

Amazon Web Services

AWS stands as a true titan in the cloud computing landscape, not just for its infrastructure but also for its extensive suite of services that address virtually every computing need imaginable. In this section, we take a journey through the rich landscape of AWS services, exploring their variety and depth and understanding how they together enable organizations to innovate, grow, and transform. Refer to the following figure:



Figure 1.4: A map of the AWS Global Infrastructure network

At the heart of AWS's allure is its extensive portfolio of services, designed to address a broad spectrum of customer requirements. These services can be categorized into several key domains, including computing, storage, databases, **machine learning (ML)**, and the **Internet of Things (IoT)** [7], and more. AWS offers **Elastic Compute Cloud (EC2)** for scalable virtual servers, Lambda for serverless computing, and **Elastic Container Service (ECS)** for containerized applications, ensuring flexibility for diverse workloads [8]. In the realm of storage, AWS **Simple Storage Service (S3)** provides highly durable and scalable object storage, while **Elastic Block Store (EBS)** offers block-level storage for EC2 instances [9]. AWS's managed database services, such as Amazon **Relational Database Service (RDS)**, DynamoDB, and Aurora, cater to diverse database needs, from relational to NoSQL [9]. For organizations venturing into **artificial intelligence (AI)** and ML, AWS offers SageMaker, which streamlines model training and deployment, and Rekognition, a powerful image and video analysis service [10]. With AWS IoT Core [7], businesses can harness the potential of the IoT, managing and analyzing data from connected devices [5].

This extensive range of AWS services showcases innovation and addresses the changing needs of businesses and developers. AWS's dedication to offering scalable, secure, and versatile solutions is clear in the wide scope of its service options. As we explore this chapter and subsequent parts of the book, we will examine these services in more detail, highlighting their potential and illustrating how they can be strategically used to build strong, scalable cloud solutions.

Compute services

In the fast-changing world of cloud computing, AWS's strength is truly evident in its wide range of compute services, each designed to serve as a fundamental part of various applications and workloads. This chapter provides a detailed look at AWS's compute services. It offers a clear understanding of their unique features and emphasizes their crucial role in creating scalable and flexible cloud-based applications.

EC2 stands as one of the cornerstones of AWS's compute offerings. It provides resizable virtual servers, known as **instances**, allowing users to scale up or down based on their computing needs quickly. With EC2, organizations can deploy applications, host websites, and manage workloads precisely and flexibly. EC2 instances come in various configurations, including compute-optimized, memory-optimized, and storage-optimized, catering to a wide range of computational requirements [11]. Furthermore, AWS Lambda, a serverless computing service, represents a paradigm shift in application development. Lambda enables developers to run code responding to events without managing servers, automatically scaling based on incoming requests. This serverless approach simplifies application development, reduces operational overhead, and accelerates time to market [12]. In addition, the ECS empowers organizations to manage and orchestrate containerized applications effortlessly. Whether using Docker containers or AWS Fargate for serverless containers, ECS streamlines the deployment and scaling of containerized workloads, making it an ideal choice for modern application architectures [13]. Refer to the following figure: