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Cloud Computing and Development Fundamentals

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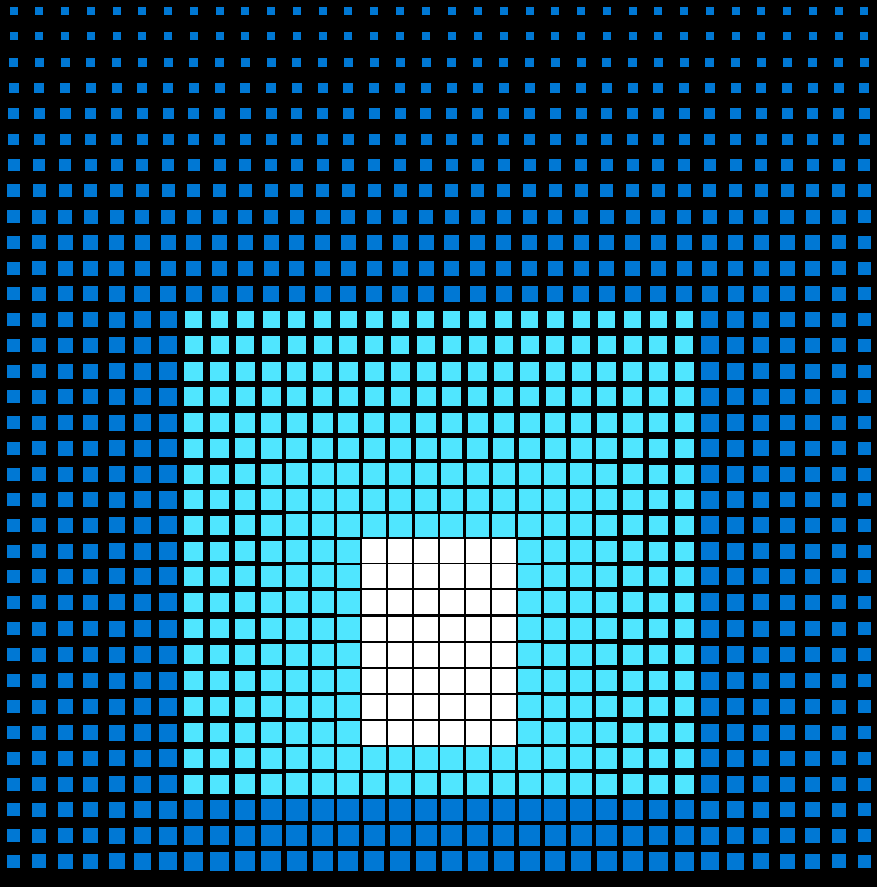

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Jonah Carrio Andersson

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Learning Microsoft Azure
by Jonah Carrio Andersson

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[FILL IN]

I would like to dedicate this first book I had ever written to my late and beloved mother Joan, who died of breast cancer in 2004 when I turned 18. She had her confidence in me since I was a child and her courage inspired me to be strong, resilient, and confident.

I also want to dedicate this book to my dear family and friends in Sweden, in the Philippines, and worldwide. They are always there to morally support me in every exciting journey I take in life and my career.

Thank you so much! Tack så mycket (Swedish) Maraming Salamat (Tagalog)

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Preface

Hello, Readers of Learning Microsoft Azure!

As the author, I would like to personally thank you for choosing to read this book. I appreciate that you picked this book to help you learn about Microsoft Azure. I hope that you find this book to be a valuable resource and content.

Software engineering and DevOps engineering with cloud technologies has been one of the most exciting experiences in this modern era! From mainframe computers to massive modern resources and technologies on the cloud. As much as the industrial revolution forever changed the manufacturing industry and our access to consumer goods, digitization has transformed how we live and work.

Microsoft Azure is a cloud computing platform that has been close to my heart. For the past several years, I have been working as a software engineer developing applications and DevOps Engineer deploying applications to the cloud. I have gained a lot of learning, hands-on experience, and technical insights and inspiration about Azure.

Azure is a modern and robust cloud service provider that technologically evolves. Microsoft Azure is a global cloud provider serving millions of organizations, customers, and modern applications. Azure brings powerful benefits not just to the business but to all members of the organization - from the leadership, project managers, clients, and engineering teams.

Building and maintaining applications or enterprise systems is part of my daily work routine. My experience in the software engineering industry and working with the cloud platform Microsoft Azure has helped me broaden my technical knowledge.

I was once involved in a cloud migration project to Azure. I had a mission to move an old legacy.NET application hosted on on-premises servers. I had full responsibility to move it by myself to a cloud computing platform. I was like a superwoman on a cloud migration mission. From designing the system architecture, re-structuring the databases, fixing the technical debts, fixing data quality issues, programming, and

even creating documentation. I put my heart into it, but that cloud migration project was a fiasco, just like some other software engineering projects.

After trying different migration alternatives: lift and shift, refactoring code, and re-architecting the infrastructure, we determined that the system needed to be re-built as though it were new. Unfortunately, that project was stopped due to a lack of cloud migration strategy, awareness of its significant benefits, knowledge about the cloud, and other factors.

It was a project that didn't make it to the finish line. Still, it was one of the most significant experiences in my cloud engineering career. No regrets, just lessons learned.

I do not want other developers or organizations to make the same mistakes we did in that cloud migration project. My cloud migration journey is one of the reasons why I am very passionate about sharing knowledge of the cloud and Azure. Through public speaking engagements, tech conferences, meetups, and with our clients, even when these opportunities are in my spare time and on weekends.

I am excited to share vital and valuable information about Microsoft Azure in this book. I hope that the contents of this book will come in handy in your work, career development, cloud migration journey, and contribution to your organization's cloud engineering projects.

Why I Wrote This Book

When I was studying Computer Science in the 1990s, my first thesis was about how the invention of Internet technology helped local communities and our society. Since then, I have become fascinated with how new technologies allow us in our daily routines and work.

As a Software Engineer and DevOps Engineer Lead, I create, build and develop technical solutions with modern technologies, including the cloud technologies offered by Microsoft Azure. I work and collaborate in full-stack software development, cloud development, and DevOps. The more I collaborate with different teams in different areas and the more problems I solve, the more technical skills and knowledge help me be in à jour or up to date along with the evolving modern technologies we have these days.

I am passionate about sharing this knowledge with others - especially those who want to gain fundamental learning of cloud computing and Microsoft Azure. This book aims to help those getting started in cloud computing and Microsoft Azure.

I hope that this book will assist and guide IT professionals, project teams, software developers, and cloud engineers choose the appropriate cloud service to use in Microsoft Azure. This knowledge will help solve your organization's customer use-cases and business requirements.

Who Should Read This Book

This book is an essential learning reference book for anybody who wants to learn about the vital cloud concepts and cloud computing services provided by Microsoft Azure. Regardless if you are a beginner or on an intermediate level in this field.

This book's information and technical knowledge will help you plan, design, and develop applications and modern technological solutions and migrate existing workloads and systems to the cloud using Microsoft Azure.

This book is open for anybody with a technical background with career roles like Software Developers, Cloud Engineers, or Cloud Solution Architects. Management or leadership roles in an IT organization, such as IT Project Managers, Technical Sales Managers, and Scrum Masters, would also benefit from learning the concepts of cloud computing in Azure. Also, teams working with traditional and on-premises legacy applications or systems will gain essential insight into designing and developing solutions in the cloud platform through Microsoft Azure service and its technical overview.

This book is also ideal for IT Professionals, Software Developers, and aspiring Cloud Engineers who want to prepare Microsoft Certifications for Azure. Certifications like the AZ-900 Microsoft Azure Fundamentals Certifications, AZ-204 Developing Solutions for Microsoft Azure, AZ-400 Designing and Implementing Microsoft DevOps Solutions, Exam AZ-305: Designing Microsoft Azure Infrastructure Solutions and other important concepts you need to learn about cloud development, data engineering and DevOps engineering in Azure.

If you are an aspiring cloud engineer who wants to study, prepare, and get certified for the AZ-900 Microsoft Azure Fundamentals Certification and AZ-204 Developing Solutions for Microsoft Azure.

Generally, the book will give you the introductory concepts you need to work with cloud development, data, DevOps, analytics, and other exciting solutions in Azure.

What You Will Learn

By the end of this book, you will be able to gain knowledge of the following:

- The essential concepts you need to know about cloud computing
- The fundamentals of Microsoft Azure as a public cloud service provider
- The different Microsoft Azure technologies that will help you and your organization develop, transform, and migrate to modern cloud environments

- A comprehensive and helpful overview of the different cloud technologies in Microsoft Azure that will help you choose the right cloud service for your demands, use-cases, software development, and cloud development projects
- A jump-start guide on how you can start developing cloud solutions and accelerate your career as an Azure Developer or Cloud Engineer
- Start developing modern cloud services, applications, and solutions in Microsoft Azure environments using your desired and supported programming languages, frameworks, and tools
- Learn about the security, identity and data management in Azure
- Learn how you can integrate cloud technologies with other services, APIs, and third-party services
- Get practical options and learn from best practices on the important things you need to consider when you migrate existing legacy applications to a cloud platform like Microsoft Azure
- Get information about the recent tools and frameworks that will help you in multi-cloud or hybrid cloud environments

Learning Microsoft Azure is your guide as you work with Microsoft Azure. I always believe in Learn By Doing way of learning. So, invest time in learning the fundamental concepts and doing some hands-on.

Navigating This Book

PART I Fundamentals of Cloud Computing and Microsoft Azure

In this introductory part of the book, you will learn about the Cloud Computing and Microsoft Azure Fundamentals.

Chapter 1 provides an introduction to the important concepts of cloud computing, how it works, the different types of its deployment models, understanding the types of cloud, what is CapEx and OpEx in cloud computing, and the benefits of utilizing cloud computing in businesses, IT organizations, society and software engineering.

Chapter 2 focuses deeper into the theoretical and technical concepts of Microsoft Azure as a public cloud platform. Learn about the Microsoft Azure core components and the different cloud services categorized by its purpose.

By the end of reading Part I, you already have gained vital knowledge and foundational concepts of Cloud Computing and Microsoft Azure.

PART II Cloud Computing Services, Networking, Storage and Databases in Microsoft Azure

This second part of the book and its chapters focus on giving you an in depth of the different technologies in Microsoft grouped into its categories.

Chapter 3 explores some of the Microsoft Azure compute services such as Azure Virtual Machines, container services like Azure Container Instances, Azure Container Registry, Azure Container Apps, Azure App services for web and mobile applications, serverless cloud solutions with Azure Functions, Azure Static Web App, and more.

Chapter 4 covers cloud networking and services in Microsoft Azure including Azure VNet, DNS, Azure Firewall, Azure Front Door, ExpressRoute, Virtual Network, VPN Gateway, Application Gateway, Load Balancer, Internet Analyzer, and more. This chapter briefly mention about Azure Orbital, a fully-managed Ground Station as a Service (GSaaS) solution in Azure.

Chapter 5 provides a technical overview of the different cloud storage and databases *(both SQL and NoSQL)* in Microsoft Azure. You will learn about cloud storage concepts, services, create databases and find useful best practices for Azure SQL Databases, Azure Cosmos DB, Database for MySql, Azure SQL Servers, Redis Cache in Azure, Azure Storage, Data Share and Manage Disks.

PART III Artificial Intelligence (AI), Machine Learning (ML), Big Data, Analytics, Internet of Things (IoT) and Security in Microsoft Azure

Chapter 6 focuses on the useful concepts you need to know about Artificial Intelligence(AI), Machine Learning Services and Cognitive Services in Microsoft Azure.

Chapter 7 explores the Big Data, Reporting and Analytics Services in Microsoft Azure. This chapter will include what you need to know about data analytics, big data, analytics and reporting services using Power BI, Azure Stream Analytics, Data Lake Analytics, Azure HD Insights and Azure Analysis Services. This chapter will help you gain the important concepts in working with large complex data using Azure services and big data tools.

Chapter 8 covers the different Azure solutions for IoT (Internet of Things), Maps Services and Cognitive services in Azure. You will learn about what Azure IoT Hub, IoT Edge, Azure Maps, Azure Spheres, and Remote Rendering services. Using Azure Developer IoT Starter Kit to get started with IoT development with Microsoft Azure.

Chapter 9 dives into identity management, compliance and cloud security services in Microsoft Azure which is important in protecting and securing your applications and cloud workloads. You will learn about Azure Active Directory and Azure AD B2C, B2E. Azure security services like Azure Key Vault, Azure Sentinel, Microsoft

Defender for Cloud, Azure security for networking services, and Azure Security Center, Data and Information Protection will be explored.

By the end of reading Part II, you already have learned some technical knowledge and hands-on experience with the different technologies in Microsoft Azure. These will help you choose what Azure technology to use for what you need in your business requirements and develop solutions with them.

PART IV Cloud Integration, Continuous Delivery/Continuous Integration (CI/CD), Infrastructure as Code and DevOps in Microsoft Azure

In this third section of the book, you will learn how you can integrate the different Azure technologies with to other services, infrastructure as a code solutions, and setup your application using Azure's deployment technologies.

Chapter 10 focuses on Microsoft Azure integrations with other services within the platform and even external services. You will learn about Continuous Delivery/Continuous Integration (CI/CD) in Azure for automatic processes what will help you and your team using Azure DevOps suite. This chapter will also include API management in communicating with different APIs, Event Grid, Azure Logic Apps, Notification Hubs, and Azure Web PubSub.

Chapter 11 guides on how to develop systems or applications using important organization suite service like Azure DevOps for team collaboration for developers and IT operations. Automating development processes using CI/CD and source code version control, what are Azure Pipelines, Github Actions with Azure DevOps. How to monitor and troubleshoot Azure resources using Application Insights. You will also get to know about other cloud technology services like Azure DevTestLabs, App Configuration, Azure Biceps, ARM Templates and more. Know what Infrastructure as a Code (IaC) is and how it helps with automation of deployments.

After reading the chapters in Part IV, you already have gained knowledge and development skills to help you work effectively as a cloud developer using the cloud integration and automation options you have. You and your agile team in your organization will also be able to collaborate and work effectively using the great features of Microsoft Azure DevOps and DevTest Labs.

PART V Cloud Management, Governance, Migration Tools and Architecture in Microsoft Azure

The fourth section of this book will give you insights in adopting and migrating successfully to the cloud.

Chapter 12 walks you through the important concepts you should know when it comes to cloud management and cloud governance in Microsoft Azure. For example, how it works with automation in the cloud, Azure Advisor, backup using Azure Backup, Azure Blueprints, Azure Policy, Azure Monitor and other known solutions for hybrid and multi-cloud.

Chapter 13 discusses about cloud migration, cloud transformation, and architectural concepts in Microsoft Azure. You will learn about the vital facts you need to learn when you are adopting, transforming or migrating to Azure. Find out the best practices and useful list of tools you can use when moving on-premises and legacy old application.This chapter also highlights the importance of having a Microsoft Azure's Well-Architected Framework.

After reading the chapters in Part V, you already have gained understanding and important knowledge cloud governance and cloud management in Microsoft Azure. These are important in designing and developing cloud solutions.You will also captured a broad understanding about the Microsoft Cloud Adoption Framework (CAF), Azure Migrate and Microsoft Assessment tools that can assist in your cloud migration projects. You will also have learned from lessons I learned from a cloud migration project experience in migration old .NET Legacy On-Premise applications to Microsoft Azure.

PART VI Cloud Development and Continuous Learning with Microsoft Azure

The fifth and final section of useful list of resources.

Chapter 14 is more focused on the cloud engineering and software development in Microsoft Azure. This chapter aims to introduce you, the reader, to the different languages you can use to get started with cloud engineering and software development with Microsoft Azure.

Further Useful Learning Resources is the final chapter with my recommended learning resources, recommended Microsoft certifications for cloud platform Azure and starting a career as a cloud engineer.

Check Self-Knowledge

In the end of each chapter mentioned, I will be providing a short list of *Check Your Knowledge* section with a maximum of 5 learning check questions related to the topics discussed. These questions will be a useful review challenge for you to check what you have learned.

Learn By Doing (Try it out!)

As a developer, I love the concept of learn by doing. I believe in theoretically learning enhanced by hands-on practices. Therefore, each chapter in this book also ends with a section called *Learn By Doing (Try it out)* where I provided a list of quickstart guides and how-to links to get started with hands-on learning related to the topic discussed in the chapter.

Learning Resources and Further Readings

Learning Microsoft Azure aims to provide the most important foundational knowledge you need to know. With consideration that we have different levels of experience and knowledge, you probably want to explore in more depth the discussed topic further. Therefore, on the end of each chapter, I will be providing a short list of recommended learning and further reading resource related to the topics discussed. Most the references are linked to the most recent documentation of Microsoft for specific technology or resource mentioned in this book.

What This Book Is Not

This book is not an advanced level book for hands-on for each cloud technology service in Microsoft Azure. Hands-on examples are provided but not in highly advanced level.

Conventions Used in This Book

The following typographical conventions are used in this book:

Italic
: Indicates new terms, URLs, email addresses, filenames, and file extensions.

`Constant width`
: Used for program listings, as well as within paragraphs to refer to program elements such as variable or function names, databases, data types, environment variables, statements, and keywords.

`Constant width bold`
: Shows commands or other text that should be typed literally by the user.

`Constant width italic`
: Shows text that should be replaced with user-supplied values or by values determined by context.

This element signifies a tip or suggestion.

This element signifies a general note about the topic discussed.

This element indicates a warning or caution.

Using Code Examples

Supplemental material (book information, code examples, exercises, etc.) will be available for download later at *https://github.com/learningazurebook*.

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I would like to acknowledge and give thanks to those who helped me, supported me, and assisted me in making this book a success from start to finish.

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Expert quotes provided by Alexey Polkovnikov, Ryan O'Connell, Håkan Silfvernagel, Adrienne Braganza Tacke, among others.

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NOTE: *Acknowledgement is still on draft and to be updated until the book is finished.*

PART I

Fundamentals of Cloud Computing and Microsoft Azure

In this introductory part of the book, you will learn about the Cloud Computing and Microsoft Azure Fundamentals.

Chapter 1 provides an introduction to the important concepts of cloud computing, how it works, and the different types of its deployment models. This chapter gives you a general perspective and understand the types of cloud computing. Know what is the difference between CapEx and OpEx in cloud computing, and the benefits of utilizing it in businesses, IT organizations, society and software engineering.

Chapter 2 focuses deeper into the theoretical and technical concepts of Microsoft Azure as a public cloud platform of Microsoft. In this chapter, you will learn about the Microsoft Azure core components and the different cloud services categorized by its purpose.

By the end of reading *Part I*, you already have gained vital knowledge and foundational concepts of Cloud Computing and Microsoft Azure.

CHAPTER 1

Cloud Computing Fundamentals

A Note for Early Release Readers

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 1st chapter of the final book. Please note that the GitHub repo will be made active later on.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *jleonard@oreilly.com*.

> *I don't need a hard disk in my computer if I can get to the server faster… carrying around these non-connected computers is byzantine by comparison.*
>
> —Steve Jobs, late Co-founder, CEO and Chairman, Apple Inc 1997

What is Cloud Computing

Before deep diving into learning Microsoft Azure, we first need to understand cloud computing. Learning the foundational principles of the cloud will help you and organizations design and develop solutions in the cloud. Azure, as a public cloud platform provides ways to build on the the cloud that are secure, scalable, reliable, cost-effective, and easy to manage.

Cloud computing is one of the significant technology innovations we have in this era. In its simple definition, cloud computing is the delivery of different computing services delivered through the Internet. These services are composed of essential

resources like web servers, databases, data storage, virtual machines, applications, network infrastructure, security tools, software, and other IT infrastructure.

It is called *Cloud Computing* because all the data and information we need are being remotely stored and accessed in a virtual space through the Internet. Also, the actual computing processing is happening in the cloud.

John McCharty's Interesting Prediction of Cloud Computing

Looking back into history, John McCarthy was an American computer scientist, cognitive scientist and also was known as the father of Artificial Intelligence said some interesting insights about cloud computing in his speech at MIT's centennial celebration in 1961. He suggested that computing can be sold like a public utility, just like a water or electricity.

Cloud computing makes life easier for us. A good and practical example of this is the possibility of saving our photos, videos and files into a cloud storage virtually with unlimited capacity instead of saving it on a local storage device with limited storage. Another good benefit is virtualizing web servers and databases instead of having the physical infrastructure or servers in costly data centers.

A few of major advantages cloud is in software engineering and modern IT innovation. Adopting and implementing cloud computing provides a fully-managed cloud computing infrastructure and services with the benefits of scalability, autoscaling, availability and performance at a flexible global scale.

Coud computing solutions give us tools and capabilities to handle peak loads based on demands at anytime at a global scale. This is complicated, expensive and time-consuming on an on-premises environments. Azure seamlessly handles scenarios like this through horizontal or vertical scaling or a combination of both.

As you read through the chapters in this book, you will be able to relate and learn how cloud computing technologies help us in different areas.

Benefits of Cloud in Software Engineering and IT

Cloud computing and software engineering are both evolving rapidly. The evolution of computing in cloud along with innovations like Machine Learning (ML), Internet of Things (IoT), Edge Computing, Quantum Computing, and Big Data have caused the increased the demand for skillsets and people who are able to skilled in these technologies and platforms in the cloud. Software developers, cloud engineers and IT professionals. This means that we, working in this software or cloud engineering field must keep ourselves up to date with the modern technologies.

Computing in the cloud enables software developer, engineers and event IT professionals to create, build, test and deploy technical cloud solutions productively, effectively, and securely. Software engineering teams who are still limited to working and developing in on-premises might encounter some technological gap and may experiencfe the risks of missing the advantages of developing cloud computing systems.

Both engineering teams, business teams and organizations may have to face the huge risk of missing the great features, benefits and capabilities that the cloud computing provides. Cloud engineering provides better speed of development, testing, maintainability, automation, scalability and so much more.

With the advancement of modern automation processes like Infrastructure as a Code (IaC) becoming available for cloud infrastructures, benefits such as infrastructure automation are making software development easier for developers and devops teams. Through IaC approach, there will be better consistency and routines for configuring systems with capabilities of replicating systems to several environments. [1]. In addition to this, solutions and platforms using Low-Code/No-Code like Power Apps, Azure Logic Apps, AI Builder, etc. on the cloud also helps IT professionals with less programming skills experience to build modern and smart applications quickly on demand.

Infrastructure as code technologies and low-code/no-code solutions will be discussed in technical details in the later chapters of this book.

In addition to the benefits cloud has for engineering teams, the IT project managers can easily manage their projects and collaborate with their teams by working agile with available modern and remote collaboration tools in the cloud. For example, Microsoft Azure DevOps which is a DevOps all-in-one collaboration suite.

Azure DevOps helps cover the entire application lifecycle. From agile project planning, source code versioning, continuous integration and continuous devely (CI/CD), testing plans, artifacts and integrations.

We will deep dive more about Azure DevOps and other cloud development integration tools in the *Chapter 11* of this book.

Overall, the innovation brought by cloud computing has helped us advance in our society, as well as improve the way we live our daily lives. Digitalization and modernization comes with great benefits; however, it also comes with its challenges. These include the challenges to prepare, to transform and to adapt to the fast-changing and evolving technologies. These barriers can be handled by learning the foundations of cloud computing which you will learn by reading through this first chapter.

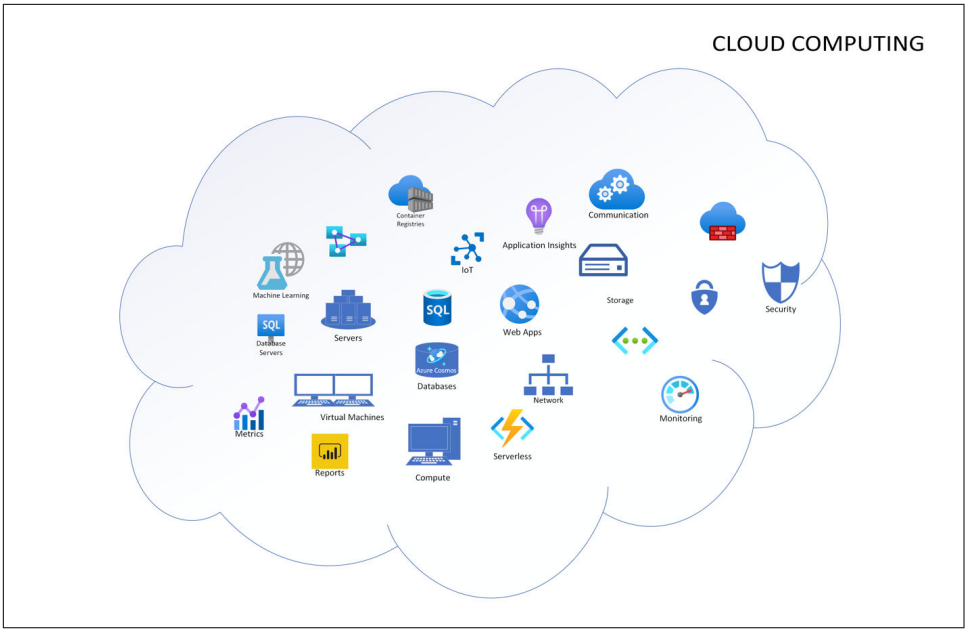

Figure 1-1. Overview of Cloud Computing

Instead of having our resources like the databases, applications, servers or infrastructure physical data centers or on-premisess, we have these resources on the cloud or Internet, as shown in *Figure 1-1*.

What are data centers?

Data centers include a room or building, important IT equipments like servers, networking tools, and storage systems. It also have secured facilities for power and cooling for the IT equipments.

Businesses and organizations consider cloud computing technology as good and strategic option because of the speed, reliability, financial savings, productivity, efficiency, security, performance and more. By the end of this chapter, you will learn the specific benefits cloud computing has for different categories.

Cloud computing is a popular option for many for these past years because of the growing demand and evolution of technological innovations for the past decades. Organizations want to improve and modernize their systems in order to innovate with the new trends in technolohgy.

At the same time, they also need to strategically consider the value of cost savings, think about the increased productivity of their teams, global scale opportunities, efficiency, performance, and security. Computing in cloud is expanding and continues to

grow is our mission to sustainability is also one of the great drivers of cloud innovation.[2]

How Cloud Works? Cloud Computing vs. Virtualization

Cloud Computing and virtualization both create useful virtual environments. Hosting compute and data resources on the cloud is better than a virtual machine for a web server or databases hosted on an on-premises environment. Hosting in the cloud provides efficiency, flexibility, and security.

The cloud is an environment while virtualization is a technology. Virtualization is type of technology that enables us to virtualize a hardware to create and simulate several machines or dedicated resources. On the other hand, the cloud is an IT environment that pools and share scalable resources across a network. Cloud environments are created to activate the great capabilities of cloud computing like running workloads within it.

Cloud Environment for Cloud Computing

Cloud computing is a modern approach to provide on-demand resources for compute, storage, network, platform, web applications and infrastructure over the internet or cloud. These are pools of virtual services and resources that are hosted on the cloud which is accessible by its users anywhere in the world. These cloud resources can be managed through self-service administrative portals. For example Microsoft Azure Portal for Microsoft cloud resources.

Cloud Hypervisor - The Key to Virtualization in the Cloud

The powerful technology of hypervisor is emerging to be a vital tool in virtualizing resources and is driving modern innovation in the cloud environments. Hypervisors make resources and applications in the cloud available to its users remotely. The ability to access and manage cloud resources over the Internet gives organizations and IT better control in managing their systems, applications, data and infrastructure in the cloud environment. Hypervisor technology is illustrated in *Figure 1-2* in a simple way.

The emerging transformation to digitalization and rising demand of better service expectations of customers are resulting in building more modern and reliable applications. For such reasons, organizations are still considering migrating or are already migrating their enterprise applications from on-premises virtual machines to the cloud environments.

A good example of the use of hypervisors in cloud computing is the Microsoft Azure cloud platform. Microsoft uses native hypervisor in Azure Cloud Platform called

Azure Hypervisor. It enables deployments of virtualized machines, web servers, database servers, enterprise applications, web services, etc. on Microsoft Azure cloud platform. The Azure hypervisor is based on Windows Hyper-V that provides various virtualization deployment, management, monitoring and security features.

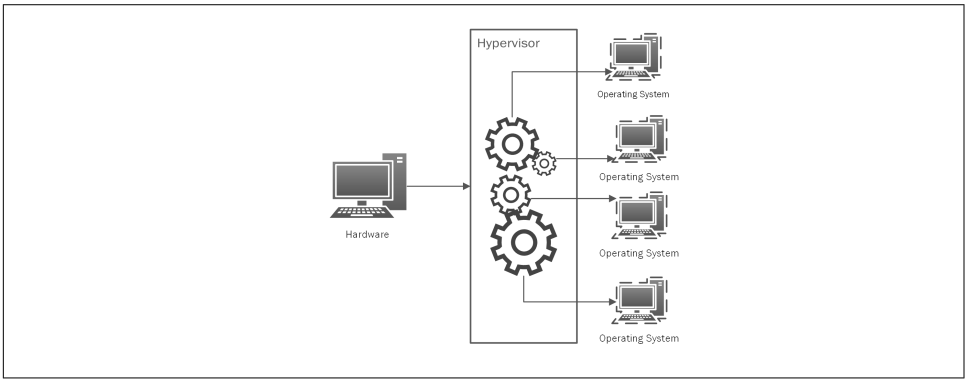

Figure 1-2. Hypervisor Technology

However, even with all of the benefits we've just described, migrating existing enterprise applications to the cloud is not an easy quick-fix journey. It requires careful planning, implementation of good strategy and more resources to re-architect, rewrite systems or applications for cloud upgrade. Through the technology of virtualization with hypervisor, it is possible to migrate existing on-premise workloads to the any cloud computing platform faster while investing less time, money and resources.

The Technology of Virtualization

Virtualization technology simulates resources and environments from a single physical hardware system. Behind this technology is the software emulated called hypervisor has the super capability to distribute a system into secure and distinct environments known as Virtual Machines (VMs). The virtual machines (VM) that we are using on our traditional web servers these days rely on the ability of hypervisor. VMs are emulations of computers running on top of a hypervisor.

Today, we have containerization as one of better alternatives to virtual machines. Unlike a virtual machine, a container is a lightweight, portable, and isolated unit of software that enables us to run multiple containers on a single host machine. Containerization is a new technology that enables us to run applications and services on the cloud.

In the later chapters of this book you will learn more about the different virtualization and container solutions in Azure. In *Chapter 13*, you will also learn more about cloud migration concepts and solutions in Microsoft Azure.

Evolution of Cloud Computing

Earlier computing technologies were mainframe computers which provided the large computational capabilities. Mainframes were powerful, highly reliable specialized for large data movements and massive I/O operations. They were mostly used by large organizations for bulk data processing. Mainframes worked on batch processing.

There are different stages of the earlier computing before we started using the modern and dynamic cloud platform like Microsoft Azure. However, the early mainframe computer systems have some similarities to modern cloud computing platforms that we have today. For example, both of them uses client-server model and thin clients. The major difference why many organizations and institutions are migrating to the cloud is because of the cost savings, increased productivity of IT teams, speed, availability, flexible scaling, efficiency, performance, and security.

The earlier cloud computing technologies of have evolved through time to create today's more dynamic technology solutions and offerings like the public cloud platform, Microsoft Azure provides.

As shown on *Figure 1-3*, the different earlier computing have evolved since the big mainframe computers in the 1960s to our modern and dynamic cloud computing today.

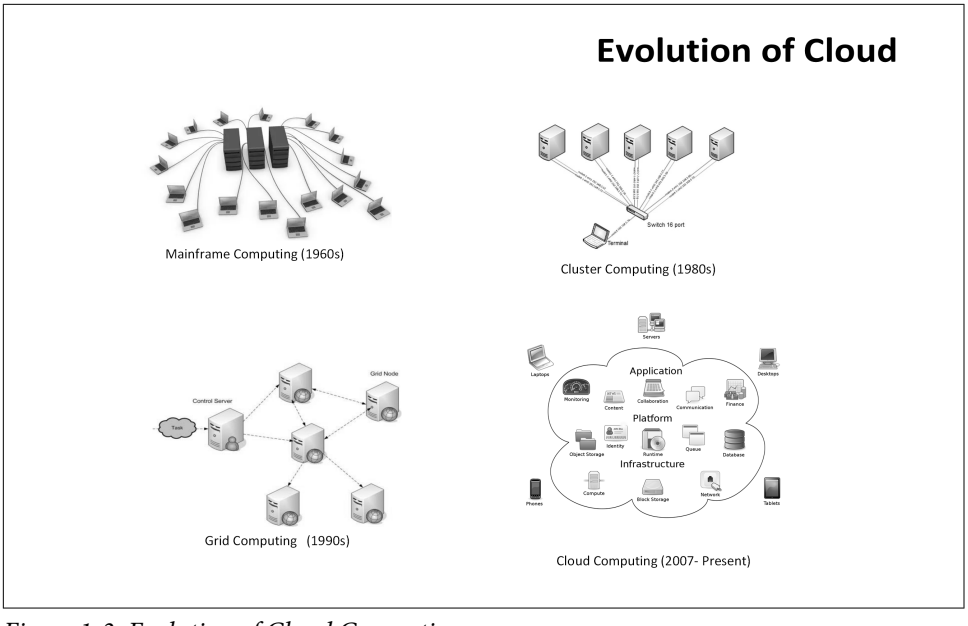

Figure 1-3. Evolution of Cloud Computing

Mainframe Computing

Mainframe computing. A high-performance computer mainframe or also known as big iron uses single unit hardware like a huge mainframe box that with several processor, centralized storage and large memory. IBM is the pioneer of mainframe computers that are mainly a system that is client/server based. It is known to have a high performance and processing power to process massive data like transactions and calculations in real time.

A mainframe has the characteristics of being time-shared, highly secured, and supports batch processing. The drawbacks of mainframe is that they are expensive hardware to maintain and it does not support X86 architecture. A great challenge of mainframe computers is that there is a limitation of skilled engineers who can maintain these big iron computers.

If you want to learn more about mainframe computers, check out IBM's good guide about mainframe computers.

Cluster Computing

Cluster computing, as shown on *Figure 1-4*, consists of tightly coupled computers (*also known as Nodes*) that work together to reach a single goal and purpose- to execute tasks. The components of a cluster in this type of computing are connected with

each other through a fast group of local area networks(LANs). When multiple computers are clustered they share the computation tasks like a distributed system.

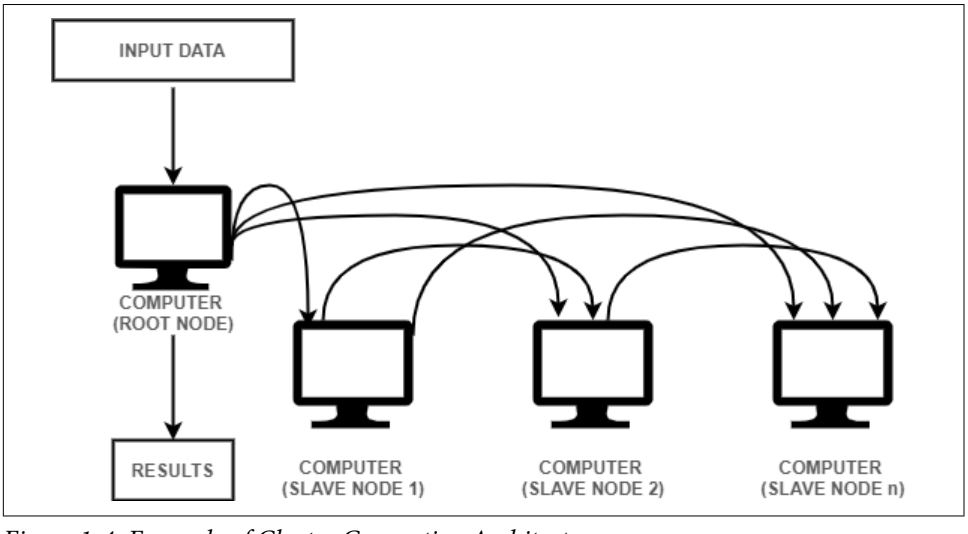

Figure 1-4. Example of Cluster Computing Architecture

There are several types of cluster computing which are commonly used for implementations of business requirements, optimization of performance, high availability clusters (*HA Clusters*), high performance clusters (*HP clusters*) and load balancing clusters.

Cost effectiveness, scalability, high-availability and speed processing are some of the benefits of using cluster computing. Cluster computing are implemented in different real-life use cases like the search engines and earthquake simulation and weather forecasting system.

The earthquake simulation is interesting and useful because the earthquake dynamics is big and challenging in geophysics and computer modeling because of extreme nonlinear nature. To learn more about these interesting earthquake simulation studies with the help of cluster computing, please read *NaradaBrokering: A Distributed Middleware Framework and Architecture for Enabling Durable Peer-to-Peer Grids* and Study Uses Supercomputers to Advance Dynamic Earthquake Rupture Models.

Cluster computing are composed of multiple computer systems considered *nodes*. All these nodes are used altogether to execute tasks. This type of computing has expanded greatly in our modern days. Azure has high-performance computing (HPC) which includes a great set of integration of resources from storage, computing and networking with workload orchestration ideal for HPC systems.

Grid Computing

Grid computing is a subset of parallel and distributed computing in which clusters of computers and a loosely coupled computer performs a huge task.

The computer resources can be geographically spread out in different locations or in several computing clusters that forms acts as the *grid*. The advantage of this is that data is processed quickly with speed because the data are stored all computers in the the data grid, as shown on *Figure 1-5*.

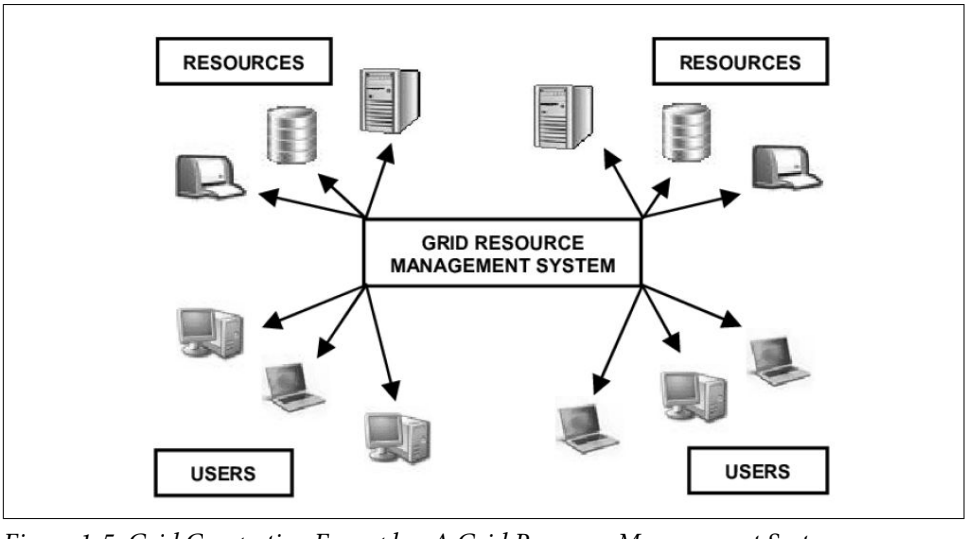

Figure 1-5. Grid Computing Example - A Grid Resource Management System

The computer systems that are on the grid in the same network work together and serves as a virtual supercomputer. All systems in the grid contribute compute resources like storage capacity and processing power.

Cloud Computing

Cloud computing has emerged and is as considered as fifth-generation computing. The evolution of mainframe computing, grid computing and cluster computing created a big path of accelerated innovation that drove and enabled the computing in cloud that we have today.

The technology of cloud computing, as shown on *Figure 1-6*, is widely used nowadays and we are continually exploring more of its capabilities in our modern digitalization. Based on the Cloud Computing Study 2022 by Foundry, there were over 40% of the companies are planning to migrate their data integration, disaster recovery, Business Intelligence (BI), Datawarehousing, Data Analytics, and backup to the cloud.

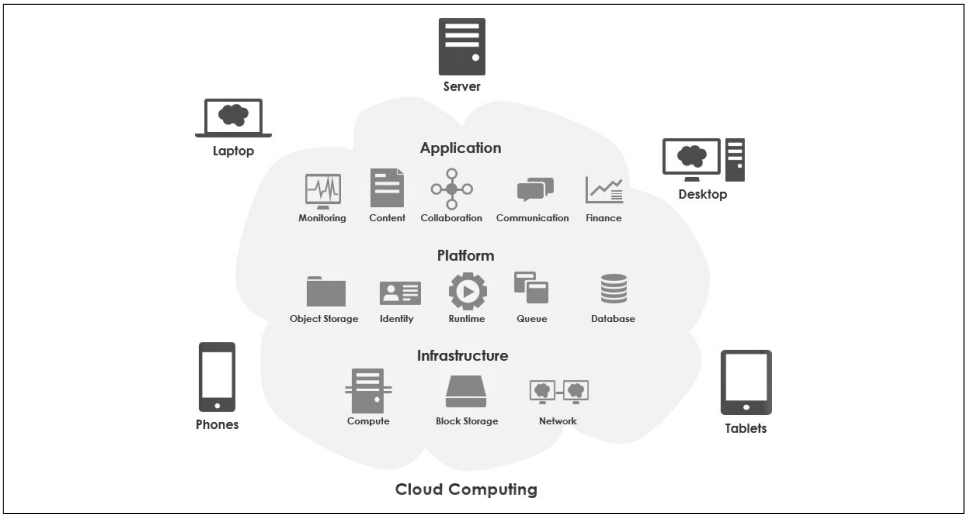

Figure 1-6. Cloud Computing Overview

Our Journey to use Modern Cloud

One of the most amazing and impactful innovation in our history are modernization and digitalization. When I was studying Computer Science in the 1990s, I used a lot of small-capacity storage floppy disks to save my documents and photos.

In contrast to what we have today, using cloud, we have many alterntives and enormous capacity to collect and store data. The data we store on the cloud is portable and is accessible anywhere. Portability of accessing data and getting the information we need when we need it, wherever we are, gives a huge list benefits and is also practical.

We live in the days of modern cloud computing that delivers reliability, scalability, agility, cost savings, portability to our applications and resources globally. *Azure compute services* which we will dive deeper in *Chapter 3*, enables us to build, manage, and scale cloud computing applications and services.

Different Types of Cloud Computing Deployment Models

The different cloud computing deployment models give us a descriptive overview of cloud computing platform in its different categories and parts. It also helps in identifying the important facts like who has access to it, how it is hosted and what is implemented.

As shown in *Figure 1-7*, there are different types of cloud deployment models that are commonly used - *Public Cloud*, *Private Cloud* , and *Hybrid Cloud*. There are also

other deployment models such as *Community Cloud* and *Multi-Clouds* that have been trending and in demand these days. These deployment models works the same way by using the technology of virtualization of servers's computing power into segmented applications with speed, reliability, scalability and storage capacities.

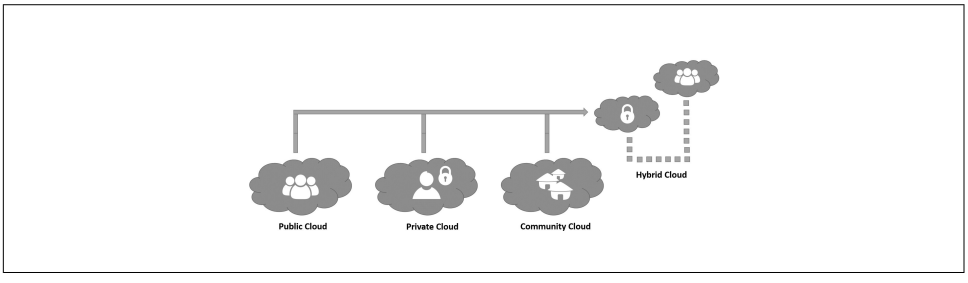

Figure 1-7. Different Types of Cloud Computing Models

Public Cloud

Public Cloud is a type of deployment model where the cloud infrastructure is available to the public or any organization using or selling cloud services. A public cloud platform is a service provided by cloud provider like Microsoft for Azure. The public cloud vendors provide cloud storage and computing resources (Operating Systems, CPU, Memory, Storage, Web Servers, Applications, or Databases) that are securely shared among its customers, with other organizations or other tenants of the cloud. Using public cloud are usually offered to its users for a subscription fee or Pay-As-You-Go basis.

For example, in Microsoft Azure, you can already get started using that platform as an individual by signing up for a free account with Pay-As-You-Go type of subscription with included set of free Azure services.

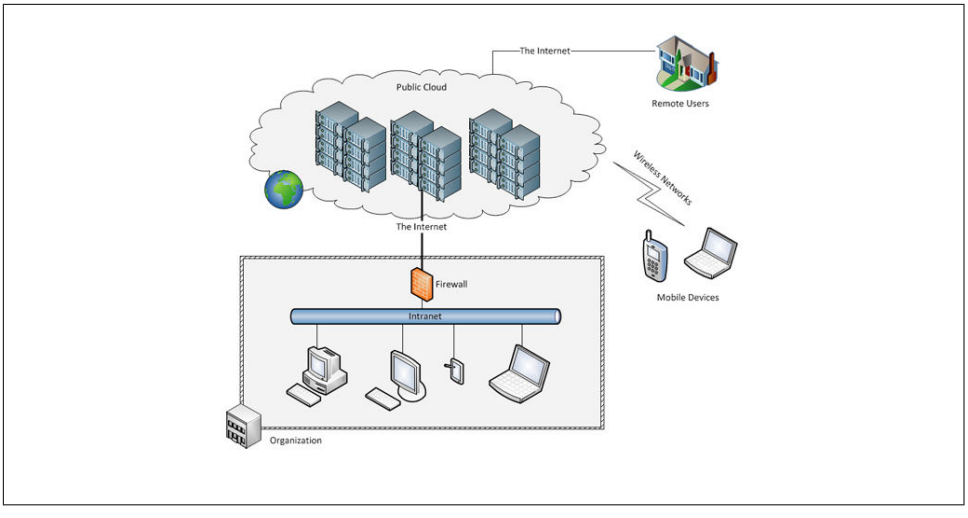

Figure 1-8. An example of several organizations using Public Cloud

There are many organizations globally that have adopted and evolved in using public cloud as their main platform for IT infrastructure and services, as illustrated on *Figure 1-8*. In particular, organizations that have the business requirement of having the workloads of their applications in public cloud can make use of this type of cloud.

The Advantages of using Public Cloud

We are in the modern era of technology with rapid acceleration around improvement and innovation. Along with this continuous shift towards digitalization, organizations must focus on delivering quality products and solutions to their customers. Organizations also want to be competitive in the global market by going beyond the geographical barriers. They want to modernize their solutions and services by investing on large-scale cloud solutions.

Whether your business is currently focused on cost reduction, aiming for global scale, better administrative management, or want modern solutions with enhanced security, there are many great benefits to moving to the public cloud. A list of some of the services available by migrating to the cloud are as follows.

- Cost Effectiveness and Cost Management
- On-Demand Services and Portability
- Scalability and Reliability
- Sophisticated and modern solutions
- Flexibility in administration through self-service cloud management portals
- Monitoring, Analytics and Reports Visualization

- Resource Pooling
- Security and Privacy
- Disaster Recovery and Geo-location

Private Cloud

Private cloud is a type of cloud infrastructure that is operated and owned by one organization - on premise or off premise. An organization that is utilizing private clouds make use of the cloud computing technology with considerations to privacy and the importance of security. This means that the access to the resources in the IT infrastructure within the organization is centralized. The organization's administration of private cloud are defined by trust boundaries.

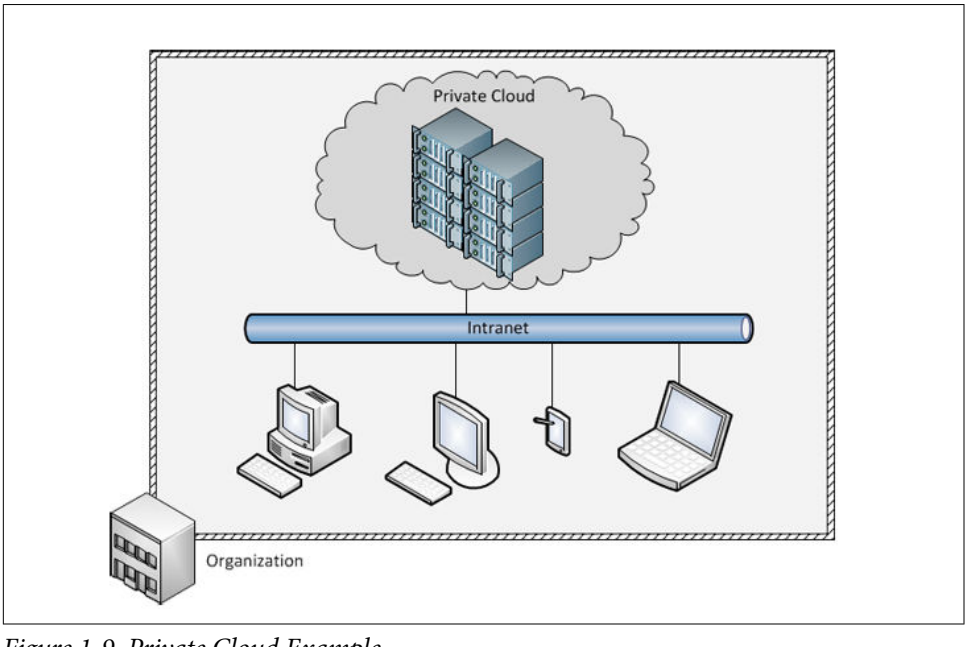

Figure 1-9. Private Cloud Example

In private clouds as shown in *Figure 1-9*, the infrastructure and its resources are typically managed on the organization's private cloud on a virtual private network. Organizations that use private cloud in their IT infrastructure are responsible in managing and maintaining their infrastructure.

Some institutions that have special requirements and IT policies that require enhanced security and control over the cloud infrastructure are commonly using private clouds. Financial institutions, government agencies, and organizations that require advanced security and strict privacy usually prefers this type of cloud.

The Advantages of using Private Cloud

- Enhanced privacy and security since resources are not shared with others
- Increased control over the infrastructure and owned resources
- Compliance to business-critical security and regulatory compliance requirements
- Flexibility to customize the environments based on the on-demand requirements of the organization or business

Community Cloud

Community Cloud is a hybrid form of private cloud. They are multi-tenant platforms that enable different organizations to work on a shared platform. This type of cloud is not often mentioned publicly but it is used widely and it exists. Community cloud is unique and special with its collaborative purpose. Usually, this cloud

The following are some examples of institutions and organizations that uses community cloud:

Government
: Most cloud providers offer community cloud for governments, they can be known as *Cloud for government*. For example, cloud provider Amazon AWS Cloud Computing for Federal Government while Microsoft has Azure Government for US government agencies and their partners. Cloud for the government sector are community clouds that are specifically meant for government since they have legal, security, private regulations, processes and services require constant communication and data transactions between different departments. They all operate on same infrastructure, with services and shared resources.

Healthcare
: Healthcare sector in the U.S. is regulated by Health Insurance Portability and Accountability Act of 1996 (HIPaA) compliance. This compliance regulates and controls the security and transfer of sensitive patient record information. Sensitive patient information includes medical records exchanged between the hospitals and laboratories. Community cloud providers that adhers to HIPAA regulations are being used by health care sectors who are adapting the cloud. Aside from the compliance, healthcare sector is also adopting the cloud computing technology to improve healthcare services and costs using artificial intelligence and machine learning.

Education
: When COVID-19 striked and affected the entire world and many countries, it has affected the education sector and institutions in many countries globally. Because of the pandemic regulations, schools got the challenge in deliverying education in person. Internet, cloud computing, and remote access to education

and learning materials have helped schools and universities by developing online education to students in some countries. Community clouds for education have helped many students continue their education and learning. Azure for Education is a cloud provider that offers cloud services such as Azure Lab Services, Teams, Office 365 Educational Plans, Azure Virtual Desktop for education.

Remote and Hybrid Work

Based on a recent statistics and study, about 16% of companies globally are 100% remote while 77% of the remote works claim that they are more productive when they are working from home. Cloud computing technologies are being used a lot lately for remote and hybrid work [3] and it will continue to change the way we work and collaborate. Some companies to allow and enable their remote employees to securely connect to their systems from any device over any network. Organizations also use community clouds for new innovation that are governed by regulations prior to hosting to public cloud. This means that community clouds are being used by used as a first initial setup hosting resources and infrastructure to a private cloud.

The infrastructure of the the community cloud supports and aims for a specific community with shared missions, compliance and security, jurisdictions, etc. Community cloud, as shown on *Figure 1-10* can be managed by a community or organization that can be managed or hosted internally or externally. In other words, it's an on-premisess of off-premise community-shared infrastructure.

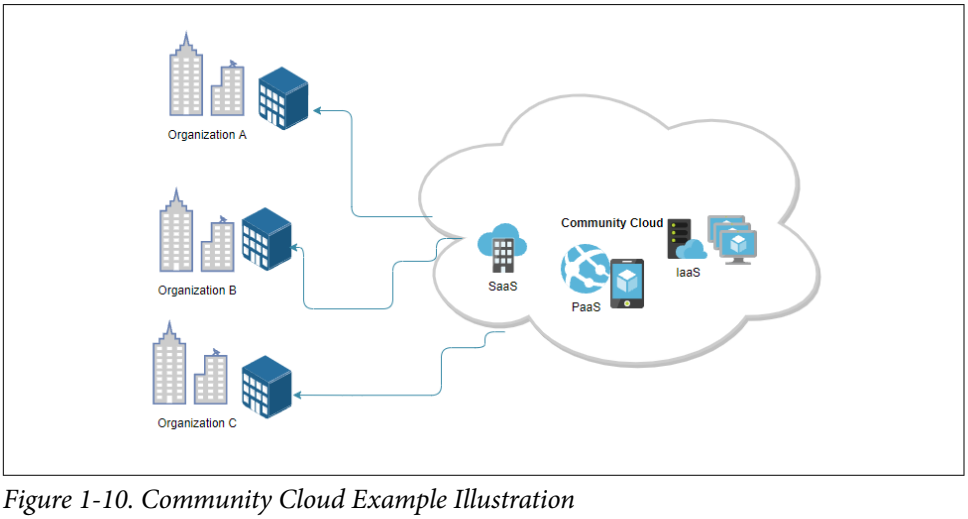

Figure 1-10. Community Cloud Example Illustration

Hybrid Cloud

Hybrid Cloud as its name describes it is a type of cloud infrastructure that is composed of multiple clouds, a combination of private, public or community cloud as

shown on *Figure 1-11*. In hybrid clouds unique entities are kept but are bound together by standardized technology which allows portability of application and data. For example load-balancing between clouds through cloud bursting.

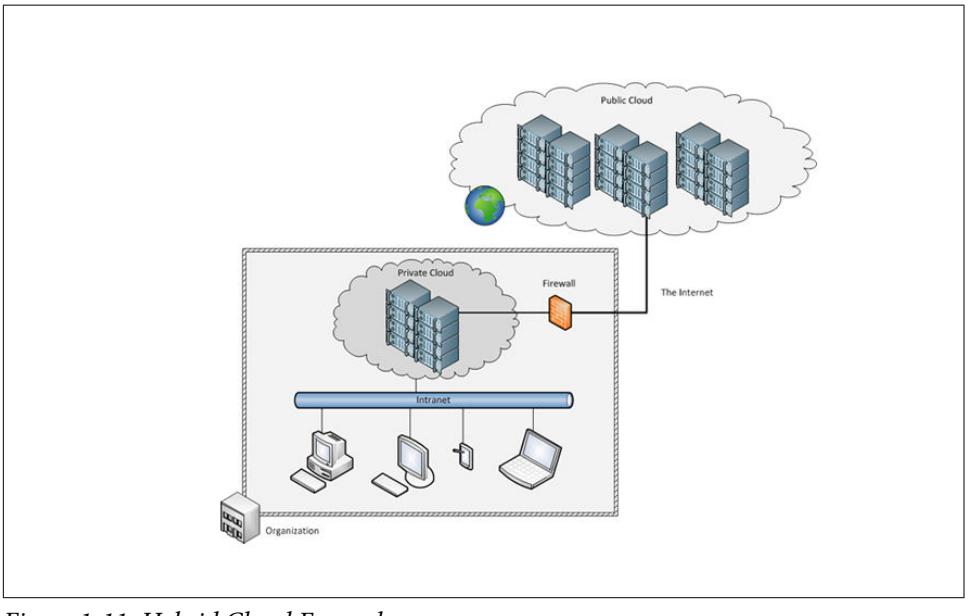

Figure 1-11. Hybrid Cloud Example

Cloud bursting is common in hybrid cloud scenarios, as shown on *Figure 1-12*. It is technique in application deployment in which an application is running in a on-premisess data center or private cloud and then it can bursts into a public cloud in case the workloads or computing capacity demands increases. This technique on the cloud computing grants access to more computing resources when needed.

A few of the known benefits of cloud bursting is its agility and ability to adjust to rapidly changing workloads. It also provides a cost-effective way to scale up and down the computing resources. One practical example is the flexibility to solve problems of handling compute workload issues when by re-routing the traffic from a private cloud and expand or "burst" it to the public cloud.

Figure 1-12. An illustration of Cloud Bursting in the Cloud

What is Multi-Cloud?

There are different cloud terms you hear these days. Aside from the hybrid cloud, there's also a term called *multi-cloud*. The term refers using multiple cloud providers. For example, an organization uses multiple cloud providers for their deployments. This is a practice in the industry that you will notice, especially with organizations who wants to avoid cloud vendor lock-in.

Multicloud is one of the recent approaches in cloud engineering. As the word itself describes, it means implementing cloud solutions with several cloud providers. Multi-cloud infrastructure usually involves both public and private cloud providers. Because of its nature, multi-cloud infrastructures are confused as hybrid cloud environments.

For example, an enterprise organization invests in expanding a cloud infrastructure. They decided to move from on-premises physical servers to virtualization-based workloads; however, their existing infrastructure requires implementation of different workloads and services from different public cloud providers. The multi-cloud option would be ideal for such use case scenario.

There are some benefits of using multi-clouds. One of the huge advantages of multi-cloud strategy for organizations is preventing the risks of cloud vendor lock-ins and risk management. Risk management in cloud deployment in case one of the cloud providers fail, it is easier to switch to another provider.

Hybrid Cloud vs. MultiClouds

While multi-cloud refers to the presence of more than one cloud deployment of the same type (*public or private*), sourced from different vendors, hybrid cloud refers to the presence of multiple deployment types (*public or private*) with some form of integration or orchestration between them.

A multicloud approach could involve two public cloud environments or two private cloud environments. A hybrid cloud approach could involve a public cloud environment and a private cloud environment with infrastructure facilitating workload portability.

These cloud approaches are mutually exclusive: You can't have both, simultaneously because the clouds will either be interconnected (hybrid cloud), or not (multicloud). Having multiple cloud deployments, both public and private, is becoming more common across enterprises as they seek to improve security, reliability, scalability and performance through an expanded portfolio of environments.

Accordingly, it's important to understand the differences between these types deployments so that you plan well how you would design your cloud architecture and infrastructure. Being aware of the benefits and limitations of hybrid and multi-cloud would be ideal for an organization's cloud strategy.

Public Cloud Computing Providers

This book is about learning Microsoft Azure, however, since we are learning about cloud computing and multi-cloud in this chapter, it is important to learn what are the other public cloud providers in the market too.

Migrating on-premises applications or systems to the cloud is not an easy process. It requires serious planning, strategy and preparation.

It is difficult to say that one cloud provider is better than the other. However, choosing the appropriate cloud provider for your organization and your teams really depends on the type of IT infrastructure you currently have, what business problems you need to solve, and your organization's business motivations. Every cloud solution and implementation should be aligned with the purpose and goal of a business.

Microsoft Azure

Microsoft Azure is one of the fastest-growing cloud provider platform offered by Microsoft. Even though Azure started years after its competitors but it is one of the leading cloud computing providers globally.

Azure offers a wide variety of cloud services in different categories including Artificial Intelligence, Machine Learning, Analytics, Blockchain, Compute, Containers, Serverless Computing, Databases, Developer Tools, DevOps, Identity Management, Integration, Internet of Things (IoT), Edge Computing, Quantum Computing solutions, Management, Media, Microsoft Azure Stack, Migration, Mixed Reality, Mobile, Networking, Security, Storage, Web, and Windows Virtual Desktop.

What makes Azure one of the most attractive and intelligent solutions is its exclusive offering of Microsoft's products and integration of services in the cloud. Azure provides the most advanced and maximum number of intelligent products and services.

This book will cover Microsoft Azure in detail.

Amazon (AWS)

AWS (Amazon Web Services) is the cloud platform of Amazon which offers a variety of services. Some of these cloud services on AWS include Virtual Private Cloud, EC2, AWS Data Transfer, Simple Storage Service, DynamoDB, Elastic Compute Cloud, AWS Key Management Service, AmazonCloudWatch, Simple Notification Service, Relational Database Service, Route 53, Simple Queue Service, CloudTrail, and Simple Email Service.

AWS is one of the top comprehensive and broadly adopted cloud platforms. This cloud platform is offering over 200 fully featured services from data centers globally. Millions of customers—including the fastest-growing startups, largest enterprises, and leading government agencies—are using AWS to lower costs, become more agile, and innovate faster.

Google Cloud Platform

Google Cloud Platform (GCP) is Google's cloud and is also one of the top public cloud providers available. Similar to AWS and Microsoft Azure, GCP also offers similar services in various categories, including compute, storage, identity, security, database, AI and machine learning, virtualization, DevOps and more. Google Cloud Services are available in 20 regions, 61 zones, and 200+ countries.

GCP is a platform that delivers a wide variation of IT products that IT professionals, businesses and software developers can take advantage of to work more efficiently and gain more flexibility.

Oracle Cloud

Oracle cloud platform is the cloud offering of Oracle corporation. Oracle cloud offers IaaS, PaaS, SaaS, and Data as a Service (DaaS). Oracle SaaS offerings are CX, HCM, ERP, SCM, EPM, IoT, Analytics, Data, and Blockchain Applications. Oracle DaaS is the Oracle Data Cloud.

Alibaba Cloud

Alibaba Cloud, founded in 2009, is not often heard in some parts of the world but is also a big public cloud provider. Alibaba Cloud is the largest cloud provider in China. Alibaba is registered and headquartered in Singapore and it was initially built to serve

Alibaba's own e-commerce ecosystem. Nowadays, they also offer public cloud services.

Alibaba offers various products and services in various categories, including Elastic Computing, Storage and CDN, Networking, Database Services, Security, Monitoring and Management, Domains and Websites, Analytics and Data Technology, Application Services, Media Services, Middleware, Cloud Communication, Apsara Stack, and Internet of Things.

There are more cloud computing vendors that are coming but the ones that I mentioned are widely recognized as top providers.

Microsoft Azure vs. Amazon AWS comparison

There was a comparison study done between Microsoft Azure and AWS in terms of running Windows Server and running SQL Servers in PaaS or IaaS deployment models. Based on the comparison, AWS is five times more expensive which means that you pay less with Azure

There are other cloud computing platforms that are not mentioned because it is outside the scope of this book. However, if you want to find out more, I recommended the Gartner Research: Magic Quadrant for Cloud Infrastructure and Platform Services, which gives the strengths and cautions of different cloud platforms.

Cloud Computing Service Models

There are different cloud service models in the cloud. These are the Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), as shown on *Figure 1-13*.

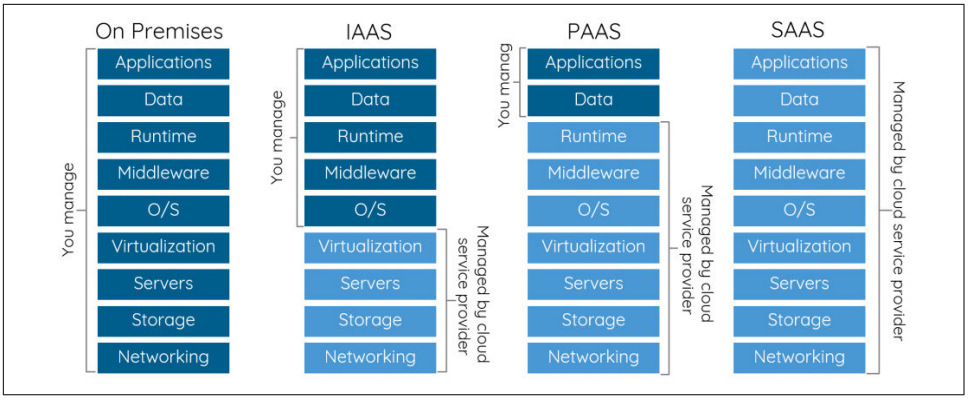

Figure 1-13. The Different Cloud Computing Models showing the different scope of what are managed by the cloud provider and what is managed by the cloud user or organization

Infrastructure as a Service (IaaS)

Infrastructure as a Service (IaaS) is a type of computing model where cloud provider like Microsoft Azure provides infrastructure as a service. Unlike the traditional infrastructure on-premisess in one physical location, they are instead provided by the public cloud vendors. Infrastructure like web servers, database servers, storage, networking and computing hardware are available to its uses on-demand. IaaS in the cloud allows its users to not worry about maintenance costs of having infrastructure on-promises. The cloud provider takes care of the maintenance, monitoring, security and load balancing.

Platform as a Service (PaaS)

PaaS is a cloud service where the third-party vendor provides the hardware and software components to users to build application supporting platforms that they need to run on the cloud. PaaS users don't need to replace their entire IT infrastructure, rather just use the vendor's hosted infrastructure services on a web browser.

Software as a Service (SaaS)

SaaS is a software on-demand cloud model, where the cloud service providers give the users access to a fully developed application created specifically for distribution. The software updates are rolled out for all users uniformly and organizations can use their own tools with the vendor provided application programming interfaces (APIs).

If we were to compare these main tree the cloud computing service models in the real world, we can look one of our favorite foods, pizza.

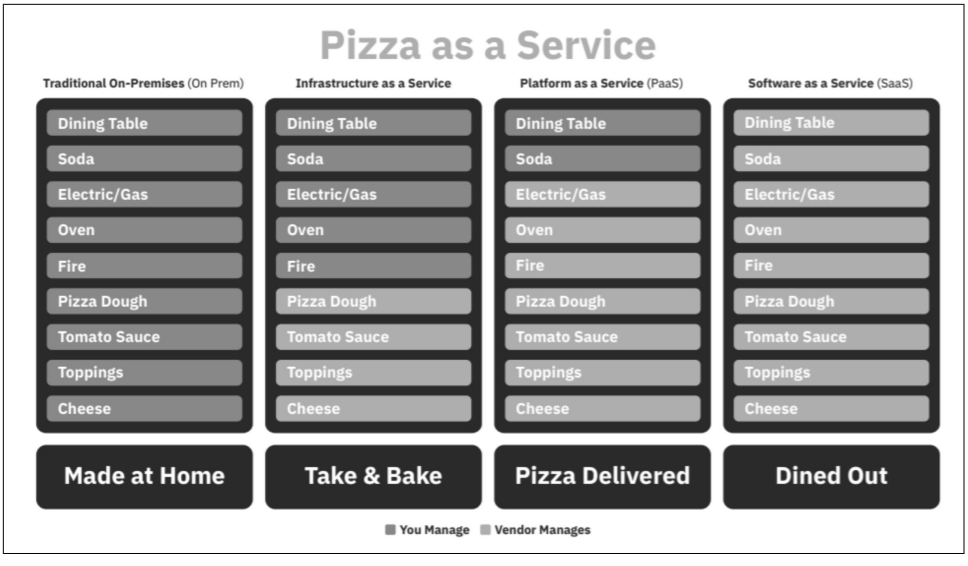

Figure 1-14. An example of cloud computing as Pizza as a Service illustration, Image Source: Pizza as a Service

In the pizza illustration example on *Figure 1-14* which was originally created in year 2014 by Albert Barron, who used to work as a Software Client Architect at IBM, [4].

We can find similarity of baking our own pizza as having our tradition on-premisess IT infrastructure. Shopping a ready-pizza from the store and bake it at home is like Infrastructure as a Service (*IaaS*). Pizza delivery is like Platform as a Service (*PaaS*) and dining out at a restaurant to order pizza is like the Software as a Service (*SaaS*) offered by the cloud provider.

Aside from *IaaS*, *PaaS*, and *SaaS*, there are other cloud computing service models are available. These other service models are Serverless, Function as a Service (FaaS), Backend as a Service (BaaS), and more. It will not be a surprise that someday there will anything X as a Service available for us.

Serverless Computing - Function as a Service and Backend as a Service

Recently, Serverless, FaaS and BaaS are some of the terms that gained its popularity and interests in the cloud computing trends. Serverless is a method of computing where backend services are provided a cloud service by a cloud service provider. Technically, it is not really server-less but "less" in this term means the servers and underlying infrastructure are abstracted. There are actually servers behind a server-less function or serverless cloud service, only that the cloud provider or serverless provider is taking it of it for its users. Cloud services on serverless usually have con-

sumption type of pricing models where the users are only charged on the usage and execution.

Figure 1-15. Example of a Serverless Architecture in Microsoft Azure

Function as a Service (FaaS) is a technical concept that aims to allow developers the freedom and productivity to create functions in a cloud environment easily, as shown on a serverless architecture example on *Figure 1-15*.

In this method, the developers will still create the application logic, yet the code is executed in stateless compute instances that are managed by the cloud provider. FaaS provides an event-driven computing architecture where functions are triggered by a specific event such as message queues, HTTP requests, etc.

In Microsoft Azure, there are different serverless solutions available such as Azure serverless compute services for applications and serverless containers.

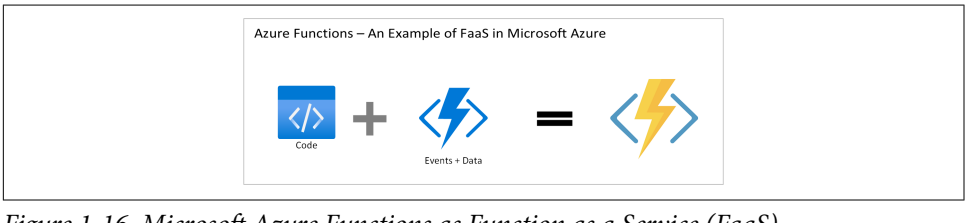

Figure 1-16. Microsoft Azure Functions as Function as a Service (FaaS)

Microsoft Azure compute services like Azure Functions, as shown on Figure 1-16, allow its users to build applications faster by eliminating the hassles of managing servers and infrastructure. It enables software developers or programmers to focus on the productivity of your development teams and only pay when the code runs. Developers can focus on developing event-driven applications using the supported language of their choice.

Implementing serverless and FaaS solutions have several benefits, especially to the software development team. In the world of software engineering, we, developers,

want to focus on delivering solutions, solving problems and build applications. Developers and engineers do not want to spend time maintaining the servers and infrastructures but usually prefers to delivery value and solutions by programming and developing applications regardless if they are on-premises or on the cloud.

With serverless computing, FaaS or Backend as a Service (BaaS), software developers or cloud engineers can focus more on being productive by focusing on the backend logic and not worrying on the infastructure management. This creates the results of speed of delivery which helps the project process.

Aside from developer benefits, the opportunity of solving problems with complex applications can be solved. Organizations can also benefit on the speed of delivery and productivity. Other benefits also includes automatic scaling, reliability, consumption-based pricing model,

Serverless architecture is one of the key software architecture design patterns that partly relates to distributed computing systems and microservices. Developers need not worry about managing and maintaining infrastructure, hardware or servers, but can focus more on developing the logic and the functionality.

The developer writes the code and leverages the infrastructure of cloud provider services and other third-party services which is primarily called BaaS (Backend as a Service). BaaS is a cloud service that takes care of the cloud infrastructure and primarily focuses on the automation of backend side development.

In *Chapter 3*, serverless and compute solutions in Azure will be covered in details.

Containers as a Service

When container development is discussed, great features of it comes up. Containers as a Service (CaaS) or development with containers is an interesting solution. By utilizing containers, you get Platform as a Service (PaaS) benefits without the overhead of Infrastructure as a Service (IaaS).

Containerization in simple terms is deploying your applications into container. A container is a runtime that contains the basic compute resources needed to run an application. The core part of the host operating system (also known as Kernel) and its shared resources like storage across a host. The shared kernel allows containers to be lightweight and faster. When hosts running, the containers in it can be quickly started. Quick starts means high availability and resiliency of the applications in the container. One example of a containerization technologies is Docker, which is one of the more popular providers of container services.

Container solutions have different advantages.

- Containers can run in cross-platform environments

- Containers are lightweight and portable
- Containers are self-contained and no need to install application dependencies
- Containers have good scalability and high availability
- Containers are quick to restart

Containers and other compute services in Azure will be covered in the *Chapter 3* of this book.

Data as a Service(DaaS)

Every website, application, system, mobile app and anything involving tech products we use have data in it. Sensitive data are being protected through data protection policies because data in this modern era is a treasured gem. This is the reason why like the other service models, data is also

Data as a Service (DaaS) focuses on providing data as a business asset by implementing data management strategies. By using this cloud service model organizations get better agility in their business. As listed on *Table 1-1*, DaaS provides organizations modern, effective and smart strategies on how to handle, manage and visualize huge and massive data that is generated everyday.

Table 1-1. Benefits of Data as a Service (DaaS) as a Cloud Service Model

Benefit	How?
Data-Driven Culture	DaaS enable organizations organize and manage their increasing data by using the datasets that are reusable, easier to analyze and visualize
Innovation and Business Growth	DaaS put data as a vital key driver in the business which open opportunities to growth and innovation. Data-driven strategies drives innovation and growth without creating huge risks
Scalability, Reliability and Flexibility	Cloud solutions usually offer DaaS solutions that are flexible and scalable
Data Monetization	Solving data operation problems and complexity can be also beneficial in monetization of the useful data available
Cost Savings	DaaS solutions can help organizations save cost of expenses by allocating the appropriate workloads for their data in the cloud.
Maintenance Tasks Automation	DaaS providers have platform and tools that automate maintenance tasks which helps the end users to self-manage their DaaS services on demand

The Challenges of Data as a Service (DaaS)

Although Data as Service (DaaS) offers great benefits to an organization, it has some known challenges.

- Risks of solving data complexity problems especially for old and unstructured data sets

- Implementing a data-driven culture with DaaS require an top-down organizational and business strategy
- Higher demand for management of data privacy and security because of the different data privacy regulations and compliances

Shared Responsibility in Cloud Computing and Azure

Considering and evaluating cloud services on any public cloud providers require careful planning and strategy for an organization. It is critical to learn and understand the shared responsibility model. The shared responsibility model helps both parties (the user and cloud vendor) share the trust and responsibility of hosting applications and resources in the cloud.

The Shared Responsibility Model illustrates shared trust and responsibility that helps in cloud security and protection of resources. For example, it helps identify which security tasks are handled by the cloud provider and which tasks are handled by the public cloud user. The shared responsibility for the workload varies depending on whether the workload is hosted on Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS), or in an on-premises data center.

With Microsoft's example of the Cloud-Enabled Shared Responsibility Model for all cloud deployment types, you own your data and identities. A public cloud user (private individual or organization) is responsible for protecting the security of the data and identities, on-premises resources, and the cloud components that the user control, what cloud services or components depend on the type of service model chosen within the cloud vendor.

Regardless of the type of deployment, the following responsibilities are always retained by you: data, endpoints, accounts, identities, and access management.

Shared Responsibility Model offers Cloud Security Advantages

The cloud offers significant advantages for solving long standing information security challenges. In an on-premisess environment, organizations likely have unmet responsibilities and limited resources available to invest in security, which creates an environment where attackers are able to exploit vulnerabilities at all layers.

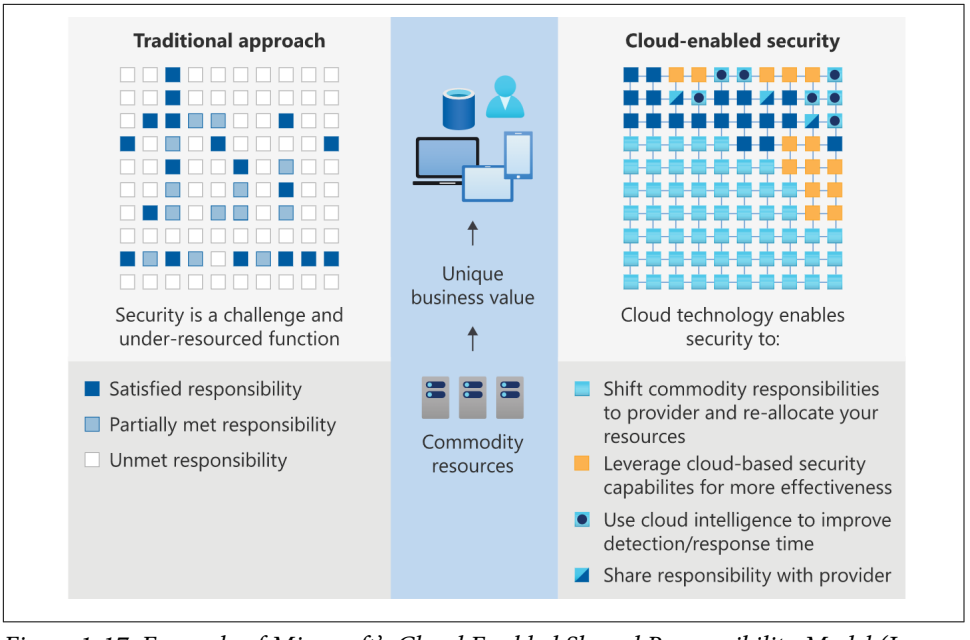

Figure 1-17. Example of Microsoft's Cloud Enabled Shared Responsibility Model (Image Credit: Microsoft Documentation, "Shared responsibility in the cloud")

As shown on *Figure 1-17*, a traditional approach where many security responsibilities are unmet due to limited resources. In the cloud-enabled approach, you are able to shift day to day security responsibilities to your cloud provider and reallocate your resources.

Capital Expeditures and Operational Expeditures

It is not possible for an organization to just migrate on-premisess resources to the cloud without knowing about benefits of it for Capital Expeditures (CapEx) and Operational Expeditures (OpEx). It is vital to identify the benefits of the comparison of these two when considering cloud computing solutions for businesses or organizations.

Capital Expenditure (CapEx)

CapEx is defined as business expenses incurred in order to create long-term benefits in the future, such as purchasing fixed assets like a building or equipment. Some examples of IT items that fall under this category would be whole systems and servers, printers and scanners, or air conditioners and generators. You buy these items once and they benefit your business for many, many years. Maintenance of such items is also considered CapEx, as it extends their lifetime and usefulness.

Operational Expenditure (OpEx)

OpEx is your operating costs, the expenses to run day-to-day business, like services and consumable items that get used up and are paid for according to use. This includes printer cartridges and paper, electricity, and even yearly services like website hosting or domain registrations. These things are necessary for your business's success but are not considered major long-term investments like CapEx items.

Typically, organizations started with traditional on-premisess physical servers and data centers that requires expensive CapEx. Expenses for data center physical space, hardwares, equipments and employees to manage the everything in place - security, maintenance, etc. can be very costly.

Cloud computing solutions offer organization the option to eliminate the hassles of traditional infrastructure on-premises by providing services with OpEx alternatives.

Benefits of Adopting and Transformation to Modern Cloud Technologies

Cloud adaptation and transformation is a complex and long process. It is not a quick-fix solution to modernize on-promise and legacy applications quickly to the cloud. However, when properly planned with smart strategies, there are a great list of benefits of it.

Cloud Computing for Business Value and Customers

How does an organization or business benefit from cloud computing? Regardless of the size of the business or organization, cloud computing helps in saving resources, time, and finances by accelerating innovation, collaboration, modernization and productivity in different teams within the organization. It also helps in providing business value for users because of enhanced user experience, speed and reliability of modern cloud applications.

Cloud Computing for IT Companies

IT Companies and organizations gain many benefits in using cloud compute solutions as the following.

Data Access Management and Portability

Cloud Computing enables businesses to access their important business-related data portably - anywhere on any device. This capability allows the entire organization to work effective and productively by focusing on deliverables. The technology of cloud storage and servers on the cloud, employees in the organization do not need to be at the office intranet to work and collaborate. Instead, information is available securely at anytime on-demand.

Cost management and efficiency

Buying and maintaining server equipment requires time, expertise and money. Rather than building your own bespoke server, which can be prone to downtime, a cloud computing provider stores data for you without all the downsides. Prices for business-oriented cloud services are still a monthly expense, but it's a manageable and predictable expense in many aspects.

Convenient Backup and Disaster Recovery Solutions

Catastrophic data loss can happen at any time and it can be time-consuming to solve such major issue when it happens. Whether that loss occurs from natural disasters, power surges, or hardware failure, affected companies are at increased risk of bankruptcy within the same year as the data loss. And while most companies have adopted backup plans, it helps to have additional contingencies in place. By utilizing the cloud to store important data, business owners can rest easy knowing that important files are safe even if hardware fails. For cloud computing solutions in Microsoft, there are some great variety of backup and disaster recovery options available for applications hosted in Azure [5]

High-Level Cloud Security and Data Privacy

Security and privacy is vital and critical part of decision-making process when it comes to using cloud computing services. The public cloud computing provider and the user or organization have shared responsibility. Hosting applications and servers on the cloud are built on trust. This is the reason setting clear expectations and being familiar with the shared responsibility model. Cloud providers take high priority on security and data privacy for their clients and consumers. They use different and strategical ways of cloud security controls to protect the resources of their users. Identity management, high-level physical security on data centers, strict personal security, and ensuring data privacy for sensitive data are taking seriously. There are dedicated security expert teams who work on scanning the cloud for possible vulnerabilities internally and externally. Performing cloud penetration testing and scanning inside and outside the cloud must be strictly authorize. Cloud providers do not tolerate any security breaches. Termination of services in case of violation of security and use policies are implemented. It may not be noticeable to many but Cloud computing is advancing our society around the world. It is also impacting our lives - daily routines, work, home, school in so many ways. It has improved our facilities for healthcare, education, communities and it is continually changing for our digitalization world wide.

Digitalization and Modernization

Digitalization and modernizations of many computer systems in different sectors were made possible because of the advancement of our technologies hosted on the cloud over the internet. Institution in different sectors like healthcare, governments, community, schools and organizations are using cloud to modernize

their services and products. The ability to make things easier through technology is an advantage.

Remote and Flexible Education and Digital Literacy
: Aside from digitalization and modernization in different sectors in our society that benefits us widely, cloud computing also helped widely in getting better education worldwide. Cloud computing with the power of Internet not just only enable us to work from home or anywhere, but it also activates the capability and power of online collaborative and self-paced modern learning environments [6]. Remote locations with internet access facilities give opportunity for literacy through online education.

Summary

In this chapter, you have learned about the fundamentals of cloud computing, its different types and its deployment models that gives you an understanding what cloud really is. You also have learned about the history and evolution of cloud computing that helped shape the modern cloud that helps our society today. You saw an overview of the different types of clouds like public, private, hybrid, community and multi-cloud - and know the differences between them. The different types deployment models such IaaS, PaaS, SaaS, CaaS, DaaS, FaaS, and Serverless which is useful for you when choosing the right cloud service to use in a cloud platform.

In this chapter, you got insights and learned about the advantages and the benefits of cloud computing in businesses, IT companies, our society worldwide, and also in the field of software engineering.

In the next chapter, we will dive into learning more about the important concepts you need to know about Microsoft Azure as a cloud platform. We will learn what cloud solutions Azure has to offer to help you and your organization.

Check Your Knowledge

1. What is cloud computing?
2. What is the difference between private cloud and public cloud?
3. Why is it important to understand the shared responsibility model in the cloud?
4. What is the different between hybrid cloud and multi-cloud?
5. What is CapEx and OpEx?

To find the answers to the *Check Your Knowledge*, turn to back of the book in the Appendix.

Recommended Resources

- Dataversity.net, A Brief History of Cloud Computing by Keith D. Foote
- Mainframes and Cloud Computing: Similarities and Differences
- Microsoft Azure - What is the cloud?
- MIT Technology Review - Who Coined *Cloud Computing*? by Antonio Regalado
- Cloud Computing Market by Service, Deployment Model, Organization Size, Vertical And Region - Global Forecast to 2026
- What is Cloud Computing? A Beginner's Guide
- Microsoft's Documentation - Cloud Computing Basics for Developers
- Gartner.com - Magic Quadrant for Cloud Infrastructure and Platform Services

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[2] Bernard Marr, 2021, "The 5 Biggest Cloud Computing Trends In 2022", Forbes.com, *https://www.forbes.com/sites/bernardmarr/2021/10/25/the-5-biggest-cloud-computing-trends-in-2022/*

[3] Shardul Bhatt, 2021, Using Cloud Computing to Build a Remote Organization", Business2Community.com, *https://www.business2community.com/cloud-computing/using-cloud-computing-to-build-a-remote-organization-02382933*

[4] Pizza as a Service, "Pizza as a Service" by Albert Barron, *https://www.linkedin.com/pulse/20140730172610-9679881-pizza-as-a-service/*

[5] Microsoft Documentation, "Backup and disaster recovery for Azure applications", *https://docs.microsoft.com/en-us/azure/architecture/framework/resiliency/backup-and-recovery*

[6] The Computer Society, "Cloud Technologies in the Education System"by James Riddle, *https://www.computer.org/publications/tech-news/build-your-career/cloud-technologies-in-the-education-system*

CHAPTER 2
Microsoft Azure Fundamentals

A Note for Early Release Readers

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 2nd chapter of the final book. Please note that the GitHub repo will be made active later on.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *jleonard@oreilly.com*.

> *We're building everything that we are doing across Azure with openness. There is Windows and Linux as first-class. Java and .NET is first-class. SQL Server 2016 and Postgres are first-class. Red Hat, VMware, Oracle, all of these applications and infrastructure can be first-class on Azure.*
>
> — Satya Nadella, CEO, Microsoft, Microsoft Inspire 2019

Previously, we learned about the important concepts you need to know about *Cloud Computing*, which is a great technology that allow us to share cloud computing resources on a *Pay-As-You-Go* model in a global scale with flexibility and security.

In this chapter, you will enhance what you learned about cloud computing by digging deeper into the world of Microsoft's greatest cloud computing platform, Azure. You will learn about the core concepts of what Azure is as a cloud provider. How Azure start, what is its purpose and how it can technically and can inspire you be innovate as you build smart, innovative and great technology solutions for your organization's demands and requirements.

You will learn about *Azure Geographies*, *Regions* and *Availability Zones* as well as *Azure Resource Manager* which gives you an overview of Azure's cloud infrastructure.

This chapter will give you a comprehensive overview of the core services in Azure. Each of those core Azure services will be explained in detail with its uses and examples in the upcoming chapters of this book.

Public cloud is a type of deployment model where the cloud infrastructure is available to the public or any organization and the resources are shared with other organizations or other cloud provider tenants.

Microsoft Azure as a Public Cloud Provider

Microsoft's computing platform is called *Microsoft Azure*, also known as *Azure*. The term *Azure* means *sky blue* color and usually the typical color of "*the cloud*". Historically, the cloud platform was called Windows Azure that was originally built on Windows Server 2008 for developers who wants to host their software applications like windows environment to the cloud [1]

Windows Azure became Microsoft's foundation of cloud and was commercially available to the public. Windows Azure became Microsoft's great and powerful cloud platform. In 2014, it was renamed to *Microsoft Azure*. Originally, Azure was a project with a code name *Red Dog*.

Azure's flexibility of being able to create, build, deploy, and manage organizations' applications on a global scale made it one of the top cloud providers worldwide. Microsoft Azure, grew to become a public cloud provider used by 95% of Fortune 500 companies.

Microsoft Azure Helps Organizations with Minimize Upfront Costs

The public cloud has features that are useful to many. These features include not requiring upfront costs for Capital Expenditures (CapEx) to scale up resources, quick provisioning and de-provisioning of applications, and flexibility for organizations to only pay for what they use.

Azure is a public cloud provider, but they also offer private, hybrid, and multi-cloud solutions to its users. Cloud services in Azure are designed to help its users build new and innovative cloud solutions that help solve our challenges in different areas.

It allows us to build, develop, manage, and run resources like servers, databases, storage, or applications in multiple cloud environments. You can use it for different use-

case scenarios in the cloud using the tools, programming languages, and frameworks that you prefer to use.

Microsoft Azure has more than 200 services and products for its users. These cloud services are available in different cloud services deployment models like Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), Server- less, Function as Service (Faas), Containers, and more.

Azure also provides edge com- puting, AI, and Machine Learning (ML) services that enable you to create smart and intelligent solutions with your existing or new applications. Without the technology of cloud computing, this would not be possible.

Benefits of a Cloud Provider

There are several benefits that a cloud provider has over the traditional on-premise physical environment, as shown on *Table 2-1*.

Table 2-1. The list of known benefits

Benefit	Description
High availability	Microsoft Azure provides high availability and redundancy across all of its worldwide data centers offering a service-level agreement that ensures 99.95% availability
Geo-distribution	Azure helps in the global enterprises by providing geo-distribution features. Geography-specific endpoints enables international enterprises comply to the regional compliance and regulations
Scalability On-demand	When demand for complexity, traffic and data expands, there should be a flexible and quick way to handle such need
Reliability	The system or application hosted should function correctly even in the face of adversity (hardware or software faults, and even human error)
Elasticity	A capability to automatically scale cloud resources based on configuration or demand
Disaster recovery	When your applications, data and systems are hosted in Azure, you can be assured of secured end-to-end backup and disaster recovery solution
Flexibility	Cloud services in Azure gives organizations flexibility by allowing them to use consumption pricing plans and full self-service management accessible anywhere
Cost Management Tools	There are tools available for cost management in Azure and users can also set budget alerts for their resource groups and resources
Advanced Compliance	Azure takes information security and compliance seriously with high standards to serve best its users
High Level Cloud Security	Azure protect all stored data with world-class and advance security. Data stored in Azure are protected with advanced encryption technologies. All data centers of Microsoft are equipped with extreme security with biometric scanners, multi-level authentication and more
OpEx vs. CapEx	Hosting to cloud means an organization can save money from Capital Expenditures (CapEx) and only pay for Operational Expenditures (OpEx)
Consumption-based pricing model	Azure gives its users the flexibility of cost management by offering consumption-based *(Pay-As-You-Go)* pricing model in most of its cloud services.
No deep technical skills required	You and your organization do not need to be very skilled technically to get started using the cloud platform. Azure provide a flexible and diverse options to give ease of use for its users

Azure Portal

The self-managed portal of Microsoft's cloud platform is called *Azure Portal*, which can be accessed by Azure users on their web browsers or via the *Azure Mobile App*. It is a web-based administration website for all types of Azure users. It is where you can manage your Azure cloud services for your organization. It is a powerful portal of cloud administration tools and resources you need. For example, in Azure Portal, you can manage your resource groups, resources in it, Azure subscriptions, security, monitoring and more, as shown on *Figure 2-1*. It has all the services available that you can use for your cloud computing solutions.

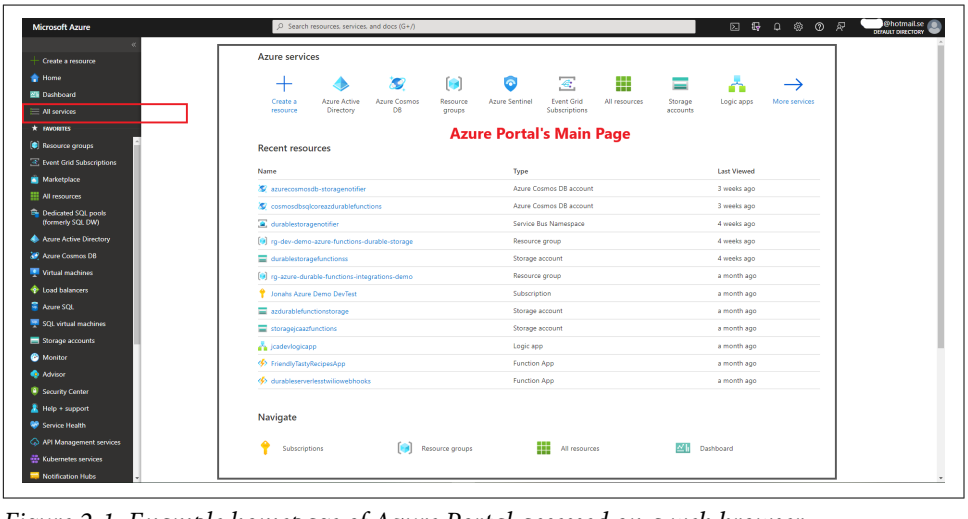

Figure 2-1. Example homepage of Azure Portal accessed on a web browser

- Access *Microsoft Azure Portal* using *Azure Mobile App*. If you don't have it, you may download it using the instructions on the link Get Azure Mobile App *https://azure.microsoft.com/en-us/get-started/azure-portal/mobile-app/?WT.mc_id=AZ-MVP-5004251*
- Access *Microsoft Azure Portal* using your favorite web browser using the link *https://portal.azure.com/*

The Azure Portal is built to be resilient, portable and accessible from anywhere in the world as long as you have an Internet connection. *Figure 2-2* shows the user interface of the Azure Mobile App which you can use to manage your Azure subscriptions and services on the go.

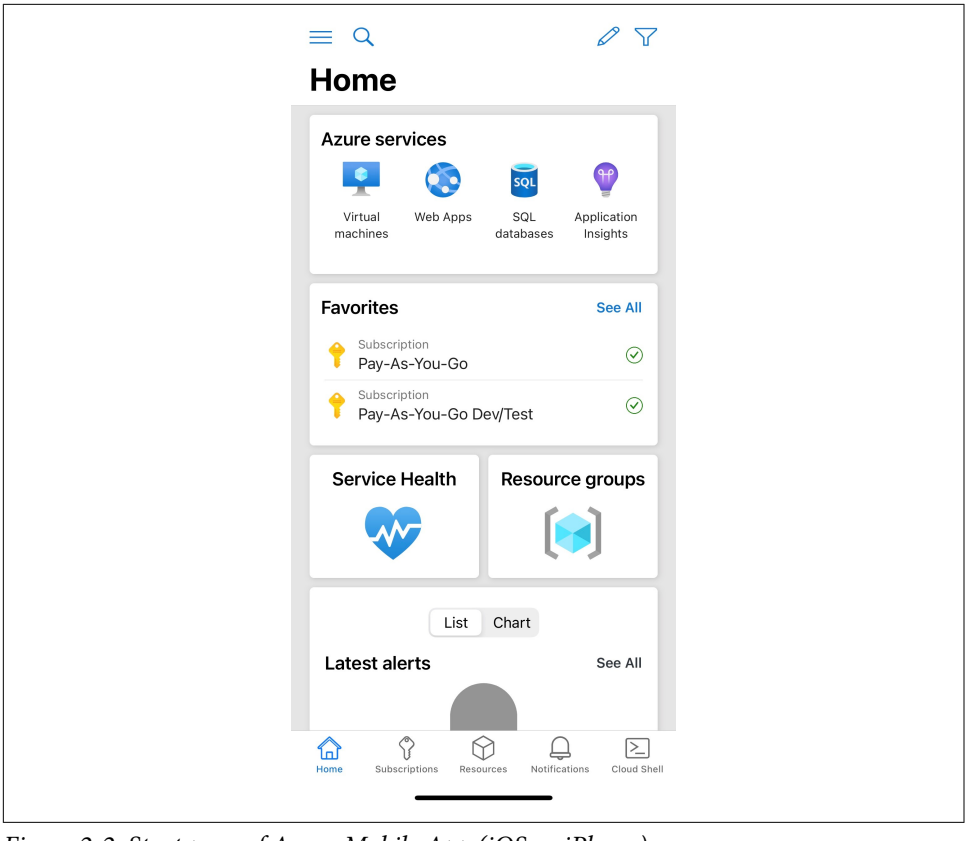

Figure 2-2. Start page of Azure Mobile App (iOS or iPhone)

The website URL of the Azure Portal is specific to the cloud where your organization is deployed in Microsoft Azure.

- For commercial use or Azure Public Cloud: *https://portal.azure.com*
- For Azure United States Government Cloud: *https://portal.azure.us*
- Azure Germany: *https://portal.microsoftazure.de*
- Azure China: *https://portal.azure.cn*

Aside from the different locations and different scope of Azure as a cloud platform in government sector and countries, there is also Microsoft Cloud for Sovereignty. It is a solution that will help Azure users in government and public sectors in the leverage the cloud based on their specific and unique requirements. These requirements can

be their compliance, security and policy requirements. It will help these sectors gain better control over their data, privacy, compliance, governmance, etc.

Features of Azure Portal

The Azure Portal has numerous of features for all types of Azure users. Organization can take control of cloud resources by governing their cloud resources on-demand globally. Software developers or cloud engineer can build, manage and monitor any type of cloud applications - from simple to complex ones regardless of architecture or programming languages.The following are some of the known features of the Azure Portal.

- Create, build, manage and monitor Azure services and cloud resources all in one place at anytime and anywhere at your own convenience
- Use command line tools and cloud shell for quick creation and deployments
- Manage and organize Azure Subscriptions and create management groups that helps in structuring and governing Azure resources
- Azure Active Directory (Azure AD) as a great tool for the management of identity, access, and permissions to resources
- Configure and manage privacy, data, security, policies and compliance which is vital for the organization's governance
- Customization of portal's dashboards helps in getting a quick overview of the status of resources right after you logged in
- Take control of monthly costs by monitoring resources through spending limits and budget alerts using using Azure Cost Management in the Azure Portal
- Search everything you need to know, create, build and manage using the Global Search feature in the portal
- Send Azure Support requests directly when you need assistance or help

Azure Marketplace is a marketplace for Azure customers to search, purchase and try-out applications and services from other service providers including Microsoft partner companies. All services on Azure Marketplaces are verified and certified to work with the Azure cloud platform.

Microsoft Azure Services

As of writing this book, all Azure services are divided into 21 categories according to their purpose. As a developer or a solution architect in an organization, or even as a beginner, it might be overwhelming to see a lot of cloud services in a cloud platform

such as Azure. However, each Azure service has its unique purpose and is built to solve specific technical problems. Azure services can be seamlessly integrated with other services and even external ones.

Each category for the Azure services helps you build and integrate cloud solutions based on your business requirements or need. For example, building a web application with integrations of API, cognitive services and reporting features would need several Azure services in categories *Artificial Intelligence/Machine Learning*, *Compute*, *Analytics*, *Databases*, *Integrations*, *Developer Tools*, etc.

Table 2-2. Overview of Microsoft Azure services in some known categories

Category	What are these categories?	Azure services
Artificial Intelligence (AI) + Machine Learning (ML)	Build the modern and next generation of applications using artificial intelligence capabilities for any developer and any scenario	Azure Boot Service, Azure Cognitive Services Azure Machine Learning, Anomaly Detector, Azure DataBricks, Azure Open Datasets, Computer Vision , Face API, Azure Immersive Reader, Azure Form Recognizer, Kinect DK, Microsoft Genomics, Azure Health Boot, Azure Applied AI Services, Azure Percept, Speech Services, etc.
Analytics	Gather and visualize any time of data regardless of its volume or velocity	Azure Analysis Services, Azure Data Explorer, Azure Data Lake Storage, Azure Data Share, Azure Databricks, Azure Stream Analytics, HDInsight, PowerBI Embedded, Azure Synapse Analytics, Data Factory, Event Hubs, R Server for HDInsight, Microsoft Graph Data Connect, Azure Purview, etc.
Compute	Access cloud compute capacity and scale on demand and only pay for the resources you use	API Apps, App Service, Azure Cycle Cloud, Azure Functions, Azure Kubernetes Service (AKS), Azure Quantum Preview, Azure Spot Virtual Machines, Azure Spring Cloud, Azure VMware Solution, Azure Batch, Cloud Services, Linux Virtual Machines, Azure Container Instances, Azure Static Web Apps, VM Scale Sets, Azure Virtual Machines, Azure Virtual Desktop, Web Apps, Azure Dedicated Host, Azure VM Image Builder, etc.
Containers	Create, build, develop and manage containerized applications with modern integration tools	Azure Kubernetes Services (AKS), Azure Container Instances, Azure Container Registry, Azure Service Fabric, Web App for Containers
Databases	Fully managed and secure cloud database services	Azure SQL Database, Azure Cosmos DB, Azure Cache for Redis, Azure Database for PostgresSQL, Azure Database for MySQL, Apache Cassandra MI, SQL Server on Virtual Machines, Azure Database Migration Service, Table Storage, Azure API for FHIR, Azure SQL Database Edge, etc.
Developer Tools	Build, manage, and continuously deliver cloud applications—using any platform or language	Azure DevOps, Azure DevTest Labs, App Configuration, Azure SDKs, Azure Lab Services, Azure Pipelines, Visual Studio, Visual Studio Code
Integration	Seamlessly integrate on-premises and cloud-based applications, data, and processes across your enterprise	API Management, Azure Event Grid, Azure Service Bus, Azure Logic Apps, Azure Web PubSub Preview, Azure Healthcare APIs Preview
Networking	Connect cloud and on-premises infrastructure and resources using networking services	Application Gateway, Azure Bastion, Azure DNS, Azure Express Route, Azure Content Delivery Network, Load Balancer, Azure Front Door, Azure Firewall, Internet Analyzer, Azure Orbital, Private Link, VPN Gateway, Virtual WAN, Virtual Network, Traffic Manager

Category	What are these categories?	Azure services
Internet of Things (IoT)	Create cloud solutions with IoT services	Azure IoT Hub, Azure IoT Central, Azure Sphere, Azure IoT Edge, Azure RTOS
Identity + Security	Protect resources, data and identity on the cloud	Azure Active Directory, Azure AD B2C, Azure Defender, Azure Security Center, Azure Key Vault, Azure Sentinel, Information Protection, DDoS Protection, etc.

Table 2-2, describes some of the common known Azure services in different categories. To view the updated list of services per category, please visit website *https://azure.microsoft.com/en-us/services/*

Some of the important Azure services in several categories will be covered in the other chapters of this book.

Overview of the Core Services of Microsoft Azure

Microsoft consistently creates new solutions, continuously updates and improve Azure services all the time.

Compute Services in Azure

Compute is usually the term used for computing resources. Compute services hosted in Azure provides computing resources like the operating systems, networking, disks, processors, networking and memory. These compute resources are available quickly and on-demand by its users. Every application is unique. An application can have many workloads that needs more than one compute services.

Currently as of date of writing, Azure has about 27 compute services available. The Azure Compute services in Azure enable us to build web and mobile applications, deploy and manage virtual machines, build apps in containers in the cloud, create batch jobs, and more. *Figure 2-3* shows an overview of compute services on Azure Portal.

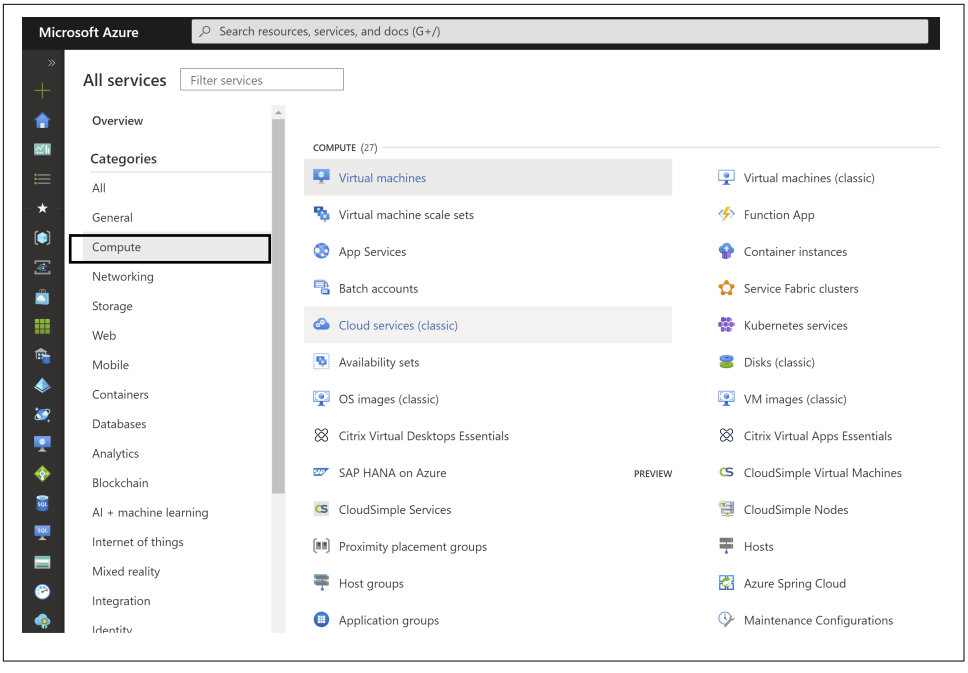

Figure 2-3. An overview of Compute services in Microsoft Azure Portal

Table 2-3 gives us an overview of some of the common Azure Compute services and their purpose.

Table 2-3. Overview of Azure Compute Services

Azure Compute	What is it for?
Azure App Service	Build and develop web and mobile apps in a fully managed cloud environment
Azure Static Web Apps	Develop modern full stack web application quickly to Azure from a code repository
Azure Virtual Machines	Quick, easy and manageable provisioning of Virtual Machines (Azure VMs) in different operating systems like Windows or Linux
Azure Virtual Machine Scale Sets	Create and provision multiple and thousands of Virtual Machines(Azure VMs) with high availability advantage
Azure Spot Virtual Machines	Save money when you provision compute capacity you don't use for your workloads
Azure Functions	Develop serverless, modern, event-driven applications, and stateful workflows
Azure Container Apps	Build and deploy fully-managed modern apps and microservices using serverless containers
Azure Kubernetes Service(AKS)	Build managed Kubernetes containers on the cloud
Azure Container Instances	Cloud-scale job scheduling and compute management with the ability to scale to tens, hundreds, or thousands of virtual machines
Service Fabric	Build microservices and perform containers orchestration in different operating systems like Windows and Linux

The technical details, use cases, and how you can get started developing with Azure compute services are covered in Chapter 3, *Microsoft Azure Cloud Compute*

Networking Services in Azure

Networking in the cloud is important in all aspects of cloud hosting. Networking services help secure both private and public cloud infrastructure. Users can customize their cloud networking setup and manage their network resources on demand.

Azure Networking services allow Azure users to meet the demands of their infrastructure's workloads on-premises, hybrid or on the cloud with high availability and enterprise-level Microsoft Zero Trust based security on networking services.

Table 2-4 shows some of the common Azure Networking services.

Table 2-4. Overview of Azure Networking services

Azure Networking	What is it for?
Azure Virtual Network	Connect virtual machines using VPN connections
Azure Bastion	Secure and easy access to your virtual machines using private RDF and SSH that are fully managed
Azure Private Link	Access cloud Azure-hosted services with privacy
Azure Firewall	Protect your resources in the cloud with high availability and low maintenance firewall
Azure Load Balancer	Load balance your application connections and requests - both inbound and outbound
Azure ExpressRoute	Create private network connections between Azure data centers and on-premises infrastructure
Azure Traffic Manager	Choose to route your network traffic for better performance
Azure VPN Gateway	Create secure private network connections in the cloud VPN

Learn more about the technical details and how you can get started with Azure networking on Chapter 4, *Microsoft Azure Cloud Networking*

Core Azure Storage Services

The storage services in Azure offers great storage for any types of data objects, Azure Virtual Machine disk storage, reliable messaging storage, and other modern data types that needs to be stored. They provide the benefits of high availability, durability, security, accessibility and manageability.

Table 2-5 shows some of the common Azure Storage services.

Table 2-5. Overview of Azure Storage services

Azure Storage service	What is it for?
Azure Blobs	Store scalable binary data, text or Data Lake Storage Gen2 big data analytics
Azure Files	Fully manageable file shares for deployments on-premises or for the cloud. Accessible anywhere through Server Message Block (SMB) Protocol

Azure Storage service	What is it for?
Azure Queues	Store large numbers of messages that you access via authenticated HTTP calls
Azure Managed Disks	Store block-level volumes for Azure Virtual Machines

Each of the core Azure storage service need to be integrated and associated with an Azure Storage account. A storage account in Azure is a container, as shown on *Figure 2-4*, of all Azure storage data like the blobs, files, tables and queues.

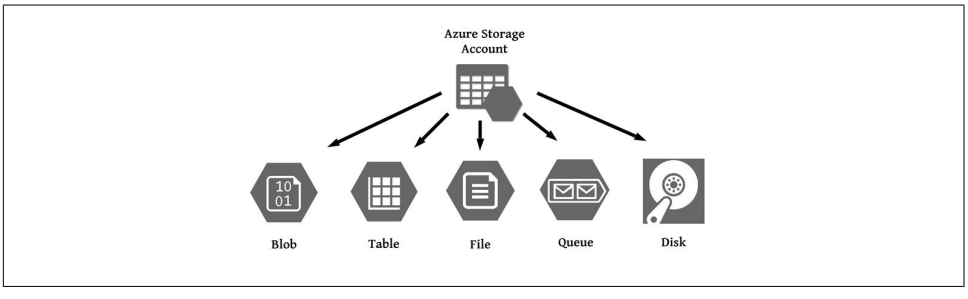

Figure 2-4. An Azure Storage Account is needed for any of the core Azure storage services

Core Azure Database Services

Azure has a great collection of database services to choose from depending on the type of data structure you need for your organization. The different types of database services in Azure are fully managed. There are appropriate databases for your data - relational, NoSQL, in-memory databases, and other modern databases.

Table 2-6 shows some of the common Azure Database services.

Table 2-6. Overview of Azure Database services

Azure Database service	What is it for?
Azure SQL Database	Cloud-hosted SQL databases that are fully-managed, intelligent and secure
Azure Cosmos DB	Create and migrate no NoSQL workloads to the cloud like Cassandra, MongoDB, and other NoSQL databases
Azure Cache for Redis DB	Build fast and scalable applications with Redis in-memory data store
Azure Database for PostgreSQL, MySQL, and MariaDB	Create fully managed and scalable databases for PostgresSQL, MySQL and MariaDB
Azure SQL Edge	Build IoT edge-optimized SQL database engine with built-in AI

Learn more about the other storage and database solutions as well as its technical details on *Chapter 5*, *Microsoft Azure Cloud Storage Services and Databases*

Identity Management and Security Services

Secure your organization's cloud resources against advanced modern threats using the identity management and security services in Azure.

Table 2-7 shows some of the common identity management and security services in Azure.

Table 2-7. Overview of Azure Identity and Security services

Azure Identity or Security service	What is it for?
Azure Active Directory (Azure AD)	Secure identity and protect users of the entire organization using SSO and multi-factor authentication
Azure Active Directory Domain Services	Join Azure virtual machines to a domain without domain controllers
Azure Information Protection	Protect your sensitive information on the cloud
Azure Active Directory External Identities	Consumer identity and access management in the cloud
Azure Key Vault	Keep control and secure your keys, connection strings and secrets
Azure Defender	Protect and detect threats for your workloads in Azure, on premises, and even in other cloud providers
Microsoft Sentinel	Gather intelligent security security information event management (SIEM) [a] and security orchestration automated response (SOAR) [b] solution to protect your resources
Azure DDoS Protection	Protect applications in Azure from Distributed Denial of Service (DDoS) attacks [c]
Azure Information Protection	Protect your sensitive information on the cloud

[a] Wikipedia, "Security information and event management, *https://en.wikipedia.org/wiki/Security_information_and_event_management*

[b] Rapid7.com, "Security Orchestration Automation and Response (SOAR) Tools and Solutions, *https://www.rapid7.com/solutions/security-orchestration-and-automation/*

[c] Cybersecurity & Infrastructure Security Agency, "Security Tip (ST04-015) - Understanding Denial-of-Service Attacks", *https://www.cisa.gov/uscert/ncas/tips/ST04-015*

What is SIEM System?

SEIM is the abbreviation of *Security Information and Event Management* which is a computer security system that can be used as a tool to collect, analyze, and perform security operations on computer systems, which can be applications or hardware. A SEIM system has features like collection and logging data from resources within your environment, creating alerts for potential security anomalies, incident management and data log visualization.

Learn more about the technical details and how you can get started with Azure user identity platform and security services on Chapter 7, *Microsoft Azure Identity and Security*

Developer Tools, Monitoring, and DevOps Services

Azure have different tools and services for cloud development, troubleshooting, monitoring, DevOps practices, Infrastructure as a Code (IaC), and Continuous Integration/Continuous Delivery (CI/CD).

Table 2-8 shows some of the common Azure developer tools and DevOps services.

Table 2-8. Overview of Azure developer tools and DevOps services

Azure service	What is it for?
Azure DevOps	All-in-one tool with great DevOps services for teams to collaborate better, share code, track work, and deliver software projects
Azure DevTestLabs	Quickly create environments using reusable templates and artifacts
App Configuration	Store your application's configuration using scalable parameters
Visual Studio	Develop, debug, deploy, manage, and diagnose cloud-scale applications on Azure, using a full-featured IDE
Visual Studio Code	Write and debug code with a lightweight and fast code editor that runs on different operating systems like macOS, Linux, and Windows

Table 2-9 shows some of the common monitoring services in Azure.

Table 2-9. Overview of useful azure monitoring tools in Azure

Azure service	What is it for?
Azure Monitor	A great tool for maximizing application performance by collecting, analyzing, visualizing and automating telemetry data in Azure and on-premises environments
Application Insights	Provides features that are useful for application performance management (APM) such as live monitoring and automatic detection of performance issues
Azure Advisor	An innovative cloud assistance in Azure that assist you in improving your deployments by recommending useful and actionable solutions that helps in securing resources, save cost, and improving performance
Log Analytics	It allows you to edit, run log queries and analyze the data collected by Azure Monitor Logs

The different core developer tools, supported programming languages for Azure, Monitoring, troubleshooting steps and DevOps services will be discussed in details on Chapter 11, *Developing with Microsoft Azure, Troubleshooting, Monitoring, DevOps, Automation, CI/CD*

Cloud Migration and Hybrid + Multicloud Cloud Services

Azure has migration and hybrid solutions that helps organizations in their cloud adoption and migration journey.

Table 2-10 shows some of the common Azure migration, hybrid and multicloud services.

Table 2-10. Overview of Azure services for migration, multi-cloud and hybrid cloud

Azure service	What is it for?
Azure Database Migration Service	Get guidance and useful tools for migrating databases from different on-premise resources to Azure
Azure Data Box	Device solution for data transfer of large amounts of data to Azure and edge compute
Azure Migrate	All in one place for all the guides and tools you need to migrate to Azure
Azure Arc	Combine and unify on-premises, hybrid, and multicloud infrastructure
Azure Stack	Build and run innovative hybrid apps across cloud boundaries

Learn more about the technical details and how you can get started with Azure migration and hybrid cloud solutions on Chapter 13, *Microsoft Cloud Migration and Hybrid Cloud Architecture Solutions*

Those are the core services in Microsoft Azure in different major categories. Each of them along with some of the categories listed in *Table 2-2* will be described in details with examples in the upcoming chapters of this book.

Core Architecture and Resource Management Concepts in Microsoft Azure

An organization in Microsoft Azure would need their Azure administrators to properly setup the core structure of the organization in the resource management. This is the first and top structure that is required before you can add cloud resources in the cloud platform. An organization with different departments with members in different roles would find this beneficial.

There are four levels for organizing your organization's resources in Microsoft Azure. As shown on *Figure 2-5*, from top to down, these are the Azure Management Groups, Azure Subscriptions, Resource Groups and Resources.

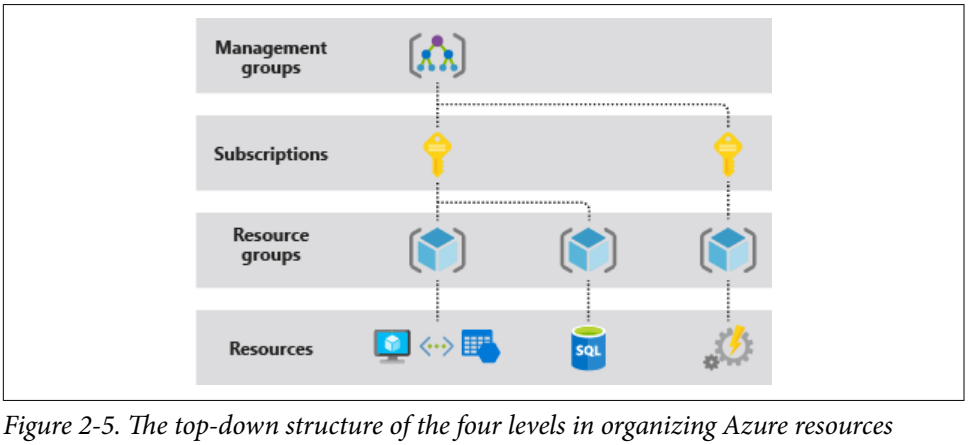

Figure 2-5. The top-down structure of the four levels in organizing Azure resources

Azure Management Groups

Azure Management Groups is the top level of the core structure of managing your cloud resources in Azure. It is useful in organizing and structuring your resources in Microsoft Azure. The management groups is where Azure administrators manage everything about user access, compliance and policies for subscriptions. The subscriptions within a management group automatically inherit the settings, conditions and restrictions added in the group.

Azure *Role-based Access Control* (RBAC) for all resources and role definitions are supported in the management groups. A person in the organization with any Azure role can be assigned to the Azure management group. Those who have access and rights to the management group can group Azure Subscriptions, see organization's management groups hierarchy and most of all can control any access to any Azure service or resource by creating and applying governance control and policies.

Azure Subscriptions

Subscriptions in Azure is like a big container for all accounts of users and what resources they have accessed or used within the subscription. Every subscription usually has amount limit of resources that a certain user can create and use. As an organization, you can use subscriptions to control the monthly bill and resources costs in your organization or your own Azure account. Using Azure subscription, the organization can also control what resources the users create, update, or delete.

Azure Resource Groups

Azure users can group their services or resources using Azure Resource Groups. A resource group in Microsoft Azure acts as logical container where resources like servers, web applications, databases, storage, monitoring, etc. are deployed, managed, and stored. Do not confuse a *Resource Group* for *Availability Set* in Azure. The *Availability Set* is the logical group for Virtual Machines (VMs).

Azure Resources

The databases, servers, virtual machines or web applications you create on Azure platform are considered Azure resources. All resources or services you create must be in added in a *Resource Group*. which acts as the logical container. In a resource group, you can have your web apps, servers, monitoring, compute services, etc. in one place.

When you are creating an Azure resource as shown on *Figure 2-6*, you would need to select an Azure Subscription, a *Resource Group* and the *Azure Region* for example, *North Europe*, where you want to add your resources.

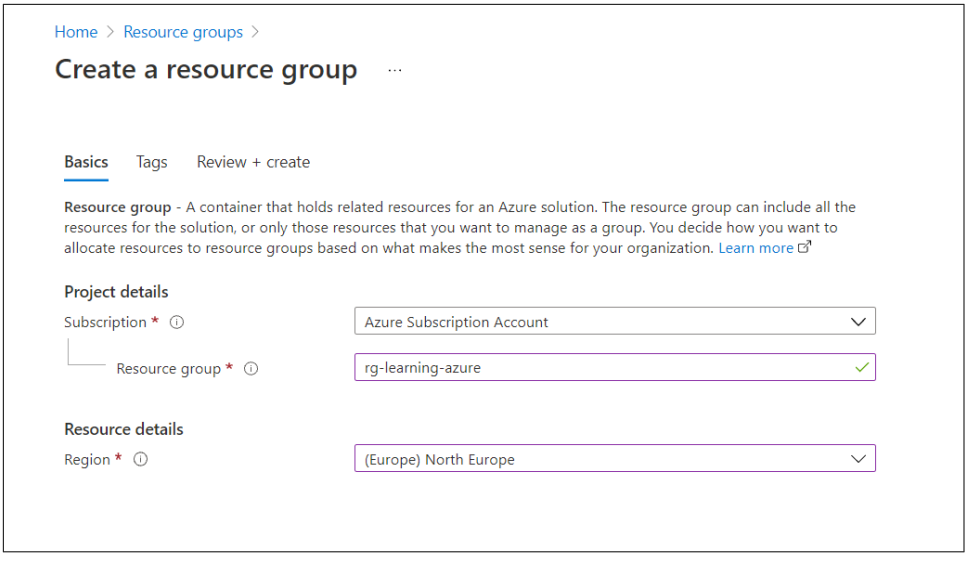

Figure 2-6. Creating Azure Resource in Azure Portal

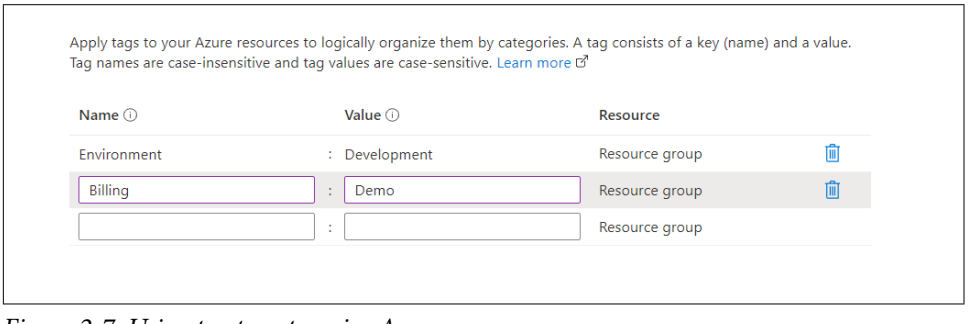

Figure 2-7. Using tag to categorize Azure resources

You can also organize your Azure resources in categories by adding tags as shown on *Figure 2-7*. These resource tags are key-value pair set that are composed of name of your tag and the value. You can set tags for categorizing your resources for billing purposes. For example, you can apply tags for your resources for different environments like resources in Dev, Test, UAT, or Production.

Azure Resource Manager

Azure Resource Manager (ARM) is also an important element in managing resources in Azure. ARM is the management and deployment service that provides users the capability to add, edit and delete resources in Azure. By using ARM, the organization can manage user access control and organize resources securely even after deployment.

Azure Resource Manager templates (ARM templates) are commonly used to automate deployments and to implement Infrastructure as Code (IaC). Azure provides native support for IaC using the ARM templates and also Azure Bicep in Azure Resource Manager.

Terraform is also supported on Azure. IaC creates a great advantage, and it enables good deployment automation of the infrastructure in the cloud. Using Infrastructure as Code, you can automate your deployment by generating templates for the same environment every time. Infrastructure as Code process minimizes the problems of environment drift during development releases.

Azure provide third-party support for other automated IaC platforms like Terraform, Red Hat Ansible, Chef Automate, and Pulumi.

Azure Bicep uses declarative, concise, and type-safe syntax to deploy Azure resources and is considered a domain-specific language (DSL). It promises the best developer experience when it comes to authoring IaC solutions in Azure. We will go through the technical aspects of it in the later chapters of this book

Azure Geographies, Regions, Region Pairs, and Azure Availability Zones

The Microsoft Azure infrastructure is built to deliver the best resiliency and high availability of cloud resources to its users. Azure infrastructure is composed of its geographies, regions, and availability zones. Knowing where to provision your resources in the right location in Azure's global infrastructure will hugely help in an organization's cloud resources management, compliance, security, and speed.

Azure Geographies

As of writing this book, Microsoft Azure has data centers worldwide in 140 countries. The data centers of Azure are secured physical buildings that are located all over the world. The entire global infrastructure of Azure is huge and widely available globally. The data centers and infrastructure of Microsoft's cloud platform are important in providing reliable, secure and innovative smart cloud solutions to its users. Learn more about the Azure data centers nearest to you by checking out *Azure Geographies*.

Azure Regions

As you can see on the Azure geographies, there are data centers all over the globe in different regions and countries. Azure regions play a vital role in cloud computing for adaptability because each country or region have its unique and different restrictions, policies, compliance, and rules. *Figure 2-8* shows an example of an Azure Region with three Availability Zones.

Of all the leading cloud providers globally, Azure has the most global geographical regions. Creating your resources in the nearest Azure geographical region is an advantage. With the global and international market we have these days, being able to choose the location and geography of your resources give flexibility and reliability. Choosing the right Azure region is also vital especially when it comes to compliance and data policies like Europe's General Data Protection Regulation (GDPR)

Before adding resources in Azure, your organization can check first if there are any legal standards or compliance that you need to comply with in your geographical area. Microsoft Azure has a list of compliance offerings for different sectors globally that you can review and learn more about.

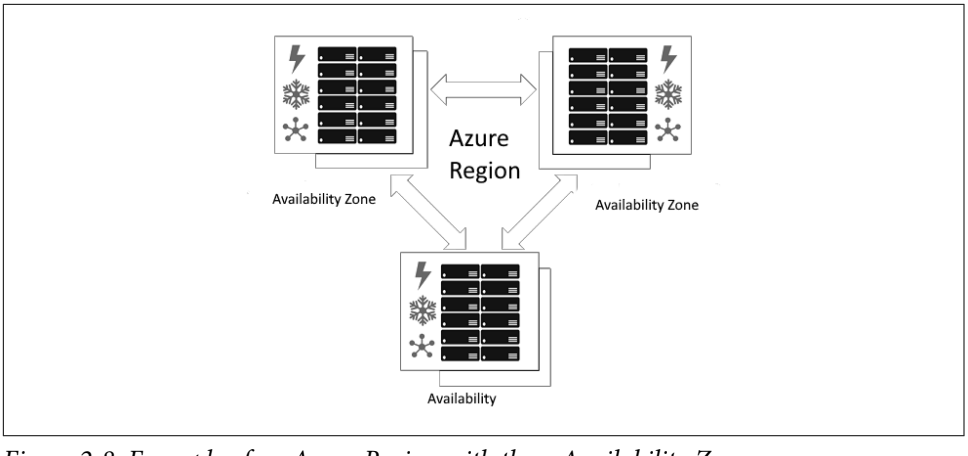

Figure 2-8. Example of an Azure Region with three Availability Zones

Azure Region Pairs

Typically, Availability Zones are created by using one or multiple data centers. There is a minimum of three zones within a region. However, what if two of the zones go down because of a huge outage? Two data centers in an outage in the same Azure region would be risky to keep the resource in operation. This is the reason why users also have the option to use Azure Region Pairs.

Azure Region Pair, as shown in *Figure 2-9*, means pairing a region with another region within the same geography. By pairing regions within the same geography, users can replicate their resources like servers, virtual machines, databases and storage in another location in case of big power outages, nature calamities, etc.

If a region in a pair goes down, the services would failover automatically to the other region in its region pair.

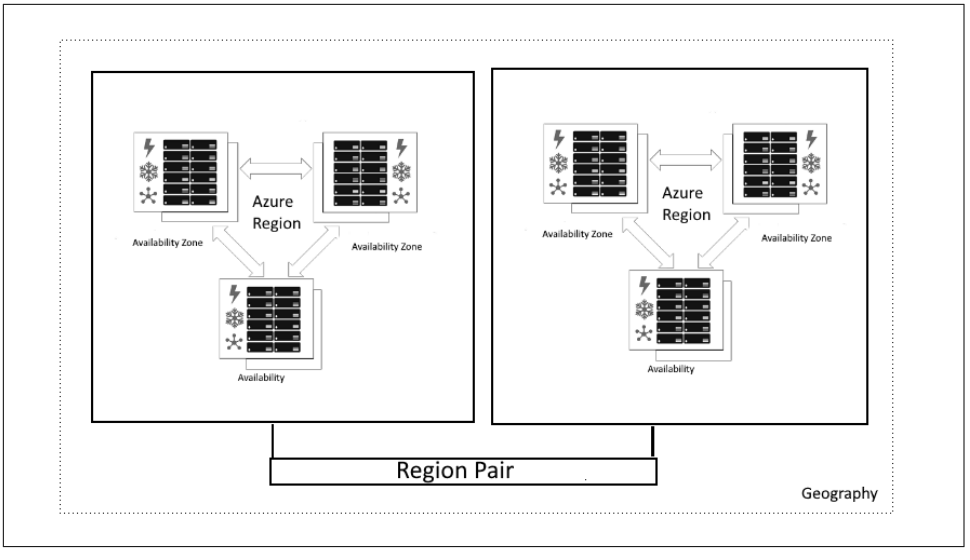

Figure 2-9. Example of Azure Region Pair

An Azure region, as shown in Figure 2-9 is often pared with another region in the same geography. For example if the region is in Europe, then it is expected that its region pair is also located within Europe or at least 300 miles away. When it is possible, Azure prefers this minimum distance of between physical data centers in a regional pair in case of natural disasters, power outages, etc. The Azure regional pair should be within the same region to for reliability in case of unexpected interruptions.

Best Practices in Azure Region Pair

Check out Azure's Business continuity and disaster recovery (BCDR) for Azure Paired Regions on *https://docs.microsoft.com/en-us/azure/best-practices-availability-paired-regions*

Azure Availability Zones

If your organization wants to make sure that your applications and cloud resources in Azure are redundant in case of failure or problems, Azure Availability Zones are your right solution. We can say that these zones are unique physical location or data center within an Azure region that offers 99.99% SLA for virtual machines uptime. An Azure Availability Zone is made up of a single or multiple datacenters with security, independent power, cooling, networking, etc.

It is important to take note that Availability Zones are not available in all regions and Azure services. SQL Managed Identity, Azure App Services and Azure Virtual Machines (Azure VMs) are supported.

Azure services supported by availablitity zones are meant to deliver resiliency, low latency, flexibility and scalability. Learn more about the services that are supported by Azure Availability Zones by region by checking out Azure Availability Zones_.

They are physically isolated data centers that are located within the same Azure region, as shown on *Figure 2-10*.

Figure 2-10. An example of Availability set of Azure Virtual Machines in an Azure Region.

An availability zone is usually composed of one or multiple data centers with independent facilities for power, networking, cooling, and support. The purpose of this isolation is to make sure that in case one of the zones stops working properly, the other zone continues to run in operation. These availability zones are connected and equipped with secure high-speed networks, which is important in running mission-critical resources for your computing, networking, storage, and data.

Availability Zones has a similarity to Availability Sets in Virtual Machines. In contrary, there is an obvious difference between them. Availability zones are used to protect resources from complete system failures in an Azure data center while *Availability sets* are used to protect applications from hardware failures within an Azure data center.

If your organization has the requirement, you can replicate or transfer your data or resources into another availability zone for a cost in Azure. For example, Azure VMs can be moved to an availability zone in a different region.

Cost Management in Microsoft Azure

Aside from organizing cloud resources using Azure Management, Resource Groups, Azure tags, and making sure that your resources are in the right Azure region, you can also manage the financial aspect of your organization's cloud consumption.

Azure's cost management tools help the organization monitor their expenses on their cloud resources consumed. These can be done by setting budget alerts and notifications to the appropriate billing or accounting team and also estimating possible monthly or yearly costs beforehand, which aids in cost planning and budgeting.

Azure Cost Management + Billing
: An administrative section in Microsoft Azure where billing and management of costs can be controlled and monitored.

Total Cost of Ownership (TCO) Calculator
: A great tool that helps organization estimate the cost savings by |https://azure.microsoft.com/en-us/pricing/tco/calculator/[migrating workloads to Azure estimations].

Azure Pricing Calculator
: A dedicated website where you can configure and estimate the costs for Azure products and features based on your use case scenarios in our projects. You can save, export and share these cost estimations, shown in *Figure 2-10*

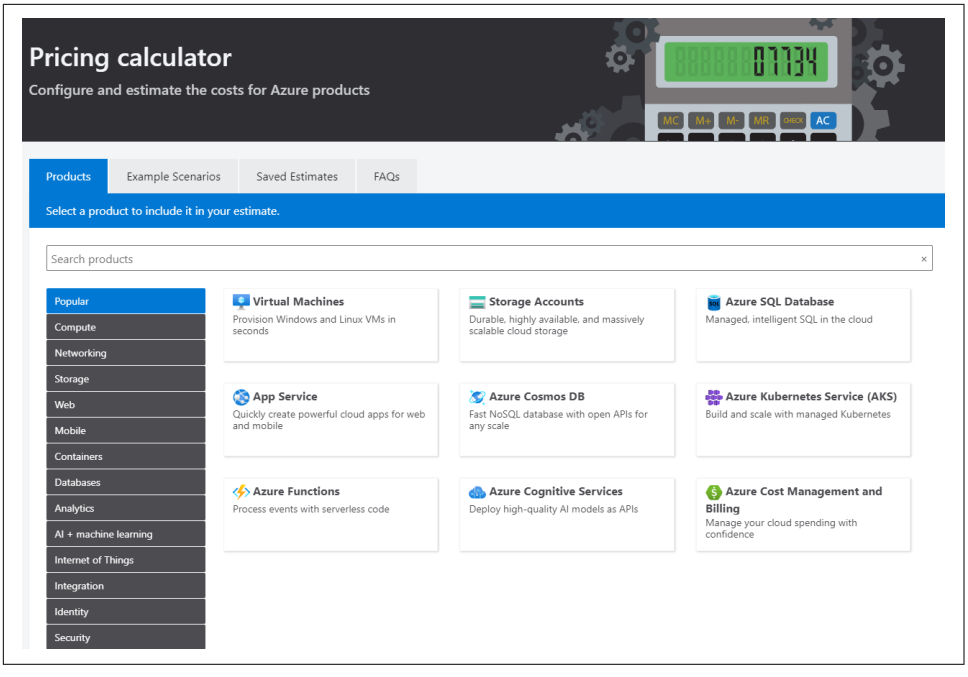

Figure 2-11. Estimate costs for Azure services or resources using Azure Pricing Calculator

Learn more about managing costs in Azure

Get an overview and learn some of the best practices in Azure billing and cost management by visiting the Microsoft Documentation *https://docs.microsoft.com/en-us/azure/cost-management-billing/*

Basic Concepts of User Identities, Roles, Active Directories in Azure

In addition to structuring cloud resources using Management Groups, Subscriptions and Resource Groups, it is also important to control user identities and access to these resources.

Azure Active Directory (Azure AD) as shown on *Figure 2-12* is the identity and user access management service of Microsoft. The users of Azure AD can manage their users identities, their roles, logins and access to internal resources as well as permissions to external services like *Azure Portal*, Office 365, and other applications.

Figure 2-12. A basic example overview of how Azure Active Directory

Azure Role-Based Access Control (Azure RBAC)

It's important for any organization to be able to manage the user access for cloud resources and resource groups in Microsoft Azure. The Azure Role-based Access Control(RBAC) helps in user access management of resources in Azure. RBAC helps in controlling what users can do.

Azure RBAC is a system for authorization and access management of resources within the Azure platform. You can filter what a certain group of users can do and cannot do depending on the type of role they have in the organization.

For example, allow database administrators to only manage (create, read, update and delete) resources related to databases within a resource group. The access can be set up for developers or software engineers who works with application development in the platform.

To learn more about Azure RBAC, watch this video Azure RBAC : The deep dark secrets of role based access control.

Azure Roles

In order to control access to resources in Azure, you need to set up and enforce user permissions by assigning *Azure Roles*. A role assignment has elements such as *Security Principal*, *Role Definition*, and *Scope*, as shown on *Figure 2-11*.

Security Principal
: A security principal is an object that represents a user, group, service principal, or managed identity that is requesting access to Azure resources. You can assign a role to any of these security principals.

Role Definition
: A role definition is a list of permissions or actions to allow a user. Such permissions can be any or a combination of actions like creating, reading, updating and deleting resources. Roles can be specific or can be in different levels.

Scope
: Scope as its term describes is the group of resources that the access applies to. When you assign a role to a user in Azure, you can define the scope to limit some tasks or actions by a user or role. This is helpful if you want to make someone a contributor, but only for a certain resource group.

As described in the previous section, the four levels of scope are management group, subscription, resource group, or resource. Also described in details on previous section *Architecture and Resource Management Concepts* in Microsoft Azure are scopes structured from top to bottom and follows the inheritance of parent-child relationship.

Figure 2-13. Example of the important elements of Azure Role Based Access (Azure RBAC)

Learn by Doing (Try it out!)

Now that you have learned about the cloud services in Azure, I recommend to try this section by practicing the hands-on exercises that will help give you a walk through and understanding.

Microsoft Azure Portal Hands-On

1. If you already have an Microsoft Azure Subscription, visit *https://portal.azure.com*
2. If you don't have a subscription yet, register for free Azure account on link *https://azure.microsoft.com/en-us/free/*

3. Explore the Azure Portal's Home Page, as shown in *Figure 2-14* is where you will see the left side bar with the default list of Azure Services and the main page has the dashboard and search bar. On the upper-right of the portal, you will be able to access the Cloud Shell, Directories + Subscriptions, Notifications, Settings, Help and Manage your Azure Account.

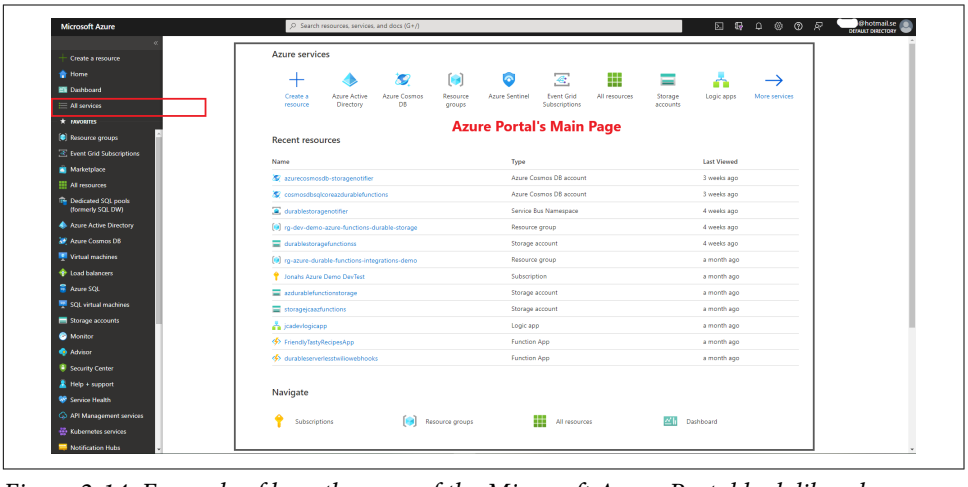

Figure 2-14. Example of how the page of the Microsoft Azure Portal look like when you signed up for an Azure account and have logged in

1. Click on *All Services* on the left panel and explore the cloud services in different categories as shown in *Figure 2-15*.

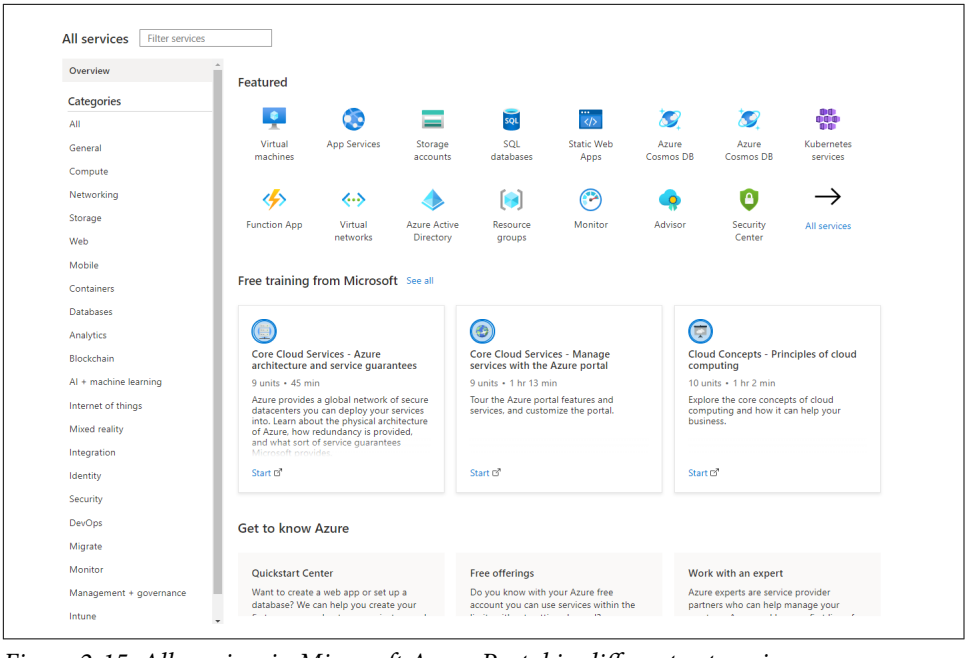

Figure 2-15. All services in Microsoft Azure Portal in different categories

1. Find *Free Offerings* in Microsoft Azure in the same page or visit *https://portal.azure.com/#blade/Microsoft_Azure_Billing/FreeServicesBlade* Explore the free Azure services available for you for 12 months with your Azure free account.

Summary

In this chapter, you have learned the fundamentals of public cloud provider, Microsoft Azure. You learned about the different Azure services in different categories *e.g., Compute, Storage, Networking, Databases, Developer Tools, Integration, Analytics and more*. Resources in Azure can be organized by and structured in to different scopes Azure Management Groups, Subscriptions and Resource Group. Azure has helpful tools to manage costs and also protection your data and resources in case of outages using availability zones and Azure Region Pairs. Azure Active Directory (Azure AD) allows you to manage users and identifies to control operations of your Azure resources.

Azure Role-based Access Control (*Azure RBAC*) is the user access control and identity management in Azure and that a role assignment is composed of three important elements - security principal, role definition, and scope. We also learned that Azure Resource Manager(ARM) templates and Terraform are used for automation of deployments to Azure and for implementing Infrastructure as a Code (IaC).

On final note, the core Azure services mentioned on this chapter will be described in detail in rest of chapters of this book.

Check Your Knowledge

1. Can you have two Azure region pairs in different geography? (*True* or *False*)
2. Azure Marketplace is where Azure users can purchase and try-out applications and services from other service providers and Microsoft partner companies. (*True* or *False*)
3. What are the top categories of core services in Azure?
4. Azure Virtual Machine Scale Sets is the compute service you need if you want to develop event-driven applications in serverless environment. (*True* or *False*)
5. What is the difference between *Azure Region* vs. *Availability Set*?

Answers

To find the answers to the *Check Your Knowledge*, turn to back of the book in the Appendix.

Recommended Resources

- Azure Global Infrastructure
- What is Azure?
- Microsoft Azure Fundamentals Learning Path
- Microsoft Documentation - How to Create an Azure Account
- Microsoft Learn - Control and organize Azure resources with Azure Resource Manager
- Directory of all Microsoft Azure Services
- Azure Charts
- Quickstart: Check access for a user to Azure resources
- Microsoft Learning Path - Build a cloud governance strategy on Azure
- Azure Blob Storage Documentation
- Microsoft Learning Path - Describe Azure Core Services
- Martin Kleppmann, 2017. "Designing Data Intensive Applications", O'Reilly Media, Inc. ISBN: 9781449373320

- What is Azure role-based access control (RBAC)? | One Dev Question: Arturo Lucatero
- Azure Real World Hands-on Training for Beginners by Ryan O'Connell

References

[1] Microsoft Documentation, "Windows Azure - Microsoft's Cloud Platform, *https://docs.microsoft.com/en-us/archive/blogs/aniyer/windows-azure-microsofts-cloud-platform*

PART II

Cloud Computing Services, Networking, Storage and Databases in Microsoft Azure

This second part of the book and its chapters focus on giving you an in-depth look at the different technologies in Microsoft Azure for categories *Compute, Networking, Databases and Storage*. These categories relate to each other and they are widely used in workloads, infrastructure and applications in the cloud.

Chapter 3 explores some of the Microsoft Azure compute services such as Azure Virtual Machines, container services like Azure Container Instances, Azure Container Registry, Azure Container Apps, Azure App Services, for web and mobile applications, serverless cloud solutions with Azure Functions, Azure Static Web App, Quatum Computing, etc.

Chapter 4 covers cloud networking and services in Microsoft Azure including Azure VNet, DNS, Azure Firewall, Azure Front Door, ExpressRoute, Virtual Network, VPN Gateway, Application Gateway, Load Balancer, Internet Analyzer, etc. You will also get an introductory overview of Azure Space and Azure Orbital which is Azure's Ground Station as a Service.

Chapter 5 provides a technical overview of the different cloud storage and databases *(both SQL and NoSQL)* in Microsoft Azure. You will learn about cloud storage concepts, services, create databases and find useful best practices for Azure SQL Databases, Azure Cosmos DB, Database for MySql, Azure SQL Servers, Redis Cache in Azure, Azure Storage, Data Share and Manage Disks.

CHAPTER 3

Microsoft Azure Cloud Compute Services

A Note for Early Release Readers

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 3rd chapter of the final book. Please note that the GitHub repo will be made active later on.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *jleonard@oreilly.com*.

> *Compute services and networking and storage are the essentials of any public cloud. Azure compute helps customers build and host application workloads of various scales and natures. It works with your current development stack or helps migrate your stack to containers or serverless and adopts the best development practices.*
>
> — Alexey Polkovnikov, Sr. Cloud Solution Architect at Microsoft & Founder of Azure Charts

Previously, we learned about Microsoft Azure as a cloud provider. We also had a good overview of Azure's different core services, which gave us a better understanding of each cloud service.

In this chapter, we will dig deeper into one core services category in Microsoft's cloud platform, Azure Compute, that will help you and your organization build cloud solutions using compute services, which will be in existing development projects regardless of whether your applications are for migration, containerization, modernization, and more.

Azure Compute for Developing Fully-Managed Systems

Azure provides computing services on-demand at a global scale and with high availability. Azure Compute is the category name used for the cloud-based computing services in Azure. It is one of the service categories in Azure that offers and provides on-demand computing resources such as high-capacity virtual disks, memory, networking, processors, and robust virtual operating systems. They are available on a Pay-As-You-Go and other pricing models that can be set up and created quickly.This is something that can be challenging to do if you are provisioning compute resources on-premises and traditional IT infrastructure.

You will find the the different compute services in *Azure Portal* by navigating to *All Services*, and then select the category *Compute* as shown in *Figure 3-1*

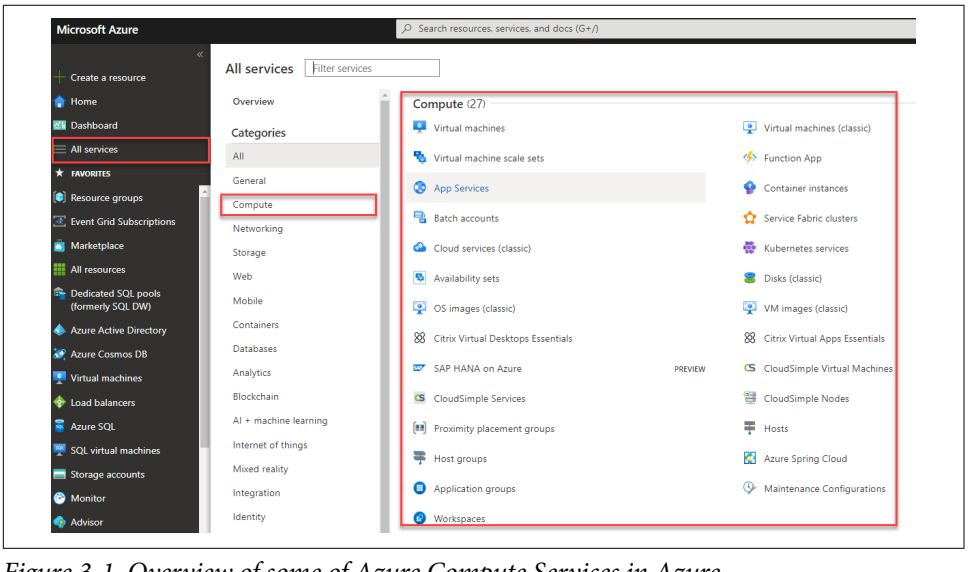

Figure 3-1. Overview of some of Azure Compute Services in Azure

Azure Compute services are used for running and hosting the workloads for our applications. Some of the familiar Azure compute resources are Azure Virtual Machines (VMs), Azure VM Scale Sets, Azure App Services, Azure Container Apps, Azure Functions, Azure Kubernetes, etc, as shown on *Figure 3-2*. These compute resources are usually categorized in different deployment models such as Infrastructure as a Service(IaaS), Platform as a Service (PaaS) and also used in combination with Serverless or separately depending on the type of applications and business solutions that need to be solved.

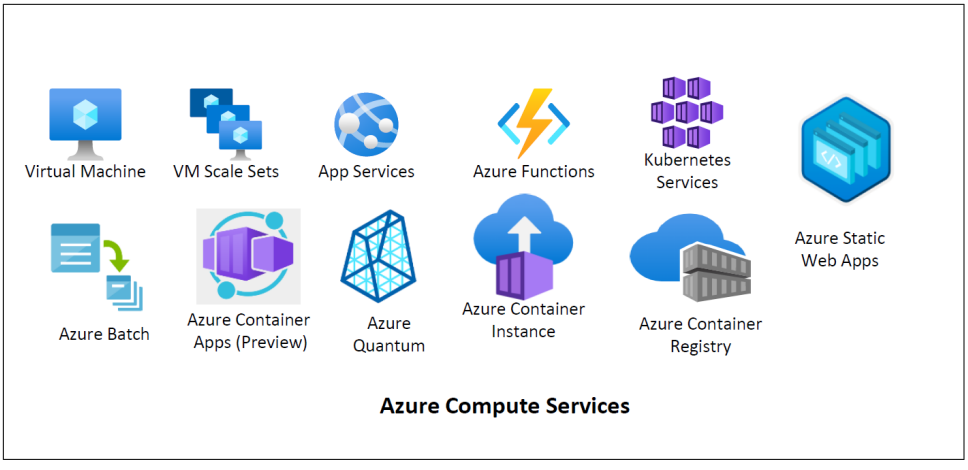

Figure 3-2. Common Azure Compute services in Azure

These compute technologies will be useful in hosting your applications in the cloud while gaining the benefits of having resources and workloads fully-managed, better security, opportunity for rapid development and innovation. IT infrasture that are still on-premises can make use of Azure Compute services to improve their systems and save time and money from the traditional IT infrastructure.

Azure Virtual Machines and Virtual Machine Scale Sets

Aside from the commonly used compute service, there is also another way to deploy applications and databases to Azure using Azure Virtual Machines and Azure VM Scale Sets that provide opportunities to do hybrid deployment of both on-premises and cloud. This enable you to deploy your applications and databases to Azure in a way that is more cost-effective and more scalable than traditional IT infrasture.

Two of the most popular services in Azure Compute category are the Azure Virtual Machines (Azure VMs) and Azure Virtual Machine Scale Sets (Azure VM Scale Sets). These services enable us to create virtual machines on the cloud quickly, on-demand at anytime and anywhere, especially for those who prefer to implement IaaS solutions for their business needs.

Azure VMs are compatible with operating systems on different platforms like Windows, Linux and other types. Azure VMs provides high-availability, scalability, realiability, and fully-managed VM management features for its users and administrators. They are also commonly-used by those seeking for *Lift-and-Shift* cloud migration scenarios.

The *Lift-and-Shift* cloud migration are known to have the key benefits such as minimal code-refactoring, re-architecture and faster migration. This cloud migration

strategy is ideal for those organizations who wants to move their existing on-premise IT infrastructure to the cloud without making major changes to the existing architecture, source code, and processes. By utilizing IaaS solutions and even container solutions for cloud migration, organizations can save time, money, and resources by restructuring and modernizing the applications.

Cloud migration options and services in Azure will be discussed in greater detail in Chapter 13 *Microsoft Azure Cloud Management and Governance*.

As you may recall from Chapter 1, virtualization co-relates to the evolution of cloud computing and it is what drives IaaS solutions we have today.[1].

Azure Virtual Machines

As mentioned Azure VMs are considered as Infrastructure as a Service (IaaS) cloud service model, it means that you have complete control of the infrastructure plus the advantage of scalable computing resources. Having full control of the infrastructure also means that you have the responsibility for maintaining it.

Azure VM may be ideal if your organization wants to have full capabilities in the installation and configuration of your infrastructure without spending money buying physical hardware or expanding data centers. Additionally, Azure has options to allow Azure VM users to manage security, monitoring, updates and patches to the operating systems.

Through virtualization in the cloud, you can deploy and host your applications on your desired OS on VMs in different servers and with shared storage. *Figure 3-3* shows a simple example diagram of running an Azure VM on Azure based on Microsoft Documentation.

Figure 3-3. An example overview of Azure Virtual Machines

Development and Applications

Through its cloud-based services, Azure VMs provide you the flexibility of virtualization and it also gives you with control over how you want to host your applications. There is a wide range of computing solutions for development, testing, running applications, and extending your data center. It gives some users the option of using custom and open-source software systems the way you need to configure it. This gives the flexibility and benefit of faster application deployments in seconds instead of weeks.

Modern Cloud App Development with Azure VMs

Azure Lab Services and Azure DevTest Labs are useful if you want to set up different development, test and lab environments for your team or for learning purposes.

Making use of Azure VMs as part of IaaS solution is useful especially if you want to take control of your on-premises resources or infrastructure. However, there are some important and practical things to consider before provisioning Azure VMs for your organization on the cloud, as described in Table 3-1.

Table 3-1. Things to Consider Before Creating Azure VMs

Consideration	Description
Basics of Networking	Azure uses virtual networks (VNets) to secure connections for Azure VMs and other cloud services in the platform. Any Azure VNet Resouces that belong to the same private network can be accessed
Name of the VM	Choosing the appropriate and consistent name of your Azure VM is part of the provisioning process. The VM name is configured as part of the operating system and is also used to define and manage it as a resource
VM Size	Options to choose VM sizes are available so that you can choose the right combination of memory, compute, and storage for type workload needed
Knowledge of VM Pricing Models	Being aware of the pricing models for Azure VMs is important to prevent unwanted costs. Azure VM pricing models come in five different types. Each type of option will vary not only in price but also in performance and availability
VM Storage	Azure VMs usually will have at least two virtual hard disks (VHDs) which is used for the storage of the operating system(OS) and the temporary storage. Determining the appropriate VM storage prior to provisioning is good to know so that the VMs you create are provisioned to handle the workloads you need. Check out Microsoft's recommendation for Virtual Machine Sizing Guidelines.
Choosing the right Operating System	There is a variety of OS images that you can install into the Azure VM, including several versions of Windows and different types of OS in Linux. Choosing the appropriated OS prior to VM provisioning is vital. Usually the choice of OS will affect the cost of hourly compute pricing as Azure combines the cost of the OS license into its price. Using Azure Cloud Shell, you can easily see the list of latest Azure VM images and OS versions using the command `az vm image list` and other required parameters.

For more details and information about Azure VM provisioning visit Microsoft's checklist for creating an Azure Virtual Machine and evaluate the different pricing models for Linux VMs and Windows VMs

Azure Virtual Machine Scale Sets

Azure Virtual Machine Scale Sets (*Azure VM Scale Sets*) is a compute service that allows you to deploy, run and manage a scalable set of multiple virtual machines (VMs). With all VMs configured the same, Azure VM Scale Sets are designed to support autoscaling capabilities. There is no requirement of pre-provisioning of VMs which makes it easier to build services at a large scale. This can be useful in developing solutions with big data, big compute and even workloads that are containerized.

When the demand for workloads increases, there is an option to add extra instances of the virtual machines. When the need for workload decreases, VM instances can be deleted or scaled down. The scaling options and processes for Azure VM Scale Sets can either be done automatically or manually depending on your workload needs. It is also possible to dynamically combine the autoscaling and manual scaling if necessary.

You can set autoscaling options on Azure VM Scale Sets as shown on *Figure 3-4*.

Figure 3-4. A simple illustration of vertical and horizontal scaling

Scaling Options for Azure VM Scale Sets

Azure VM Scale Sets are meant to help us save some money from the the risk of having high costs in having multiple virtual machines in the cloud. Therefore, new instances of virtual machines are recommended to be created or provisioned when necessary. In Azure, there is an autoscaling option to scale up and down the number of compute resources that are being allocated based on its demand at a certain time. You can scale your virtual machines using *horizontal scaling* or *vertical scaling*.

An a good example of a typical horizontal scaling is when you add or remove some VMs from a scale set. On the other hand, vertical scaling you are adding additional resources in your VMs like upgrading the memory, disk memory, and CPU power.

Azure Hybrid Benefit and Azure Spot Virtual Machines

As your workloads and VMs increases in IaaS model, using Azure VMs can be expensive. Azure has optional services like Azure Hybrid Benefit and Azure Spot VMs. *Azure Hybrid Benefit* is a license benefit that helps organizations save money by reducing the costs of running workloads in the cloud. The benefit gives the option for organizations to use their own on-premises Windows Server and SQL Server licenses that are Software Assurance-enabled on Azure.

The Azure Hybrid Benefit Savings Calculator is also a useful tool in analyzing the financial benefits you will gain. Learn more how this licensing benefit and save money on Azure VMs by availing and making use of your organization's on-premises licenses for Windows Server and SQL Server.

In addition this, Azure Spot VMs can help saving costs through unused capacity.

Finally, both Azure VMs and Azure VM Scale Sets are two great options for hosting databases, storage, and applications for your organization. They are both ideal especially if your organization are still in the process of getting started in your cloud migration journey and prefer to have some of your resources, data and workloads on-premises.

Azure App Service

Azure App Service is considered as Platform as a Service (PaaS) and is an HTTP-based service that enable us to host web applications on the cloud. If you do not have the need to have full control of your infrastructure like the demand for using Azure VMs, then App Service is one of the most commonly used fully-managed PaaS services for web applications development. By considering Azure App Service you can quickly build, deploy, and scale enterprise-grade web, mobile, and API apps running on any platform. You can meet rigorous performance, scalability, security, and compliance requirements while using a fully managed platform to perform infrastructure maintenance.

Figure 3-5, shows a simple example architecture from Microsoft Documentation website with implementation of an App Service in an App Service Plan. The Web app has integrations with other services like Azure Active Directory for authentication, Azure

Front Door, Queue for message, Azure Functions for serverless backend logic to database storage to Azure SQL and Cosmos DB databases using Redis Cache.

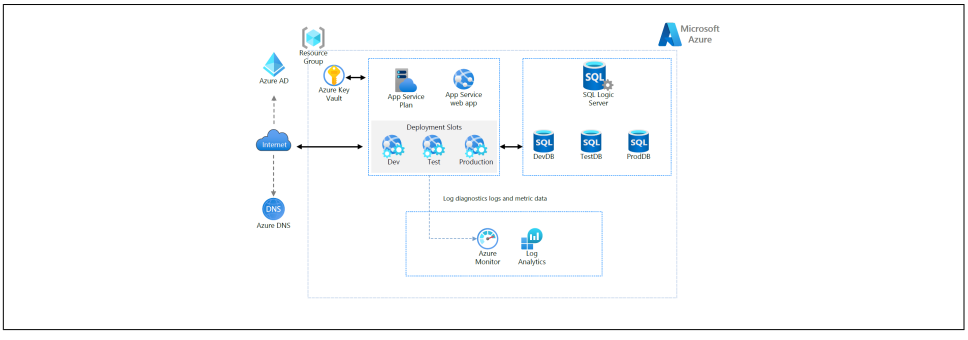

Figure 3-5. A basic example a web application implementing Azure App Service in different environments Dev, Test and Production using Deployment Slots. The application has its Azure SQL Databases on SQL Server and integrates with Azure Monitor for logging the metrics and diagnostics for the web application.

Modern application development is more efficient using App Service because it has features good for web applications for autoscaling, automation, security, workload balancing, monitoring and support for continuous delivery and continuous integration *(CI/CD)* with Azure DevOps, Docker Hub, Github and other more. The list of key benefits for using Azure App service, as listed and described on *Table 3-2*.

Azure App Service plan determines the type of pricing model and how much you pay for the Azure compute resources consumed monthly.

Table 3-2. Benefits of using Azure App Service

Benefits	Description
Multiple languages and frameworks	App Service has first-class support for different frameworks and programming languages ASP.NET, ASP.NET Core, Java, Ruby, Node.js, PHP, or Python. You can also run PowerShell and other scripts or executables as background services
Managed environments	App Service automatically patches and maintains the OS and language frameworks which enables developers to spend more time writing code and worry-less about setting up the platform
Containerization	Containerized or dockerize your application and host it on a custom container (Linux or Windows) in App Service. Using Docker Compose, you can deploy and run multi-container apps
Optimized DevOps	Set up continuous integration and deployment with Azure DevOps, GitHub, BitBucket, Docker Hub, or Azure Container Registry. Promote updates through test and staging environments. Manage your apps in App Service by using Azure PowerShell or the cross-platform command-line interface (CLI)
Global Scale and high availability	Host your apps anywhere in Microsoft's global data center infrastructure with autoscaling or manual scaling capabilities, and high availability
Integration with On-Premises and SaaS Platforms	There are a wide variety of connectors available for enterprise systems, SaaS services, and external services. Data from on-premises systems can also be accessed using features like Hybrid Connections and Azure Virtual Networks.

Benefits	Description
Security and compliance	You can secure your App Service by adding Azure Active Directory for user authentication or Single Sign On (SSO) with external services like Google, Facebook, Twitter, or Microsoft account. You can set-up Managed Service Identities and restrict some IP addresses for security
Application templates	If you need to use app templates, there are a list of them in the Azure Marketplace, such as WordPress, Joomla, and Drupal
Integration with Visual Studio and Visual Studio Code	Development team can code, deploy and debug using the great IDEs like Visual Studio and Visual Studio Code
API and mobile features	App Service provides turn-key CORS support for RESTful API scenarios, and simplifies mobile app scenarios by enabling authentication, offline data sync, push notifications, and more
Serverless logic	Web apps can be integrated well with serverless code like used in Azure Functions. This means that you can run a serverless code, scripts and call API endpoints on-demand without having to manage infrastructure or explicitly provisioning. Using the consumption plan pricing model, you only pay for the compute time when your instance for Azure Functions are running.

So, we learned that Azure App Service allow us to develop and host our applications and APIs using our preferred the programming language as PaaS without managing infrastructure. App Service also supports single-page application (SPA), open source content management systems (CMS) like WordPress, Apps on Azure Arc, Static HTML sites, multi-container apps using Docker, etc.

Static Web Apps

Azure Static Web Apps is a type of single-page application service which allows you to develop full stack SPA web applications that complete CI/CD integration with a code repository platform like GitHub or Azure DevOps. Static Web Apps are known to be reliable, quick and fast applications. A few of the prerequisites in developing Static Web Apps are an Azure and GitHub Account since the source code needs to be setup with GitHub Actions for the automation of the deployment workflow.

Static Web App in Azure gives us the option to build modern web applications with modern frameworks and libraries we have today. For example, this Azure service can be integrated with Blazor Web Assembly applications, React, Angular, Vue, or Svelte. It is also designed to integrate well with serverless development by using Azure Functions as back-end or for APIs. If you need guidance in choosing between the traditional web applications compared to using SPAs, check out this good Microsoft documentation, Choose Between Traditional Web Apps and Single Page Apps (SPAs) about it.

Figure 3-6. Azure Static Web Apps Example Overview

Figure 3-6 shows how Azure Static Web Apps workflow happens after updating to a source code. Any code changes trigger the deployment workflow using GitHub Actions or Azure DevOps Pipelines.

Key Benefits and Uses of Azure Static Web Apps

There are many ways and technologies to create modern application in the cloud these days. If you think your application must expose a rich user interface with many features. Static Web Apps doesn't require reloading the page as users take actions or navigate between areas of the app.

The use cases and benefits to using Static Web Apps are as follows:

- Build modern web applications with JavaScript frameworks and libraries like Angular, React, Svelte, Vue, WebAssembly application like Blazor, Next.js, and more.
- Bring Your Own Functions Support for serverless development especially if you already have existing Azure Functions to implement
- Seamless developer experience and CI/CD with GitHub Actions or Azure DevOps
- Globally distributed static content closer to location of the users of your web applications
- Free and auto-renewable SSL certificates for both *Free* and *Standard* pricing models
- Custom domains support with TLS
- Seamless security with support of reverse-proxy when calling APIs, which requires no CORS configuration [2]
- Authentication with common identity providers like with Azure Active Directory, GitHub, Twitter, etc.

- Customizable authorization role definition and assignments
- Back-end routing rules enabling full control over the content and routes of your app

Pricing Plans for Azure Static Web Apps

Free and *Standard* plans are the two different pricing models to choose for Static Web Apps. Choosing the appropriate plan depends on the requirements and use cases. Learn more about the list of features of each plan on Azure Static Web Apps hosting plans and be sure to reference the quotas page before determining the best fit for your needs.

Oryx is the build engine of Azure Static Web Apps. It helps in building the frontend and the API in your web application. It is a smart build engine because it automatically builds the steps and executes them for you depending on the type of framework you have implemented in the app.

Frontend Framework Configuration

Since Azure Static Web Apps dynamically allow us to build SPA using the frontend framework of our choice, the differences on the configuration exists. The build configuration values needs to be specific to the type of framework or library is used for the frontend.

Learn more about it Configure front-end frameworks and libraries with Azure Static Web Apps

In conclusion, Azure Static Web Apps are idea for modern SPAs and for hosting static web content with support for globally distribution, scalability, speed, security, integration, and ease of use for both development and deployment.

Azure Web App for Containers

Azure Web App for Containers enables you to deploy your applications as containers in the cloud with the capability to use custom docker images with support for autoscaling and easy deployment. Container registries like Docker Hub or Azure Container Registry can be used to pull the images of your application. An example architecture of Azure Web App for Containers is shown in *Figure 3-7*.

Figure 3-7. Example architecture of Azure Web App for Containers.

The Web App for Containers in Azure also has the feature to develop a custom container and multi-container (Preview) apps using Cloud Shell and Docker.

Serverless Compute Services

One of the powerful and promising compute services in Azure is the serverless compute services. Since the technology of Serverless computing came, developers had the opportunity to be effective by building applications without maintaining and worrying about the underlying infrastructure. Technically, the servers and infrastructure of applications in serverless compute are automatically provisioned, which means they are managed and scaled by Azure, the cloud service provider. As a developer, this helps you focus on writing the code and the application development.

Benefits of Serverless Architecture in the Cloud

In simple terms, serverless computing is a model where backend services are provided as a cloud service.

For example, an organization can make use of the serverless or backend services from Azure with the advantage of having a consumption type of pricing model, which means you pay as you use. *Figure 3-8* illustrates how serverless computing can help save money from building and maintaining servers and infrastructure the traditional way.

On-premises IT infrastructure is expensive to have because it relies on our own physical hardware and data center to host our systems and web applications on our own servers.

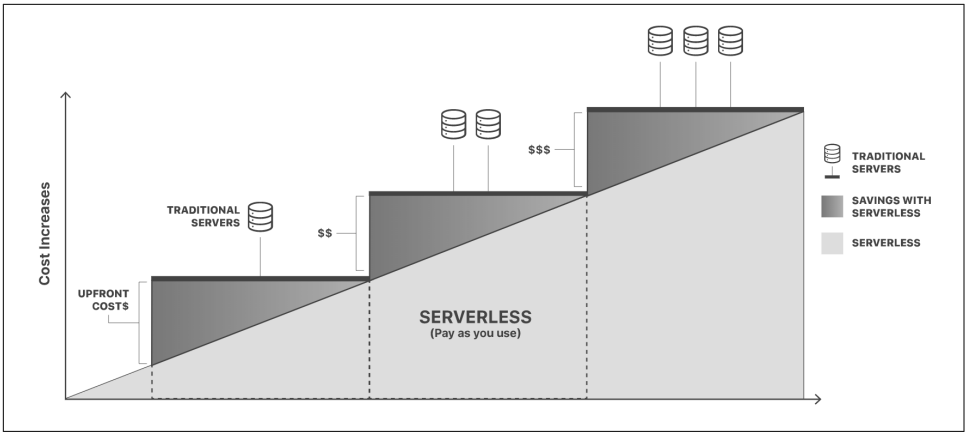

Figure 3-8. An illustration of how serverless computing helps in cost savings in IT infrastructure

Because serverless providers like Azure provides autoscaling capabilities, they can help reduce the cost of maintaining physical servers or data centers.

Azure Functions

Azure Functions is a powerful compute service for serverless computing. Serverless functions in Azure are ideal when you're concerned only about the code running your service and not the underlying platform or infrastructure. For example, you can use Azure Functions for the backend logic of your APIs or integration with other services or APIs. This compute service is event-driven, which means it can be used if you need to do tasks in response to an event. For example an HTTP triggered message arriving in an Azure Service Bus Queue that passes the queue message to another enterprise application or service.

Benefits of Azure Functions

- Write less code by focusing on writing the logic you need to write
- Focus on development and delivery
- Worry less on maintaining the servers and infrastructure
- Save on costs by paying only when functions are running
- Flexibility of using different languages and frameworks supported
- Autoscaling
- Wide variety of integration options with other services

Components of Azure Functions

Azure Functions is designed for event-driven applications. It has two components as the following:

Triggers
: An Azure function will not run without the help of triggers. A trigger based on any event defines how an Azure function is invoked. It is important to take note that an Azure function must have only one trigger and the triggers in a function can have corresponding data usually serves as the payload.

Bindings
: To declaratively connect another resource to the function; bindings are optional and may be connected as input, output, or both. Data from bindings is provided to the function as parameters. You can mix and match to suit your needs.

Both the triggers and bindings let you avoid hard-coding access to other services. Your function receives data (content of a queue message) in function parameters. You send data (to create a queue message) by using the return value of the function.

When you create and configure your Azure Function, it is worth to know that all triggers and bindings have specific direction_property in the functions configuration file *function.json*. Triggers always has the *in* direction and the bindings use *in* and *out* depending if it was an input or an output. There is another direction called *inout* which is supported in some bindings. Learn more about Azure Functions triggers and bindings.

Create and Build Azure Functions

Azure Functions can be developed in different programming languages like C#, Java, PowerShell, Javascript, Python, Typescript, etc. Try building your first Azure Functions via Microsoft's Getting Started with Azure Functions.

Azure Durable Functions

Durable Functions is an extension of Azure Functions that lets you write stateful functions in a serverless compute environment. It has the same standard features of Azure Functions but its main key purpose and use is for developing serverless stateful workflows and orchestration. It enables you to solve some complex problems by defining and authoring your workflows using orchestrator functions and stateful entities.

Creating and developing stateful workflows with Durable Functions is beneficial in certain use case scenarios like automating business processes like approval workflow that requires a human response or interaction. For example, when you have a sce-

nario that requires you to wait for an external event. Durable Functions helps in keeping workflows stateful by managing state, checkpoints, and restarts the workflow for you. Because of its benefits, developers gain productivity and can focus on writing the code, implementing the business logic and delivering the business requirements.

Durable Functions as of date of writing supports the following languages like *C#*, *JavaScript*, *Python*, *F#*, and *PowerShell*.

The Durable Task Framework (DTFx) is the library behind Azure Durable Functions. DTFx allows its users to write long running (stateful) and persistent workflows (orchestrations) in programming language C#.

Learn more about this framework on GitHub and watch this interesting video about it Building workflows with the Durable Task Framework on On.NET.

Key Features and Benefits of Azure Durable Functions

- Take control of complex use case workflows
- Solve event-driven scenarios in your applications
- Develop stateful orchestration workflows of your functions or tasks in serverless environments
- Worry-less on maintaining infrastructure
- Pay only for instances when your function apps are running
- Integration flexibility with other Azure services and APIs

Components of Azure Durable Functions

Azure Durable Functions have important components or function types that play important roles in the serverless stateful workflow and orchestration of tasks. A typical durable function app in Microsoft Azure is usually composed of different types of Azure Functions. Each of them can be stateful or stateless depending on the type of you are using and what it should be doing.

Durable functions have four known types: the client functions, orchestrator functions, activity functions, and entity functions, as illustrated in *Figure 3-9*.

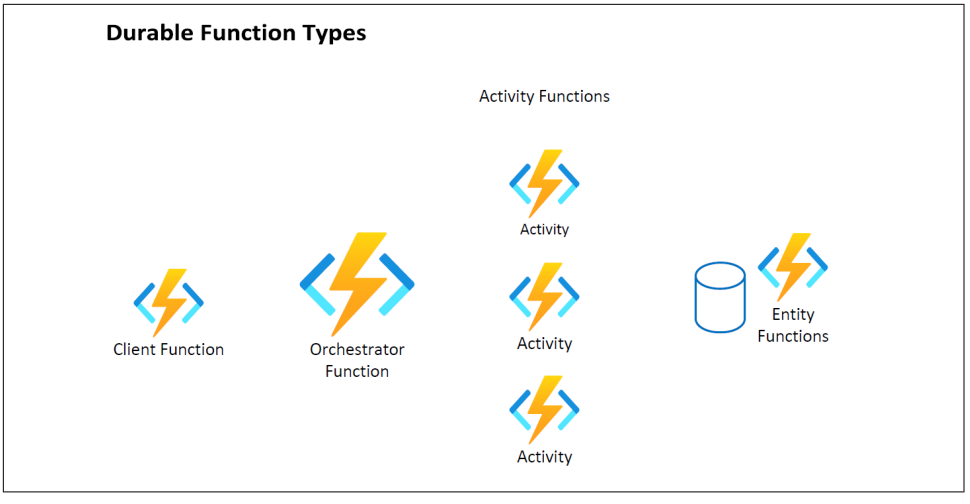

Figure 3-9. The known function types of Azure Durable Functions

Let's take a look at the details of each of these durable function types to better understand how it all works altogether in authoring and developing stateful workflows or orchestration.

Client Functions. Client functions perform a big role in starting the orchestration of durable functions workflow. It needs to have an orchestration client binding to trigger the instance of the orchestrator functions.

Any Azure function that is non-orchestrator can be considered as a client function. For example, you can trigger and start the orchestration of your workflow using HTTP trigger, Azure Cosmos DB trigger, Azure Service bus trigger, and other triggers supported by Azure Functions framework. The difference is that a normal function has from a client function is that it uses a *DurableClient* output binding as shown in code *Example 3-1* which is an example from one of my serverless development and demo projects I published on my GitHub repository for one of the application patterns, *Function Chaining* which will be discussed in details further in this chapter.

Example 3-1. An example of a client function that use the Azure BLOB trigger to start the orchestration of the durable workflow by calling the orchestrator function called StorageOrchestrator

```
[FunctionName("BlobTriggerStart")]
    public static async Task BlobTriggerClientFunction([BlobTrigger("photoscon
tainer/{name}",
        Connection ="StorageConnectionString")]  CloudBlockBlob myBlob, string
name,
        ILogger log, [DurableClient] IDurableOrchestrationClient starter)
    {
```

```
        try
         {
            log.LogInformation($"Started orchestration trigged by BLOB trigger.
                                    A blob item with name = '{name}'");

            // Function input comes from the request content.
            if (myBlob != null)
            {
                var blobItem = new CloudBlobItem
                {
                    Name = myBlob.Name,
                    BlobUrl = myBlob.Uri.AbsoluteUri.ToString(),
                    Metadata = (Dictionary<string, string>)myBlob.Metadata,
                    FileType = myBlob.BlobType.ToString(),
                    Size = myBlob.Name.Length.ToString(),
                    ETag = myBlob.Properties.ETag.ToString()
                };

                var instanceId = await starter.StartNewAsync("StorageOrchestrator",
blobItem);
                log.LogInformation($"Started orchestration ID = '{instanceId}'.");
            }
            else
            {
                log.LogError($"The blob was trigged but myCloudBlob was empty");
            }
        }
        catch (Exception ex)
        {
            //TODO Error handling
            log.LogError("Something went wrong. Error : " + ex.InnerException);
            throw;
        }
    }
```

Orchestrator Functions. Orchestrator functions describe how actions are executed and the order in which actions are executed. Orchestrator functions describe the orchestration in code (C# or JavaScript) as shown in Durable Functions application patterns. An orchestration can have many different types of actions, including activity functions, sub-orchestrations, waiting for external events, HTTP, and timers. Orchestrator functions can also interact with entity functions.

Important note to know about Orchestrator Functions

Orchestrator functions are written using ordinary code, but there are strict requirements on how to write the code. Specifically, orchestrator function code must be deterministic. Failing to follow these determinism requirements can cause orchestrator functions to fail to run correctly. Detailed information on these requirements and how to work around them can be found in the code constraints topic. Learn more about deterministic APIs.

When the orchestrator function gets triggered by any type of client function using the the durable orchestration trigger, it starts the orchestration and runs the workflow that you authored and designed in your code.

Code *Example 3-2* shows a simple example of the orchestrator function with a durable stateful workflow by calling the activity functions that does the work in greeting hello to the passed cities as an input.

Example 3-2. An example of an orchestrator function called StorageOrchestrator that uses the Function Chaining pattern. The orchestrator function checks if the BLOB data passed from the client function BlobTriggerStart is not empty or of null value before it calls the other activity functions SendMessageToServiceBusQueue, SendSmsCallviaTwilio, and SendEmailNotification.

```
[FunctionName("StorageOrchestrator")]
    public static async Task<string> RunOrchestrator([OrchestrationTrigger]
                            IDurableOrchestrationContext context, ILogger log)
    {
        try
        {
            var uploadedBlob = context.GetInput<CloudBlobItem>();
            bool isEmailSentToAdmin;

            //Chain #1 Send Message with BLOB details to Service Bus Queue
            var queueMessage = await context.CallActivityAsync<string>(
                                        "SendMessageToServiceBusQueue", uploaded
Blob);

            if(queueMessage != null)
            {
                //Chain #2 Send SMS and call via TwilioAPI
                var isSmsCalledUser = await context.CallActivityAsync<bool>(
                                            "SendSmsCallviaTwilio", serviceBusMes
sage);

                //Chain #3 send email using Sendgrid API
                if (isSmsCalledUser)
                {
                    isEmailSentToAdmin = await context.CallActivityAsync<bool>(
```

```
                                                    "SendEmailNotice",
uploadedBlob);
                }

                log.LogInformation($"A new blob named {uploadedBlob.Name} was
queued" +
                                   $"and added to service bus queue. \n" +
                                   $" SMS sent = {isSmsSentAndCalledUser} to user.
\n" +
                                   $" Access via URL: {uploadedBlob.BlobUrl}" +
                                   $" and email sent.");
            }

            return $"Orchestration done with Id: {context.InstanceId}";
        }
        catch (Exception ex)
        {
            //TODO Handle possible errors and do a retry if needed or retry a func
tion
            log.LogError($"Something went wrong " + ex.Message);
            throw;
        }
    }
```

Example 3-2 uses function chaining with a few tasks to do; however, you can actually combine the different patterns to create a more complex orchestration. Application patterns will be discussed after the components and types of Azure Durable Functions are introduced.

Additionally, in an orchestration, you also have the option to write sub-orchestrations within your orchestrations. To learn more about the important things you need to follow and know, you may read more about it on Microsoft's Documentation for Azure Functions

Activity Functions. Activity functions are the basic unit of work in a durable function orchestration. Activity functions are the functions and tasks that are orchestrated in the process. For example, you might create an orchestrator function to process an order. The tasks involve checking the inventory, charging the customer, and creating a shipment. Each task would be a separate activity function. These activity functions may be executed serially, in parallel, or some combination of both.

Another simple template example from Microsoft documentation is shown in *Example 3-3*. This is an example of the activity functions that receives the parameter of the string of *cityName*. The *HelloGreeter_Activity* does its job to output and greeting hello to the city once it is triggered using the *ActivityTrigger*.

Example 3-3. An example of the first task or activity being called by the orchestrator StorageOrchestrator. The activity function SendMessageToServiceBusQueue has the

logic to send BLOB data uploadedcloudBlob and compose a string text message to be sent and saved in the Azure Service Bus queue. Once that queue message is saved in the queue storage in Azure, it will return that queue message to the orchestrator function StorageOrchestrator.

```
[FunctionName("SendMessageToServiceBusQueue")]
    public static async Task<string> SendMessageToAzureServiceBusQueueAsync([Activi
tyTrigger]
            CloudBlobItem uploadedBlob, ILogger log, ExecutionContext executionCon
text)
    {
        log.LogInformation($"Received data {uploadedBlob.Name}, format {uploaded
Blob.FileType}.");

        //Config settings for Azure Service Bus
        var azureServiceBusConfig = new ConfigurationBuilder()
            .SetBasePath(executionContext.FunctionAppDirectory)
            .AddJsonFile("local.settings.json", optional: true, reloadOnChange:
true)
            .AddEnvironmentVariables()
            .Build();

        var serviceBusConnection = azureServiceBusConfig["AzureServiceBusConnection
String"];
        var serviceBusQueue = azureServiceBusConfig["ServiceBusQueueName"];
        string composedMessage = "";

        try
        {
            if (uploadedcloudBlob != null)
            {
                log.LogInformation($"Composing message to be sent to the queue");

                composedMessage = $"A blob image {uploadedBlob.Name} was added
queue </br> " +
                                        $"Blob Type: {uploadedBlob.FileType} </br>
" +
                                        $"Blob URL: {uploadedBlob.BlobUrl} </br> "
+
                                        $"Message sent via Azure Durable Functions
App";

                await using (ServiceBusClient client = new ServiceBusClient(service
BusConnection))
                {
                    //Create sender
                    ServiceBusSender sender = client.CreateSender(serviceBusQueue);

                    //Create message
                    ServiceBusMessage message = new ServiceBusMessage(composedMes
sage);
```

```
                    //Send Message to ServiceBus Queue
                    await sender.SendMessageAsync(message);
                    log.LogInformation($"Sent queue message: {serviceBusQueue}");
                    return composedMessage;
                }
            }
            else
            {
                return composedMessage;
            }
        catch (Exception ex)
        {
            log.Error($"Something went wrong sending queue message to {serviceBus
Queue}");
            log.Error($"Exception {ex.InnerException}");
            throw;
        }

    }
```

If look through the overview of the *StorageOrchestration* workflow using Durable Functions, as soon as the user uploads a blob image to the storage account, a queue message is composed to be queued to an Azure Service Bus queue which will then make some tasks of sendinge e-mail, call or SMS to the user or the administrator. This is just a simple implementation and you can do more complex things with the Azure Durable Functions. If you want to try out some of the different patterns, you can try checking out the list of interesting projects on Azure Serverless Community Library.

Entities Functions. Entity functions define operations for reading and updating small pieces of state. We often refer to these stateful entities as durable entities. Like orchestrator functions, entity functions are functions with a special trigger type, entity trigger. They can also be invoked from client functions or from orchestrator functions. Unlike orchestrator functions, entity functions do not have any specific code constraints. Entity functions also manage state explicitly rather than implicitly representing state via control flow.

When you use Entity operations in your function, you can use the following types of operations:

- **Entity Id**: Your target entity
- **Operation Name**: Name of the operation to be performed on the entity
- **Operation Input** (Optional): Input parameter for the operation
- **Scheduled Time** (Optional): Delivery time of the operation

Durable Entities in .NET

If you are using .NET for Durable Entity Functions, there are two ways you can define your durable entities: *class-based* and *function-based*. The *class-based syntax* usually describe entities and its operations as classes or methods which is is more flexible and readable, especially if you want to use interaces. On the other hand, *function-based syntax* allows you to get precision control over your entity functions such as how entity state is managed or the entity operations are being dispatched.

Limitations of Entity Functions

Entity functions and related functionality in Durable Functions are only available in version 2.0 and higher. They are currently supported in .NET, JavaScript, and Python. As of date of writing, the feature is not available in Java or Powershell yet.

If you want to see the entire source code of these durable function types examples, please free to clone my GitHub repository: Azure Durable Functions (Function Chaining Example) in C# .NET (Starter Template). You may use it as a template to get started with your own durable functions or as a reference to this section of the book.

Orchestration Trigger kickstarts Durable Functions

So how do Durable Functions get triggered? Durable Functions have trigger bindings which helps in the execution of the functions for orchestration, activity and entity. The Orchestrator trigger is designed to execute if a new instance of orchestration is being scheduled. Or when the current instance of the orchestrations receives a new event. Such event can be coming from external clients, HTTP trigger, durable timer events, etc.

The Orchestrator trigger configuration is unique and can be customized depending on the the type of programming languages you are using to code your function app. For example, authoring functions in .NET uses the class OrchestrationTriggerAttribute. If you are authoring it in Powershell, Javascript, or Python, you need to define the configuration for this trigger on the *functions.json* file, as shown in *Example 3-5*.

Example 3-4. Example format of the functions.json file which describes the configuration for a durable function app. The property orchestration is optional.

```
{
    "name": "<Name of input parameter in function signature>",
    "orchestration": "<Optional - name of the orchestration>",
    "type": "orchestrationTrigger",
```

```
    "direction": "in"
}
```

The Orchestrator is Deterministic

Of all the Durable Functions types, the orchestrator functions play an important role in keeping your workflow running smoothly. Event sourcing is used in order to maintain the state and reliability of task execution. The orchestrator need to be designed in a deterministic way because the workflow you write in the code will be replayed many times. It expects the same result each replay. For this reason there are some documented and recommended code constraints to follow when designing the workflow in the orchestrator.

Table 3-3 lists some of the code constraints, or dos and don'ts, that you need to know when designing and writing your workflow in the orchestrator function.

Table 3-3. The DOs and DONTs of Writing a Workflow Orchestration in the Orchestrator Function

DONTs	DOs - What you can do instead
Avoid generating GUIDs or random numbers	Make use of the NewGuid() method within the context
Don't access configurations and data	Pass data stores or configuration into activity functions
Never create infinite loops in the orchestrator	CreateAsNew() method in the Durable Orchestration context can be used instead
Prevent having blocking APIs and threads *(Sleep, Run, Delay)*	Use the DurableOrchestrationContext to control the state of your tasks
Never use standard CurrentDateTime() method ex. in .NET	Use CurrentUtcDateTime() method in context instead

There are other important things to consider when you design your stateful orchestration with Azure Durable Functions that fall outside the scope of this book but may be useful for your particular use case. Learn more about the other common orchestrator function code constraints in the Microsoft documentation.

Durable Function Types - Stateful or Stateless?

One of the features that makes Durable Functions effective and useful is its capability to keep the workflow or orchestration of our activity functions stateful. Redhat has a good cloud native article explaining about what is the difference between stateful vs. stateless and the Microsoft article Affairs of State: Serverless and Stateless Code Execution with Azure Functions is also a worth checking out especially for design considerations and best practices for development for Azure Functions in serverless architecture.

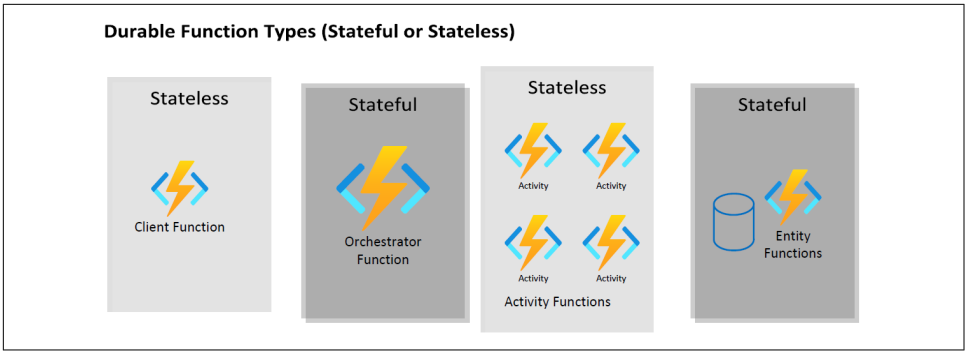

Figure 3-10. The different state for each of the Durable Function Types

Figure 3-10 gives us an illustration what state each durable function type is. Client and activity functions are like the standard Azure Functions that are stateless. On the other hand, the Orchestrator and the Entity functions are stateful.

Application Patterns for Serverless Stateful Workflows

One of the key features that makes it a great serverless compute service is that it enables us to write stateful workflows in serverless architecture or environment. Stateful workflows and orchestrations are special in a way that it helps us solve some of the complex problems in our applications. Normally, complex orchestration use case scenarios are difficult to handle by just using normal functions that loses its state (stateless)[3].

There are six known application patterns that have been documented by Microsoft for Azure Durable Functions. These patterns are useful recommendation in solving some of the common complex use case scenarios in the serverless architecture that we will explore next.

Function Chaining. In the function chaining pattern shown in *Example 3-6*, a sequence of functions executes in a specific order like a chain. The output of one function is applied as the input of the next function.

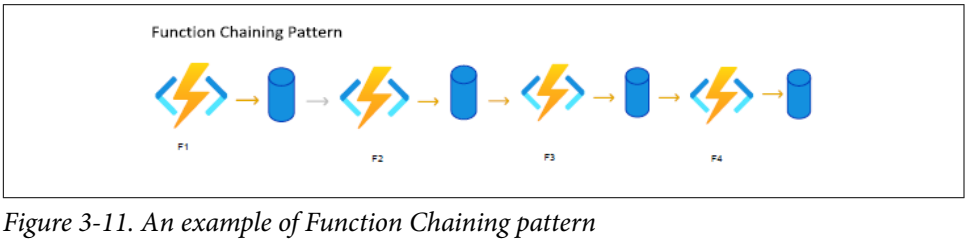

Figure 3-11. An example of Function Chaining pattern

You can use Durable Functions to implement the function chaining pattern concisely as shown in the following example.

Example 3-5. A code block example of Function Chaining pattern

```
[FunctionName("FunctionChainingExample")]
public static async Task<object> Run([OrchestrationTrigger] IDurableOrchestrationCon
text context)
{
    try
    {
        var result1 = await context.CallActivityAsync<object>("MyFunction1", null);
        var result2 = await context.CallActivityAsync<object>("MyFunction2",
result1);
        var finalresult = await context.CallActivityAsync<object>("MyFunction3",
result2);
        return  await context.CallActivityAsync<object>("MyFunction4",finalresult);
    }
    catch (Exception)
    {
        // Error handling, activities or retry-functions to handle exception
    }
}
```

In this example, the values *MyFunction1*, *MyFunction2*, *MyFunction3*, and *MyFunction4* are the names of other functions in the same function app. You can implement control flow by using normal imperative coding constructs. Code executes from the top down. The code can involve existing language control flow semantics, like conditionals and loops. You can include error handling logic in try/catch/finally blocks.

Fan Out / Fan In. In the fan out/fan in pattern, you execute multiple functions in parallel and then wait for all functions to finish, as shown on *Example 3-7*. Usually the aggregation work is done on the results that are returned from the functions as illustrated in *Figure 3-12*.

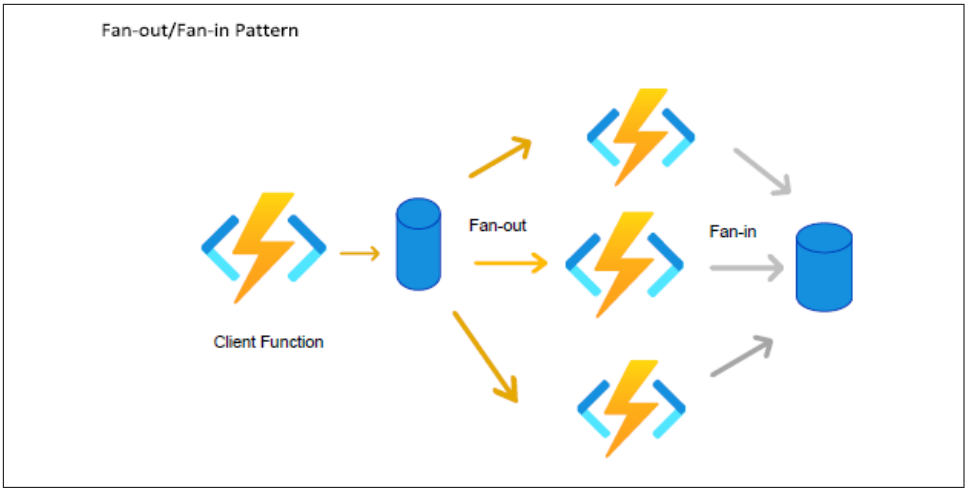

Figure 3-12. An example of Fan-out/Fan-in Pattern

Example 3-6. A code block example of Fan-out/Fan-in pattern

```
[FunctionName("FanOutFanInExample")]
public static async Task Run([OrchestrationTrigger] IDurableOrchestrationContext con
text)
{
    var parallelTasks = new List<Task<int>>();

    // Get a list of N work items to process in parallel.
    object[] workBatch = await context.CallActivityAsync<object[]>("F1", null);
    for (int i = 0; i < workBatch.Length; i++)
    {
        Task<int> task = context.CallActivityAsync<int>("F2", workBatch[i]);
        parallelTasks.Add(task);
    }

    await Task.WhenAll(parallelTasks);

    // Aggregate all N outputs and send the result to F3.
    int sum = parallelTasks.Sum(t => t.Result);
    await context.CallActivityAsync("F3", sum);
}
```

With normal functions, you can fan out by having the function send multiple messages to a queue. Fanning back in is much more challenging. To fan in, in a normal function, you write code to track when the queue-triggered functions end, and then store function outputs.

Async HTTP APIs. If you want to solve the problems related to state coordination of long-running operations with external clients or APIs, then Async HTTP APIs pattern might be useful in solving it.

A common way to implement Async HTTP API pattern is by having the long-running action triggered by an HTTP call, and then redirecting the client to a status endpoint that they can poll to learn when the operation completes. *Figure 3-13* shows a simple illustration on how the flow of it starting, doing the work and getting the status over HTTP.

Durable Functions provide built-in APIs that simplify the code we write for interacting with long-running function executions.

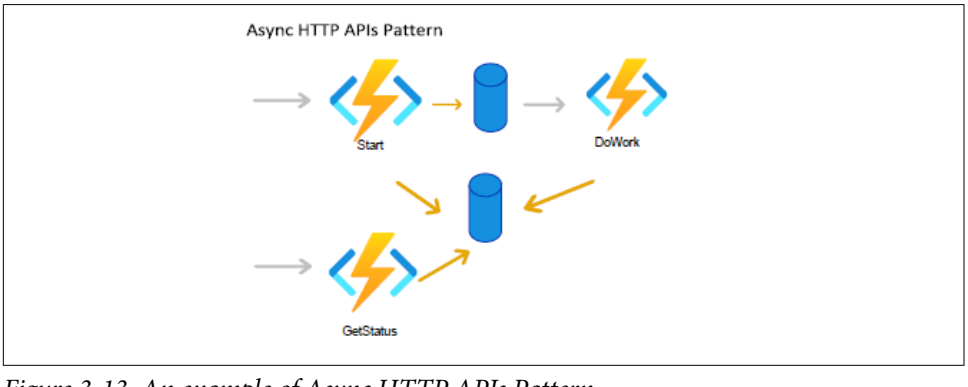

Figure 3-13. An example of Async HTTP APIs Pattern

Example 3-8, shows a simple way how we can use Async HTTP APIs pattern to make a HTTP request to any URL or endpoint.

Example 3-7. A code block example of Async HTTP API pattern checking website status and content via HTTP

```
[FunctionName("CheckWebsiteContentFunction")]
public static async Task CheckWebsite([OrchestrationTrigger]
                    IDurableOrchestrationContext context, ILogger log)
{
    try
    {
       Uri jonahsWebsite = new Uri("https://jonahandersson.tech");

       //Make an HTTP request ex. GET or POST to specific endpoint or URL
       DurableHttpResponse httpResponse = await context.CallHttpAsync(HttpMe
```

```
thod.Get,jonahsWebsite);

       if((int))httpResponse.StatusCode >= 500 && (int)httpResponse.StatusCode <
600)
            throw new HttpRequestException("Hey, there is a server error!");
       else
            log.LogInformation($"Completed");
            log.LogInformation($"Response Code: {httpResponse.StatusCode}");
            log.LogInformation($"Content: {httpResponse.Content}");
    }
    catch (Exception)
    {
        // Error handling, activities or functions to handle exception.
    }
}
```

Finally, if you want to learn more about how you can use Durable Functions Async HTTP APIs and exposing asynchronous, long-running processes over HTTP, check out this Microsoft documentation about its HTTP Features.

Monitor Pattern. The monitor pattern refers to a flexible recurring process in a workflow - for example, polling until certain conditions are met. A regular timer-trigger can address a simple scenario, such as a periodic cleanup job, but its interval is static and managing instance lifetimes becomes complex. Durable Functions enables flexible recurrence intervals, task lifetime management, and the ability to create multiple monitor processes from a single orchestration.

An example use case where monitor pattern can be useful is when you have to run monitoring job processes, as illustrated in *Example 3-9*.

Example 3-8. A code block example of recurring monitoring job workflow using Monitor pattern

```
[FunctionName("MonitorCleanUpJobStatus")]
public static async Task Run([OrchestrationTrigger] IDurableOrchestrationContext con
text)
{
    int cleanUpJobId = context.GetInput<int>();
    int jobPollingInterval = GetPollingInterval();
    DateTime expirationTime = GetExpiryTime();
    string emailAddress = GetEmailAddress();

    while (context.CurrentUtcDateTime < expirationTime)
    {
        // Monitor job status by job id.
        var status = await context.CallActivityAsync<string>( "GetJobCleanUp", clea
nUpJobId);
        if (status == "Completed")
        {
```

```
            // Perform an action when a condition is met.
            await context.CallActivityAsync("SendMonitoringAlert", emailAddress);
            break;
        }

        // Orchestration sleeps until this time.
        var nextMonitorCheck = context.CurrentUtcDateTime.AddSeconds(jobPollingIn
terval);
        await context.CreateTimer(nextMonitorCheck, CancellationToken.None);
    }

    // Perform more work here, or let the orchestration end.
}
```

So, the monitor pattern can be useful in implementing tasks or monitoring jobs that are recurring and needs to be stateful. You can also combine it with durable timer to control the time and workflow based how you prefer it to be.

Human Interaction. There are some processes and tasks that requires some kind of human interaction. The tricky thing about involving us humans in an automated process is that we are not always as highly available 24/7 and responsive like computer systems or cloud systems. For this major reason, developing solutions for the automation of processes can be beneficial. Often timers and programming logic are used to do this, as shown on example of approval work flow on *Figure 3-14* and *Example 3-15*.

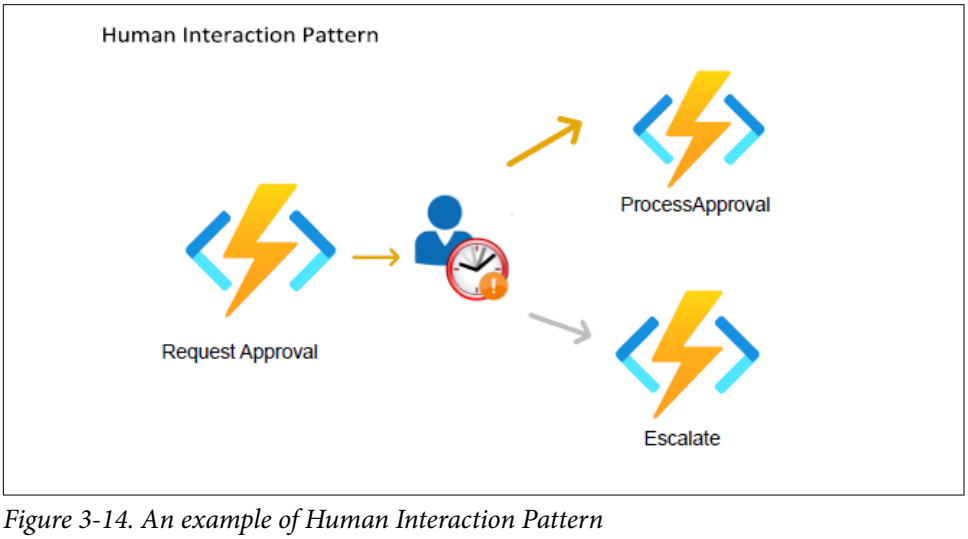

Figure 3-14. An example of Human Interaction Pattern

Example 3-9. A code block example of a simple manager approval workflow coded in C# using Human Interaction pattern

```
[FunctionName("ApprovalFromManagerWorkflow")]
public static async Task Run([OrchestrationTrigger] IDurableOrchestrationContext con
text)
{
    await context.CallActivityAsync("RequestApprovalFromManager", null);
    using (var timeout = new CancellationTokenSource())
    {
        DateTime dueTime = context.CurrentUtcDateTime.AddHours(72);
        Task durableTimeout = context.CreateTimer(dueTime, timeout.Token);

        Task<bool> humanInteractionEvent = context.WaitForExternalEvent<bool>("Manag
erApprovalEvent");
        if (humanInteractionEvent == await Task.WhenAny(humanInteractionEvent, dura
bleTimeout))
        {
            timeout.Cancel();
            await context.CallActivityAsync("ProcessRequest", humanInteractionE
vent.Result);
        }
        else
        {
            //If there is no approval or it timed out
            await context.CallActivityAsync("EscalateToAnotherPerson", null);
        }
    }
}
```

Aggregator Pattern. If you want to collect or aggregate event data over a specific period of time into a single, transmittable entity, then the aggregator pattern is ideal to be used in your durable orchestration. The event data that are being collected and aggregated can be coming from several and different multiple resources which can also be delivered into batches or groups. These event data may be scattered over time. The aggregator is designed to take possible logical action when the event data comes and those external services or clients might need to query these event data that are being aggregated.

The aggregator pattern is not easy to implement in normal functions that are not stateful because of the big challenge of concurrency problems. In normal stateless functions, you need to handle the concurrent multiple threads with same data and also make sure that the aggregator runs on a VM at a time. There are code examples on the official documentation website if you want to learn how to implement the aggregator pattern for stateful entities.

These different application patterns of Durable Functions are useful in different scenarios depending on the type of complex problems or use case scenarios you are try-

ing to solve in your serverless or backend part of your applications. If you want to learn more about real examples, there are a few publications about the use of serverless and Azure Durable Functions on the following papers.

- Durable Functions: Semantics for Stateful Serverless
- Serverless Workflows with Durable Functions and Netherite

Container Services in Azure

One of the great ways to modernize applications for the cloud platform like Microsoft Azure is to build and develop them using containers. One of the major benefits of using containers is Azure is cost-savings for organizations who wants to lift and shift their existing applications to the cloud without making making huge changes. By containerizing existing applications or building them into microservices can help deliver value to the business and application users.

Applications that are containerized have great capabilities like modern tools for development and CI/CD with fully managed container management using the services like Azure Kubernetes. Containers can also be fully controlled and integrated with Azure Active Directory for user access management and security.

Azure Containers and Azure Kubernetes Service

Container Instances and Azure Kubernetes Service are Azure compute resources that you can use to deploy and manage containers. Containers are lightweight, virtualized application environments. They're designed to be quickly created, scaled out, and stopped dynamically. You can run multiple instances of a containerized application on a single host machine.

Azure Container Registry

Azure Container Registry(ACR) allows you to build, store, and manage container images and artifacts in a private registry for all types of container deployments. Use Azure container registries with your existing container development and deployment pipelines. You can also use Azure Container Registry Tasks (ACR Tasks) to build container images in Azure on-demand, or automate builds triggered by source code updates, updates to a container's base image, or timers.

Getting started in creating Azure Container Registry

You can create Azure Container Registry in different ways using the Azure CLI, Azure Portal, PowerShell, Bicep, and ARM templates.

Azure Container Instance

Deploying applications and systems in containers is one of the common app modernization technologies today. Many organizations are considering containerization for many reasons including the benefits of convenient packaging and deployment of applications into containers to the cloud.

Figure 3-15. An example overview of Azure Container Instance

Azure Container Instances (ACI) allows us to run containers in Azure instead of running and managing virtual machines for our applications, as illustrated on *Figure 3-15*. ACI allows you to run and isolate applications and implement task jobs automation.

Azure Container Apps

Azure Container Apps (ACA) is compute service that is designed for developing and deploying applications and microservices using serverless containers. It has great features including containerized apps without managing complex infrastructure and also support for built-in authentication for security.

Although it is not required to use the built-in authentication and authorization in Azure Container Apps, it useful because you make use of the variety of common authentication and identity providers including third-party providers *e.g., Microsoft Identity Platform, Azure Active Directory, Google, Twitter, GitHub, etc.*

ACA combines the benefits of serverless and PaaS that provides a platform for multiple container applications in a serverless environment as shown in *Figure 3-16*. This container solution in Azure as application lifecycle in three different phases *e.g., Deployment, Update, and Deactivate* based on revisions.

When do Azure Container Apps Shutdown?

Aside from the different phases of the application lifecycle mentioned, the Azure Container Apps also has a shutdown phase. This phase is triggered when the container app is being deactivated, delated or being scaled in for updates.

Figure 3-16. An example illustration of the environment of Azure Container Apps with containers apps or microservices.

There are different container services in Azure but the following benefits and uses shown on *Table 3-3* defines an overview of how it differs from the others.

Table 3-4. Common Uses and Benefits of Azure Container Apps

Uses and Benefits	Description
Running applications in Microservices	Develop, deploy and manage your microservices applications in serverless containers with Distributed Application Runtime(Dapr) integration
Deploying API endpoints	The HTTP traffic can be split into different versions of an application with autoscaling features based on concurrent HTTP traffic or requests
Hosting applications with background processing	Run stateful and long-running background jobs or tasks with autoscaling capabilities based on CPU or memory usage
Managing even-driven processing	Manage and auto scale event-driven processes

Implementing Azure Container Apps mean that you can build containerized applications code using any preferred programming language or frameworks, build microservices, and have the option to use it with technologies like Distributed Application Runtime(Dapr), Kubernetes Event-Driven Autoscaling (KEDA) and envoy.

Figure 3-17. An example illustration of Azure Container Apps

Figure 3-17 gives an overview of Azure Container Apps and its features along with integration options for Dapr, KEDA, Envoy and the Azure Kubernetes Service (AKS).

Learn more about KEDA by watching this video KEDA: Event Driven and Serverless Containers in Kubernetes - Jeff Hollan, Microsoft, you may also go through the lessons on the Microsoft Learning Path, Scale container applications in Azure Kubernetes Services (AKS) using KEDA

If you are also curious about the official KEDA documentation, visit the official GitHub page of KEDA for code examples and also check out KEDA scalers that helps you detect if a deployment should be disabled or enabled.

KEDA is a Kubernetes-based Event Driven Autoscaler. KEDA allows your to manage and control the scaling of any container in Kubernetes according to the number of events that needs to be processed. Using *Azure Container Apps* with KEDA (Kubernetes Event-Driven Autoscaler) allows you to automatically scale your applications down to 0 based on HTTP traffic or requests, CPU or memory or any of KEDA's event-driven scalers like Azure Service Bus, Azure Monitor, Azure Event Hubs, SQL DB, Redis and more).

Aside from making use of KEDA, you can also deploy an Azure Container App from *Azure Container Registry (ACR)* using Azure CLI and set up the CI/CD using Azure DevOps Pipelines.

Furthermore, Azure Container Apps are considered top-level Azure resources which means that you can develop it as Infrastructure as Code (IaC) methods using ARM templates, Azure Bicep, Azure CLI, Powershell and other external tools like Terraform and ARM resources are top-level Azure resources, so deployment is done through the standard Azure methods - ARM Template/Bicep, PowerShell, CLI as well as third-party tools such as Pulumi and Terraform.

Azure Kubernetes Services

Kubernetes (K8s) is open-source orchestration software for deploying, managing, and scaling containers. Azure Kubernetes Service (AKS) is ideal if you have use case scenarios where you need full container orchestration. AKS also includes that feature of coordinated application upgrades, automatic scaling, and a feature to perform service discovery across multiple containers.

The following are some of the different uses of AKS in real life scenarios:

- Ease of deployment and management of microservices-based applications because of its features like streamlined horizontal scaling, self-healing, load balancing, and support secret management
- AKS support secure CI/CDa and DevOps implementation with Kubernetes which help improves the speed and security of the development and deployment process
- Provides support for real-time data ingestion for IoT
- Deploy a Machine Learning model as a web service in Azure Kubernetes Service

Figure 3-18 shows a simple example of a use case of AKS.

Figure 3-18. An example reference architecture of microservices architecture on Azure Kubernetes Service.

Furthermore, AKS offers serverless Kubernetes, an integrated continuous integration and continuous delivery (CI/CD) experience, and enterprise-grade security and governance. This allows development and operations teams to collaborate together on a single platform to build, deliver, and scale containerized applications.

Microsoft's Free Learning Books for Kubernetes

Microsoft Azure has free learning resources that you can check out to get started about Azure Kubernetes, Distributed Systems, and Cloud Native Computing architecture.

AKS helps container development simple because of container orchestration capabilities. It also provide developers with the ease of containers deployment and management. Also, one of the good features of is the node auto-repair.

Quantum Computing in Azure - Making Sense of it

Quantum computing is new to many of us. It is promising when the information we read about quantum computing is anywhere. It seems interesting this technology might be the solution to our most significant challenges in the world today - in the field of agriculture, health, energy, material science, etc.[4] Quantum computers are controllable quantum mechanical devices that exploit the properties of quantum physics to perform computations.[5]

Quantum computing provides the exponential advantages when it comes to increasing the speed of some computational tasks. These advantages are possible because of quantum mechanics: superposition, interference, and entanglement. The difference between standard computers and quantum computers is the applications in quantum computers are probabilistic. In comparison, the computers we use daily are usually deterministic. Each possible result produced by quantum algorithms has an associated probability amplitude.[6].

There's a lot that can be said on this topic, and if you'd like to learn more, you can read more on Quantum computing history and background.

Uses of Quantum Computing

Quantum computers are useful in solving problems that require complex calculation with variations of possible combinations. For example using quantum computing in the fields of cryptography, mechanical systems simulation, machine learning, and algorithms.

Azure Quantum

Azure Quantum is the quantum cloud platform of Microsoft. It is cloud service with a diverse set of quantum solutions and technologies used to solve some quantum computing related problems. Even though quantum computing is a new technology, you can prepare for the future of it, by starting to write your code at the algorithm level.

Azure Quantum Development Kit

Azure Quantum Development Kit (Azure QDK) used for development with Azure Quantum using Q#, our quantum-focused programming language and Azure Quantum, our quantum cloud platform. Build and run Q# programs on quantum hardware or formulate solutions that execute optimization solvers running on classical hardware on Azure.

Getting Started with Azure QDK and Q#

Quantum computers are useful in solving problems that require complex calculation with variations of possible combinations. For example using quantum computing in the fields of cryptography, mechanical systems simulation, machine learning, and algorithms. To try an example yourself, check out this Quantum Random Number Generator in Q#

Azure Quantum seems promising technology; however, it is not widely used by general public and developers yet. I have attended one of the Azure Quantum Developer Workshops in the past, and I am very excited to see how it will be used in the future. I created my first Q# program in 2021 and I still have a lot to learn if I wanted to use it in the future.

If you want to try it out to explore, I recommend Microsoft's Quantum Learning Resources like the Quantum Computing Foundations Learning Path and join the Q# Community.

Learn By Doing (Try it out!)

Instead of creating customized hands-on learning labs for the topics discussed in the this chapter, the following quick-start tutorials are most recommended as they are updated based on Microsoft's technical updates for the service. This section is recommended and optional.

Creating and Provisioning VMs in Azure

- Microsoft Quickstart Tutorial for creating a Windows VM in Azure Portal
- Microsoft Quickstart Tutorial for creating a Linux VM in Azure Portal

Developing Azure Web Apps

- Microsoft Quickstart Tutorial hosting a web application using Azure App Service
- Microsoft Quickstart Tutorial on how to deploy and run a containerized web app with Azure App Service

Serverless Development with Azure Functions

- Choose your desired programming language by following through the serverless lessons at Azure Functions University on GitHub

Develop Serverless Containers using Azure Container Apps

- Microsoft Quickstart Tutorial for deploying a Dapr Application to Azure Container Apps using Azure CLI
- Microsoft Quickstart Tutorial for deploying a Dapr Application to Azure Container Apps using Azure CLI
- Microsoft's Tutorial for deploying a Dapr Application to Azure Container Apps using an ARM or Bicep template

Try programming and solving a problem with Azure Quantum

- Quickstart: Solve an optimization problem in Azure Quantum

Summary

In this chapter, we learned about one of the most widely used category of services used in Microsoft Azure, Azure Compute. Azure Compute services allow us to create and build modern applications and systems regardless if it is for standard use for the web and different architectures like serverless, microservices or containers.

Sserverless computing provides advantages such as auto-scalling, consumption pricing model, isolating different logic functions, and developer productivity without the hassles of spending costs and resources in maintaining servers. If you want to build serverless stateful workflows and orchestrations by code, you can also do that using Azure Durable Functions, which has a set of important authoring and coding constaints worth to take note of.

We learned how compute services like Azure App Service can empower and equip us in our modern app development. With Azure Static Web Apps we are able to create fast and reliable SPA with deployment automation with GitHub Workflow. We can implement powerful backend services and function apps using the event-driven features of Azure Functions and Durable Functions for stateful workflow orchestrations. Also, Azure Kubernetes and Azure Container apps allow us to create serverless container apps with orchestration, scaling and load-balancing capabilities. We also learned about Azure Quantum service and Quantum SDK for creating cloud solutions that help solve complex problems that can only be solved by quantum computing.

Finally, all these compute services are available in Azure so that developers, teams, and organizations can build and deploy better applications and systems that are more scalable, efficient, and secure.

Check Your Knowledge

1. What is the difference between Azure VMs from Azure VM Scale Sets?
2. What are Azure Spot VMs?
3. Why do you think Azure Container Apps are the best way to deploy microservices?
4. What Azure Compute service would you use if you want to write stateful serverless workflows?
5. What programming language and developments tools would you primarily need for Azure Quantum?

To find the answers to the *Check Your Knowledge*, turn to back of the book in the Appendix.

Recommended Resources

- AzureCharts.com
- Choose an Azure compute service for your application
- Microsoft Azure Functions Documentation
- Azure Durable Functions Documentation
- Developer's Guide to Durable Entities in .NET
- Microsoft Documentation of Azure Container Registry
- Azure Container Apps Official Documentation
- Azure App Service Microsoft Documentation
- Azure Quantum Documentation (Preview)
- Learn the Basic of Kubernetes
- Core concepts for Azure Kubernetes Service (AKS)

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CHAPTER 4

Microsoft Azure Cloud Networking

A Note for Early Release Readers

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 4th chapter of the final book. Please note that the GitHub repo will be made active later on.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *jleonard@oreilly.com*.

> *Azure networking is essential to any public cloud, it allows us to bring both on-premise and cloud networks together. We can scale resources to meet our demands as well as protect our infrastructure; this gives us the flexibility to change to meet any resource demand that our organization or customer may need. With Azure networking, we get compliance and security. It also saves on costs and time which gives us the flexibility to adapt and meet our demands, both current and future.*
>
> — Ryan O'Connell, IT Solutions Architect, Microsoft Azure MVP, Microsoft Certified Trainer, IT Manager, Blogger at RockITWorks

Now that we've learned about the common modern *Azure compute services* and their benefits for application development in Microsoft Azure, we will deep dive into the concepts you need to learn to implement these compute services with the known networking services in Azure. By the end of this chapter, you will have learned how you can use the appropriate networking service with existing applications. These will also help in planning networking and hybrid solutions in Azure.

Azure Networking

Azure Networking is a category of services in Microsoft Azure that provides fully-managed and scalable networking and connectivity options like making a connection between your on-premise data center to the cloud. With networking services in Azure, you can also build secure virtual network infrastructure, manage your application's network traffic and protect them against DDoS attacks. Networking resources in Azure can also be used to enable secure remote access to internal resources within your organizations and globally route your network connectivity with features of monitoring and security.

Figure 4-1 shows us an overview of some of the most commonly used networking and connectivity resources in Microsoft Azure. These services help in integrate your on-premise data center with Azure, load balancing your network traffic, and protecting your network from DDoS attacks.

Figure 4-1. An overview of the common networking, connectivity and network security services in Azure

Using your Azure subscription, while logged in, you can view all of the Azure resources you can create on the networking category on the Azure Portal. You just need to click *Create a resource* and select the *Networking* category on the Azure Marketplace, and there you can explore the rest of the networking resources by Microsoft and Microsoft Partners.

By making use of the Azure Marketplace you will be able to see a list of different types of Azure resources, apps and services for different categories and deployment models.

Azure Networking Services Categories

There are many networking services to choose from in Azure and they are categorized into groups according to their purpose.

Services for Connectivity
: The services under this group category are the Azure networking resources that you can create and build for connectivity-related solutions in the cloud. For example, if you want to connect your Azure resources to your on-premise resources, you can use them such as Azure Virtual Network (Azure VNet), Express- Route, Virtual WAN, Virtual network NAT Gateway, VNet Peering service, VPN Gateway, Azure Bastion, and Azure DNS.

Services for Application Protection
: The networking services under this group category are intended for networking resources that will help secure and protect your applications or systems in Azure. For example, you can implement networking services like Azure Load Balancer, Firewall, VNet Endpoints, Private Link, and DDoS protection.

Services for Application Delivery
: The services under this category are ideal in use-case scenarios you need for application delivery. Such networking resources include *Azure Content Delivery Network* (Azure CDN) for content delivery, global routing web traffic using *Azure Front Door Service*, load balancing your traffic across Azure regions globally using the Azure Traffic Manager, and other resources like Application Gateway, and Internet Analyzer.

Services for Network Monitoring
: Monitor your network resources using any or a combination of these networking services in Azure - Network Watcher, ExpressRoute.Monitor, Azure Monitor, or VNet Terminal Access Point (TAP).

We'll explore each of these categories in greater detail throughout the rest of the chapter to give a better understanding of the different networking services for different use cases and scenarios.

Azure Networking Services for Connectivity

Azure provides a network infrastructure that is robust, fully managed, and dynamic to support complex network architecture. These network solutions vary from creating public access to applications network security and making hybrid connections between infrastructure on-premises and on the cloud.

Azure Virtual Network

Azure Virtual Network (Azure VNet) plays an important role in building the networks within the Azure infrastructure. It is a fundamental block of keeping your Azure resources in a private network where you can securely manage and connect to other external networks (public and on-premises) over the Internet.

Azure VNet goes beyond the usual on-premise and traditional networks that we know. Aside from the benefits of isolation, high availability, and scalability, Azure VNet helps secure your Azure resources by allowing you to administrate, filter, or route network traffic based on your preference.

For example, *Azure VMs* are basically connected or attached to an Azure VNet through virtual network interface cards (VNICs), as shown in *Figure 4-2*, where an Azure VM is attached to three NICs: *Default*, *NIC1*, and *NIC2*)

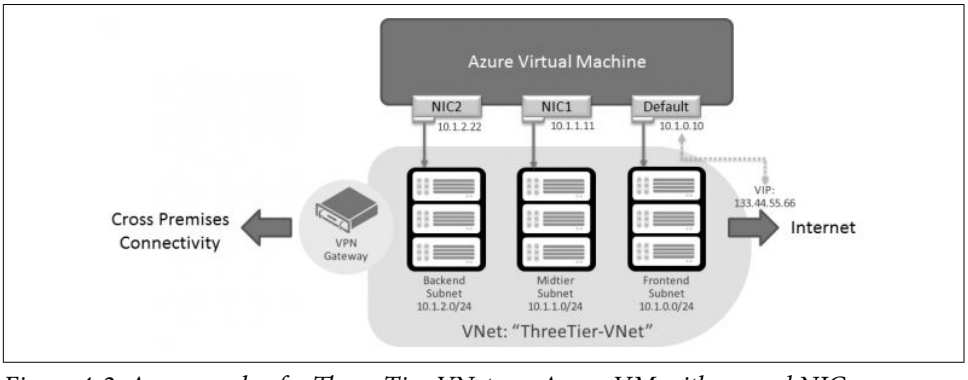

Figure 4-2. An example of a Three-Tier VNet, an Azure VM with several NICs

Azure resources need to securely communicate with each other internally in its private network, over the internet, and also networks on on-premise infrastructure. Azure VNet makes this possible for these. Let's take a closer look at these forms of communication.

Internet Communication
: Azure VNet, by default is capable of communicating outbound to the Internet. If you want to communicate to an Azure resource inbound, you may do that using an Azure Public IP address or Azure Load Balancer that is set public.

Communication and Connection with Azure resources
: Azure resources can securely communicate through the virtual network, VNet Peering and by extending virtual network service endpoints. For example, it is possible to deploy some dedicated Azure resources like *AKS*, Azure Batch, Azure SQL Manage Instance, Azure AD Domain Services, Azure Container Instance (ACI), Azure Functions, Azure App Service Environments, Azure VM Scale Sets within the same virtual network.

Network traffic routing and filtering
: The network traffic can be filtered between subnets in several ways. Network security groups (NSG) and application security groups can be used to control security rules (inbound and outbound) to control and filter network traffic. Another good option is the make use of a network virtual appliance virtual

machine where you can configure your firewall settings, and network rules and optimize your WAN. On Azure Marketplace, you will find some of networking appliance managers available for external services or within Microsoft.

Azure VNet Peering

Azure Virtual Network Peering (VNet Peering) allows you to connect several *virtual networks* in Azure. The connectivity and traffic between the virtual machines in the peered virtual networks uses Microsoft's infrastructure on a secure private network. Virtual networks that are peered can directly share and connect with the resources located in either virtual networks.

Currently, Azure supports both Virtual network peering and Global network peering. The difference between these two is that Global network peering connects virtual networks across Azure regions while Virtual network peering connects virtual networks within the same Azure region.

Figure 4-3 shows us an example illustration and overview of how VNet Peering works between two virtual networks, *VNet A* and *VNet B* which has a several connections to other networking resources.

Figure 4-3. An example of a VNet Peering in Azure

Both virtual network peering and global virtual network peering support gateway transit, which is a property in peering that allows a virtual network to make use of the peered virtual network's *VPN gateway* for the cross-premises connectivity or VNet-to-VNet connectivity. You can configure Configure VPN gateway transit for VNet peering through Azure Portal, Powershell, ARM template and Azure CLI.

Troubleshooting VNet Peering Issues

Azure VNet Peering issues can occur; therefore, troubleshooting is necessary to understand the root cause of the issue. One of the common troubleshooting questions to consider is whether the virtual networks are in the same subscription or not and if they are in the same region or a different region. For more details about different types of problems with VNet peering, please refer to Microsoft's documentation on Troubleshooting VNet Peering issues.

On a final note, VNet peering uses IP addresses. It is good to know that there are two types of IP addresses that are you used in Azure - Public IP and Private IP The *Private IP addresses* are used for the connectivity and Azure resources communication within the same *Resource Group*. On the other hand, *Public IP addresses* are used to allow Internet resources to communicate inbound to Azure Azure resources. Using this type of IP address enables communication of Azure resources and public-facing Azure services over the Internet.

Learn more about IP services and some recommended best practices for Azure Virtual Network.

Azure Virtual Wide Area Network

Azure Virtual WAN is a managed networking service and unified framework used for networking, security, and routing functionalities. The Azure Global Network is what enables Azure Virtual WAN to be available. It includes Site-to-site, Point-to-site VPN connectivity, ExpressRoute, etc.

Virtual WAN helps organizations or business units to connect to the Internet and other Azure resources. For example, networking and remote user connectivity, which is effective and useful for those who prefer to work from home or anywhere they want.

The following are some of the known features of Azure Virtual WAN:

- Branch connectivity (via connectivity automation from Virtual WAN Partner devices such as SD-WAN or VPN CPE).
- Site-to-site VPN connectivity.
- Point-to-site VPN connectivity for remote users
- Private connectivity using ExpressRoute
- Intra-cloud connectivity for virtual networks
- Inter-connectivity using VPN ExpressRoute
- Routing, Azure Firewall, and encryption for private connectivity

Azure Virtual WAN also has benefits like integrated connectivity solutions in the hub and spoke, automated spoke configuration, and troubleshooting and monitoring tools. Also, when configuring it, you would need Virtual WAN resources such as Virtual WAN, Virtual Hub, Hub virtual network connection, Hub-to-hub connection, hub route table, and site resource

Figure 4-4 shows an example of Azure Virtual WAN being used and implemented for remote connectivity.

Figure 4-4. An overview Azure Virtual WAN,

Migrating to Azure Virtual WAN

Since each migration is unique, we won't cover this in detail. However, there are options and resources available to help you navigate your migration to Azure Virtual WAN.

Azure Virtual WAN is a broad and complex topic itself. If you want to deep dive into it, I recommend reading Microsoft's Virtual WAN Documentation.

Azure Express Route

Azure Express Route allows you to expand networks that are on on-premises into Microsoft's cloud infrastructure using a connectivity provider over a private connection. Basically, this networking service gives the capability of connecting your on-premise networks with Azure, Microsoft's cloud. This connection between an on-premise network and Azure can be initiated using an any-to-any (IPVPN) network with Layer 3 connectivity, which enables you to interconnect with Microsoft's cloud to your own on-premise WAN or data center.

The connection in Azure Express Route is private, and the traffic with this connection does not go over the Internet. This means that the connections made using Express Route promise speed, reliability, availability and better security compared to connections over the public networks.

A secure network connection can be established with other cloud resources in Microsoft like Microsoft 365, Dynamic 365, and Microsoft Azure, as shown in *Figure 4-5*.

Figure 4-5. An overview of how Azure Express Route connections between public and on-premises networks, Image Credit: Microsoft Documentation

Express Route has several useful features such as support for different connectivity models between your on-premises network and Azure. As shown in *Figure 4-6*, these connectivity models can be done using service providers or directly. As for using service providers there are currently three types of models - *Cloud exchange co-location*, *Point-to-point Ethernet connection*, and there's also the *Any-to-any (IPVPN) connection*. *ExpressRoute Direct* can also be used for direct connection model to Microsoft Azure.

Figure 4-6. A basic example of the different connectivity models of Azure Express Route

Express Route Direct is a good Azure service ideal if you want to directly connect your network into Microsoft's network globally at peering locations up to 10-Gps speed of connectivity. You can create *ExpressRoute Direct* connection through the Azure Portal, Azure CLI, and Azure CLI. Learn more about ExpressRoute Direct circuits, workflows, VLAN tagging, SLA, and pricing.

NAT Requirements for using Express Route

When you configure and manage Express Route, NATs are needed to connect to Microsoft cloud services using Express Route. Connectivity service providers usually offers NAT management as a service. Otherwise, there are some NAT requirements for Microsoft peering and even Azure public peering. There are also some ExpressRoute routing requirements that you need to be aware of.

Azure ExpressRoute has the option to implement private peering for Azure resources like virtual machines and Azure Virtual Desktop RDP Shortpath within the virtual networks.

Azure ExpressRoute Global Reach. Aside from the different connectivity models of Azure Express Route for direct connection and service providers, there is also another type of related networking service called *ExpressRoute Global Reach*, which is designed for scenarios like connecting an organization's branch offices across the world.

For example, if your Express Route service provider does not operate in certain locations or countries of your office branch, you may consider using the service provider locally in that location or country. By doing this as an alternative solution, Microsoft will be able to help and provide a solution to connect your organization's branch offices to your main Express Route service provider in your main office location using its global network and Express Route.

The locations of the ExpressRoute are the starting connection point to the globally distributed network infrastructure of Microsoft. Due to this great capability Express Route users are able to connect around the world using Microsoft's network.

Azure VPN Gateway

A VPN gateway is a specific type of virtual network gateway that is used to send encrypted traffic between an Azure virtual network and an on-premises location over the public Internet. You can also use a VPN gateway to send encrypted traffic between Azure virtual networks over the Microsoft network. Each virtual network can have only one VPN gateway. However, you can create multiple connections to the same VPN gateway. When you create multiple connections to the same VPN gateway, all VPN tunnels share the available gateway bandwidth.

Different Types of VPN Gateway Connections

In order to create a VPN Gateway connection, we need to know the different configurations for VPN gateway connections. These different types of connections will give you a clear overview and understanding on what is ideal to use based what suits your business requirements.

Site-to-Site VPN (S2S)
: The Site-to-Site (S2S) connection runs over *IPsec/IKE (IKEv1 or IKEv2)* VPN tunnel. IPsec VPN is one one of the common VPN protocols used for establishing VPN connection. The S2S VPN gateway connections can be implement hybrid or cross-premises use case scenarios. This type of gateway also requires a VPN device that must be located on-premises. This VPN device should have a public IP address designated to it.

Point-to-Site VPN
: The Point-to-Site (P2S) type of VPN connection is applicable if you want to connect a client computer to a virtual network like Azure VNet. In this the type of VPN connection that needs to be initiated from the client computer which is useful for remote working.

VNet-to-VNet (IPsec/IKE VPN tunnel)
: Unlike the P2S VPN connection, the VNet-to-VNet connection is for connecting between VNets, even virtual networks on on-premises. This type of VPN gateway uses secure connection using IPsec/IKE. Configuring for multiple sites connection is also possible in this type of VNet-to-VNet connection.

Site-to-Site and ExpressRoute
: The network traffic for the Site-to-Site VPN gateway is securely encrypted through the public Internet. ExpressRoute is also good in creating a private and direct connection from WAN to Azure and other Microsoft services. This means that configuring ExpressRoute together with Site-to-Site VPN have advantages especially if it is set for the same virtual network.

VNet-to-VNet Connections Good to know

The VNets you connect using VNet-to-VNet (IpSec/IKE VPN Tunnel) connections can be in different or same Azure regions, subscriptions, and deployment models.

One of the important steps when configuring the VPN gateway is choosing the appropriate type. A virtual network can only have one VNet gateway and it is important to choose the correct type of gateway. For example, if you are configuring it for VPN, then you would need to use the *GatewayType = Vpn* and for *ExpressRoute* would be its keyword value. Check the guide for configuring VPN Gateway settings and some requirements that you need to know.

Azure NAT Gateway for Virtual Networks

Azure Virtual Network NAT (*Network Address Translation*) helps in simplifying the outbound Internet connectivity for virtual networks (*one or several subnets*). Once a subnet is associated with a NAT gateway, the NAT gives the benefit of providing a

Source Network Address Translation (*SNAT*). When VNet NAT is configured on a subnet level, the outbound connectivity will use the specified static public IP addresses. *Figure 4-7* shows a basic illustration of how Azure VNet NAT gateway works with a virtual machine with public IP.

Figure 4-7. A basic example of an instance-level Public IP with a virtual machine and NAT

The following are some of the benefits of using Azure VNet NAT.

Security and Privacy
: Azure VNet NAT Gateway doesn't need to have public IP addresses; therefore, the connection between virtual networks is fully private and secured. Resources can still connect to external resources outside VNet even without public IP addresses

Scalability
: There is a benefit of scalability because all compute resources belong to a subnet. All subnets can communicate and use the same resource in the same virtual network. An example of this is automatic scaling is possible with the use of Public IP Prefix, which assists in identifying and scaling how many outbound IP addresses are required.

Resiliency
: One of the good things to know is that NAT does not have any individual dependency on other compute instances which is the result of it being a distributed and fully-managed service. This feature and capability make it very resilient as a software-defined networking service.

Performance
: The performance of using NAT Gateway is satisfactory because as mentioned it is a software defined networking service, which means it that when it is running it will not have a negative effect on the network bandwidth.

Azure VNet NAT Gateway provides you with the ability to control who has access to your organization's resources and what locations they can be accessed. For these reasons, NAT Gateway can be useful whitelisting a group of people working as contractors for a company.

NAT is not applicable and supported to work with basic Public IP addresses and load balancers. If you need to use NAT Gateway in your implementation, you would need to use Standard versions instead or upgrade Azure Public Load Balancers to higher versions.

If you want to try designing a virtual network using NAT Gateway, check Microsoft Docs: Designing virtual networks and a recorded video about it on Azure Friday.

Azure DNS

Azure DNS is a hosting service for DNS domains that provides name resolution by using Microsoft Azure infrastructure. By hosting your domains in Azure, you can manage your DNS records by using the same credentials, APIs, tools, and billing as your other Azure services. You can't use Azure DNS to buy a domain name. For an annual fee, you can buy a domain name by using App Service domains or a third-party domain name registrar. Your domains then can be hosted in Azure DNS for record management.

The following are some of the known key features of the use of Azure DNS:

Reliability and performance
: DNS domains in Azure DNS are hosted on Azure's global network of DNS name servers. Azure DNS uses anycast networking. Each DNS query is answered by the closest available DNS server to provide fast performance and high availability for your domain.

Security
: Azure DNS is secured because is linked to Azure Resource Manager which associated to user identity control service like Azure RBAC and Azure Resource Lock Resource locking is used to prevent other users in your organization from accidentally deleting or modifying critical resources.

Alias records
: Azure DNS supports alias record sets. You can use an alias record set to refer to an Azure resource, such as an Azure public IP address, an Azure Traffic Manager profile, or an Azure Content Delivery Network (CDN) endpoint. If the IP address of the underlying resource changes, the alias record set seamlessly updates itself during DNS resolution. The alias record set points to the service instance, and the service instance is associated with an IP address. Also, you can now point your apex or naked domain to a Traffic Manager profile or CDN endpoint using an alias record.

Easy To Use
: Azure DNS does not currently support DNSSEC. In most cases, you can reduce the need for DNSSEC by consistently using HTTPS/TLS in your applications. If DNSSEC is a critical requirement for your DNS zones, you can host these zones with third-party DNS hosting providers.

Azure DNS Limitation for DNSSEC

Domain Name System Security Extentions (DNSSEC) are currently not supported in Azure DNS. However, you can have a work-around alternative of using HTTP/TLS in the configuration of your applications. If your DNS zones require DNSSEC, then you choose to host them externally through DNS providers.

By using Azure DNS, you host your own domain websites in Azure, manage your DNS records and integrate it with the resources hosted in Azure. If you have an existing domain, there are a number of ways to host it in Azure DNS. Microsoft has different guides for setting up your own custom domain oon a function app, web app, blob storage, or other Azure resources.

Azure Bastion

The Azure Bastion service is a new, fully platform-managed PaaS service that enables secure virtual machine connections. It provides secure and seamless RDP/SSH connectivity to your virtual machines directly in the Azure portal over TLS. When you connect via Azure Bastion, your virtual machines do not need a public IP address.

Azure Bastion is a service for networking in Azure that will allow you to connect to a virtual machine from a web browser and the Azure portal. It is a fully platform-managed PaaS service provisioned inside your virtual network.

It provides secure and seamless RDP/SSH connectivity to your virtual machines directly over TLS. This means that when you connect to your VMs via Azure Bastion, your VM does not require a public IP address, agent, or client software like we normally do.

You can connect securely via RDP and SSHto all of the VMs in the virtual network where Azure Bastion is provisioned. By doing this, you are securely connecting to your virtual machines and are not exposing RDP/SSH ports to the public Internet.

The following are some of the key benefits and uses of Azure Bastion:

RDP and SSH directly in a web browser
: Since Azure Basion uses HTML5-based web client, you can access your virtual machines on any device. This means that you don't need to download supported RDP or SSH client to connect to a VM. You can connect to your virtual machines

securely using RDP and SSH session directly on any web browsers through the Azure portal.

No Public IP Not Required on the Azure VM
: Azure Bastion opens the RDP/SSH connection to your Azure virtual machine using private IP on your VM. You don't need a public IP on your virtual machine.

Save time from managing Network Security Groups (NSGs)
: Azure Bastion is a fully managed platform PaaS service from Azure that is hardened internally to provide you secure RDP/SSH connectivity. You don't need to apply any NSGs to the Azure Bastion subnet. Because Azure Bastion connects to your virtual machines over private IP, you can configure your NSGs to allow RDP/SSH from Azure Bastion only. This removes the hassle of managing NSGs each time you need to securely connect to your virtual machines.

Protection against port scanning
: Virtual machines are secured and protected against port scanning by rogue and malicious users located outside your virtual network.

Protect against zero-day exploits
: Azure Bastion is a fully platform-managed PaaS service and the Azure platform protects against zero-day exploits by keeping the Azure Bastion protected from exploits by keeping everything updated for you.

Azure Bastion can be considered as a flexible and secured way to connect virtual machines on the go. If you want to learn more about it and how it is used, check out this video guide on how to use Azure Bastion to connect securely to your Azure VMs on Azure Friday.

Services for Application Protection

This section describes networking services in Azure that help protect your network resources. Using any or a combination of these networking services in Azure, you can secure your applications and workloads in the cloud.

Azure Firewall

Azure Firewall is a cloud-native and intelligent network firewall security service that provides the best of breed threat protection for your cloud workloads running in Azure. It's a fully stateful, firewall as a service with built-in high availability and unrestricted cloud scalability.

The following are the different category types of Azure Firewall which helps in identify which is right for your needs.

Azure Firewall Standard

As shown in *Figure 4-8*, the Azure Firewall Standard provides Layer 3 to Layer 7 firewall filtering and threat intelligence feeds from Microsoft Cyber Security. These treat feeds can be used to notify any important altert and can even deny network traffic from/to any malicious domains and IP addresses to protech Azure resources against possible hacking or attacks.

Azure Firewall Premium

As shown in *Figure 4-9*, there is another alternative category called Azure Firewall Premium. This category provides advanced capabilities such as signature-based IDPS that enables detection of attacks by analyzing and detecting for specific patterns. These patterns can include byte sequences in network traffic or any known malicious instruction sequences used by malware. This tier also support 3rd party offerings available from WatchGuard, Sophos, Palo Alto, Check Point, and the like.

Figure 4-8. A basic example of Azure Standard

Figure 4-9. A basic example of Azure Premium

Known issues for Azure Firewall

There are documented and known issues for both the Standard and Premium version of Azure Firewall. These issues and limitations are good to know.

Aside from the different Azure Firewall categories and tiers, you can centrally manage Azure Firewalls across multiple Azure subscriptions using the Azure Firewall Manager. It supports setting up centralized security and route management. This firewall policy can be utilized by applying a common set of firewall rules in your network or application in your Azure tenant. Azure Firewall Manager supports firewalls in environments like VNet and Virtual WANs (Secured Virtual Hub).

Azure Firewall is an excellent choice to secure your Azure resources. I expect that the team behind Azure Firewall will continue to add features to both standard and premium tiers. As mentioned above, I will be leading with Azure Firewall when designing solutions for our customers.

Azure DDoS Protection

Azure DDoS Protection provides counter measures against the most sophisticated DDoS (Distributed Denial of Service) threats that can cause severe and highly impactful loss for its victims. Azure's DDoS protection service provides advanced DDoS mitigation features for your application and resources.

Furthermore, customers using Azure DDoS Protection have access to support and communicate with DDoS experts using the Azure DDoS Rapid Response during an active attack. Azure DDoS Protection Standard plan is a prerequisite to this support.

Figure 4-10 shows a basic illustration and example of how Azure DDoS protection works in securing an application gateway in a virtual network.

Figure 4-10. A basic illustration of Azure DDos protection for a web application in a virtual network

If you are an engineer with a role involving securing resources in Azure, I recommend learning the basic concepts of Azure security and protecting Azure resources from DDoS attacks.I recommend you to check out Microsoft's learning path for Introduction to Azure DDoS Protection.

Azure Private Link

Azure Private Link enables you to access Azure PaaS Services (for example, Azure Storage and SQL Database) and Azure hosted customer-owned/partner services over a private endpoint in your virtual network. Traffic between your virtual network and the service travels through the Microsoft backbone network. Exposing your service to the public internet is no longer necessary. You can create your own private link service in your virtual network and deliver it to your customers.

Web Application Firewall

Azure Web Application Firewall (WAF) provides protection to your web applications from common web exploits and vulnerabilities such as SQL injection, and cross site scripting. *Figure 4-11* shows an example illustration on how Azure WAF works.

Azure WAF provides out of box protection from OWASP top 10 vulnerabilities via managed rules. Additionally users of WAF, can also configure custom rules, which are customer managed rules to provide additional protection based on source IP range, and request attributes such as headers, cookies, form data fields or query string parameters.

Figure 4-11. A basic example of Azure Web Application Firewall

Users or Azure administrators can choose to deploy Azure WAF with Application Gateway which provides regional protection to entities in public and private address space. It is also possible to deploy Azure WAF with Azure Front Door which provides protection at the network edge to public endpoints.

Network Security Group (NSG)

Network Security Groups (NSGs) are built-in tools for network control that allow us to control incoming and outgoing traffic on a network interface or at the subnet level. They contain sets of rules that allow or deny specific traffic to specific resources or subnets in Azure. An NSG can be associated with either a subnet (by applying security rules to all resources associated with the subnet) or a Network Interface Card (NIC), which is done by applying security rules to the Virtual Machine (VM) associated with the NIC.

Figure 4-12 illustrates how NSG is being used at different levels to protect several virtual machines in different subnets in a virtual network.

Figure 4-12. An example implementation overview of a virtual network protected with NSG

Azure Load Balancer

Azure Load Balancer is a load balancing networking service that provides the capability of distributing traffic across multiple virtual machines (Azure VMs) or a group of resources in a single Azure region. This resource is known for its best performance with ultra-low latency. The algorithm for Azure Load Balancer uses a tuple-based hashing distribution, which means that the tuple hashes itself on the bases of its elements.

Figure 4-13 shows us an example of a 5-tuple hash (*source IP, source port, destination IP, destination port, and protocol type*) that are to be mapped to the traffic to any available servers.

Figure 4-13. An illustrative example of Azure Load Balancer with 5-tuple hash distribution

The hash-based and source IP affinity are both supported in the Azure Load Balancer service. This means that you have the option to set up the configuration of your preferred distribution mode for traffic distribution.

Key Uses of Azure Load Balancer. Azure Load Balancer, as shown in *Figure 4-14* is a powerful resource to use of creating applications that are highly available and scalable for inbound and outbound connections.

The following are some of the uses and benefits of using the standard Azure Load Balancer:

- Improve the distribution of Azure resources with better availability
- Configure connectivity and load balancing of Azure VMs for incoming and outgoing traffic
- Monitoring of Azure resources that are being load-balanced and distributed by the Azure Load Balancer
- Require port forwarding, load-balance with IPv6, multiple ports or IP addresses
- Ability to migrate load balancing resources across different Azure regions

Figure 4-14. An example of a hash base type of load balancing in Azure.

The load balancer operates in *Open Systems Interconnection* (OSI) model at layer 4 which distributes traffic based on protocol, source IP address and port numbers and destination IP address and port. The main purpose of load balancer is to distribute the inbound flows from both backend and frontend pool instances.

Azure Load Balancer has some important components, as described in *Table 4-15*, a few key components which can be configured in your Azure subscription on the *Azure Portal*. You also have the option to configure it using other Azure tools like *Azure Powershell*, *Azure CLI*, or *ARM* templates.

Table 4-1. Azure Load Balancer Components

Component	Description
Frontend IP Configuration	The IP address (Public or Private) you set on a Load Balancer will be your client's access point. The type of load balancer depends on what kind of IP address you have. For example, the Private IP address for the internal load balancer while the public IP is for the public load balancer
Backend pool	It is generally recommended to add more instances to the backend pool in order to cost-effectively scale and handle high demands of incoming traffic. To optimize the operations, it is worth considering designing for the least number of individual backend pool resources
Load Balancer rules	A load balancer rule configured with protocol - all and port - 0 is known as a High Availability (HA) port rule. This rule enables a single rule to load-balance all TCP and UDP flows that arrive on all ports of an internal Standard Load Balancer. The HA ports load-balancing rules help you with critical scenarios, such as high availability and scale for virtual network appliances (NVAs) inside virtual networks
Health probes	A health probe is used to determine the health status of the instances in the backend pool. During load balancer creation, configure a health probe for the load balancer to use. This health probe will determine if an instance is healthy and can receive traffic
Inbound NAT rules	An inbound NAT rule forwards incoming traffic sent to frontend IP address and port combination. The traffic is sent to a specific virtual machine or instance in the backend pool. Port forwarding is done by the same hash-based distribution as load balancing
Outbound rules	An outbound rule configures outbound Network Address Translation (NAT) for all virtual machines or instances identified by the backend pool. This rule enables instances in the backend to communicate (outbound) to the internet or other endpoints.

Component	Description
High Availability Ports	The HA ports load-balancing rules help you with critical scenarios, such as high availability and scale for network virtual appliances (NVAs) inside virtual networks. The feature can help when a large number of ports must be load-balanced

Azure Load Balancer with Several Frontends

If you need a need to set up load balancers in more than one front-end, you can also configure it for multiple frontends, check out Microsoft's guide for Multiple frontends for Azure Load Balancer

Load balancing is a term commonly used for workload distribution across several computing resources. This process helps optimize the uses of resources, fix issues with response times, increase throughput, and prevent single resource overloading. In Azure, there are other known services for load balancing such asTraffic Manager, Azure Front Door, and Application Gateway.

To learn and investigate more on which load balancing network service is suitable for specific scenarios, check out Reviewing Network options and identitifying requirements for workload networking.

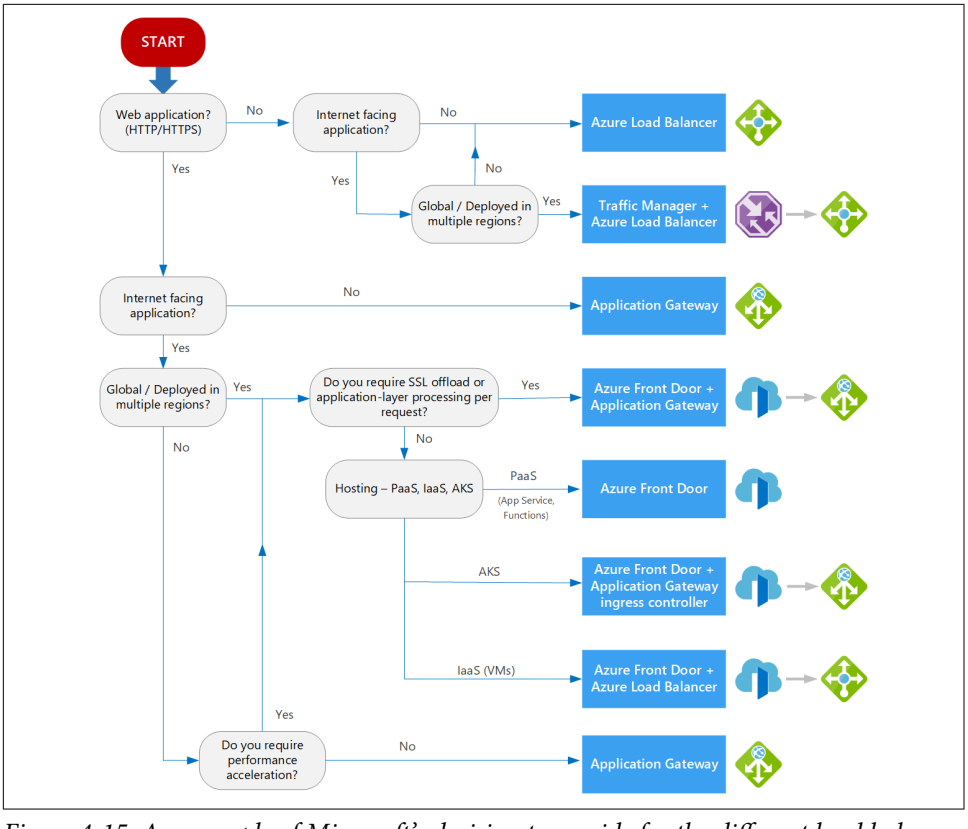

Figure 4-15. An example of Microsoft's decision tree guide for the different load balancing options. Image Credit: Microsoft Documentation

Each application can have different implementations and can consists of multiple workloads. Each workload needs to be evaluated separately. There are several load balancing options in Azure, the load balancing decision tree guide provided by Microsoft is shown in *Figure 4-14*. You can also read the details of this flowchart in the Microsoft's guide for Load Balancing Options.

Azure Networking Services for Application Delivery

Application delivery is another group category for Azure networking services. The following networking services in Azure, like Azure Front Door, Azure CDN, Azure Balancer, etc., will help speed up delivery and user experience on your cloud-hosted applications globally.

Azure Front Door

Azure Front Door is a global, scalable entry-point that uses the Microsoft global edge network to create fast, secure, and widely scalable web applications. With Front Door, you can transform your global consumer and enterprise applications into robust, high-performing personalized modern applications with content that reach a global audience through Azure.

By making use of the Azure Front Door service, the content on your applications will be delivered quickly to your application users wherever they are located. This service uses Microsoft's global edge network that interconnected to many POPs distributed around the world.

With Front Door you can develop, operate, and scale out your dynamic web applications and even static content. It also allows you to configure, manage, and monitor the global routing for your web traffic by optimizing for top-tier end-user performance and reliability through quick global failover.

The following are the additional key benefits and uses of Azure Front Door:

- Cookie-based session affinity which is useful for keeping a user's session active on the same device or server
- SSL offloading and certificate management
- Custom domains if you want to configure your own domains
- Integration with Web Application Firewall (WAP) for security
- HTTP/HTTPS redirection
- URL re-writes and custom redirection
- Smart monitoring for resources in the backend that will help track and debug issues
- Multiple websites hosting and support for wildcard domains
- End-to-end IPv6 connectivity and HTTP/2 protocol support

There are different tiers to choose from when using this service, the *Azure Front Door Standard* and *Azure Front Door Premium*. If you want to find out the details of the different tiers, check out Microsoft's guide for Azure Front Door Tiers.

Azure Application Gateway

Azure Application Gateway is a load balancer for web traffic. It enables you to manage and control the traffic to your web applications. It is an Application Delivery Controller (ADC) as a service that supports several layer 7 load-balancing capabilities for your applications.

Microsoft's Azure Application Gateway is ranked is top #3 in Application Delivery Controllers solutions based on Peerspot.com ranking survey

The following are some of the features of Application Gateway:

- Support for autoscaling (Scale up and Scale down) based on the ongoing traffic load of your application
- SSL/TLS termination at the gateway to secure unencrypted traffic to servers
- Zone redundancy and support for multiple *Availability Zones* to ensure high availability and fault tolerance
- URL-based routing, multiple site hosting and redirection
- Protection and security using Web Application Firewall (WAF)
- Use as Ingress Controller for Azure Kubernetes Service (AKS) cluster
- Integration with Azure Monitor for monitoring, logging and insights

Azure has several fully-managed load-balancing solutions that suit different use case scenarios or needs. *Azure Load Balancer* is an alternative if you want to do load balancing at the network layer level. There's also *Azure Front Door* for optimizing global routing for your web traffic and *Azure Application Gateway* if you need server load balancing at the application layer.

Azure Traffic Manager

The Azure Traffic Manager is a DNS-based traffic load balancer. This networking service allows you to effectively distribute traffic to your public-facing applications across the global Azure regions. Traffic Manager also provides your public endpoints with high availability and quick responsiveness.

Let's take a look at some of the key features of Azure Traffic Manager:

Integrate and associate hybrid applications
: Traffic Manager supports external, non-Azure endpoints enabling it to be used with hybrid cloud and on-premises deployments, including the "burst-to-cloud," "migrate-to-cloud," and "failover-to-cloud" scenarios.

Improve availability, maintainability and performance
: Azure Traffic Manager promises to deliver high availability for critical applications. It is done by monitoring endpoints and automatic failover if an endpoint goes down. You can have planned maintenance done on your applications without downtime. Traffic Manager can direct traffic to alternative endpoints while the maintenance is in progress. It can help improve your application's performance by directing web traffic to the endpoint with the lowest latency.

Manage complex traffic distribution and advanced deployments

By using Mested Traffic Manager profiles, you can use multiple traffic-routing methods to create flexible rules to scale to the demands of more complex and larger deployments.

Different routing methods for Traffic Manager

Priority, *Weighted*, *Geographic*, *Performance*, *Multivalue*, *Subnet* are the traffic-routing methods supported by Azure Traffic Manager. These routing methods are used to check how the network traffic are routed to different service endpoints.

Figure 4-16. An example of Azure Traffic Manager being used for a web application to scale and load balance traffic on hybrid cloud environment

The *Figure 4-15* shows an example of how Azure Traffic Manager can be used to direct web application's client request to the a specific endpoint based on the traffic-routing method being configured.

Important note about Traffic Manager vs. Front Door

Both the Azure Traffic Manager and Azure Front Door have similarities but also differences. For example, when it comes to routing options, *Traffic Manager* uses *On-premise routing* at a DNS-layer; while *Azure Front Door* works with HTTP-requests which has an independent scalability. As for protocols, *Traffic Manager* works with any protocol like UDP, TCP, HTTP, and more. In contrary, Front Door uses HTTP-acceleration which mean that its traffic is being on proxy at the edge network of Microsoft.

If you have several instances in different Azure regions and if one of these instances fails during the health check, it is expected that the traffic for your application is

directed to the Azure region that is healthy. However, a performance problem can occur in case of latency of the traffic to a region that is located far away.

Therefore, there are some performance considerations to think about when using and managing Azure Traffic Manager. There are several tools that you can use to measure your DNS latency and performance. Discussing the technical details of these traffic monitoring tools is beyond the scope of this book. If you want to learn more about it, check out Microsoft's recommendation for Measuring Traffic Manager Performance.

Azure CDN

Azure Content Delivery Network (CDN) is a global CDN solution for delivering high-bandwidth content by caching these content in different locations. You can choose to use Azure CDN for applications hosted in Azure or any other servers or location.

The Azure CDN enables you to cache static objects which can be coming from your web applications, Azure Blob storage, or a web server that is publicly avaialable. It uses the closest point of presence (POP) server, as shown in *Figure 4-16*, which helps accelerate dynamic content.

Figure 4-17. Example of POP (Point of Present) with Azure CDN.

The following are some of the features of Azure CDN:

- Improved and better performance and user experience for end-users globally
- Gain the ability to scale to handle instantaneous high load and demand
- Azure storage blobs can be used to cache content to make it publicly available
- CDN caching of web content, images, scripts, and other web assets
- Allows you to cache content based on specific query strings
- Access the cached content from a custom domain through CDN HTTP Endpoint mapping

Azure CDN have different tiers such as *Azure CDN Standard from Microsoft, Azure CDN Standard from Akamai, Azure CDN Standard and Premium from Verizon*. Prior to setting up your Azure CDN account, you should understand the different tiers and the comparison of the different features they offer.

Azure Networking Services for Network Monitoring

This section describes networking services in Azure that help monitor your network resources such as the Azure Network Watcher, Azure Monitor Network Insights, Azure Monitor, ExpressRoute Monitor, etc. We will take a look at the overview of each of these services and how to use them to monitor your network.

Azure Network Watcher

Azure Network Watcher is a composed of different tools used for monitoring, diagnosing, logging, and metrics management for an *Azure Virtual Network*. This networking service is commonly used to track and monitor network health statuses of IaaS services such as virtual machines, application gateways, load balancers, virtual networks, etc.

The following are some of the benefits of using Azure Network Watcher:

- Monitor communication between virtual machines and network endpoints at regular intervals with alerts and notifications.
- Get a visualization of the overview and the relationships of Azure resources in a virtual network
- Detect and troubleshoot any network traffic filtering problems between your VMs
- Diagnose problems of network routing and outbound connections for virtual machines
- Virtual machines packet capturing that helps detect possible network anomalies

To highlight, Azure Network Watcher is useful when you are troubleshooting issues related to or detecting network traffic anomalies in Azure IaaS resources. For example, if you want to troubleshoot a problem with a VPN connection between two virtual machines, you can use Azure Network Watcher to monitor the traffic between the two virtual machines.

Finally, there is one limitation of using Azure Network Watcher that is worth knowing. It is not going to work with web analytics and monitoring PaaS services because this service was not designed to be used with these two services.

Azure Monitor Network Insights. Azure Monitor Network Insights provides an overall view of health and metrics for all the network resources that you have deployed and

hosted in Azure. This network insights service is part of Azure Monitor that allows you to track networking metrics easily without any advanced configuration.

It is structured around these key components of monitoring:

- **Network health and metrics** for the visualization of all your networking resources with the option to search, filter, setup alerts and dependency view
- **Connectivity** helps you visualize all the configured tests done via Connection Monitor
- **Traffic** gives you a view of all flow logs for Network Security Groups (NSGs) and also the Traffic Analytics for the selected set of subscriptions, grouped by location.
- **Diagnostic Toolkit** Diagnostic can be used in troubleshooting the network issues such as IP flow verification, packet capture, etc.

If you are using Azure Monitor for monitoring and gathering metrics for your Azure resources, then network insights is good tool to use especially when you have multiple networking resources hosed in Azure.

Azure Space - Networking beyond the Clouds

Azure Space is one of the most-advanced innovations of Microsoft. Microsoft wanted to create networking and connectivity beyond the clouds, to the space. It was created and serves as an eco-system and platform for the space community.

As of the date of writing, there are three services created for Azure Space: *Azure Orbital*, *Azure Modular Data Center*, and *Azure Orbital Emulator*.

Figure 4-18. An illustration of how the global satellites and networks are connected using Azure Orbital.

Azure Orbital
: Azure Orbital is a fully-managed Ground Station As-a-Service (GSaaS) under the category of Azure Space. As of this day of writing, this service is currently on the Preview version. It helps users to communicate, downlink, schedule service and control their satellites, and scale operations from Azure. With the use of Azure Orbital, integrated data processing is easy and managed on the Azure platform. Data being processed are transferred securely through the user's virtual network, which can be stored on Azure Storage or any Azure service. The main uses of Azure Orbital is for global communications and earth observation *Figure 4-18* shows us an illustration of how Azure Orbital (GSaaS) is connected to Azure Data centers using Azure WAN and connects to the Global Communications and Orbiting satellites up in space using an orbital downlink.

Azure Orbital Emulator
: Azure Orbital Emulator is the tool that enables satellite developers to use AI algorithms and evaluate before launching. Complex satellite networking can be simulated by this emulator. The Orbital Emulator assists in getting simulations and perspective on how the application functions when it is in orbit. This tool enables the satellite developers to test their applications in the cloud (Azure) first before they deploy them to space.

Azure Modular Datacenter
: The Azure Modular Datacenter(MDC) was designed and created to help users who need cloud computing solutions in hybrid, challenging environments and remote locations. As a user of MDC, you have the capability to deploy your own self-contained transportable data center unit near the location you need it to be. In simple terms, Azure provides a portable data center unit (MDC units) that is fully equipped with full network connectivity and secure network connectivity using satellite communications.

Finally, if your organization is interested in learning more about the Azure Orbital and cloud services for the spaces, I recommend checking out about their Azure Space Partner Community program.

Learn By Doing (Try it out!)

Instead of creating customized hands-on learning labs for the topics discussed in this chapter, the following quick-start tutorials are most recommended as they are updated based on Microsoft's technical updates for these technologies. This section is recommended and optional.

- Quickstart: Create a virtual network using the Azure portal
- Create a Site-to-Site Connection in Azure Portal

- Quickstart: Create a public load balancer to load balance VMs using the Azure Portal
- Tutorial: Create a site-to-site VPN connection in the Azure Portal
- Create and provision an ExpressRoute circuit

Summary

In this chapter, we went through the basic concepts, descriptions, features and even limitations of the most common networking services and tools in Azure. We learned that networking services are categorized by its different purposes *e.g.,* connectivity, application delivery, security and monitoring. These networking services grouped by categories give us an overview and idea on which right networking Azure service to use along with compute resources in your cloud application development.

Azure has several *load balancing solutions* Front Door, Traffic Manager, Application Gateway, or a combination of any. We also learned that Azure networking goes beyond the clouds of *cloud computing* to the space through *Azure Space* services like *Azure Orbital*, *Azure Orbital Emulator* and *Azure Modular Datacenter* that are offered as *Ground Station As-a-Service* (GSaaS). GSaaS allows space explorers and researchers to communicate globally through space stations for research and innovation purposes.

In the next chapter, we will learn more about the different storage and database solutions in Azure.

Check Your Knowledge

1. What is the basic and fundamental block of a private network in Azure that enables your Azure resources to communicate with each other?
2. How can you protect and secure your applications in Azure using the networking resources available? (List down a few examples)
3. You need to securely connect your on-premises network to Azure in a private connection; which Azure networking services would you use?
4. What networking service would you use if you want to filter inbound and outbound traffic of Azure resources and securing your VNets?
5. What Azure networking service would you use if you want to features like Dynamic site acceleration, file compression, geo-filtering, and set caching rules for web content?

To find the answers to the *Check Your Knowledge*, turn to the back of the book in the Appendix.

Recommended Learning Resources

- Azure Networking Fundamentals
- Explore Azure Networking Services
- Microsoft Learn: Architect network infrastructure in Azure
- Networking Services YouTube Tutorial by Adam Marczak
- Microsoft Azure Master Class - Networking by John Savill
- Azure Networking Architecture Documentation
- Working Remotely with Azure Networking Services
- Azure CDN Documentation
- Azure Orbital Documentation
- MC2MC Community: Zero to Hero with Azure Virtual WAN by Derek Smith
- Microsoft Azure Networking Book by Avinash Valiramani
- Microsoft Documentation: Azure Orbital
- E-Book: Kubernetes on Azure

CHAPTER 5

Microsoft Azure Cloud Storage and Databases

A Note for Early Release Readers

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 5th chapter of the final book. Please note that the GitHub repo will be made active later on.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *jleonard@oreilly.com*.

> *At the heart of any application is the data, and whether that data is an image, an arbitrary fact about lumpia, or something in between, it needs to be stored somewhere! Luckily, there are plenty of data storage and database options that suit specific needs. Which do you use? That will depend on some key factors, like how you intend to interact with your data, how much of it you need to store, what kind of data you are storing, and how your application is structured. In the end, choosing the right database and data storage options can mean the difference between a resilient, scalable, and delightful application... and one that is not, so choose wisely!*
>
> — Adrienne Braganza Tacke, Senior Developer Advocate and Software Engineering Leader at Cisco

In the previous chapter, we learned about the importance of networking in the cloud infrastructure of Microsoft and the different *Azure networking* services for different important purposes. Implementing databases services like relational databases and

Microsoft SQL Services has been a great part of the software development with Microsoft technology stack. [1]

In this chapter, we will learn about the benefits of cloud storage in Azure and the different cloud database services for both the different types of data. Cloud storage services are important in our personal daily practical data management, software development and cloud engineering today. Specially for handling our data, managing it and protecting our data operations securely. By the end of this chapter, you will gain knowledge about the different data storage and database solutions that you can use for your modern web applications and data storage hosted in Microsoft Azure.

The Importance of Data Storage and Databases in the Cloud

In the data-driven generation today, organizations and businesses consider data to be the most available asset. Having a good set of strategies for storing data for our enterprise applications and systems is critical and vital for the success of businesses and organ- izations in this modern era.

Cloud computing has been helpful to many organizations moving forward to digitalization, and also cloud solutions have helped bioscience research, innovation, and collaboration.[2] Cloud computing aids in collaborative research by providing secure access to important digital tools and data management systems with powerful, reliable and scalable computing resources.

The volume of enterprise data grows exponentially, and the value and importance of data are crucial for businesses today. The data we store of any kind, e.g., analytical data, financial data, client data, vendor data, etc., continues to expand when our businesses grow. Therefore, it is important to have a sustainable data storage solution that can handle the data we store.

The traditional way of storing data will soon fade away, and storing data in the cloud will be the new way of storing data. Storing our data in the cloud provides the benefits of highly scalable, secure storage for business applications, systems, and workloads that will also help in cost-effectiveness in the long run.

Data professionals, e.g., database administrators, data engineers, data scientists, and data analysts, play important and vital roles in your data-driven organizations, society, and cloud solutions today. These career roles are essential to the business, and they are involved with the engineering and management of the enterprise data that we store in your digital storage or databases through our systems and applications.

If you are a data professional working with data in your job, then reading this book this chapter will help you accelerate your skills in data engineering and cloud devel-

opment by learning more about the different solutions for data storage and databases in Microsoft Azure.

Data Storage Management in the Cloud

Data storage management is crucial in any organization today. Users of your systems or applications need to be able to access and manage their data whenever and wherever they are. Therefore, storing data in any cloud platform, like Azure, has been an effective solution and option for data storage management. Another factor that is important when it comes to data storage management is the policy for data retention.

Data retention policy helps organizations define which data they need to retain for security, compliance, and operational reasons. These retention policies are important to have, especially when the business data continues to increase and grow exponentially. Storage management for data, e.g., structured or unstructured, will assist in resource provisioning, configuration, cost-management, and evaluation.

Using Microsoft Azure as a cloud storage provider, you can easily manage your data storage and its retention policy for your Azure resources. For example, if you are using Azure Storage, you can set up time-based retention policies for immutable blob data.

Why Digital Storage in the Cloud is Useful

There are many good reasons why cloud storage is beneficial to us and businesses [3]. Nowadays, storing data digitally and cloud storage has been the most efficient and convenient for us. Cloud storage allows users to minimize the use of using a physical local hard disk or storage that has the risk of getting lost. Storing data digitally enables global and remote access with dynamic options to upgrade the storage capacity on-demand when we need it.

Enterprises and businesses can save money [4] by using cloud storage services. They don't need to spend money on the expenses of storing their data in their own servers or data centers. Cloud computing providers offer these storage services with features of security, reliability, and scalability at a global scale.

Some of the other reasons why cloud storage is beneficial are the synchronization of data securely stored on the cloud, which makes it easier for users to share and access important files or content across any device from anywhere. Aside from the flexibility of upgrading your storage anytime, there is also a great advantage of better storage management with better data backup management and disaster recovery benefits that the cloud provider offers. So in case of an emergency of data loss, you can worry-free retrieve and restore your backup data from the cloud.

Big Data, Structured Databases, and Non-Structured Databases

As mentioned earlier, the data we collect and store can expand enormously as our demands and businesses grow. The term *Big Data* is a commonly used word to describe large volumes of data that can be difficult to manage. As cloud computing continues to evolve, so is big data, which helps in many ways. For example, data can be used to analyze and improve a business' customer service strategy. [5]

Also, these days, the data that we generate and are collected through our applications in the cloud are enormous and getting huge, which means we need to find ways to handle the complexity and heterogeneity of these varieties of data. Using our traditional relational databases has its challenges in handling such massive unstructured data that we need to handle and manage.

In order to understand the importance of big data, we need to understand the different types of data that we can store in the cloud. The different known data types are structured data and unstructured data.

Structured Data
: Structured data (SQL) is highly-organized and formatted so that it's easily searchable in relational databases. Unstructured data has no predefined format or organization, making it much more difficult to collect, process, and analyze. Examples of relational database systems are Microsoft SQL Server, Oracle, MySQL, Azure SQL Database, Postgres, Azure SQL Database, and many more. Structured databases like SQL have their limitations in handling other types of data.

Non-structured Data
: Non-structured (NoSQL) data is a type of data that does not have structure. It means it is without a predefined format. Usually, these types of data are considered qualitative types of data like video files, text files, audio files, mobile activity history logs, posts on social media, images from a satellite, etc. It is a type of data that is hard to deconstruct because it has a predefined structure. This means that unstructured data cannot be organized and structured the way we usually do it on typic relational databases like SQL. The common types of databases that are suitable for storing and managing non-structured data are the non-relational or NoSQL databases. In the world of open-source, for example, there are common types of NoSQL databases like key-value stores, document databases, graph databases, and column databases. A data lake in Azure can also be used to analyze and manage unstructured data.

Now that we have learned the different types of data that we can collect and store digitally, we will be able to easily identify and make good better decisions on which is the

right Azure cloud storage or databases are suitable for the data we collect in our applications or systems, regardless if they are stored on an existing on-premise databases or already hosted on the cloud.

Figure 5-1 shows an illustration about the difference of structured databases and non-structured SQL databases.

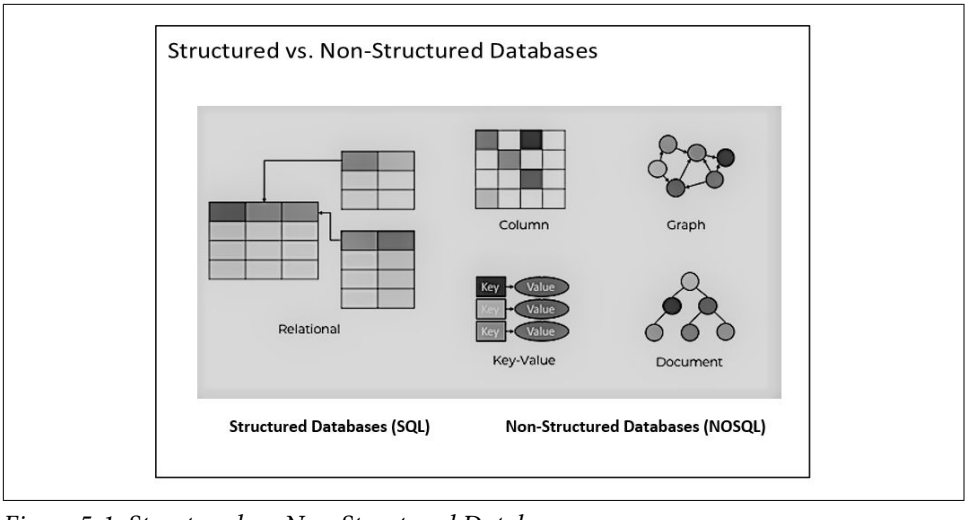

Figure 5-1. Structured vs. Non-Structured Databases

Making sense of the difference - Structured vs. Unstructured Data

Structured data is quantitative type of data that is highly-organized and structured for easy searchable in traditional relational databases that we are familiar with. On the other hand, *Unstructured data* is qualitative which is considered *unstructured* and no specific predefined format nor structure. Most of the time, structured data are easier to collect, process and analyze compared to unstructured data.

Being able to understand whether the data type of data *e.g., structured or non-structured* is important to know not just from a business and knowledge perspective but also in finding ways and good judgment on what is the ideal type of cloud storage service or database solution that you need when storing and managing these data to a cloud platform such as Microsoft Azure.

Azure Storage and Database Services in the Cloud

Microsoft has a great variety of cloud storage solutions for different types of data storage use case scenarios. Our applications and systems need storage and databases

to store, manage, analyze, and visualize enterprise and application data. There are solutions available for storage, databases, visualization and analytics of data in Azure.

Azure Storage

The Azure Storage platform is a cloud-based fully-managed data storage solution in Microsoft Azure that allows users to store and manage their data in the cloud. Azure Storage provides durable, secure, scalable, and highly-available storage via HTTP, HTTPS, or REST API for any type of data of any size in your organization.

Azure storage has several benefits to organizations, including its users of any roles. The cloud storage platform in Azure provides secure and durable data storage management in the cloud by ensuring that the data stored in the cloud is safe, secured, and available in case of unexpected system failure or emergency. Users can replicate their data across different geographic locations and data centers for backup and disaster recovery.

Another great feature of Azure Storage is that it is created and built to be scalable, which means that it is able to handle the performance, capacity, and storage demands of your organization. It is designed to be flexible and can be scaled up and down to meet your business needs. Using Azure Portal and the free cloud storage tool Azure Storage Explorer you can easily administrate your data in Azure Storage from the cloud directly from your computer on any operating system.

IT professionals, data engineers, and developers have great productive tools to use with Azure storage, such as Azure storage client libraries to build APIs and web services with Azure Storage platform using the different support languages supported like C#, Java, Python, C++, Typescript, and many more. Cloud engineers and Azure developers can also build scripts, configuration, and automation tasks using the widely used tools in Azure like the Azure Powershell and Azure CLI.

The different types of Azure Storage Data Services and their specific use cases and purposes will be discussed in detail in the later sections of this chapter.

Database Services in Azure

Aside from Azure Storage there are other fully-managed solutions in handling the data we collect and store from and to our applications. Azure provides different types of cloud database services in Azure that are known to be powerful, reliable and scalable. There are different options for both relational, non-relational (NoSQL) and in-memory database solutions available for modern cloud application development use case scenarios for your organization.

Services for Azure Storage

We have learned that Azure has different types of services for both cloud storage and databases. In this section of the book, we will learn about the different types of services are available for cloud storage depending on the type of data your organization needs to store and manage. Table 5-1 shows some of the common Azure storage services that you can use for different use cases, purposes and of course the type and the size of data you are trying to collect and store.

Table 5-1. Different Types of Azure Storage Data Services

Name	Description and Purpose
Azure Blob Storage	If you need a massive object store that should be scalable then storing blobs *e.g* text and binary data would be ideal using Azure Blobs. It is ideal for example if you want to store and manage your BLOB files on the cloud on any accessible web browsers on any platform for distributed access for external users or applications. Big data analytics through Data Lake Storage as well as backup and recovery solutions are also supported in this service.
Azure Files	If you need a file storage service that is ideal for storing and managing files on any accessible web browsers on any platform for distributed access for external users or applications. Azure Files is a file share in Azure that is fully managed and can be accessed using some of the standard protocols like Network File System (NFS) and Server Message Block (SMB) protocols.
Azure Queues	If you need to securely store large numbers of messages between applications that are reliable. Azure Queues enable you to store messages in queues to be processed between components of your applications. These queue messages can be accessed securely using- REST, HTTP, or HTTPS protocols.
Azure Tables	If you need to store non-structured or schemaless store of your structured data that can be accessed authentically internally and externally the cloud infrastructure in Azure then Azure Tables would be ideal to use.
Azure Managed Disks	If you want to handle and manage large block-level storage volumes or if your workloads need a support for virtual disk features and storage for infrastructure as a service (IaaS) or virtual machines deployment.

Azure Blob Storage

Azure Blob Storage is a cloud-based object storage service that allows you to store and manage your BLOB data in the cloud. This service is able to handle massive text and binary data, especially unstructured types.

Some of the common uses of Azure Blob Storage are managing images, videos, or files on any web browser and device, if you need to store files for external distribution or access either for business purposes or personal use.

If you want to stream BLOB files like videos or audio files for your video streaming services or podcast, you can also use the Azure Blob Storage service to access these data from your application or directly from your browser. Another important use is also for performing a backup and archive of data which is useful and important in data management.

One of the most important concepts you need to know when you are setting up your Azure Blob Storage is its different components of it. Blob Storage has three types of resources: the Azure storage account, the container in this storage account, and then the data object or BLOB items that you store in this container, as shown in *Figure 5-2*.

Let's check what are the different components of Azure Blob Storage:

Storage Account
: You need a storage account primarily because it is a unique namespace for your BLOB data. Azure Storage account is important because it actually provides a unique URL address or link to every object data you store in your storage. Usually when you setup or create your storage account, you would need to decide and choose a unique account name. The Azure Storage blob endpoint and account storage name becomes the base link address for the data objects in your storage account. If your storage account is named *learningmicrosoftazurestorage*, then the default endpoint link for Blob storage is *learningmicrosoftazurestorage.blob.core.windows.net*.

Containers
: In an Azure Storage Account, there is usually a container that is associated and saved under its level. You can have more than one or unlimited number of containers in a storage account. Also, in each of your container, there is no limitations to number of data objects or BLOBs that you can store. Containers are where you organize your set of blobs just like how we organize our photos or videos traditionallly in a standard file system. Basically, containers are like our traditional digital folders on our computers. It has a resemblance of a file system directory.

Blobs
: There are different types of blobs that Azure Storage supports: *Block blobs*, *Append Blobs* and *Page Blobs*. The *Block blobs* are primary used to store text and binary data.that that can be individually handled. The *Block blobs* can handle in storing blob up to the size of 190.7 TiB. The second type of blob is called *Append blobs*, which are composed of block blobs specially used for append operations. These types of blobs can be used for scenarios like VM data logging. The third type are the *Page blobs* which are useful in storing random access files up to 8TB for example it can store Azure Virtual Machines virtual hard drive (VHD).

The data objects you store in Azure Blob storage is accessible anywhere worldwide throuh secured and authenticated protocols like HTTPS. Your development team or your organization can implement application solutions with Azure Blob Storage by making use of the development tools and technologies supported. Such technologies including using client libraries for different programming languages like .NET, Java,

Python, Node.js, Ruby, PHP, etc. Data can be accessed securely using REST API, Azure CLI, and Azure Powershell.

Naming conventions to be mindful of when using Azure Blob Storage

The container where you store your BLOB objects have its properties and metadata too. There are some naming conventions and best practices you need to consider when working with Azure Blob Storage. To find our more about it, check our Microsoft's Documentation Naming and Referencing Containers, Blobs, and Metadata

Azure Files

Managed file shares for cloud or on-premises deployments. Azure Files offers fully managed file shares in the cloud that are accessible via the industry standard Server Message Block (SMB) protocol or Network File System (NFS) protocol.

Azure Files file shares can be mounted concurrently by cloud or on-premises deployments. SMB Azure file shares are accessible from Windows, Linux, and macOS clients. The NFS Azure Files shares are accessible from Linux or macOS clients. Additionally, SMB Azure file shares can be cached on Windows Servers with Azure File Sync for fast access near where the data is being used.

Table 5-2 shows some of the common use cases and benefits of using Azure Files.

Table 5-2. Common and Practical Use Cases of Azure Files

Uses and Benefits	Description
Replacement of on-premises file servers	For easy sharing and global access Azure Files can be used as an alternative to Network-attached Storage(NAS) or tradional storage on-premises
Flexible option to Migrate Applications	It is easy to "lift and shift" applications to the cloud that expect a file share to store file application or user data. Azure Files supports both the "classic" lift and shift and the "hybrid" lift and shift scenarios
Simplify cloud development	Run stateful and long-running background jobs or tasks with autoscaling capabilities based on CPU or memory usage
Persistent Volume for Containerization	Containers deliver "build once, run anywhere" capabilities that enable developers to accelerate innovation. For the containers that access raw data at every start, a shared file system is required to allow these containers to access the file system no matter which instance they run on.

Azure Queue Storage

Azure Queues is a storae service that is useful for storing large numbers of messages in the cloud that you can access and manage anywhere securely. A queue message can

be up to 64 KB in size and can contain millions of messages depending on the storage capacity allowed on your account.

There are some components in Azure Queues: Storage account, URL format, Queue and Message.

URL format
: The URL format of Azure Queue Storage are endpoint or URL in this URL format: *storageaccountname.queue.core.windows.net* which means that if you want to access an image name called *my-image* from a queue storage, you may access it using the following address: *storageaccountname.queue.core.windows.net/my-image*

Storage account
: An Azure storage account stores the data objects for your queue messages in the storage account that you created. The storage account is a unique namespace that allows you to access your storage anywhere over secured protocols over the Internet like HTTP or HTTPS. Azure storage account is known for its durability, security, scalability, and high availability.

Queue
: Usually a set of message can be contained in queue. When it comes to setting up names for your queue storages there are naming conventions to be mindful of. For example, the queue name is required to be in all lowercase

Message
: A message in an Azure Queue Storage can be in any format (up to 64 KB) and the allowed maximum time-to-live(TTL) before version the the date 2017-07-29 is seven days and for later versions after that is the maximum TTL can be any positive number, or -1 indicating that the message doesn't expire. When you miss setting this TTL parameter, usually the default would automatically be seven days.

Azure Table Storage

If your organization needs to collect, store and manage large amounts of structured data, then Azure Table Storage would be ideal for handling it. Azure Table Storage is a NoSQL data storage that is capable of internal and external authenticated calls from and to Azure. Azure table storage is ideal for storing structured data or relational data.

Some of the usual cases you can use Azure Table Storage includes:

- Collection and storage of terabytes(TBs) of structured data for web applications

- Data access using the OData protocol and LINQ queries for WCF Data Services in .NET Libraries
- If you want to store easy to denormalized and non-complex datasets
- Quick data queries using clustered indexing

Azure Table Storage has several components: *Storage account, URL format, Table and Properties*. Let us go through the definition of each of the components.

Storage Account
: All access to Azure Storage is done through a storage account. All access to Azure Cosmos DB is done through a Table API account.

URL format
: Azure Table Storage accounts use this format for its URL: *http://mystorageaccount.table.core.windows.net*. If you are using the Azure Cosmos DB Table API account with this service, the URL format is *http://mystorageaccount.table.cosmosdb.azure.com/*. Using OData protocol you can also directly access Azure table storage using these URL formats.

Table
: A collection of entities is called a table which actually doesn't implement and enforce a schema. A table can have entities with different sets of properties.

Properties
: A property is a name-value pair. Each entity can include up to 252 properties to store data. Each entity also has three system properties that specify a partition key, a row key, and a timestamp. Entities with the same partition key can be queried more quickly, and inserted/updated in atomic operations. An entity's row key is its unique identifier within a partition.

Azure Table Storage will automatically scale as demand increases especially if you need to use it for storing and querying large sets non-relational or structured data.

Work with the data in Azure Storage using Azure Storage Explorer

To manage your data or files easily on your Azure Storage Account. You can make use of the free stand-alone app Azure Storage Explorer on any platform like Windows, macOS, and Linux.

Azure Managed Disks

Azure Managed Disks are recommended solution if you have block-level storage volumes for IaaS *Azure VMs*and Azure VMware solutions. This cloud storage solution is virtualized disks on the cloud. You can literally consider it as a virtualized version of your on-premises physical storage. These virtual managed disks in Azure are fully

managed, which means that when you set it up, you would need to choose some of the properties like the size, the location, the type of the disk, e.g., ultra disks, standard SSDs, premium solid-state drives (SSD), etc. and the operating system you want to install on the disk.

Table 5-3 describes good uses of Azure Managed Disks.

Table 5-3. Known Benefits of Azure Managed Disks

Uses and Benefits	Description
Availability, High Durability and Scalability	Managed disks are built to be really durable by assuring and securing several data replications, at least three replications which gives high durability and promises avalability of 99.999% in cases of data loss or failures
Availability Sets and Availability Zones Integration	Availability sets is supported and can be integrated with Azure Managed Disks to solve the problem of single point of failure through isolation. Azure Availability Zones also protects your resources from failures in the data center.
Easy and flexible VM Deployments	Managed disks enables you to create up to 50,000 VM disks per Azure subscription per region. *Azure VM scale sets* are a great way to scale your VM workloads while allowing you deploy thousands of virtual machines in a scale set alone which helps you save money
Secured	Managed disks are designed with security by default which means it is uses RBAC (Role Based Access Control) to protect your data from unauthorized access, the storage are encrypted e.g., Server Side Encryption (SSE) and Azure Disk Encryption (ADE)

Azure Storage Security Best Practice Tips

When we develop and use Azure Storage in cloud development in any platform or programming language, we commonly use SAS (Shared Access Signature) SAS (Shared Access Signature) to access the storage account from your apps or code. However, using SAS for Azure storage access can come with a few major security risks.

For example, if SAS token is compromised, the attacker can access your data. Therefore, it is important to be aware of the best security practices you need to know when using SAS for Azure storage access.

One of the top security recommendations for Azure Storage is to always use HTTPS to distribute SAS, set up some SAS tokens expiration policy, and always use user delegation for SAS whenever it is possible.

Check out a list of recommended storage security best practices and the best practices on using SAS with Azure Storage on Microsoft's documentation.

Finally, after we read and learned through different types of Azure services for data storage, you should be able to know which one is the best for your needs or business requirements.

Azure Database Services

In the earlier part of this chapter, we learned the common uses and benefits of cloud storage for users and organizations. However, there are still many businesses and organizations that are still having challenges with the data platform strategies with their systems or applications today. Some organizations have outdated data platforms that could use some modernization and upgrades to something better.

There's been a significant trend of moving existing systems to the cloud, building new applications quickly with the cloud, and offloading some on-premises costs. You need a plan for how to move some workloads to the cloud. And you need to understand how to set up your organization for success. You also need to understand how the role of a database administrator (DBA) or data professional stays the same and what changes you'll have to make.

Azure SQL as Fully Managed Database Service

Azure SQL Database is a commonly-used cloud database service. It is known to be always up to date and considered a fully managed relational database service developed and built for cloud computing. Using Azure SQL databases, you are able to create SQL databases will a list of good features and capabilities for your applications.

Azure SQL Deployment Options

There are different deployment options available for Azure SQL. Depending on your current workloads and infrastructure, you can choose to deploy your relational databases in different ways like:

SQL Server on Azure Virtual Machines
: SQL Server on a virtual machine is considered IaaS. SQL Server on a virtual machine is a version of SQL Server that runs in an Azure VM. It's just SQL Server, so all your SQL Server skills should directly transfer, though Azure can help automate backups and security patches. SQL Server on an Azure virtual machine is referred to as infrastructure as a service (IaaS). You're responsible for updating and patching the OS and SQL Server, apart from critical SQL Server security patches.

SQL Managed Instance
: The SQL Managed Instance is a PaaS deployment option of Azure SQL that allow organizations to save some money on virtual machines or servers. It helps by giving you the users, an instance of SQL Server but removes much of the overhead of managing a virtual machine. Most of the features available in SQL Server are available in SQL Managed Instance. This option is ideal for customers who want to use instance-scoped features and want to move to Azure without re-architecting their applications.

SQL Database

SQL Database is a PaaS deployment option of Azure SQL that abstracts both the OS and the SQL Server instance away from users. This deployment option allows you to just get a database and start developing applications. SQL Database is also the only deployment option that supports scenarios that require unlimited database storage (hyperscale) and autoscaling for unpredictable workloads (serverless). SQL Database has the industry's highest availability SLA. It provides other intelligent capabilities related to monitoring and performance, partly because Microsoft manages instances.

History of Azure SQL

In 2008, when Microsoft Azure (previously called Windows Azure), one of its top key components and an important part of it was Micro- soft SQL Services. From SQL, Azure was renamed to Azure SQL. Today, both SQL Server and Azure SQL continually evolved with great and better features that even expand to support and work with other open-source databases, PostgreSQL, MariaDB, and MongoDB.

Our modern enterprise systems today are rapidly improving and evolving with modern technologies which also means that in these systems or applications we need to handle and manage large volumes of assorted and diverse data in various formats and types. Therefore, choosing the right data store for your business data is a critical decision.

Check out Microsoft's important guide in choosing the right data store and the considering data technology choices on the *Ready* phase recommendation of the *Microsoft Cloud Adoption Framework for Azure*.

Azure Cosmos DB

Azure Cosmos DB is a fully managed NoSQL database for modern app development. Azure Cosmos DB takes database administration off your hands with automatic management, updates, and patching. It also handles capacity management with cost-effective serverless and automatic scaling options that respond to application needs to match capacity with demand.

Solutions that benefit from Azure Cosmos DB. Any web, mobile, gaming, and IoT application that needs to handle massive amounts of data, reads, and writes at a global scale with near-real response times for a variety of data will benefit from Cosmos DB's guaranteed high availability, high throughput, low latency, and tunable consistency.

Figure 5-2. An illustration of Azure Cosmos DB

The following are some of the useful benefits of using Azure Cosmos DB for your data solutions:

Guaranteed Scalable Speed
: Gain unparalleled SLA-backed speed and throughput for global access, and instant speed and elasticity with SLA support. There is also a support for multi-region writes and data distribution to any Azure region.

Easier App Development
: Development is easier and efficient with open source APIs and SDKs supported by Azure Cosmos DB. You have the option to integrate with other Azure services that are commonly used in modern cloud-native app development like Azure Functions, IoT services, Azure Kubernetes Service, App Service, etc. Different programming languages are also supported. For example, SDKs for .NET, Node.js, Java, and Python.

Mission-critical ready
: Azure Cosmos DB promises high availability and enterprise-level security that helps the business running. Azure provides the option to easily distribute and replicate your data to any Azure region.

Fully managed and cost-effective
: Using Azure Cosmos DB service on Azure is cost-effective and useful as it is a fully-managed cloud service. It is easy to work with database management that you can do on demand using the Azure Portal, Azure CLI, etc. Azure Cosmos DB also support the Serverless (Consumption Plan) pricing model.

Based on the list of features and benefits of Azure Cosmos DB, it is promising and innovative that there are so many ways we can store our data depending on what we really need to build, create and deliver for our businesses.

Learning Different Consistency Levels of Azure Cosmos DB

One of the common confusion of those who are just getting started in Azure Cosmos DB is understanding its different types of consistency levels. It is hard to understand and make sense of it especially when you are not familiar with the concepts of consistency levels, replicas, and throughput in Azure Cosmos DB.

When you are working with Azure Cosmos DB for your databases, it is essential to understand the different consistency levels such as the *Strong, Bounded staleness, Session, Consistent prefix and Eventual*.

For distributed databases, consistenty is an important concept to understand especially when working with managed cloud databases like the Azure Cosmos DB. Distributed cloud databases are operational across different physical locations. Furthermore, distributed databases depends on replication configuration which usually for the purposes of low latency and high availability, or can be both.

Depending on the priority and requirements, there is a trade-off between choosing the read consistency, availability, latency, and throughput in our distributed cloud databases, as defined by the PACELC theorem.

In terms of distributed cloud databases, the term *Replicas* can be considered as copies of source data that are the same or identital. These replicas can be hosted in different or another Azure Region. Usually the replication is configured for disaster recovery and geo-based distribution purposes.

If you are replicating your distrubuted databases in the cloud in Azure regions that is located away from your users, there might be possible issues with performance, response time, and latency. Therefore, it is recommended that when configuring the replication, it is ideal to choose the right consistency level for your needs.

Technical details of each consistency levels is beyond the scope of this book; however, if you want to see the comparison and deep dive what is best for your distributed database workloads, I recommend checking out Microsoft's Guide for Consistency Levels in Azure Cosmos DB.

Azure Cosmos DB integration with Azure Synapse Link

Azure Synapse Link for Azure Cosmos DB is an optional integration that can be used for cloud-native hybrid transactional and analytical processing (HTAP) capability that enables real time analytics over operational data in Azure Cosmos DB.

You can gain cost savings on Azure Cosmos DB using Data Retention with Time to Live (TTL) and the Free Tier. When you use Azure Cosmos DB you do not have to pre-reserve your storage in advance because you get billed for the storage you have consumed directly. However, there are use case scenarios that requires high-write

might have an effect on the costs. In order to save costs, you can set a time-to-live (TTL) for your data. This is a time interval after which the data will be deleted. This means that the data that you have already have stored elsewhere can be immediately purged. By doing this, you can you can keep your relevant data updated. Learn more about TTL on Azure Cosmos DB.

Also, you can also make use of the Azure Cosmos DB Tier if you as a developer, your team or your organization are just getting started with the service, or just trying to develop small production application workloads for testing or try out.

The Variety of Azure Cosmos DB APIs. Azure Cosmos DB has different and several options for us users in terms of database APIs. The known database Azure Cosmos DB APIs to choose from includes the Core (SQL) API, Gremlin API, MongoDB API, Cassandra API, and Table API.

These Cosmos DB database APIs helps us to store and manage variety of real-world data such tables, key-value data, graphs, documents, and column-family data models.

The following database APIs enable database engineers, developers and even organizations not to spend so much effort or money on resource in adopting into Azure Cosmos DB. Using these APIs your existing tools, systems, and skillsets can easily get started usingt he same data modelling and querying techniques in respective databases where the existing data are stored.

Azure Cosmos DB APIs are fully-managed service in Azure's cloud platform. These APIs have features like throughput and storage automatic scaling. It also guarantees flexibility and performance to its users because of its global scale features. The following list are some of the APIs that are currently available for Azure Cosmos DB.

Core(SQL) API
: Using Core(SQL) API, you are able to store data in document format and fully manage it with best end-to-end experience with good features and SDK client libraries. The Azure Cosmos DB for SQL API accounts allows database developers and engineers to query database items using the Structured Query Language (SQL) syntax in querying JSON objects. This API is ideal if you are considering to migrate from databases like for example Oracle, HBase, DynamoDB, etc. Also, if you want to modernized technologies to build your apps, SQL API is the recommended option. SQL API supports analytics and offers performance isolation between operational and analytical workloads.

Gremlin API
: Gremlin API is useful and worth considering for graph queries and if you have a requirement to store data as edges and vertices. This API is recommended for scenarios involving dynamic data with complex relations. They are too complex that they cannot be modeled with the standard relational SQL databases. The

Gremlin API for Azure Cosmos DB combines the features of the algorithms of graph databases with highly scalable, managed infrastructure. This API is based on the Apache TinkerPop graph computing framework and uses the partition strategy of Azure Cosmos DB to do the operations for read and write. A few common use case scenarios where Gremlin API can be useful is for customers graph, geo spatial data, social network graphs, data from Internet of Things (IoT) devices that needs to be represented into graph, etc.

API for MongoDB
: The API for MongoDB is specific to MongoDB databases which stores data in a document structure, typically on BSON format. It is compatible with MongoDB wire protocol but not necessarily using code related to MongoDB. Using API for MongoDB is ideal and great choice if you want to work with MongoDB ecosystem. If you already have an existing apps with MongoDB, you can just update the connection configurations and migrate existing data using native MongoDB tools or the Azure Database Migration Service.

Cassandra API
: Cassandra API of Azure Cosmos DB is useful if you want to store data written for Apache Cassandra which is usually data in column-oriented schema. This API in Cosmos DB promises a highly distributed API for databases that uses Apache Cassandra. It enables horizontal scaling in storing large volumes of data and offers a flexible approach to a column-oriented database schema. Use this API if your Cassandra databases need to have elasticity and want to take advantage of the fully-managed feature of Azure Cosmos DB. You can use the native Apache Cassandra features, tools, and ecosystem when you use this API, which means that you don't need to manage the infrastructure like Java VM, garbage collect, etc.Apache Cassandra client drivers are also supported to connect to the Cassandra API.

Table API
: The Table API in Azure Cosmos DB stores data in key-value pair format and only supports OLTP scenarios. Any applicationwritten for Azure Table storage can be migrated to the Table API with minimal code changes and can also make use of the premium capabilities.

Azure Cosmos DB and its available APIs give us the flexibility in choosing the appropriate database API for our needs. Let's learn further about another interesting feature that Azure Cosmos DB offers for distributed database workloads.

Global Distrution and Replication using Azure Cosmos DB. Azure Cosmos DB is a fully-managed and globally distributed database system that allows you to read and write data from the local replication of your databases. It enables replication of data to all the regions associated with your Cosmos account.

It is popular cloud database service in Azure that is intented to deliver elastic scalability of throughput, low latency, well-defined semantics for the consistency of data, and high availability. Thefore, if your application needs fast response time in any location or region in the world, if it's required to be always online, then building modern applications with on Azure Cosmos DB would be considerably ideal.

A set of databases can be configured to be globally available and distributed in any of the Azure regions. To strategically lower the latency, it is recommended to provision your databases to the Azure Region closes to where your application or database users are. Theforefore, choosing the required regions rely on the global reach of where your users are located. Azure Cosmos DB replicates the data to all the Azure regions that are associated and linked with your Cosmos DB account.

Azure Cosmos DB gives you flexibility by giving you the option to add or remove the regions associated with account when needed. When you update your region for your account, your application doesn't need to be paused or redeployed. Cosmos DB is available in all five distinct Azure clouds environments available to customers.

Figure 5-4 shows how the distribution of Azure Cosmos DB is replicated and setup globally.

Figure 5-3. Microsoft's Example of Globe Distribution using Azure Cosmos DB

Azure Cosmos DB Data Migration Tool

If your team in your organization has a need to migrate or import data from external sources into a container in Azure Cosmos DB, I recommend checking out the Azure Cosmos DB Data Migration tool that allows you to import data from sources in file formats as CSV, JSON, XML, SQL, Azure Table Storage, MongoDB, DynamoDB of Amazon, and even from other Azure Cosmos DB API collections.

For detailed information and guide, check out Microsoft's Documentation Tutorial: Use Data migration tool to migrate your data to Azure Cosmos DB

Choosing an Database API for Azure Cosmos DB

Azure Cosmos DB gives us different options of APIs, which helps us easily migrate our data to Azure. This is regardless if you are trying to build new applications or migrate existing ones. However, every business requirement is unique and different from case to case; therefore, I would recommend you to check this Microsoft guide with a great workflow diagram that can help you with your decision process within your organization.

If you want to know more, I recommend checking this guide Choose an API in Azure Cosmos DB if you and your team are uncertain about which API to choose.

Deploying Azure Cosmos DB as Infrastructure as Code (IaC) is also possible. Azure enables developers and cloud engineers to automate deployments with the feature of being able to integrate and use Azure Bicep in managing Azure Cosmos DB resources. To learn more about how you can do that check this Microsoft's guide on how you can manage Azure Cosmos DB Core (SQL) API resources with Bicep

Based on what we learned so far, Azure Cosmos DB has great features for any type of data. Choosing the right data store or database in Azure is an important step regardless if you are considering modernizing or upgrade on your existing enterprise systems or currently planning to build a new application hosted on the cloud.

Learn By Doing (Try it out!)

Instead of creating customized hands-on learning labs for the topics discussed in this chapter, the following quick-start tutorials are most recommended as they are updated based on Microsoft's technical updates for these technologies. This section is recommended and optional.

- Microsoft Documentation: How to create a storage account
- Microsoft Documentation Quickstart: Upload, download, and list blobs with the Azure portal
- Quickstart: Build a console app by using the .NET to manage Azure Cosmos DB SQL API account resources
- Microsoft Quickstart: Build a .NET Framework or Core application using the Azure Cosmos DB Gremlin API account
- Microsoft Learn Module: Explore Azure database and analytics services

Summary

In this chapter, we learned massively about the different types of technologies in Azure for storage and database solutions in the cloud. We learned about Azure Storage which is an important namespace in creating Azure Blob Storage. Aside from the great capabilities of Azure Blob storage, we also learned about the other storage options for IaaS Virtual Machine, such as Azure Managed Disks. Azure File Share is useful in sharing files.

We also learned about the Azure Cosmos DB, its database APIs ideal for different types of databases regardless if they are structured or non-structured. We got some tips and important things to consider when choosing the right API for your Azure Cosmos DB solution, as well as useful resources and links to read further when it comes to choosing the right data storage or database technologies based on your needs.

This chapter has helped us gain knowledge and make better decisions in choosing the right Azure service to use for our applications: existing or new ones to be built or migrated.

Check Your Knowledge

1. What is the difference between structured and non-structured data types?
2. What Azure SQL service (PaaS) supports instance-scoped features like CLR and Service Broker?
3. What free tool can you use to manage your Azure storage locally on your computer?
4. Why would you consider using Azure Cosmos DB for your data?
5. What is the difference between Azure Blob Storage and Azure File Share?

To find the answers to the *Check Your Knowledge*, turn to the back of the book in the Appendix.

Recommended Learning Resources

- Cloud Academy, 10 Benefits of Using Cloud Storage
- Microsoft, Azure SQL for Beginners
- Microsoft Learning Path: Implement and manage storage in Azure
- Azure Cosmos DB Documentation
- Microsoft Documentation: Elements of a Azure Cosmos DB Account

- Azure Cosmos DB by Microsoft
- TTL on Azure Cosmos DB
- Microsoft: Replace your file server with a serverless Azure file share
- Azure Cosmos DB free tier
- Microsoft Documentation: MongoDB Introduction

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PART III

Artificial Intelligence (AI), Machine Learning (ML), Big Data, Analytics, Internet of Things (IoT) and Security in Microsoft Azure

This third section of the book and its chapters focus on teaching the foundational concepts of artificial intelligence, machine learning, Internet of Things (IoT), Edge technologies, security, and identity management in Microsoft Azure.

Chapter 6 focuses on the useful concepts you need to know about Artificial Intelligence(AI), Machine Learning, Cognitive Services, and Bot Services in Microsoft Azure.

Chapter 7 explores the Big Data, Reporting, and Analytical Services in Microsoft Azure. This chapter will include what you need to know about data analytics, big data, and reporting services in Power BI, Stream Analytics, Data Lake Analytics, Event Hubs, HD Insights, and more.

Chapter 8 explores the different services in Azure for Internet of Things (IoT), Maps, Edge services, and other smart solutions in the cloud for smart things.

Chapter 9 dives into identity management, compliance, and cloud security services in Microsoft Azure which is important in protecting and securing your applications and cloud workloads. You will learn about Azure Active Directory and Azure AD B2C, B2E. Azure security services like Azure Key Vault, Azure Sentinel, Defender for

Cloud, Azure security for networking services, and Azure Security Center, Data and Information Protection will be explored.

By the the end of this section of you will be able to build intelligent applications using the advanced technologies and services for AI, ML, Big Data, Analytics, and Security in Azure.

CHAPTER 6

Microsoft Azure Artificial Intelligence (AI), Machine Learning, Cognitive Services

A Note for Early Release Readers

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 6th chapter of the final book. Please note that the GitHub repo will be made active later on.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *jleonard@oreilly.com*.

> *Making applications easy to use and enabling users to focus on the work that adds the most value will be integral when developing applications going forward. Artificial Intelligence is a central technology for achieving this. Using Azure, all options are covered: a developer can use Cognitive Services to add cognitive intelligence into applications without needing any AI/ML skills. Machine learning engineers and Data Scientists can use Azure Machine Learning in all parts of the project lifecycle. Citizen Developers using low code/no code solutions such as Power Apps can make use of AI Builder to make an app more intelligent.*
>
> — Håkan Silfvernagel, Manager AI and Big Data at Miles AS, Microsoft AI MVP and Microsoft Certified Trainer

In the previous chapter, we learned about how vital data storage and databases are in cloud computing in Azure and its resources. We learned about the different cloud storage options for different use and types of data, especially in processes and operations in our applications. In this chapter, we will dive deeper into how we can use the

data we have hosted in the cloud through our modern applications in the world of Artificial Intelligence (AI), Machine Learning (ML), and other cognitive services in Azure that will help us build smart systems to help us in our daily routines.

Artificial Intelligence (AI) - An introduction

Before we can deep dive into the important key and technical concepts of AI, and ML, and learn about the cognitive services in Azure, we need to learn the basics of what they are and how they are useful to us, our applications, and organizations, and society.

AI will ultimately reshape how work is done as the technology replaces tasks typically performed by employees and changes how day-to-day decisions are made. Use cases mainly fall into three categories: automating and optimizing, generating insight and creating human-like engagement (e.g., chatbots and virtual assistants).

As technology rapidly changes, Artificial Intelligence (AI) has become one of the trending buzzword and technologies that are continually evolving. Even though AI has been shown in many science fiction movies and TV shows, we still have a lot to learn about this technology. The sci-fi movies we watch also give us the unclear and common misconception that AI and machine learning will take away our jobs, and that this technology will replace the human workforce in the future.

In spite of these things, we need to understand with an open mind and awareness of the value and the significance of this important area of computer science.

Artificial intelligence (AI) applies advanced analysis and logic-based techniques, including machine learning. It is used to interpret events, support and automate decisions and take action. It is a technical subject that goes far beyond many other areas in terms of comprehending the different intricacies and factors involved. Therefore, scientific and mathematical skills are often required when you are working with roles related to AI-related roles in the industry.

Some of the common programming languages used with AI-related jobs include Python, C#, and R. There are other tools in many platforms today that can be used, including the AI tools available in Microsoft Azure.

The history of AI

Artificial intelligence has changed the way we live with innovative technologies. AI has taken a storm in every industry and has a profound impact on every sector of society. The term AI was first coined in 1956 at a conference.[1]The discussion of the conference led to interdisciplinary natural language generation. The advent of the internet helped technology to progress exponentially. AI technology was a stand-alone technology, but nowadays, the applications are widespread everywhere. The history of AI can also be seen on this infographic of the timeline on the LiveScience website.

A press release paper entitled, "Gartner Identifies Three Imperatives Driving the Top Trends in Data and Analytics for 2022", included in the following quote:

> AI is becoming more pervasive, yet most organizations cannot interpret or explain what their models are doing, resulting in a lack of trust and transparency. Organizations are not prepared to manage the risks of fast-moving AI innovation and are inclined to cut corners around model governance including security, escalating the negative consequences of misperforming AI models, such as incorrect business decisions or worse, those impacting life or death.
>
> As AI regulations proliferate globally, they are mandating certain auditable practices that ensure trust, transparency and consumer protection. By 2026, Gartner anticipates organizations that develop trustworthy purpose-driven AI will see over 75% of AI innovations succeed, compared to 40% among those that don't.

The quote tells us that artificial intelligence (AI) is the future of technology that continues to help expand our horizons and achieve new cognitive services. On the other hand, because of the effects of AI having impact in the lives of people and our society, we need to focus on doing the work to handle security, deal with the risks associated with AI, and improve performance outcomes.

Today, AI has been used and implemented in application development, cloud development, data science, and more. This reveals that it has the capabilities to take data science and technology to the next level. The AI platform in Microsoft Azure AI platform offers a wide range of services and capabilities that can be used to build intelligent applications. These tools and services for AI and ML in Azure will be discussed in the later part of this chapter.

Examples of AI Technologies and Terms You Need to Know

AI technologies are widely used in different fields. The following are some of the known and latest AI technologies you need to know and what they are for.

Natural Language Processing (NLP)

NLP is an intuitive form of communication between humans and intelligent systems using our human languages. NLP drives modern interactive voice response (IVR) systems by processing language for communication improvement. For example, a common application of NLP today is the use of chatbots in websites and systems that we use in different businesses and industries.

Internet of Things (IoT)

IoT comprises the network of physical objects, or things, that contain embedded technology to sense or interact with their internal workings and the external environment. This doesn't include general-purpose devices, such as smartphones. Examples of IoT in action range from smart plugs to driverless vehicles. IoT relies on a wide range of IT endpoints and gateways to function and data to drive the AI, especially for real-time responses (e.g., for autonomous vehicles).

Computer Vision(CV)

An AI technology that can help us process real-life images through image capturing, processing, and analysis. CV allows machines to understand and gathers contextual, meaningful, and useful information from the real world. Techniques for CV have some unique requirements for infrastructure and technology that may be different from traditional approaches used for Machine Learning(ML). CV is getting better at accurately identifying objects that can help in the development and applications, such as self-driving cars, automated retail stock checks, and automatic drones.

Synthetic Data

In machine learning terms, synthetic data is artificially generated and resembles or replicates the statistical properties of actual data without the real data's identifying properties (e.g., id, name, or any personal details). To generate valuable outcomes with this, AI requires an enormous capacity for data. Synthetic data will be an essential source of large datasets that can model outlying scenarios while protecting sensitive and personal data.

Virtual Agents/Conversational AI agents

A valuable tool for instructional designers. A typical virtual agent is a computer application that interacts with us. Web and mobile applications provide chatbots as their customer service agents to interact with humans to answer their queries. Virtual agents are considered software-as-a-service(SaaS) these days.

Edge AI

An AI technique embedded at the touchpoint where physical devises meet the digital world, Edge AI helps enable IoT. One example is Azure Percept and you can also perform task such as deploying AI and machine learning computing on-premises and to the edge.

Generative AI
: A type of AI technology that learns about artifacts from data. After learning from data, it generates innovative new creations that are similar without repeating or copying the original. This is what makes it potentially helpful in creating new forms of creative content like video.

These AI technologies listed are helpful in many ways across industries and are still evolving today. Therefore, the demand for AI professionals working with these technologies is growing.

Why Should You Learn AI?

Development and engineering in the cloud, especially in Azure, involve learning a lot of new technologies and concepts. Understanding the different technologies and their applications in real-life scenarios and business cases is essential. Whether you have a role in leadership, sales or development team, or engineering, learning at least the fundamental concept of AI is necessary.

AI is an essential modern skill to have
: It is a skill that is worth learning. Based on O'Reilly's Radar report on the state of AI adoption, the most significant barriers are issues with data and a lack of skilled people. The future of work involves automation and as such everyone should know basic concepts of AI. Acquiring such skills will future-proof your career. The rise of AI in the commercial world will also create many job opportunities in various industries. Aside from gaining the necessary skills in AI, there are also some important considerations to think about before implementing AI into any type of business.

High demand of AI-related jobs and careers
: Learning AI technologies and tools will help you upskill your competencies in this area and give you better career opportunities. Gaining knowledge and career experience in this field will help you get job roles like being a Machine Learning Engineer, Software Engineer working with modern applications with AI technologies, Data Analyst, Research Engineer, Business Intelligence Developer, and Data Scientist.

Help build better, intelligent, and inclusive applications
: Working with AI-related jobs and technologies also allows for making a difference. Since AI can help us build better and more intelligent systems, we can contribute to making our lives and others easier. Also, the more we develop our applications and systems to be more inclusive and human, the better and more useful our systems become for daily uses and purposes. The AI implementation in some industries gives many benefits. For example, virtual assistants and customer service chatbots that we have today. These AI-built tools and services are

helping improve our product delivery and customer service satisfaction, which benefits any business or organization depending on what category it might be.

AI is a flexible and versatile field in tech
: AI technology and its use may probably affect some parts of human life. For example, AI improvements and solutions in industries like customer service, finance, security, fraud detection, and even healthcare can be valuable and helpful. Virtual Health Assistants(VSA) can assist and aid medical patients. VSA helps if the patients are on the correct prescribed medication, make suggestions on some of the essential health treatments, and may provide ideal diet recipes based on the data history of previous illness and medical records. If you're interested in learning more, I recommend the role of artificial intelligence in healthcare: a structured literature review medical paper on the role of AI in healthcare.

Benefits of AI to Businesses

Artificial Intelligence is a hot topic for businesses, especially in e-commerce.[2]. The capabilities of AI are evolving which provides opportunities to companies on how to make a promising approach to customer engagement in real-time, manage their operations, and ensure business continuity, especially when many are working and doing business hybrid and remotely. Businesses and companies are finding new ways to innovate and expand opportunities along with the advancement of technology.

IT and data analysis leaders can use AI techniques to solve a wide array of business problems and generate significant returns on investment; however, the question for most organizations is how to use artificial intelligence to create or accelerate digital business growth.

The main opportunities of artificial intelligence lie in its ability to:

- Reveal better ways of doing things through advanced probabilistic analysis of outcomes
- Interact directly with systems that take actions, enabling the removal of human-intensive calculations and integration steps
- Gartner's research consistently shows that CIOs see an enormous opportunity in the benefits of AI but still struggle to capture those advantages in practice.

Research about AI in Retail

There is an available interesting infographic report about AI in Retail that was published and forecasted by Juniper Research. This report reveals and concludes the projection of the amount of total retail spending for machine learning in the year 2023 and the projected annual software spend on AI demand forecasting compared to 2018.

This also tells us that spending on machine learning in AI will continue to grow at a projected rate of 230% between 2019 and 2023. Approximately 325,000 retailers will be using machine learning in some form by 2023 and intelligent checkout technologies in e-commerce or shops will help facilitate 1.4 billion transactions in 2023.

MLOps and DevOps: Why Data Makes It Different

Deploying machine learning projects to production can be challenging because of many factors. In cloud development and software development, we have DevOps. In the Machine Learning world, there is also a term called *MLOps*, which means Machine Learning Operations. There is a good article *MLOps and DevOps: Why Data Makes It Different* from O'Reilly's Radar reports on what makes MLOps and DevOps different. If you'd like to learn more about differnet trends in artificial intelligence and machine learning, then I recommend this article about thetrends in artificial intelligence and machine learning.

Make sure to establish an enterprise strategy for AI to identify use cases and success metrics from the outset. Common ways of measuring benefits include risk reduction, speed of the process, improved sales, increased customer satisfaction, and reduced labor needs or costs. Many business cases rely on a combination of benefits, both tangible and intangible.

> We're just at the beginning of an explosion of intelligent software.
>
> —Tim O'Reilly, founder

As Tim O'Reilly said, we are just in the initial phase of evolving and growing intelligent software and applications. I believe that cloud development in Microsoft Azure and other cloud platforms will be fundamental in how we do business and work with our innovations and digital products with our customers in the future.

Machine Learning

Machine learning (ML) is a type of artificial intelligence (AI) that allows software applications to become more accurate at predicting outcomes without being explicitly

programmed. The algorithms in Machine Learning use historical data as input to predict new output values. ML is a critical technology that enables AI to solve problems. Despite common misperceptions, machines do not learn. They store and compute — admittedly in increasingly complex ways.

ML is a purely analytical discipline. It applies mathematical models to data to extract knowledge and find patterns humans would likely miss. ML also recommends actions but does not direct systems to take action without human intervention. Machine learning creates an algorithm or statistical formula (referred to as a "model") that converts a series of data points into a single result. ML algorithms "learn" through "training," in which they identify patterns and correlations in data and use them to provide new insights and predictions without being explicitly programmed.

Recommendation engines are an everyday use case for machine learning. Other popular uses include fraud detection, spam filtering, malware threat detection, business process automation (BPA), and Predictive maintenance. Machine Learning systems are considered unique and complex because of various components.[3]

These different complex components in an ML system are usually composed of machine learning algorithms, training data, evaluation metrics, business logic, and more. Additionally, Data engineers, analysts, data scientists, ML engineers, and users are also involved in developing ML systems.

The difference between AI and Machine Learning

Artificial intelligence and machine learning often get misinterpreted, but they are closely interconnected and related. In a use case scenario, AI and ML are used together. For example, an AI system is built on techniques like machine learning to create and study the patterns in the training data. Data scientists then optimize these ML models to provide the best results.

Deep Learning

A variant of machine learning algorithms. Deep learning uses multiple layers of algorithms to solve problems by extracting knowledge from raw data and transforming it at every level. Deep learning can outperform traditional ML (or shallow learning techniques) by working with complex and often high-dimensional data, such as images, speech, and text. Still, either rule-based systems or traditional ML can effectively solve many AI problems.

In most organizations, deep learning solutions are not yet a significant part of the product roadmap (rule-based systems or traditional ML can effectively enable most AI use cases today), but their use is quickly increasing alongside advancements in data processing and breakthroughs in computational techniques.

Using ML, including deep learning, to make predictions enables an AI-driven process to automate the selection of the most favorable result, eliminating the need for a human decision maker.

Ethical AI and Responsible AI

In the future, it has been predicted that robotics and artificial intelligence (AI) are technologies that are prone and suspected to have a vast and essential impact on the improvement of humanity. Important questions are being raised about what humans should do with these systems we teach to think like us and what these learning systems can or should do. The possible risks in letting them do the work for us and how we can effectively manage and control these AI-built systems.[4]

In practical terms, Ethical AI makes sure that initiatives related to AI initiatives of any organization, company, or entity follow and maintain human dignity and should not cause any harm to people or society. It is broad in its spectrum, which means that any AI technologies and products should be built and designed with fairness, liability, safety, and security. One of the commonly known examples and questions raised for ethical AI is the example of a use case of self-driving cars in relevance to handling situations with humans in case of accidents.

There have been many discussions about the ethical implications. For example, the use of AI in enterprises, and the vision to build strategies for ethical AI strategies. Pew Research Center did research that indicates that even a decade from today, it is not likely that the design of ethical AI design will be widely adopted.

The research, based on a survey of 602 technology innovators, business and policy leaders, researchers, and activists conducted by Pew Research Center and Elon University, showed that a majority worried that the evolution of AI by 2030 will continue to be primarily focused on optimizing profits and social control and that stakeholders will struggle to achieve a consensus about ethics.[5]

When asked whether AI systems used by organizations that employ ethical principles focus primarily on the public good by 2030, 68% said they will not. The research added that "ethical" implies adopting AI in a transparent, responsible, and accountable manner. For others, it means ensuring their use of AI remains consistent with laws, regulations, norms, customer expectations, and organizational values. Ethical AI also promises to guard against the use of biased data or algorithms, assuring that automated decisions are justified and explainable.

Microsoft have developed Fairlearn, an open source suite of tools to be used for Responsible AI. Fairlearn is a Python package that helps implement several algorithms to detect and mitigate group fairness issues in machine learning models. It is an essential toolkit for machine learning researchers and developers because, through responsible AI, we would want to train machine learning models and teach the team

to behave reasonably. Fairness in responsible AI is important and can be done in a few ways: fairness towards individuals and groups. Fairlearn is developed and aims to fix fairness issues in AI.

Microsoft's Responsible AI Tools and Resources

Microsoft aims to provide education and knowledge and spread awareness of responsible AI to everyone. There are useful learning resources available on resources on website *https://www.microsoft.com/en-us/ai/responsible-ai-resources* that can help you, your organization and your team to responsibly use and develop AI at any of innovation - from concept, development, deployment, and more. There's also the Responsible AI Toolbox that will help you gain a better understanding of AI systems more responsibly.

The topic and discussion about Artificial Intelligence are trending but also very important to understand. Most specifically, the importance of Ethical AI and Responsible AI in any design, development, and implementation processes.

Azure Cognitive Services

Azure Cognitive Services are artificial intelligence (AI) and cloud-based services that help us build intelligent and smart applications by implementing cognitive intelligence into our applications.

Regardless of the type of framework and programming platform, your Azure services are usually accessible for development using client library SDKs for different programming languages, REST APIs, and platforms built with user interfaces. Because of the variety and flexibility of using these cognitive services and tools, you don't need to be an expert in AI to be able to add and apply cognitive services features to your applications.

Some of the known uses for Azure Cognitive Services include being able to customize pre-trained machine learning models using AI innovation and research. Using cloud and container development technologies available today, we are also able to deploy cognitive services from a cloud computing platform to edge computing.

Azure Cognitive Services gives you the opportunity to build cognitive solutions that can see, hear, speak, understand, and even make decisions. These solutions are grouped into different categories: Speech, Vision, Language and Decision.

Figure 6-1 illustrates an overview of the Azure Cognitive Services that are useful and available for developers to use and implement in their applications.

Figure 6-1. An overview of the different Azure Cognitive Services

Table 6-1 reveals some of the commonly used Azure Cognitive Services based on different cognitive categories and how they are useful.

Table 6-1. Different Types of Azure Cognitive Services

Cognitive API Category	Name	Description
Speech	Speech Service	Add speech-enabled features to applications in different ways such as speech-to-text, speech translation, text-to-speech, and many more.
Vision	Computer Vision	Gives you the ability and access to cognitive algorithms that are advanced and beneficial for image processing and image recognition. If you want to customize and build your own image classifications, there is also Custom Vision cognitive service that you can make use of.
Vision	Face Service	This cognitive service gives you access to different types of face algorithms that help detect and recognize faces
Language	Azure Language Service	If you need to analyze and understand text, you can use this service with the help of Natural Language Processing (NLP) features
Language	QnA Maker	The QnQ maker service allows you to build a question-and-answer AI service based on the content structured
Language	Language Understanding (LUIS)	LUIS is a cloud-based conversational AI that uses the intelligence of ML to help predict the overall meaning of a person's conversational or natural language text. This conversational AI will then be able to process and gather important information from it
Language	Translator	Translate the messages and text in your application by using the cognitive translator service that provides machine-based real-time text translation. The Azure Anomaly Detector has an interactive demo and example that will help you understand it works. In order to use this demo, you would need an Anomaly resource, endpoint and API key.
Decision	Anomaly Detector	This AI-based detector will help you detect and monitor the possible abnormalities in time series data.
Decision	Content Moderator	Using this cognitive decision service you are able to add monitoring for possible offensive, undesirable, and risky content in your application or solutions. Content Moderator is an AI service for moderating content by scanning images, text, videos, etc. and automatically flags to it. This will help build compliance and regulations for your users

Cognitive API Category	Name	Description
Decision	Personalizer	Personalizer allows you to choose the best experience to show to your users, learning from their real-time behavior.

These cognitive services are indeed useful in making our applications more intelligent and smarter at the same time help us save time.

Build Your First Intelligent App with Cognitive APIs

There is a free e-book entitled Building Intelligent Apps with Cognitive APIs from O'Reilly that provides in-depth knowledge about building smart applications using Cognitive APIs.

Important note on using Azure Cognitive Services

In July 2022, Microsoft made Azure Cognitive Services as Limited Access services to the public to follow consistent Microsoft Responsible AI Principles. Limited Access services require users to register to use it and only customers managed by Microsoft are eligible for access. For more information, check out Microsoft's Documentation at Limited Access features for Cognitive Services

Azure Machine Learning

Azure Machine Learning is a cloud service for machine learning-related solutions, which helps and aids in the improvement and management of a machine learning project's lifecycle.

Professionals like data scientists and engineers working with ML or AI can use the available features and tools for designing and developing ML workflow tasks. Such tasks related to this field include designing the ML models, training it, and also managing the lifecycle of MLOps or Machine Learning Operations.

You can create a model in Azure Machine Learning or use a model built from an open-source platform, such as Pytorch, TensorFlow, or scikit-learn. MLOps tools help you monitor, retrain, and redeploy models.

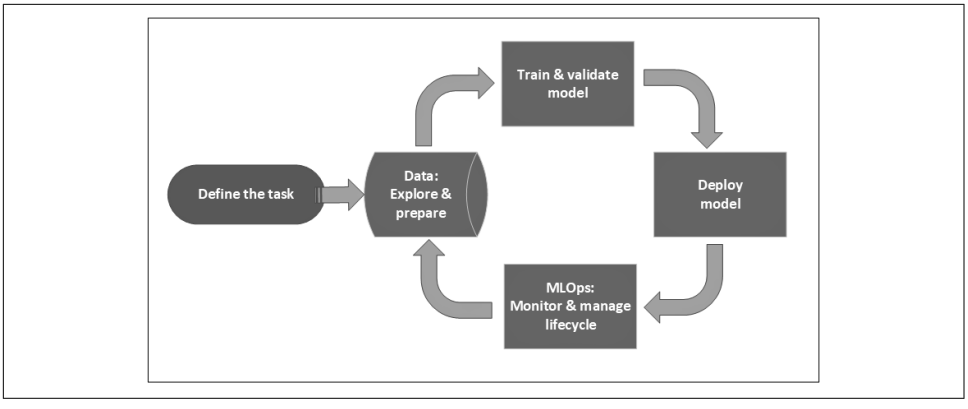

Figure 6-2. Example of typical Azure Machine Learning's Development Lifecycle

Figure 6-2 shows us a simple example of how the machine learning models are being developed. As with many processes, you first need to define what the task is. Then explore and prepare your data for a specific purpose or use case. At this point, you'll be ready to train and validate your model, then deploy it. Once it's deployed, you'll want to monitor and manage your model which will ultimately bring you back to exploring your data, creating a continuous loop. Some workflows have fresh data pushes every few hours, others every few days. Your needs will be determined by your MLOps team as they monitor and manage the lifecycle.

The development cycles are created, designed and developed within a machine learning project which involves several professionals in different roles in AI or ML. The development lifecycle for a ML project is often a repetitive and iterative process. It involves experimentation and analysis of data, machine learning algorithms and training models.

Just like any other project in software engineering and cloud development, Azure Machine Learning cloud service enables its users to work together and collaborate on a machine learning project.

Usually in a machine learning project in Microsoft Azure, you would need to create a workspace called Azure Machine Learning Workspace as a logical container for the project.

A workspace organizes a project and allows for collaboration for many users all working toward a common objective. Users in a workspace can easily share the results of their runs from experimentation in the studio user interface or use versioned assets for jobs like environments and storage references.

When a project is ready for operationalization, users' work can be automated in a machine learning pipeline and triggered on a schedule or HTTPS request. Models can be deployed to the managed interface solution, for both real-time and batch

deployments, abstracting away the infrastructure management typically required for deploying models.

Azure Machine Learning Studio

The web portal for data scientist developers in Azure Machine learning, this studio combines no-code and code-first experiences for an inclusive data science platform.

Azure Machine Learning Studio is Microsoft's central point of contact for Machine Learning Computation in the Azure cloud. It is the successor of the Microsoft Machine Learning Studio Classic, which will be retired in 2024. Microsoft expanded the number of features and possibilities within their Azure ML Studio and the progress is still ongoing. Microsoft tries to make the creation of and the work with algorithms and experiments as simple as possible. As a result, you can expect that also Azure ML will get more and more features with automation and click surface than with hard-coded algorithms.

The menu options in Azure ML Studio is divided into three main sections: *Author, Assets, and Manage*. as described in the following list.

- *Author* is a section in studio that deals with the creation of the code and set-up of your machine learning processes
- *Assets* are the actually the resources that are stored and created within the section of Author. Assets include the pipelines created in the Designer that controls the resources' workflow from inputting datasets over a pipeline to the endpoints for the output (e.g. connection to real systems via REST API)
- *Manage* is for the system behind the scenes that includes the computation clusters and instances, datastores on which the datasets are stored, and the integrations into other systems

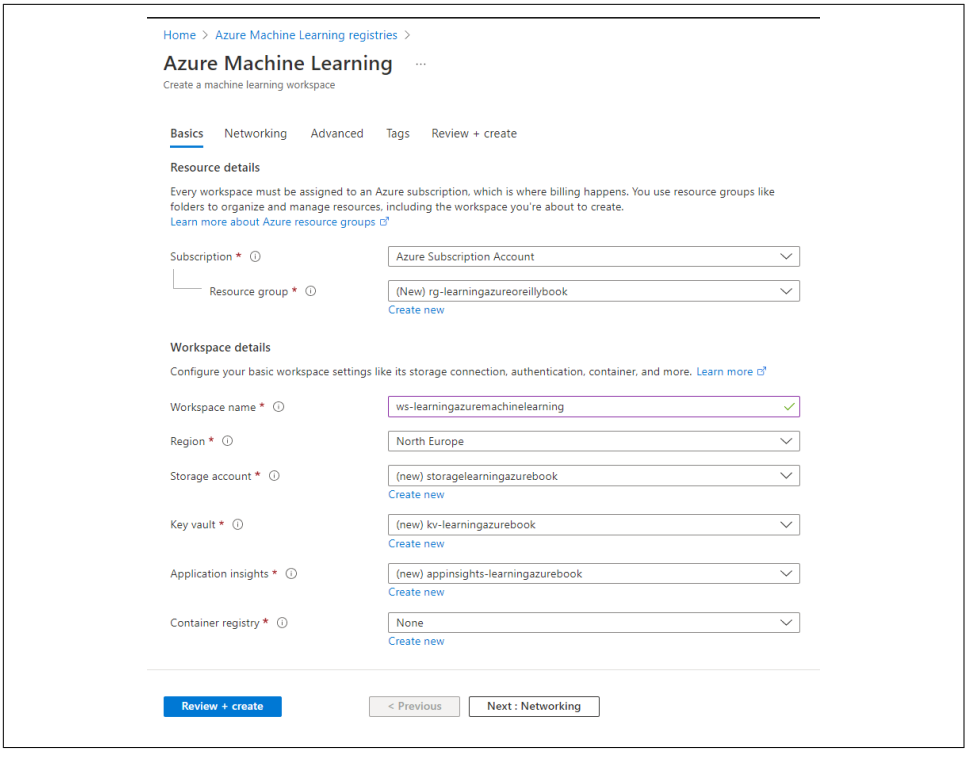

Figure 6-3. Illustration of an Azure Machine Learning Workspace creation on Azure Portal

Figure 6-3 illustrates and example of how to create an Azure Machine Learning workspace in Azure to get started in creating a ML project.

Finally, in order to prepare before the deprecation of Azure Machine Learning Studio in 2024, I recommend to check this useful guide for Azure Machine Learning Adoption Framework for a basic "lift and shift" migration from the classic version of this ML studio.

Automated Machine Learning

Automated Machine Learning (AutoML) is perfect for creating models without using code. It's a No-Code UI, which means that you will be able to follow through along instructions easily. You will be able to work with machine learning projects with out any programming skills required. There is a limitation of this tool. For example, you cannot build the most complex models.

There are data featurization in Automated Machine Learning that are worth checking out. They will help automate machine learning experiments.

AI Builder for Power Platform

AI Builder is a Microsoft Power Platform capability that provides AI models that are designed to optimize your business processes. AI Builder enables your business to use intelligence to automate processes and glean insights from your data in Power Apps and Power Automate. With AI Builder, you don't need coding or data science skills to access the power of AI. You can build custom models tailored to your needs, or choose a prebuilt model that is ready to use for many common business scenarios.

You can use AI Builder in one of two ways, depending on the model you will be using. You can use AI models in the formula bar, add components using AI Builder and also can use the Microsoft Power Fx expressions to consume AI Builder models in Power Apps.

Microsoft Power Fx is a low-code general-purpose programming language based on spreadsheet-like formulas. It is a strongly typed, declarative, and functional language, with imperative logic and state management available as needed. Check out the overview documentation of Microsoft Power Fx.

There is also a good learning path to learn more about building with AI Builder on Power Platform.

Azure Applied AI Services

Azure Applied AI Services helps you and your organization build and deploy AI-based solutions. Modernize your business processes faster with Azure Applied AI Services. Applied AI Services bring together Azure Cognitive Services, task-specific AI, and business logic to offer you turnkey AI services for common business processes.

Automate document processing, improve customer service, understand the root cause of anomalies, and extract insights from any content—all with Azure Applied AI services. Plus, extend Applied AI Services by using your own AI models from Azure Machine Learning.

Specialized AI services for specific business scenarios like modernizing business processes with task-specific AI to solve common scenarios. It enables you to accelerate development with built-in business logic that enables you to launch solutions in days rather than months.

Azure Applied AI Services are high-level services focused on empowering developers to quickly unlock the value of data by applying AI to their key business scenarios. Built on top of the AI APIs of Azure Cognitive Services, Azure Applied AI Services are optimized for critical tasks ranging from monitoring and diagnosing metric anomalies, mining knowledge from documents, enhancing the customer experience

through transcription analysis, and boosting literacy in the classroom, document understanding and more.

Previously, companies would have to orchestrate multiple AI skills, add business logic to it, and then create a user interface (UI) in order to go from development to deployment for their scenario. These steps would consume time, expertise, and resources. These "scenario-specific" services provide developers with these benefits "out of the box."

Let's take a closer look at some of the Applied AI Services in Microsoft Azure:

Azure Form Recognizer
: Enables organizations to consume information hidden within documents to increase productivity, automate business processes and generate knowledge and insights. Azure Form Recognizer is a service that lets you build automated data processing software using machine learning technology to identify and extract text, key/value pairs, selection marks, tables, and structure from your documents. The service outputs structured data that includes the relationships in the original file, bounding boxes, confidence and more. This tool provides accurate results without heavy manual intervention or extensive data science and automates data entry in your applications to enrich your documents' search capabilities.

Azure Cognitive Search
: Unlock the information that are important and valuable to perform an action or make decisions. Azure Cognitive Search is the only cloud search service that provides built-in AI capabilities. It has capabilities to enrich all types of information that will help you identify and explore valauable content at any scale. Use cognitive skills for language, vision, and speech. You can also use custom machine learning models to discover some insights from all types of content. The Azure Cognitive Search also offers semantic search capability, which uses advanced machine learning techniques to understand user intent and contextually rank the most relevant search results.

Azure Bot Service
: Enable rapid creation of customizable, sophisticated, conversational experiences with pre-built conversational components enabling business value right out of the box. Azure Bot Service Composer is an open-source visual authoring canvas for developers and multidisciplinary teams to build bots. Composer integrates language understanding services such as LUIS and QnA Maker and allows sophisticated composition of bot replies using language generation.

Azure Immersive Reader
: Enhance reading comprehension and achievement using AI. The Azure Immersive Reader is an inclusively designed tool that implements proven techniques to improve reading comprehension for new readers, language learners, and people

with learning differences such as dyslexia. With the Immersive Reader client library, you can leverage the same technology used in Microsoft Word and Microsoft OneNote to improve your web applications.

Azure Metrics Advisor
: Protecting the organizations' growth by enabling them to make the right decision based on intelligence from metrics of businesses, services, and physical assets. Azure Metrics Advisor uses AI to perform data monitoring and anomaly detection in time series data. The service automates the process of applying models to your data and provides a set of APIs and a web-based workspace for data ingestion, anomaly detection, and diagnostics - without needing to know machine learning. Developers can build AIOps, predictive maintenance, and business monitoring applications on top of the service.

So those are the different Applied AI Services that are available in Microsoft Azure and they are indeed useful in certain scenarios and use cases not just automation, innovation, efficiency, and productivity, but also in providing technological tools for accessibility and inclusion in the technologies we have today.

Microsoft's O'Reilly Book on Azure AI

Microsoft Azure has an e-book available to anyone who wants to learn more about Azure AI. This book is currently available for free on the Microsoft Azure website and is also available on O'Reilly's platform

The Cognitive Services in Azure follow guidelines and share information about how to responsibly use artificial intelligence in applications. Check out Microsoft's Guide for Resposible AI with Cognitive Services in different areas.

The Azure AI Infrastructure uses High-performance computing (HPC) that uses a large number of GPU-based computers to solve complex mathematical tasks that help in different problems that we have in our society today.

HPC is frequently used in the following areas: Engineering, Weather Modeling, Finance, Genomics, Simulations, and more. In addition to this, a Software-as-Service(SaaS) solution uses HPC to solve a problem in computer-aided engineering in Azure's cloud platform.

Learn By Doing (Try it out!)

Instead of creating customized hands-on learning labs for the topics discussed in this chapter, the following quick-start tutorials are most recommended as they are updated based on Microsoft's technical updates for these technologies. This section is recommended and optional.

- Quickstart: Create workspace resources you need to get started with Azure Machine Learning
- Train an image classification TensorFlow model using the Azure Machine Learning Visual Studio Code Extension
- Tutorial: Forecast demand with no-code automated machine learning in the Azure Machine Learning Studio
- Tutorial: Get started with a Python script in Azure Machine Learning
- Azure Cognitive Service for Computer Vision: Quickstart: Optical character recognition (OCR)
- Azure Machine Learning Hands on Labs
- Set up no-code AutoML training with the studio UI

Summary

In this chapter, we have learned the basics of what AI really is and how it relates to ML. These two innovations in technology are useful in many ways. Through AI and ML, we can train models using our training data to build useful AI solutions for our businesses and applications.

As a cloud platform, Microsoft Azure provides a wide range of services that can be used to automate the process of creating and deploying ML models. AI in Azure is composed of several major categories: Azure Applied AI Services, Azure Cognitive Services, Azure AI Infrastructure, and Azure Machine Learning. Azure Cognitive Services provides a set of APIs that can be used by developers, data scientists, data engineers, and AI experts in different areas and categories of business applications. There are also Azure services and tools that will help us automate tasks and workflows.

We also learned about the benefits of AI and ML in different areas and how important it is to take considerations of developing AI-driven solutions responsibly by making use of Responsible AI. Microsoft Azure, as a cloud platform and company, is also conscious and responsible for the use of AI by implementing Microsoft Responsible AI standards that help us to make sure that our AI solutions are safe, secure, responsible, and ethical.

Check Your Knowledge

1. What is Artificial Intelligence?
2. What is the name of an open-source AI fairness project made with Python and is developed by Microsoft?

3. What is the difference between AI and Machine Learning?
4. List a few of the Azure cognitive services that help us build and add cognitive features to our applications with the help of AI and Machine Learning.
5. Why do you think Responsible AI and Ethical AI are important in building AI solutions?

To find the answers to the *Check Your Knowledge*, turn to back of the book in the Appendix.

Recommended Learning Resources

- Standford University - Human-Centered Artificial Intelligence, Artificial Intelligence Index Report 2022
- O'Reilly Media, AI Adoption in the Enterprise 2021 Report by Mike Loukides
- AI Papers to Read in 2022 by Ygor Serpa
- O'Reilly Media: Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition by Aurélien Géron
- O'Reilly Media: AI and Machine Learning for Coders by Laurence Moroney, ISBN: 978-1-492-07819-7
- AI42 Community - An AI Community and School for Everyone
- Elements of AI: Free AI Courses in Different Languages
- Digital Silk: Artificial Intelligence and Machine Learning
- University of Washington: History of AI
- Fairlearn: Improve Fairness of AI systems
- Microsoft: Responsible AI Resources
- Zero to Hero: Azure AI Developer Learning Journey
- Technical leaders agree: AI is now a necessity to compete
- How Microsoft drives responsible AI
- Free e-Book: Mastering Azure Machine Learning
- Microsoft's framework for building AI systems responsibly
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition by Aurélien Géron
- Responsible Machine Learning by Patrick Hall, Navdeep Gill, and Benjamin Cox
- Microsoft Whitepaper: Machine Learning solutions with enterprise security and scale

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CHAPTER 7

Big Data, Reporting and Analytics Services in Azure

A Note for Early Release Readers

With Early Release ebooks, you get books in their earliest form—the author's raw and unedited content as they write—so you can take advantage of these technologies long before the official release of these titles.

This will be the 7th chapter of the final book. Please note that the GitHub repo will be made active later on.

If you have comments about how we might improve the content and/or examples in this book, or if you notice missing material within this chapter, please reach out to the editor at *jleonard@oreilly.com*.

Previously, we learned about how Artificial Intelligence (AI), Machine Learning(ML), and Azure Cognitive Services can be used to build intelligent applications to help us in our daily tasks and work. We explored using these cognitive services to use collected data to develop applications and enterprise-level solutions that will help us in the broader perspective. In this chapter, we'll shift gears and dive deeper into how we can use and visualize data collected using cloud services to analyze and understand it better.

Introduction to Big Data, Reporting and Analytics Services in Azure

In our daily routine, it is no secret that we collect, process, and work with data in our applications, mobile phones, tablets, etc. These actions generate data points, and understanding that data at scale through extensive data analysis turns datasets into something actionable. This level of analysis is referred to as big data analytics, and it's the foundation of many data-driven business and enterprise decisions.

By being data-driven as a business or an organization, guessing and misconceptions can be avoided. Visually representing this data to gain insights is helpful in many ways. Before we can transfer our basic information as valuable insights, we need to set up a process for data analysis.

Visually representing this data to gain insights is helpful in many ways. Before we can transfer our basic information as valuable insights, we need to set up a process for data analysis.

Furthermore, every project is unique and can strategically use a different approach. Through cloud computing and advanced technology solutions, we have the opportunity to solve these challenges. We can combine a cloud-based data warehouse with an analysis system that is compatible with the cloud platform. There is also an alternative option to leverage a hybrid workflow by combining cloud-managed services with private clouds.

Before you can transform your raw data into insights, you need to set up an analysis process. Each project merits a different approach. You might want to consider factors like how you would prefer to collect and visualize your data. Where would you like to collect this information, and how would your organization like to manage it effectively? Or perhaps how you would like to optimize these enterprise data to improve your services to your users.

You can use a combination of a cloud-based data warehouse with a compatible analysis service. Alternatively, you can combine managed services with private clouds. Or you can set up your hybrid operation.

What is Big Data?

The term *Big Data* is a trending topic in technology today, especially since data is considered to have great value. What does working with big data mean? Does it help improve how we handle data collection, reporting, and analysis in our enterprise applications on the cloud or on-premises?

The use case scenarios of big data solutions can be found in many areas. Examples include social media, the Internet of Things (IoT), gaming, etc. In these given exam-

ples, millions of users generate large volumes of data through data streams that need to be handled quickly and in real time.

Systems built to handle big data are specialized to solve the challenges of its four Vs or characteristics. These four V-s are *Volume, Variety, Velocity, and Veracity*. Let us deep dive into the details of these four Vs for us to understand them better:

Volume
: While we generate data every day in different ways, some of the data we generate is of a large volume that needs to be handled differently. Technology platforms used in industries like e-commerce, social media, IoT, gaming, etc., generate large sets of data continuously around the clock. For example, connected cars spread across the globe send live telemetry data to their car manufacturing company's systems. If we combine all these telemetry data daily, it would be a massive volume of data and can only be solved by big data systems.

Variety
: Traditionally, the data we are familiar with and are used to working on are structured data in different types or formats. The data format can be text, time, number, etc., which we commonly collect and store using relational database systems. Increasingly, the evolving demand and use of unstructured data for things like live streaming of media files, images, feeds on Twitter, websites, live logs, etc., makes it challenging to have a data analytics system to analyze all these data types. This data variation is one of the challenges big data systems solve.

Velocity
: A velocity of data often refers to how high the speed of incoming data processing is. As mentioned earlier, gaming or IoT systems that require speed of delivery and data processing are good examples of the need for velocity.

Veracity
: The veracity or integrity of data is an essential aspect of big data. It is because it checks and verifies data authenticity, trustworthiness, precision, and accuracy. Veracity is vital mainly when the data to be analyzed will be used in making critical analytical decisions. The accuracy and reliability of data are crucial for trustworthy output or results.

Additionally, these challenges can be solved in a cost-efficiently way using big data systems. Today's big data technology platforms use distributed processing for scalability, fault tolerance, and high throughputs.

In distributed processing, multiple computing resources work together to execute a task. Hadoop is a big data solution built on distributed processing concepts. It can handle computer nodes that can work together up to tens of petabytes (PBs)[1] of data to perform a query task.

For example, Azure HDInsight (a managed Hadoop cloud service) and Azure Databricks are widely used big data platforms on Microsoft Azure. We will learn more about the different big data services and solutions throughout the rest of this chapter.

Figure 7.1 shows an example of the typical data flow process in Big Data which involves data collection, storage management, then big data analytics, where a decision-making unit is critical in moving further to the network optimization unit.

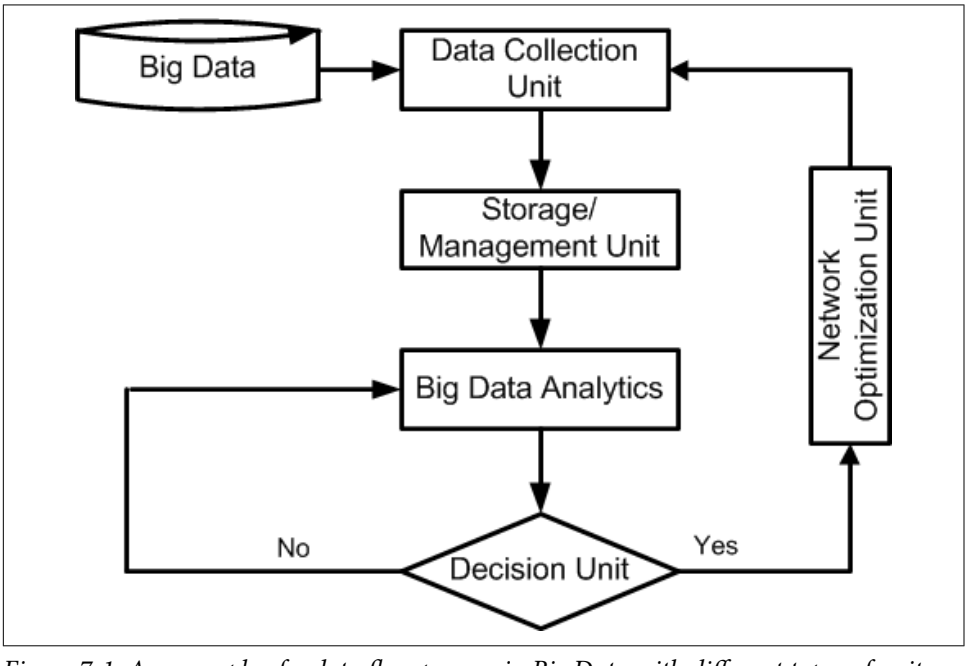

Figure 7-1. An example of a data flow process in Big Data with different types of units

Big Data Solutions in Azure

Cloud services for Artificial Intelligence (AI), Big Data, and Analytics are part of the cloud platform Azure provides to its users. The big data solutions and services in Azure give an advantage and flexibility to those users who want to make the most of the synergy of combining cloud computing capabilities with analytics.

Regardless of if they are structured or unstructured data or if they are data of high volumes that require colossal storage capacity. Azure Big Data services come with fully managed infrastructure and real-time analytics. In addition to this, they can also be well integrated with other cloud resources in Azure. Examples include integration with other analytics, machine learning, storage, and database services.

Aside from computing, networking, hybrid, and other cloud solutions, Microsoft Azure also provides a wide range and a list of services that can help you set up a sig-

nificant data infrastructure. Including databases, data processing or management tools, analytics, etc., to work and manage complex data sources.

Common Use Cases of Big Data in Microsoft Azure

Aside from computing, networking, hybrid, and other cloud solutions, Azure provides a range of services that can help you set up a big data infrastructure, from databases to data processing and analytics to machine learning and integrating complex data sources.

The following are some of the everyday use cases of using Big Data in the Azure cloud platform:

Databases
: Azure database options include self-managed Table Storage, self-managed databases hosted on a virtual machine, and managed databases such as SQL Server, PostgreSQL, MySQL, and MariaDB. If you are interested in a fully managed service, you can use Cosmos DB by Azure. Cosmos is a scalable, flexible, low-latency service that supports global deployment and replication of multiple database engines. Its APIs are compatible with many tools, including MongoDB, Cassandra, Apache Spark, SQL, Jupyter Notebook, Table Storage, Gremlin, and more. Azure also provides SQL Data Warehouse, for large-scale structured data and Azure Data Lake for unstructured data

Analytics
: Azure provides a wide variety of analytics products and services. Currently, a few of the known services are HDInsight and Azure Analysis Services. Analysis Services in Azure provide an enterprise-class analysis engine that can collect data from multiple sources and turn it into an easy-to-use semantic BI model. The service integrates predefined database models and can generate interactive dashboards and reports. It is not necessary to write code or manage data processing.

Data Engineering
: You can use two primary Azure services to create complex data pipelines: Azure Data Factory and Azure Data Catalog. Data Factory provides serverless integration for local and cloud-based data repositories. These two category of data engineering tools in Azure will be discussed in more detail in the next section.

Machine Learning
: Azure provides various solutions for *artificial intelligence and machine learning*, including Azure Machine Learning Services (AMLS). The AMLS lets you create customized models for machine learning without the programming skills required by using a zero-code drag-and-drop interface and a code-first environment. It is compatible with open-source tools and platforms such as PyTorch, TensorFlow, Open Neural Network Exchange(ONNX), and sci-kit learn in

Python. Azure Machine Learning Services helps automate machine learning with tools like automated feature selection, algorithm selection, and hyperparameter scanning.

Complex Big Data Pipeline Tools in Azure

Big data can be complex to visualize and analyze; sometimes, you must create pipelines to handle them. In Azure, two big data solution tools would help complex big data pipelines. Let us briefly overview these tools: *Azure Data Factory* and *Azure Data Catalog*.

Azure Data Factory

The Azure Data Factory allows you to do serverless integration for both cloud-based and local data repositories. Using Data Factory, you can perform tasks for extract, load, transform (ELT) or extract, transform, load (ETL) using the available data connectors provided natively by Azure. Some built-in connectors in Azure Data Factory for data sources are from Google Big Query, Amazon S3, and many other data sources from other platforms and on-premises. Furthermore, transferring or copying existing data from Azure File Storage to Data Factory is possible.

This service in Azure allows you to build ETL through a visual editor, which gives flexibility to those who prefer to do it without writing code or scripts. The tool for Data Factory enables you to automate the process with scheduling, drag-and-drop components, and even create event-based triggers.

Azure Monitor is also an excellent monitoring service that can be well integrated with Azure Data Factory. It helps you gain the overall view and visibility to manage the performance of data flowing through CI/CD pipelines.

Azure Data Catalog

Azure Data Catalog is a fully managed metadata catalog for enterprise use. It supports a record for metadata that helps in data asset discovery. It allows you to crowdsource metadata and annotations to users like data analysts, engineers, or data scientists.

It provides a way to enable these types of users to discover, understand, register, enrich, and consume data sources. Data professionals can share their knowledge and collaborate, which can help make data more easily searchable and accessible.

You can handle complex big data pipelines using Azure Data Factory and Azure Data Catalog. However, it is important to note that Azure is replacing Azure Data Catalog with the service by 2025. If your organization has existing Azure Data Catalog accounts, you need to start planning your migration to *Microsoft Purview*.

Building, Configuring and Deploying Big Data on Azure

Microsoft recommends a four-step process for designing and building a new big data solution in the Azure cloud. These processes include evaluation, architecture, configuration, and production preparation.

Evaluation of a Big Data Goal and Solution

Before choosing a service, you need to evaluate your big data goals. You must understand the type of data you want to include and how to format it. For example, web scraping data differs from the information you get from an IoT device. The amount and type of data used will assist in planning for data ingestion and identifying what kind of storage is required. Once you know what type of data needs to be processed, a decision on how to analyze it must be made.

If your team doesn't have a data scientist, you can use one of the big data service alternatives available. For this case, using machine learning in the system would be beneficial. It is also worth considering machine learning scripting languages and tools.

In addition, if your organization is still in the starting process of your cloud journey, you should familiarize yourself with the full scope of an Azure migration. It is a recommendation to consider starting an intelligent and effective by considering to start your project by initially migrating the core applications and processes to the cloud.

Identifying Big Data Architecture

Suppose you want to create your own solution. Define an initial architecture based on the results of your evaluation. This architecture should depend on your legacy systems (*if you have existing big data infrastructure in your local data center*) and the skills of your development and operations teams.

Solutions for Big data usually involve one more workload type, like batch processing of big data sources at rest, real-time processing of big data that are in motion, interactive exploration of big data, machine learning, and predictive analytics.

Therefore, a typical big data architecture should be able to handle complex or large amounts of data for ingestion, processing, and analysis that traditional database systems and applications cannot take. The Big Data Architecture Style for Azure would help you and your organization gain insights as you plan to design, implement and build your solutions for big data.

Preparation of Production Environment

After selecting the services, you need, you can configure and prepare your production environment. Your exact configuration will depend on your chosen services, the combination of data sources, and whether you are creating a hybrid or pure cloud

environment. Whatever specific structure you use, you should monitor as many processes as possible to get the best performance and return on your investment.

Azure Monitor and Log Analytics can help prepare for production use. Monitoring applications and cloud solutions will be discussed in the later chapters. It is also recommended to define and enforce a privacy and security policy and implement a backup, restore, and disaster recovery for your big data system. Based on these processes and guidance in building a big data solution, you should be able to make a solution ready to use in the cloud.

Data Analytics - Making Sense of it and its Importance

Data gathering, extracting, transforming, and modeling data is called data analytics. The purpose and objective of data analytics are to gather and find valuable information to help in business decision-making processes. When we think about analytics, we are reminded of comparing numbers and analyzing data using spreadsheets.

Historically, analytics were used to interpret business insights. At the beginning of the 1970s, businesses began employing electronic technology, including relational databases, data warehouses, machine learning (ML) algorithms, web searching solutions, data visualization, and other tools with the potential to facilitate, accelerate, and automate the analytics process.

Yet, along with these advances in technology and increasing market demand, new challenges have emerged. A growing number of competitive, sometimes incompatible analytics and data management solutions ultimately created technological silos within departments and organizations and with external partners and vendors. Some of these solutions are so complicated that they require technical expertise beyond the average business user, which limits their usability within the organization.

Modern data sources have also taxed the ability of conventional relational databases and other tools to input, search, and manipulate large categories of data. These tools handle structured information, such as names, dates, and addresses. Unstructured data produced by modern sources — including email, text, video, audio, word processing, and satellite images cannot be processed and analyzed using conventional tools.

Accessing a growing number of data sources and determining what is valuable is difficult, especially since most data produced today is semi-structured or unstructured.

The Different Types of Data Analytics

The best type of data analytics for a company depends on its stage of development. Most companies are likely already using some analytics, but it typically only affords insights to make reactive, not proactive, business decisions.

Businesses are increasingly adopting sophisticated data analytics solutions with machine learning capabilities to make better business decisions and help determine market trends and opportunities. Organizations that do not start to use data analytics with proactive, future-casting capabilities may find business performance lacking because they cannot uncover hidden patterns and gain other insights.

Let us take a look and understand the different types of data analytics that will help you in your big data and analytics project.

Predictive Data Analytics

Predictive analytics may be the most used category of data analytics. Businesses use predictive analytics to identify trends, correlations, and causation. The classification is divided into predictive and statistical modeling; however, knowing that the two go hand in hand is essential. For example, an advertising campaign for t-shirts on Facebook could apply predictive analytics to determine how closely the conversion rate correlates with a target audience's geographic area, income bracket, and interests. From there, a predictive modeling could be used to analyze the statistics for two or several target audiences. And then provide possible revenue values for each demographic.

Prescriptive Data Analytics

The prescriptive analytics is where AI and big data are combined to help predict outcomes and identify what actions to take. This type of data analytics is composed of random testing and optimization. Using advanced features in Machine Learning (ML), prescriptive data analytics can help answer questions such as the best possible solution or action in decision-making. With the help of ML, you have the option to test and verify the correct variables and recommend new ones that are more likely to generate a positive outcome.

Diagnostic Data Analytics

Diagnostic data analytics may not be as exciting as predicting the future; however, analyzing past data can be essential in guiding your business. Diagnostic data analytics is examining data to understand the cause and event or why something happened. Techniques such as drill down, data mining, correlations, and data discovery are often employed. Diagnostic data analytics usually help detect and answer why something occurred.

Descriptive Data Analytics

Descriptive analytics is the backbone of reporting. Business intelligence (BI) tools would not be possible without the descriptive data analytics. It helps answer the essential questions like "how many, when, where, and what" of any data. There are two categories of descriptive data analytics: canned reports and ad hoc reports

Data analytics can help in many ways and is essential because it helps businesses optimize their performances. Implementing data analytics strategies in companies or organizations can help reduce costs by learning and identifying possible and valuable ways of doing business. Data analytics help organizations make better business decisions by analyzing user trends, customer satisfaction data, etc., which helps create better services and products.

Azure provides a wide variety of analytics products and services. Currently, the most popular services are HDInsight and Azure Analysis Services. Analysis Services provides an enterprise-class analysis engine that can collect data from multiple sources and turn it into an easy-to-use semantic BI model. The service integrates predefined database models and can generate interactive dashboards and reports.

There's no need for writing code or managing data processing. HDInsight is an enterprise service that focuses on open-source analytics and is compatible with popular platforms like Apache, Hadoop, Spark, and Kafka. It integrates with Azure services like SQL Data Warehouse and Azure Data Lake, making it easy to create analytical pipelines. Azure HDInsight can integrate with custom analysis tools and supports many popular languages, such as Python, Javascript, R, .NET, and Scala.

Azure Big Data Services and its Architecture

Azure includes many services that are available to use in big data architecture. They fall roughly into two categories: Managed services, including Azure Data Lake Store, Azure Data Lake Analytics, Azure Synapse Analytics, Azure Stream Analytics, Azure Event Hub, Azure IoT Hub, and Azure Data Factory.

Figure 7-2 shows an example of a big data architecture designed to help handle huge and complex data of traditional database systems and applications. The big data architecture allows ingestion, processing, and analysis of data. The recommended architecture for big data comprises several components like data sources, data storage, real-time ingestion, batch processing, and stream processing with machine learning to reporting.

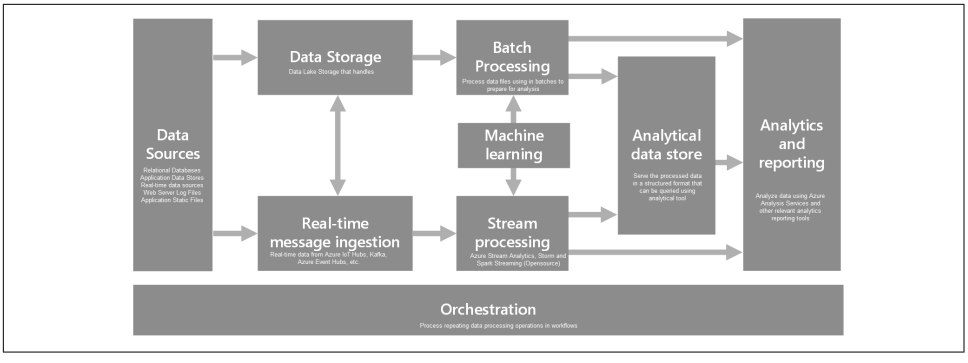

Figure 7-2. An example of a big data architecture style and flow with examples of Azure services

Azure includes many benefits that can be used in a big data architecture in two categories:

- Managed services that include the Azure Data Lake Store, Azure Data Lake Analytics, Azure Synapse Analytics, Azure Stream Analytics, Azure Event Hub, Azure IoT Hub, and Azure Data Factory
- Open-source technologies based on platforms like Apache, Hadoop, HBase, Hive, Pig, Spark, Storm, Oozie, Sqoop, and Kafka. These technologies are available on Azure in the Azure HDInsight service

Azure Data Lake

Azure Data Lake is a big data solution based on multiple cloud services in the Microsoft Azure ecosystem. It allows organizations to ingest various data sets, including structured, unstructured, and semi-structured data, into an infinitely scalable data lake enabling storage, processing, and analytics.

Azure Data Lake Storage Gen2 lets you run big data analytics lakes on top of Azure Blob Storage. Its pricing model is tied closely to Azure Blob Storage pricing, but there are differences depending on your use cases or needs for big data.

Azure NoSQL for Big Data and Analytics

NoSQL databases are non-relational databases that can flexibly support data. These databases are highly scalable and provide integration support to various applications and workloads. The NoSQL databases are popular alternatives to traditional databases and drive robust support from cloud vendors like Azure.

Big data storage for NoSQL databases can use Azure Cosmos DB and Hbase on HDInsights. Additionally, there is also a fully-managed data exploration service like Azure Data Explorer that can also be used for analytical databases

Azure Stream Analytics

Data streams with an example shown in *Figure 7-3*, are being used in data analytics and data engineering to enable sensors, applications, Internet of Things (IoT), gateways and smart monitoring devices to gather and broadcast real-time continuous event data known as data streams. Streaming data is high volume and has a lighter payload than nonstreaming systems.

Data engineers use Azure Stream Analytics to process streaming data and respond to data anomalies in real time. You can use Stream Analytics for Internet of Things (IoT) monitoring, web logs, and point of sale (POS) systems.

Figure 7-3. An overview of the different Azure Stream Analytics in action with use case and Azure services

Azure Stream Analytics is useful in scenarios where your organization must respond to real-time data events or analyze large batches of data in a continuous time-bound stream. Or perhaps your organization must choose and decide whether to work with streaming or batch data.

Data ingestion can happen from applications and gateways into an event hub or IoT hub. The event hub or IoT hub then streams the data into Stream Analytics for real-time analysis.

Batch systems process groups of data stored in an Azure Blob store. They do this in a single job that runs at a predefined interval. Don't use batch systems for business intelligence systems that can't tolerate the predefined interval. For example, an autonomous vehicle can't wait for a batch system to adjust its driving. Similarly, in real-time, a fraud-detection system must decline a questionable financial transaction.

Azure Synapse Analytics

Azure Synapse Analytics (formerly Azure SQL Data Warehouse) is a limitless analytics service that combines data integration, enterprise data warehousing, and big data analytics. It allows you to query data on your terms, using serverless or dedicated options—at scale. Azure Synapse combines these worlds with a unified experience to ingest, explore, prepare, transform, manage, and serve data for immediate BI and machine learning needs.

Furthermore, Azure Synapse Analytics is the next Azure SQL Data Warehouse generation. It enables you to transform and load from any data source – both relational and non-relational databases. Regardless if you are doing these on-premise or in Azure. It unifies all the data and lets you process and analyzes it using the SQL language. Azure Synapse Studio is a good tool to use for creating a workspace.

Azure Databricks

Azure Databricks is an analytics service based on Apache Spark. Apache Spark is a veteran tool that quickly processes huge amounts of unstructured data. Databricks supports languages like Python, Scala, Java, SQL, and R, and AI/ML libraries like TensorFlow and PyTorch, allowing you to work with Spark data using any of these languages and frameworks. In addition, Databricks integrates with Azure Machine Learning, and helps in giving you access to many pre-trained machine learning algorithms.

Databricks lets you set up managed Apache Spark clusters with auto-scaling and auto-termination, eliminating the complexity of setting up Spark in your local data center. *Figure 7-4* illustrates and example of implementation of Azure Data Bricks.

Figure 7-4. An example illustration of Azure Data Bricks implementation

Azure Data Lake Storage

Azure Data Lake Gen2 is designed for enterprise big data analytics with dedicated features and capabilities. It is built on Azure Blob Storage that includes the features and elements of Azure Data Lake Storage Gen1.

The Data Lake Storage Gen2 promises some good features that benefit security, performance, and management. It supports file system semantics, file-level protection, and scaling options. Since it is built on top of Azure Blob Storage, there are flexible options for storage types in different tiers. There are also low-cost options and support for high availability and disaster recovery.

Azure HDInsight for Hadoop, R Server, HBase, Spark and Storm Clusters

The open-source platform Apache Hadoop has played a major role in the world of big data for the past decade. Even though it is not so popular, the ecosystem of Hadoop continues to evolve and has compelling use cases. It allows you to perform complex, distributed analysis tasks on virtually any volume of data.

Azure HDInsight is an open-source, managed analytics, and cloud-based service for users that require bigger and broader support for analytics capabilities for big data. Organizations that need to process huge quantities of data with streaming or historical data capabilities could take advantage of this.

Using Azure HDInsight for big data and analytics, you can create significant data clusters using Hadoop and scale them based on your demands and workloads. It allows you to implement Hadoop analytics for existing data by integrating with other Azure services and tools like Azure Data Lake Storage and the Azure Data Factory.

The support for Hadoop benefits those who need to use the capabilities of Hadoop tooling like Hbase, Apache Spark, Storm, Hive, and Apache Kafka. In addition, Azure HD Insight also provides monitoring, high availability, security, and compliance at an enterprise scale in Azure. You will benefit from Azure HDInsight if you use custom code to process and analyze large datasets with the latest big data processing frameworks such as Spark, Hadoop, Hive, Kafka, or Hbase.

Azure HDInsight gives you full control over the configuration of your clusters and the software installed on them. You might also consider HDInsight if you migrate Hortonworks, Cloudera, or MapR collections from on-premises environments or other clouds. Azure HDInsight can be used for a variety of scenarios for big data. These data types can be historical or real-time data used for data warehouses, data science, the Internet of Things (IoT), data science, and hybrid data solutions.

Azure Data Factory

Azure Data Factory is an Extract Transform Load (ETL) service. ETL is a term from the old days of large-scale structured data processing. An ETL process takes a structured database, cleans it, and converts the data into a suitable format for analysis. Data Factory helps you build ETL and Extract Load Transform (ELT) strategies using a visual editor without code or configuration.

Data Factory provides built-in connectors with over 90 data sources, including Amazon S3, Google BigQuery, and many on-premise data sources. You can also copy the data from Data Factory to Azure File Storage

Azure Analysis Services

Azure Analysis Services is a fully managed platform as a service (PaaS) that provides enterprise-grade data models in the cloud. It is ideal for an enterprise that needs an analytics engine as managed cloud service. It can be configured using infrastructure as code tools like the Azure Resource Manager (ARM template), Azure Bicep, and Terraform. You have the option to combine data from multiple sources and build them as one semantic model.

It allows you to develop high-performance Business Intelligence (BI) solutions with secured access and fast time to delivery. It can be configured to perform autoscaling based on the analytical workload, and you pay only for the resources you consume. Analysis Services also lets you import existing tabular models.

Figure 7-5. An overview of the different Azure Analysis Services

In *Figure 7-5*, you will find an overview of the different kinds of solutions and tools used for analysis in Azure.

Power BI Embedded Analytics

Microsoft Power BI is a leading data analytics service in Azure. Many people are familiar with Power BI because they interact with reports in the Power BI service or the Power BI for mobile apps. This service enables many options for different kinds of roles. Those working with data analytics and reporting can use Power BI easily.

In addition, cloud engineers and software developers can use any Power BI content embedded in their applications by programming it. Developers can programmatically embed Power BI analytics in applications to visualize and present data or reports. The end users of the Power BI embedded analytics can easily make view the actual data, reports and can easily make decisions based on facts and statistics, as shown in *Figure 7-6* that illustrates of Power BI Embedded Analytics.

You can embed Power BI content in any app by using an HTML iframe element. It is purpose-built for developers and it it can be used with client APIs, REST APIs, and there are SDK for different programming languages and platform such as in .NET, JavaScript, and TypeScript.

Figure 7-6. An illustration of PowerBI

Suppose you are a developer who wants to learn more about how you can enrich your data analytics and reporting using Power BI embedded analytics. In that case, I recommend checking out the Microsoft's Guide on How to Embed Power BI into web application or Portals.

Microsoft Purview for Data Governance

Microsoft Purview (previously Azure Purview) is a solution in the governance portal that provides a unified data governance service that helps you manage your on-premises, multi-cloud, and software-as-a-service (SaaS) data.

It helps automate data discovery through data classification and scanning as a service for assets across your data estate. Once the metadata and descriptions of the discov-

ered data assets are, they can be integrated into your data estate's map. Purpose-built apps create environments for data discovery, access management, and insights.

Microsoft has documented Microsoft Purview account architectures and best practices that will help with centralized your data governance solutions. Additionally, the Microsoft Purview governance portal also provides features for governing data, such as the Data Catalog, Data Estate Insights, Data Sharing, and discovery challenges for data consumers.

Try Free Premium Versions of Microsoft Purview solutions

If you want to try the different solutions and features of Microsoft Purview, a 90-day Microsoft Purview solutions trial is available. It is a good option for the organization to explore the Azure Purview capabilities for compliance needs. Microsoft 365 E3 and Office 365 E3 customers can start now at the Microsoft Purview compliance portal trials hub.

The Microsoft Purview Data Lifecycle Management (formerly Microsoft Information Governance) provides you with tools and capabilities to retain the content you need to keep and delete the content you don't. Controlling and deleting content is often required for compliance and regulatory requirements. However, deleting content without business value may help you manage risk and liability. For example, it reduces security and compliance risks.

Final Note on Data Management and Analytics in Azure

A final note worth emphasizing is that organizations that desire and want good quality analytics should work with accurate, trustworthy, and robust data. Data and information security practices are highly recommended to ensure your enterprise data is secured both in transit and at rest.

Azure Data Encryption at rest and using different types of data encryption models are a few of the tools offered by Microsoft Azure to protect and secure your enterprise data according to your organization's data security and compliance requirements.

Learn By Doing (Try it out!)

Instead of creating customized hands-on learning labs for the topics discussed in this chapter, the following quick-start tutorials are most recommended as they are updated based on Microsoft's technical updates for these technologies. This section is recommended and optional.l.

- Azure Synapse Analytics for data engineers
- Microsoft Quickstart: Share and receive Azure Storage data in-place with Microsoft Purview Data Sharing
- Quickstart: Create an account in the Microsoft Purview governance portal
- Analyze data with Apache Spark in Azure Synapse Analytics
- Create Apache Hadoop clusters using the Azure REST API

Summary

In this chapter, we have learned about the fundamental concepts of Big Data, such as its characteristics, common uses and benefits, and its importance to data science, analytics, machine learning, and reporting. We also learned about Azure's different big data, analytics, and reporting services. Also, we learned about Microsoft Purview's solutions in the governance portal provides a unified data governance service that helps you manage your on-premises, multi-cloud and software-as-a-service (SaaS) data.

Check Your Knowledge

1. Big data, data science, and analytics are evolving and trending. Why do you think they are essential?
2. Big data and analytics tools without good cybersecurity protection could put an organization at security risk and vulnerable to data breaches or cyberattacks. What do you think an organization can do as precautions to prevent this from happening?
3. What are the common challenges in building big data solutions?
4. Apache Hadoop is used in some big data analytics solutions. Why do you think Hadoop is commonly used in big data analytics?
5. How does Azure Synapse Analytics differs from Azure Data Lake Analytics?

To find the answers to the *Check Your Knowledge*, please turn to back of the book in the Appendix.

Recommended Learning Resources

- Microsoft's Cloud-Scale Analytics
- Microsoft Documentation for Azure Analysis Services
- Microsoft Purview Data Governance Documentation

- Hands-On Data Warehousing with Azure Data Factory by Christian Cote, Michelle Gutzait, Giuseppe Ciaburro
- Video: Azure Analysis Services Overview to learn how Azure Analysis Services fits in with Microsoft's overall Business Insights capabilities
- O'Reilly Book - Stream Analytics with Microsoft Azure
- Video: The future of data governance: Introducing Microsoft Purview
- Microsoft Documentation: Big data Architecture style
- Microsoft Learn: Introduction to data analytics on Azure
- Data Science for Beginners
- Modern analytics architecture with Azure Databricks
- Pluralsight Course: Data Science with Microsoft Azure
- Data Exposed: Big Data Cluster Security
- Video: Azure Analysis Services Overview

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Jonah has 15 years of working experience in different tech roles and industries. She has several years of experience in software development in C# .NET and cloud development with Microsoft Azure. Furthermore, she likes solving challenging, complex problems, programming back-end, and software engineering, and cloud development in .NET with cloud computing technologies like Microsoft Azure.

Jonah likes continuous learning, connecting with other developers, and sharing her technical knowledge at her workplace and through public speaking.

She is the founder of *Azure User Group Sweden*, a virtual and global Azure Users Group Community in Sweden that is an open and inclusive tech community for cloud development in Azure. Jonah organizes the technical sessions related to Microsoft Azure cloud services and is also active in sharing her knowledge through this community group.

Jonah wants to make a difference in the tech world by being a role model, advocating gender equality, diversity and inclusion in tech, being a mentor to youth and young women, inspiring tech and cloud technologies and helping them choose a tech career path in software engineering.

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