Official Google Cloud Certified

Associate Cloud Engineer

Study Guide

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Dan Sullivan

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to Katherine

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A book is a team effort—more so for this book than any I've written before.

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About the Author

Dan Sullivan is a principal engineer and software architect at New Relic. He specializes in streaming analytics, machine learning, and cloud computing. Dan is the author of *NoSQL for Mere Mortals* and several LinkedIn Learning courses on databases, data science, and machine learning. Dan has certifications from Google and AWS along with a Ph.D. in genetics and computational biology.

Contents at a Glance

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Introduction

Google Cloud Platform (GCP) is a leading public cloud that provides its users with some of the same software, hardware, and networking infrastructure used to power Google services. Businesses, organizations, and individuals can launch servers in minutes, store petabytes of data, and implement global virtual clouds with GCP. It includes an easy-to-use console interface, command-line tools, and application programming interfaces (APIs) for managing resources in the cloud. Users can work with general resources, such as virtual machines (VMs) and persistent disks, or opt for highly focused services for Internet of Things (IoT), machine learning, media, and other specialized domains.

Deploying and managing applications and services in GCP requires a clear understanding of the way Google structures user accounts and manages identities and access controls; you also need to understand the advantages and disadvantages of using various services. Certified Associate Cloud Engineers have demonstrated the knowledge and skills needed to deploy and operate infrastructure, services, and networks in Google Cloud.

This study guide is designed to help you understand GCP in depth so that you can meet the needs of those operating resources in Google Cloud. Yes, this book will, of course, help you pass the Associate Cloud Engineer certification exam, but this is not an exam cram guide. You will learn more than is required to pass the exam; you will understand how to meet the day-to-day challenges faced by cloud engineers, including choosing services, managing users, deploying and monitoring infrastructure, and helping map business requirements into cloud-based solutions.

Each chapter in this book covers a single topic and includes an "Exam Essentials" section that outlines key information you should know to pass the certification exam. There are also exercises to help you review and reinforce your understanding of the chapter's topic. Sample questions are included at the end of each chapter so you can get a sense of the types of questions you will see on the exam. The book also includes flashcards and practice exams that cover all topics you'll learn about with this guide.

What Does This Book Cover?

This book describes products and services in GCP. It does not include G Suite administration topics.

Chapter 1: Overview of Google Cloud Platform In the opening chapter, we look into the types of services provided by GCP, which include compute, storage, and networking services as well as specialized services, such as machine learning products. This chapter

also describes some of the key differences between cloud computing and data center or on-premise computing.

Chapter 2: Google Cloud Computing Services This chapter provides an overview of infrastructure services such as computing, storage, and networking. It introduces the concept of identity management and related services. It also introduces DevOps topics and tools for deploying and monitoring applications and resources. GCP includes a growing list of specialized services, such as machine learning and natural language processing services. Those are briefly discussed in this chapter. The chapter introduces Google Cloud's organizational structure with a look at regions and zones. The chapter concludes with a discussion of Cloud Launcher for deploying packaged applications.

Chapter 3: Projects, Service Accounts, and Billing One of the first things you will do when starting to work with GCP is to set up your accounts. In this chapter, you will learn how resources in accounts are organized into organizations, folders, and projects. You will learn how to create and edit these structures. You will also see how to enable APIs for particular projects as well as manage user identities and their access controls. This chapter describes how to create billing accounts and link them to projects. You will also learn how to create budgets and define billing alerts to help you manage costs. Finally, the chapter describes how to create Stackdriver accounts, which are used as part of the monitoring system in GCP.

Chapter 4: Introduction to Computing in Google Cloud In this chapter, you will see the variety of options available for running applications and services in GCP. Options include Compute Engine, which provides VMs running Linux or Windows operating systems. App Engine is a platform as a service (PaaS) option that allows developers to run their applications without having to concern themselves with managing VMs. If you will be running multiple applications and services, you may want to take advantage of containers, which are a lightweight alternative to VMs. You will learn about containers and how to manage them with Kubernetes Engine. This chapter also introduces Cloud Functions, which is for event-driven, short-running tasks such as triggering the processing of an image loaded into Cloud Storage. You will also learn about Firebase, a set of services well suited for providing backend infrastructure to mobile applications.

Chapter 5: Computing with Compute Engine Virtual Machines In this chapter, you will learn how to configure VMs, including selecting CPU, memory, storage options, and operating system images. You will learn how to use GCP Console and Cloud Shell to work with VMs. In addition, you will see how to install the command-line interface and SDK, which you will use to start and stop VMs. The chapter will also describe how to enable network access to VMs.

Chapter 6: Managing Virtual Machines In the previous chapter, you learned how to create VMs, and in this chapter you will learn how to manage individual and groups of VMs. You will start by managing a single instance of a VM using the GCP console and then perform the same operations using Cloud Shell and the command line. You

will also learn how to view currently running VMs. Next, you'll learn about instance groups, which allow you to create sets of VMs that you can manage as a single unit. In the section on instance groups, you will learn the difference between managed and unmanaged instance groups. You will also learn about preemptible instances, which are low-cost VMs that may be shut down by Google. You will learn about the cost-benefit trade-offs of preemptible instances. Finally, the chapter closes with guidelines for managing VMs.

Chapter 7: Computing with Kubernetes This chapter introduces Kubernetes Engine, Google's managed Kubernetes service. Kubernetes is a container orchestration platform created and released as open source by Google. In this chapter, you will learn the basics of containers, container orchestration, and the Kubernetes architecture. The discussion will include an overview of Kubernetes objects such as pods, services, volumes, and namespaces, as well as Kubernetes controllers such as ReplicaSets, deployments, and jobs.

Next, the chapter turns to deploying a Kubernetes cluster using GCP console, Cloud Shell, and SDK. You will also see how to deploy pods, which includes downloading an existing Docker image, building a Docker image, creating a pod, and then deploying an application to the Kubernetes cluster. Of course, you will need to know how to monitor a cluster of servers. This chapter provides a description of how to set up monitoring and logging with Stackdriver, which is Google's application, service, container, and infrastructure monitoring service.

Chapter 8: Managing Kubernetes Clusters In this chapter you will learn the basics of managing a Kubernetes cluster, including viewing the status of the cluster, viewing the contents of the image repository, viewing details about images in the repository, and adding, modifying, and removing nodes, pods, and services. As in the chapter on managing VMs, in this chapter you will learn how to perform management operations with the three management tools: GCP console, Cloud Shell, and SDK. The chapter concludes with a discussion of guidelines and good practices for managing a Kubernetes cluster.

Chapter 9: Computing with App Engine Google App Engine is Google's PaaS offering. You will learn about App Engine components such as applications, services, versions, and instances. The chapter also covers how to define configuration files and specify dependencies of an application. In this chapter, you will learn how to view App Engine resources using GCP console, Cloud Shell, and SDK. The chapter also describes how to distribute workload by adjusting traffic with splitting parameters. You will also learn about autoscaling in App Engine.

Chapter 10: Computing with Cloud Functions Cloud Functions is for event-driven, serverless computations. This chapter introduces Cloud Functions, including using it to receive events, evoke services, and return results. Next, you'll see use cases for Cloud Functions, such as integrating with third-party APIs and event-driven processing. You will learn about Google's Pub/Sub service for publication- and subscription-based processing and how to use Cloud Functions with Pub/Sub. Cloud Functions are well suited to respond to events in Cloud Storage. The chapter describes Cloud Storage events and how to use Cloud

Functions to receive and respond to those events. You will learn how to use Stackdriver to monitor and log details of Cloud Function executions. Finally, the chapter concludes with a discussion of guidelines for using and managing Cloud Functions.

Chapter 11: Planning Storage in the Cloud Having described various compute options in GCP, it is time to turn your attention to storage. This chapter describes characteristics of storage systems, such as their time to access, persistence, and data model. In this chapter, you will learn about differences between caches, persistent storage, and archival storage. You will learn about the cost-benefit trade-offs of using regional and multiregional persistent storage and using nearline versus coldline archival storage. The chapter includes details on the various GCP storage options, including Cloud Storage for blob storage; Cloud SQL and Spanner for relational data; Datastore, Bigtable, and BigQuery for NoSQL storage; and Cloud Firebase for mobile application data. The chapter includes detailed guidance on choosing a data store based on requirements for consistency, availability, transaction support, cost, latency, and support for different read/write patterns.

Chapter 12: Deploying Storage in Google Cloud Platform In this chapter, you will learn how to create databases, add data, list records, and delete data from each of GCP's storage systems. The chapter starts by introducing Cloud SQL, a managed database service that offers MySQL and PostgreSQL managed instances. You will also learn how to create databases in Cloud Datastore, BigQuery, Bigtable, and Spanner. Next, you will turn your attention to Cloud Pub/Sub for storing data in message queues, followed by a discussion of Cloud Dataproc, a managed Hadoop and Spark cluster service, for processing big data sets. In the next section, you will learn about Cloud Storage for objects. The chapter concludes with guidance on how to choose a data store for a particular set of requirements.

Chapter 13: Loading Data into Storage There are a variety of ways of getting data into GCP. This chapter describes how to use the command-line SDK to load data into Cloud SQL, Cloud Storage, Datastore, BigQuery, BigTable, and Dataproc. It will also describe bulk importing and exporting from those same services. Next, you will learn about two common data loading patterns: moving data from Cloud Storage and streaming data to Cloud Pub/Sub.

Chapter 14: Networking in the Cloud: Virtual Private Clouds and Virtual Private Networks In this chapter, you'll turn your attention to networking with an introduction to basic networking concepts, including the following:

- IP addresses
- CIDR blocks
- Networks and subnetworks
- Virtual private clouds (VPCs)
- Routing and rules
- Virtual private networks (VPNs)
- Cloud DNS

- Cloud routers
- Cloud interconnect
- External peering

After being introduced to key networking concepts, you will learn how to create a VPC. Specifically, this will include defining a VPC, specifying firewall rules, creating a VPN, and working with load balancers. You will learn about different types of load balancers and when to use them.

Chapter 15: Networking in the Cloud: DNS, Load Balancing, and IP Addressing In this chapter, you will learn about common network management tasks such as defining subnetworks, adding subnets to a VPC, managing CIDR blocks, and reserving IP addresses. You will learn how to preform each of these tasks using Cloud Console, Cloud Shell, and Cloud SDK.

Chapter 16: Deploying Applications with Cloud Launcher and Deployment Manager Google Cloud Launcher is GCP's marketplace of preconfigured stacks and services. This chapter introduces Cloud Launcher and describes some applications and services currently available. You will learn how to browse Cloud Launcher, deploy applications from Cloud Launcher, and shut down Cloud Launcher applications. The chapter will also discuss Deployment Manager templates to automate the deployment of an application and launch a Deployment Manager template to provision GCP resources and configure an application automatically.

Chapter 17: Configuring Access and Security This chapter introduces identity management. In particular, you will learn about identities, roles, and assigning and removing identity roles. This chapter also introduces service accounts and how to create them, assign them to VMs, and work with them across projects. You will also learn how to view audit logs for projects and services. The chapter concludes with guidelines for configuring access control security.

Chapter 18: Monitoring, Logging, and Cost Estimating In the final chapter, we will discuss Stackdriver alerts, logging, distributed tracing, and application debugging. Each of the corresponding GCP services is designed to enable more efficient, functional, and reliable services. The chapter concludes with a review of the Pricing Calculator, which is helpful for estimating the cost of resources in GCP.

Interactive Online Learning Environment and TestBank

Studying the material in the *Official Google Certified Associate Cloud Engineer Study Guide* is an important part of preparing for the Associate Cloud Engineer certification exam, but we provide additional tools to help you prepare. The online TestBank will help you understand the types of questions that will appear on the certification exam.

The sample tests in the TestBank include all the questions in each chapter as well as the questions from the assessment test. In addition, there are two practice exams with 50 questions each. You can use these tests to evaluate your understanding and identify areas that may require additional study.

The flashcards in the TestBank will push the limits of what you should know for the certification exam. There are 100 questions provided in digital format. Each flashcard has one question and one correct answer.

The online glossary is a searchable list of key terms introduced in this exam guide that you should know for the Associate Cloud Engineer certification exam.

To start using these to study for the Google Certified Associate Cloud Engineer exam, go to `www.wiley.com/go/sybextestprep` and register your book to receive your unique PIN. Once you have the PIN, return to `www.wiley.com/go/sybextestprep`, find your book and click Register or Login, and follow the link to register a new account or add this book to an existing account.

Exam Objectives

The Associate Cloud Engineer certification is designed for people who create, deploy, and manage enterprise applications and infrastructure in GCP. An Associate Cloud Engineer is comfortable working with Cloud Console, Cloud Shell, and Cloud SDK. Such individuals also understand products offered as part of GCP and their appropriate use cases.

The exam will test your knowledge of the following:

- Planning a cloud solution using one or more GCP services
- Creating a cloud environment for an organization
- Deploying applications and infrastructure
- Using monitoring and logging to ensure availability of cloud solutions
- Setting up identity management, access controls, and other security measures

Objective Map

The following are specific objectives defined by Google at `https://cloud.google.com/certification/guides/cloud-engineer/`.

Section 1: Setting up a cloud solution environment

1.1 Setting up cloud projects and accounts. Activities include:

- Creating projects
- Assigning users to predefined IAM (Identity and Access Management) roles within a project
- Linking users to G Suite identities

- Enabling APIs within projects
- Provisioning one or more Stackdriver accounts

1.2 Managing billing configuration. Activities include:

- Creating one or more billing accounts
- Linking projects to a billing account
- Establishing billing budgets and alerts
- Setting up billing exports to estimate daily/monthly charges

1.3 Installing and configuring the command-line interface (CLI), specifically Cloud SDK (e.g., setting the default project)

Section 2: Planning and configuring a cloud solution

2.1 Planning and estimating GCP product use using the Pricing Calculator

2.2 Planning and configuring compute resources. Considerations include:

- Selecting appropriate compute choices for a given workload (e.g., Compute Engine, Kubernetes Engine, App Engine)
- Using preemptible VMs and custom machine types as appropriate

2.3 Planning and configuring data storage options. Considerations include:

- Product choice (e.g., Cloud SQL, BigQuery, Cloud Spanner, Cloud Bigtable)
- Choosing storage options (e.g., Regional, Multiregional, Nearline, Coldline)

2.4 Planning and configuring network resources. Tasks include:

- Differentiating load balancing options
- Identifying resource locations in a network for availability
- Configuring Cloud DNS

Section 3: Deploying and implementing a cloud solution

3.1 Deploying and implementing Compute Engine resources. Tasks include:

- Launching a compute instance using Cloud Console and Cloud SDK (gcloud) (e.g., assign disks, availability policy, SSH keys)
- Creating an autoscaled managed instance group using an instance template
- Generating/uploading a custom SSH key for instances
- Configuring a VM for Stackdriver monitoring and logging
- Assessing compute quotas and requesting increases
- Installing the Stackdriver Agent for monitoring and logging

3.2 Deploying and implementing Kubernetes Engine resources. Tasks include:

- Deploying a Kubernetes Engine cluster
- Deploying a container application to Kubernetes Engine using pods
- Configuring Kubernetes Engine application monitoring and logging

3.3 Deploying and implementing App Engine and Cloud Functions resources. Tasks include:

- Deploying an application to App Engine (e.g., scaling configuration, versions, and traffic splitting)
- Deploying a Cloud Function that receives Google Cloud events (e.g., Cloud Pub/Sub events, Cloud Storage object change notification events)

3.4 Deploying and implementing data solutions. Tasks include:

- Initializing data systems with products (e.g., Cloud SQL, Cloud Datastore, BigQuery, Cloud Spanner, Cloud Pub/Sub, Cloud Bigtable, Cloud Dataproc, Cloud Storage)
- Loading data (e.g., command-line upload, API transfer, import/export, load data from Cloud Storage, streaming data to Cloud Pub/Sub)

3.5 Deploying and implementing networking resources. Tasks include:

- Creating a VPC with subnets (e.g., custom-mode VPC, shared VPC)
- Launching a Compute Engine instance with custom network configuration (e.g., internal-only IP address, Google private access, static external and private IP address, network tags)
- Creating ingress and egress firewall rules for a VPC (e.g., IP subnets, tags, service accounts)
- Creating a VPN between a Google VPC and an external network using Cloud VPN
- Creating a load balancer to distribute application network traffic to an application (e.g., global HTTP(S) load balancer, global SSL proxy load balancer, global TCP proxy load balancer, regional network load balancer, regional internal load balancer)

3.6 Deploying a Solution using Cloud Launcher. Tasks include:

- Browsing the Cloud Launcher catalog and viewing solution details
- Deploying a Cloud Launcher marketplace solution

3.7 Deploying an Application using Deployment Manager. Tasks include:

- Developing Deployment Manager templates to automate deployment of an application
- Launching a Deployment Manager template to provision GCP resources and configure an application automatically

Section 4: Ensuring successful operation of a cloud solution

4.1 Managing Compute Engine resources. Tasks include:

- Managing a single VM instance (e.g., start, stop, edit configuration, or delete an instance)
- SSH/RDP to the instance
- Attaching a GPU to a new instance and installing CUDA libraries
- Viewing current running VM inventory (instance IDs, details)
- Working with snapshots (e.g., create a snapshot from a VM, view snapshots, delete a snapshot)
- Working with images (e.g., create an image from a VM or a snapshot, view images, delete an image)
- Working with instance groups (e.g., set autoscaling parameters, assign an instance template, create an instance template, remove an instance group)
- Working with management interfaces (e.g., Cloud Console, Cloud Shell, Cloud SDK)

4.2 Managing Kubernetes Engine resources. Tasks include:

- Viewing current running cluster inventory (nodes, pods, services)
- Browsing the container image repository and viewing container image details
- Working with nodes (e.g., add, edit, or remove a node)
- Working with pods (e.g., add, edit, or remove pods)
- Working with services (e.g., add, edit, or remove a service)
- Working with management interfaces (e.g., Cloud Console, Cloud Shell, Cloud SDK)

4.3 Managing App Engine resources. Tasks include:

- Adjusting application traffic splitting parameters
- Setting scaling parameters for autoscaling instances
- Working with management interfaces (e.g., Cloud Console, Cloud Shell, Cloud SDK)

4.4 Managing data solutions. Tasks include:

- Executing queries to retrieve data from data instances (e.g., Cloud SQL, BigQuery, Cloud Spanner, Cloud Datastore, Cloud Bigtable, Cloud Dataproc)
- Estimating costs of a BigQuery query
- Backing up and restoring data instances (e.g., Cloud SQL, Cloud Datastore, Cloud Dataproc)
- Reviewing job status in Cloud Dataproc or BigQuery
- Moving objects between Cloud Storage buckets

- Converting Cloud Storage buckets between storage classes
- Setting object lifecycle management policies for Cloud Storage buckets
- Working with management interfaces (e.g., Cloud Console, Cloud Shell, Cloud SDK)

4.5 Managing networking resources. Tasks include:

- Adding a subnet to an existing VPC
- Expanding a CIDR block subnet to have more IP addresses
- Reserving static external or internal IP addresses
- Working with management interfaces (e.g., Cloud Console, Cloud Shell, Cloud SDK)

4.6 Monitoring and logging. Tasks include:

- Creating Stackdriver alerts based on resource metrics
- Creating Stackdriver custom metrics
- Configuring log sinks to export logs to external systems (e.g., on premise or BigQuery)
- Viewing and filtering logs in Stackdriver
- Viewing specific log message details in Stackdriver
- Using cloud diagnostics to research an application issue (e.g., viewing Cloud Trace data, using Cloud Debug to view an application point in time)
- Viewing GCP status
- Working with management interfaces (e.g., Cloud Console, Cloud Shell, Cloud SDK)

Section 5: Configuring access and security

5.1 Managing Identity and Access Management. Tasks include:

- Viewing account IAM assignments
- Assigning IAM roles to accounts or Google Groups
- Defining custom IAM roles

5.2 Managing service accounts. Tasks include:

- Managing service accounts with limited scopes
- Assigning a service account to VM instances
- Granting access to a service account in another project

5.3 Viewing audit logs for project and managed services

Cloud Computing Components

- Compute resources
- Storage
- Networking
- Specialized services

Difference between Cloud Computing and Data Center Computing

- Rent instead of own resources
- Pay-as-you-go-for-what-you-use model
- Elastic resource allocation
- Specialized services

Assessment Test

1. Instance templates are used to create a group of identical VMs. The instance templates include:
   - **A.** Machine type, boot disk image or container image, zone, and labels
   - **B.** Cloud Storage bucket definitions
   - **C.** A load balancer description
   - **D.** App Engine configuration file

2. The command-line command to create a Cloud Storage bucket is:
   - **A.** `gcloud mb`
   - **B.** `gsutil mb`
   - **C.** `gcloud mkbucket`
   - **D.** `gsutil mkbucket`

3. Your company has an object management policy that requires that objects stored in Cloud Storage be migrated from regional storage to nearline storage 90 days after the object is created. The most efficient way to do this is to:
   - **A.** Create a cloud function to copy objects from regional storage to nearline storage.
   - **B.** Set the `MigrateObjectAfter` property on the stored object to 90 days.
   - **C.** Copy the object to persistent storage attached to a VM and then copy the object to a bucket created on nearline storage.
   - **D.** Create a lifecycle management configuration policy specifying an age of 90 days and `SetStorageClass` as nearline.

4. An education client maintains a site where users can upload videos, and your client needs to assure redundancy for the files; therefore, you have created two buckets for Cloud Storage. Which command do you use to synchronize the contents of the two buckets?
   - **A.** `gsutil rsync`
   - **B.** `gcloud cp sync`
   - **C.** `gcloud rsync`
   - **D.** `gsutil cp sync`

5. VPCs are _____ resources.
   - **A.** Regional
   - **B.** Zonal
   - **C.** Global
   - **D.** Subnet

6. A remote component in your network has failed, which results in a transient network error. When you submit a `gsutil` command, it fails because of a transient error. By default, the command will:
   - **A.** Terminate and log a message to Stackdriver
   - **B.** Retry using a truncated binary exponential back-off strategy
   - **C.** Prompt the user to decide to retry or quit
   - **D.** Terminate and log a message to Cloud Shell

7. All of the following are components of firewall rules except which one?
   - **A.** Direction of traffic
   - **B.** Action on match
   - **C.** Time to live (TTL)
   - **D.** Protocol

8. Adding virtual machines to an instance group can be triggered in an autoscaling policy by all of the following, except which one?
   - **A.** CPU utilization
   - **B.** Stackdriver metrics
   - **C.** IAM policy violation
   - **D.** Load balancing serving capacity

9. Your company's finance department is developing a new account management application that requires transactions and the ability to perform relational database operations using fully compliant SQL. Data store options in GCP include:
   - **A.** Spanner and Cloud SQL
   - **B.** Datastore and Bigtable
   - **C.** Spanner and Cloud Storage
   - **D.** Datastore and Cloud SQL

10. The marketing department in your company wants to deploy a web application but does not want to have to manage servers or clusters. A good option for them is:
    - **A.** Compute Engine
    - **B.** Kubernetes Engine
    - **C.** App Engine
    - **D.** Cloud Functions

11. Your company is building an enterprise data warehouse and wants SQL query capabilities over petabytes of data, but does not want to manage servers or clusters. A good option for them is:
    - **A.** Cloud Storage
    - **B.** BigQuery
    - **C.** Bigtable
    - **D.** Datastore

12. You have been hired as a consultant to a startup in the Internet of Things (IoT) space. The startup will stream large volumes of data into GCP. The data needs to be filtered, transformed, and analyzed before being stored in GCP Datastore. A good option for the stream processing component is:
    A. Dataproc
    B. Cloud Dataflow
    C. Cloud Endpoints
    D. Cloud Interconnect

13. Preemptible virtual machines may be shut down at any time but will always be shut down after running:
    A. 6 hours
    B. 12 hours
    C. 24 hours
    D. 48 hours

14. You have been tasked with designing an organizational hierarchy for managing departments and their cloud resources. What organizing components are available in GCP?
    A. Organization, folders, projects
    B. Buckets, directories, subdirectories
    C. Organizations, buckets, projects
    D. Folders, buckets, projects

15. During an incident that has caused an application to fail, you suspect some resource may not have appropriate roles granted. The command to list roles granted to a resource is:
    A. `gutil iam list-grantable-roles`
    B. `gcloud iam list-grantable-roles`
    C. `gcloud list-grantable-roles`
    D. `gcloud resources grantable-roles`

16. The availability of CPU platforms can vary between zones. To get a list of all CPU types available in a particular zone, you should use:
    A. `gcloud compute zones describe`
    B. `gcloud iam zones describe`
    C. `gutil zones describe`
    D. `gcloud compute regions list`

17. To create a custom role, a user must possess which role?
    A. `iam.create`
    B. `compute.roles.create`
    C. `iam.roles.create`
    D. `Compute.roles.add`

18. You have been asked to create a network with 1,000 IP addresses. In the interest of minimizing unused IP addresses, which CIDR suffix would you use to create a network with at least 1,000 addresses but no more than necessary?

A. /20

B. /22

C. /28

D. /32

19. A team of data scientists have asked for your help setting up an Apache Spark cluster. You suggest they use a managed GCP service instead of managing a cluster themselves on Compute Engine. The service they would use is:

A. Cloud Dataproc

B. Cloud Dataflow

C. Cloud Hadoop

D. BigQuery

20. You have created a web application that allows users to upload files to Cloud Storage. When files are uploaded, you want to check the file size and update the user's total storage used in their account. A serverless option for performing this action on load is:

A. Cloud Dataflow

B. Cloud Dataproc

C. Cloud Storage

D. Cloud Functions

21. Your company has just started using GCP, and executives want to have a dedicated connection from your data center to the GCP to allow for large data transfers. Which networking service would you recommend?

A. Google Cloud Carrier Internet Peering

B. Google Cloud Interconnect – Dedicated

C. Google Cloud Internet Peering

D. Google Cloud DNS

22. You want to have GCP manage cryptographic keys, so you've decided to use Cloud Key Management Services. Before you can start creating cryptographic keys, you must:

A. Enable Google Cloud Key Management Service (KMS) API and set up billing

B. Enable Google Cloud KMS API and create folders

C. Create folders and set up billing

D. Give all users grantable roles to create keys

23. In Kubernetes Engine, a node pool is:

- **A.** A subset of nodes across clusters
- **B.** A set of VMs managed outside of Kubernetes Engine
- **C.** A set of preemptible VMs
- **D.** A subset of node instances within a cluster that all have the same configuration

24. The GCP service for storing and managing Docker containers is:

- **A.** Cloud Source Repositories
- **B.** Cloud Build
- **C.** Container Registry
- **D.** Docker Repository

25. Code for Cloud Functions can be written in:

- **A.** Node.js and Python
- **B.** Node.js, Python, and Go
- **C.** Python and Go
- **D.** Python and C

Answers to Assessment Test

1. A. Machine type, boot disk image or container image, zone, and labels are all configuration parameters or attributes of a VM and therefore would be included in an instance group configuration that creates those VMs.

2. B. `gsutil` is the command line for accessing and manipulating Cloud Storage from the command line. `mb` is the specific command for creating, or making, a bucket.

3. D. The lifecycle configuration policy allows administrators to specify criteria for migrating data to other storage systems without having to concern themselves with running jobs to actually execute the necessary steps. The other options are inefficient or do not exist.

4. A. `gsutil` is the command-line tool for working with Cloud Storage. `rsync` is the specific command in `gsutil` for synchronizing buckets.

5. C. Google operates a global network, and VPCs are resources that can span that global network.

6. B. `gcloud` by default will retry a failed network operation and will wait a long time before each retry. The time to wait is calculated using a truncated binary exponential back-off strategy.

7. C. Firewall rules do not have TTL parameters. Direction of traffic, action on match, and protocol are all components of firewall rules.

8. C. IAM policy violations do not trigger changes in the size of clusters. All other options can be used to trigger a change in cluster size.

9. A. Only Spanner and Cloud SQL databases support transactions and have a SQL interface. Datastore has transactions but does not support fully compliant SQL; it has a SQL-like query language. Cloud Storage does not support transactions or SQL.

10. C. App Engine is a PaaS that allows developers to deploy full applications without having to manage servers or clusters. Compute Engine and Kubernetes Engine require management of servers. Cloud Functions is suitable for short-running Node.js or Python functions but not full applications.

11. B. BigQuery is designed for petabyte-scale analytics and provides a SQL interface.

12. B. Cloud Dataflow allows for stream and batch processing of data and is well suited for this kind of ETL work. Dataproc is a managed Hadoop and Spark service that is used for big data analytics. Cloud Endpoints is an API service, and Cloud Interconnect is a network service.

13. C. If a preemptible machine has not been shut down within 24 hours, Google will stop the instance.

14. A. Organizations, folders, and projects are the components used to manage an organizational hierarchy. Buckets, directories, and subdirectories are used to organize storage.

15. B. `gcloud` is the command-line tool for working with IAM, and `list-grantable-roles` is the correct command.

16. A. `gcloud` is the command-line tool for manipulating compute resources, and `zones describe` is the correct command.

17. C. `iam.roles.create` is correct; the other roles do not exist.

18. B. The `/22` suffix produces 1,022 usable IP addresses.

19. A. Cloud Dataproc is the managed Spark service. Cloud Dataflow is for stream and batch processing of data, BigQuery is for analytics, and Cloud Hadoop is not a GCP service.

20. D. Cloud Functions responds to events in Cloud Storage, making them a good choice for taking an action after a file is loaded.

21. B. Google Cloud Interconnect – Dedicated is the only option for a dedicated connection between a customer's data center and a Google data center.

22. A. Enabling the Google Cloud KMS API and setting up billing are steps common to using GCP services.

23. D. A node pool is a subset of node instances within a cluster that all have the same configuration.

24. C. The GCP service for storing and managing Docker containers is Container Registry. Cloud Build is for creating images. The others are not GCP services.

25. A. Node.js 6, Node.js 8, and Python are the languages supported by Cloud Functions.

Chapter 1

Overview of Google Cloud Platform

THIS CHAPTER COVERS THE FOLLOWING OBJECTIVE OF THE GOOGLE ASSOCIATE CLOUD ENGINEER CERTIFICATION EXAM:

✓ **1.0 Setting up a Cloud Solution Environment**

Official Google Cloud Certified: Associate Cloud Engineer: Study Guide
By Dan Sullivan
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Google Cloud Platform (GCP) is a public cloud service that offers some of the same technologies used by Google to deliver its own products. This chapter describes the most important components of GCP and discusses how it differs from on-premise data center–based computing.

Types of Cloud Services

Public cloud providers such as Google, Amazon, and Microsoft offer a range of services for deploying computing, storage, networking, and other infrastructures to run a wide array of business services and applications. Some cloud users are new companies that start in the cloud. They have never owned their own hardware and software. Other cloud customers are enterprises with multiple data centers that use public clouds to supplement their data centers. These different kinds of users have different requirements.

A company that starts on the cloud can choose services that best fit its application and architectural needs without having to consider existing infrastructure. For example, a startup could use GCP's Cloud Identity and Access Management services for all authentication and authorization needs. A company that has already invested in a Microsoft Active Directory solution for identity management may want to leverage that system instead of working solely with the cloud's identity management system. This can lead to additional work to integrate the two systems and keep them synchronized.

Another area of concern for enterprises with their own infrastructure is establishing and maintaining a secure network between their on-premise resources and their public cloud resources. If there will be high-volume network traffic between the on-premise systems and the public cloud, the enterprise may need to invest in dedicated networking between its data center and a facility of the public cloud provider. If the volume of traffic does not justify the cost of a dedicated connection between facilities, then the company may use a virtual private network that runs over the public Internet. This requires additional network design and management that a company that is solely in the cloud would not have to address.

Public cloud providers offer services that fall into four broad categories.

- Compute resources
- Storage
- Networking
- Specialized services such as Machine Learning Services

Cloud customers typically make use of services in more than one of these categories.

Compute Resources

Computing resources come in a variety of forms in public clouds.

Virtual Machines

Virtual Machines are a basic unit of computing resources and a good starting point for experimenting with the cloud. After you create an account with a cloud provider and provide billing information, you can use a portal or command-line tools to create VMs. Google Cloud Platform offers a variety of preconfigured VMs with varying numbers of vCPUs and amounts of memory. You can also create a custom configuration if the preconfigured offerings do not meet your needs.

Once you create a VM, you can log into it and administer it as you like. You have full access to the VM, so you can configure file systems, add persistent storage, patch the operating system, or install additional packages. You decide what to run on the VM, who else will have access to it, and when to shut down the VM. A VM that you manage is like having a server in your office that you have full administrator rights to.

You can, of course, create multiple VMs running different operating systems and applications. GCP also provides services, such as load balancers, that provide a single access point to a distributed back end. This is especially useful when you need to have high availability for your application. If one of the VMs in a cluster fails, the workload can be directed to the other VMs in the cluster. Autoscalers can add or remove VMs from the cluster based on the workload. This is called *autoscaling*. This helps both control cost by not running more VMs than needed and ensure that sufficient computing capacity is available when workloads increase.

Managed Kubernetes Clusters

Google Cloud Platform gives you all the tools you need to create and manage clusters of servers. Many cloud users would rather focus on their applications and not the tasks needed to keep a cluster of servers up and running. For those users, managed clusters are a good option.

Managed clusters make use of containers. A container is like a lightweight VM that isolates processes running in one container from processes running in another container on the same server. In a managed cluster, you can specify the number of servers you would like to run and the containers that should run on them. You can also specify autoscaling parameters to optimize the number of containers running.

In a managed cluster, the health of containers is monitored for you. If a container fails, the cluster management software will detect it and start another container.

Containers are good options when you need to run applications that depend on multiple micro services running in your environment. The services are deployed through containers, and the cluster management service takes care of monitoring, networking, and some security management tasks.

Serverless Computing

Both VMs and managed kubernetes clusters require some level of effort to configure and administer computing resources. Serverless computing is an approach that allows developers and application administrators to run their code in a computing environment that does not require setting up VMs or kubernetes clusters.

Google Cloud Platform has two serverless computing options: App Engine and Cloud Functions. App Engine is used for applications and containers that run for extended periods of time, such as a website backend, point-of-sale system, or custom business application. Cloud Functions is a platform for running code in response to an event, such as uploading a file or adding a message to a message queue. This serverless option works well when you need to respond to an event by running a short process coded in a function or by calling a longer-running application that might be running on a VM, managed cluster, or App Engine.

Storage

Public clouds offer a few types of storage services that are useful for a wide range of application requirements. These types include the following:

- Object storage
- File storage
- Block storage
- Caches

Enterprise users of cloud services will often use a combination of these services.

Object Storage

Object storage is a system that manages the use of storage in terms of objects or blobs. Usually these objects are files, but it is important to note that the files are not stored in a conventional file system. Objects are grouped into buckets. Each object is individually addressable, usually by a URL.

Object storage is not limited by the size of disks or solid-state drives (SSDs) attached to a server. Objects can be uploaded without concern for the amount of space available on a disk. Multiple copies of objects are stored to improve availability and durability. In some cases, copies of objects may be stored in different regions to ensure availability even if a region becomes inaccessible.

Another advantage of object storage is that it is serverless. There is no need to create VMs and attach storage to them. Google Cloud Platform's object storage, called Cloud Storage, is accessible from servers running in GCP as well as from other devices with Internet access.

Access controls can be applied at the object level. This allows users of cloud storage to control which users can access and update objects.

File Storage

File storage services provide a hierarchical storage system for files. File systems storage provides network shared file systems. Google Cloud Platform has a file storage service called Cloud Filestore, which is based on the Network File System (NFS) storage system.

File storage is suitable for applications that require operating system–like file access to files. The file storage system decouples the file system from specific VMs. The file system, its directories, and its files exist independent of VMs or applications that may access those files.

Block Storage

Block storage uses a fixed-size data structure called a *block* to organize data. Block storage is commonly used in ephemeral and persistent disks attached to VMs. With a block storage system, you can install file systems on top of the block storage, or you can run applications that access blocks directly. Some relational databases can be designed to access blocks directly rather working through file systems.

In Linux file systems, 4KB is a common block size. Relational databases often write directly to blocks, but they often use larger sizes, such as 8KB or more.

Block storage is available on disks that are attached to VMs in Google Cloud Platform. Block storage can be either persistent or ephemeral. A persistent disk continues to exist and store data even if it is detached from a virtual server or the virtual server to which it is attached shuts down. Ephemeral disks exist and store data only as long as a VM is running. Ephemeral disks store operating system files and other files and data that are deleted when the VM is shut down. Persistent disks are used when you want data to exist on a block storage device independent of a VM. These disks are good options when you have data that you want available independent of the lifecycle of a VM, and support fast operating system– and file system–level access.

Object storage also keeps data independent of the lifecycle of a VM, but it does not support operating system– or file system–level access; you have to use higher-level protocols like HTTP to access objects. It takes longer to retrieve data from object storage than to retrieve it from block storage. You may need a combination of object storage and block storage to meet your application needs. Object storage can store large volumes of data that are copied to persistent disk when needed. This combination gives the advantage of large volumes of storage along with operating system– and file system–based access when needed.

Caches

Caches are in-memory data stores that maintain fast access to data. The time it takes to retrieve data is called *latency*. The latency of in-memory stores is designed to be submillisecond. To give you a comparison, here are some other latencies:

- Making a main memory reference takes 100 nanoseconds, or 0.1 microsecond
- Reading 4KB randomly from an SSD takes 150 microseconds
- Reading 1MB sequentially from memory takes 250 microseconds

- Reading 1MB sequentially from an SSD takes 1,000 microseconds, or 1 millisecond
- Reading 1MB sequentially from disk takes 20,000 microseconds, or 20 milliseconds

Here are some conversions for reference:

- 1,000 nanoseconds equal 1 microsecond.
- 1,000 microseconds equal 1 millisecond.
- 1,000 milliseconds equal 1 second.

These and other useful timing data are available at Jonas Bonér's "Latency Numbers Every Programmer Should Know" at `https://gist.github.com/jboner/2841832`.

Let's work through an example of reading 1MB of data. If you have the data stored in an in-memory cache, you can retrieve the data in 250 microseconds, or 0.25 millisecond If that same data is stored on an SSD, it will take four times as long to retrieve at 1 millisecond. If you retrieve the same data from a hard disk drive, you can expect to wait 20 milliseconds, or 80 times as long as reading from an in-memory cache.

Caches are quite helpful when you need to keep read latency to a minimum in your application. Of course, who doesn't love fast retrieval times? Why don't we always store our data in caches? There are three reasons.

- Memory is more expensive than SSD or hard disk drive (HDD) storage. It's not practical in many cases to have as much in-memory storage as persistent block storage on SSDs or HDDs.
- Caches are volatile; you lose the data stored in the cache when power is lost or the operating system is rebooted. You can store data in a cache for fast access, but it should never be used as the only data store keeping the data. Some form of persistent storage should be used to maintain a "system of truth," or a data store that always has the latest and most accurate version of the data.
- Caches can get out of synchronization with the system of truth. This can happen if the system of truth is updated but the new data is not written to the cache. When this happens, it can be difficult for an application that depends on the cache to detect the fact that data in the cache is invalid. If you decide to use a cache, be sure to design a cache update strategy that meets your requirements for consistency between the cache and the system of truth. This is such a challenging design problem that it has become memorialized in Phil Karlton's well-known quip, "There are only two hard things in computer science: cache invalidation and naming things." (See `https://martinfowler.com/bliki/TwoHardThings.html` for riffs on this rare example of computer science humor.)

Real World Scenario

Improving Database Query Response Time

Users expect web applications to be highly responsive. If a page takes more than 2 to 3 seconds to load, the user experience can suffer. It is common to generate the content of a page using the results of a database query, such as looking up account information

by customer ID. When a query is made to the database, the database engine will look up the data, which is usually on disk. The more users query the database the more queries it has to serve. Databases keep a queue for queries that need to be answered but can't be processed yet because the database is busy with other queries. This can cause longer latency response time, since the web application will have to wait for the database to return the query results.

One way to reduce latency is to reduce the time needed to read the data. In some cases, it helps to replace hard disk drives with faster SSD drives. However, if the volume of queries is high enough that the queue of queries is long even with SSDs, another option is to use a cache.

When query results are fetched, they are stored in the cache. The next time that information is needed, it is fetched from the cache instead of the database. This can reduce latency because data is fetched from memory, which is faster than disk. It also reduces the number of queries to the database, so queries that can't be answered by looking up data in the cache won't have to wait as long in the query queue before being processed.

Networking

When working in the cloud, you'll need to work with networking between your cloud resources and possibly with your on-premise systems.

When you have multiple VMs running in your cloud environment, you will likely need to manage IP addresses at some point. Each network-accessible device or service in your environment will need an IP address. In fact, devices within GCP can have both internal and external addresses. Internal addresses are accessible only to services in your internal GCP network. Your internal GCP network is defined as a virtual private cloud (VPC). External addresses are accessible from the Internet.

External IP addresses can be either static or ephemeral. Static addresses are assigned to a device for extended periods of time. Ephemeral external IP addresses are attached to VMs and released when the VM is stopped.

In addition to specifying IP addresses, you will often need to define firewall rules to control access to subnetworks and VMs in your VPC. For example, you may have a database server that you want to restrict access to so that only an application server can query the database. A firewall rule can be configured to limit inbound and outbound traffic to the IP address of the application server or load balancer in front of the application cluster.

You may need to share data and network access between an on-premise data center and your VPC. You can do this using one of several types of *peering*, which is the general term for linking distinct networks.

Specialized Services

Most public cloud providers offer specialized services that can be used as building blocks of applications or as part of a workflow for processing data. Common characteristics of specialized services are as follows:

- They are serverless; you do not need to configure servers or clusters.
- They provide a specific function, such as translating text or analyzing images.
- They provide an application programming interface (API) to access the functionality of the service.
- As with other cloud services, you are charged based on your use of the service.

These are some of the specialized services in Google Cloud Platform:

- AutoML, a machine learning service
- Cloud Natural Language, a service for analyzing text
- Cloud Vision for analyzing images
- Cloud Inference API, a service for computing correlations over time-series data

Specialized services encapsulate advanced computing capabilities and make them accessible to developers who are not experts in domains, such as natural language processing and machine learning. Expect to see more specialized services added to Google Cloud Platform.

Cloud Computing vs. Data Center Computing

Although it may seem that running VMs in the cloud is not much different from running them in your data center, there are significant differences between operating IT environments in the cloud and an on-premise or colocated data center.

Rent Instead of Own Resources

Corporate data centers are filled with servers, disk arrays, and networking equipment. This equipment is often owned or leased for extended periods by the company, a model that requires companies to either spend a significant amount of money up front to purchase equipment or commit to a long-term lease for the equipment. This approach works well when an organization can accurately predict the number of servers and other equipment it will need for an extended period and it can utilize that equipment consistently.

The model does not work as well when companies have to plan for peak capacity that is significantly higher than the average workload. For example, a retailer may have an average

load that requires a cluster of 20 servers but during the holiday season the workload increases to the point where 80 servers are needed. The company could purchase 80 servers and let 60 idle for most of the year to have resources to accommodate peak capacity. Alternatively, it could purchase or lease fewer servers and tolerate the loss in business that would occur when its compute resources can't keep up with demand. Neither is an appealing option.

Public clouds offer an alternative of short-term rental of compute capacity. The retailer, for example, could run VMs in the cloud during peak periods in addition to its on-premise servers. This gives the retailer access to the servers it needs when it needs them without having to pay for them when they are not needed.

The unit cost of running servers in the cloud may be higher than that of running the equivalent server in the data center, but the total cost of on-premise and short-term in the cloud mix of servers may still be significantly less than the cost of purchasing or leasing for peak capacity and leaving resources idle.

Pay-as-You-Go-for-What-You-Use Model

Related to the short-term rental model of cloud computing is the pay-as-you-go model. When you run a virtual server in the cloud, you will typically pay for a minimum period, such as 10 minutes, and then pay per minute used thereafter. The unit cost per minute will vary depending on the characteristics of the server. Servers with more CPUs and memory will cost more than servers with fewer CPUs and less memory.

It is important for cloud engineers to understand the pricing model of their cloud provider. It is easy to run up a large bill for servers and storage if you are not monitoring your usage. In fact, some cloud customers find that running applications in the cloud can be more expensive than running them on-premise.

Elastic Resource Allocation

Another key differentiator between on-premise and public cloud computing is the ability to add and remove compute and storage resources on short notice. In the cloud, you could start 20 servers in a matter of minutes. In an on-premise data center, it could take days or weeks to do the same thing if additional hardware must be provisioned.

Cloud providers design their data centers with extensive compute, storage, and network resources. They optimize their investment by efficiently renting these resources to customers. With sufficient data about customer use patterns, they can predict the capacity they need to meet customer demand. Since they have many customers, the variation in demand of any one customer has little effect on the overall use of their resources.

Extensive resources and the ability to quickly shift resources between customers enables public cloud providers to offer elastic resource allocation more efficiently than can be done in smaller data centers.

Specialized Services

Specialized services are, by their nature, not widely understood. Many developers understand how to develop user interfaces or query a database, but fewer have been exposed to the details of natural language processing or machine learning. Large enterprises may have the financial resources to develop in-house expertise in areas such as data science and machine vision, but many others don't.

By offering specialized services, cloud providers are bringing advanced capabilities to a wider audience of developers. Like investing in large amounts of hardware, public cloud vendors can invest in specialized services and recover their costs and make a profit because the specialized services are used by a large number of customers.

Exam Essentials

Understand different ways of delivering cloud computing resources. Computing resources can be allocated as individual VMs or clusters of VMs that you manage. You can also use managed kubernetes cluster (GKE) that relieve you of some of the operational overhead of managing a kubernetes cluster. Serverless computing options relieve users of any server management. Instead, developers run their code in a containerized environment managed by the cloud provider or in a compute platform designed for short-running code. Developers and DevOps professionals have the most control over resources when they manage their own servers and clusters. Managed services and serverless options are good choices when you do not need control over the computing environment and will get more value from not having to manage compute resources.

Understand the different forms of cloud storage and when to use them. There are four main categories of storage: object, file, block, and in-memory caches. Object storage is designed for highly reliable and durable storage of objects, such as images or data sets. Object storage has more limited functionality than file system–based storage systems. File system–based storage provides hierarchical directory storage for files and supports common operating system and file system functions. File system services provide network-accessible file systems that can be accessed by multiple servers. Block storage is used for storing data on disks. File systems and databases make use of block storage systems. Block storage is used with persistent storage devices, such as SSDs and HDDs. Caches are in-memory data stores used to minimize the latency of retrieving data. They do not provide persistent storage and should never be considered a "system of truth."

Understand the differences between running an IT environment on-premise or in the cloud. Running an IT environment in the cloud has several advantages, including short-term rental of resources, pay-as-you-go model, elastic resource allocation, and the ability to use specialized services. The unit cost of cloud resources, such as the cost per minute of a mid-tier server, may be higher in the cloud than on-premise. It is important to understand the cost model of your cloud provider so you can make decisions about the most efficient distribution of workload between cloud and on-premise resources.

Review Questions

1. What is the fundamental unit of computing in cloud computing?
   - **A.** Physical server
   - **B.** VM
   - **C.** Block
   - **D.** Subnet

2. If you use a cluster that is managed by a cloud provider, which of these will be managed for you by the cloud provider?
   - **A.** Monitoring
   - **B.** Networking
   - **C.** Some security management tasks
   - **D.** All of the above

3. You need serverless computing for file processing and running the backend of a website; which two products can you choose from Google Cloud Platform?
   - **A.** Kubernetes Engine and Compute Engine
   - **B.** App Engine and Cloud Functions
   - **C.** Cloud Functions and Compute Engine
   - **D.** Cloud Functions and Kubernetes Engine

4. You have been asked to design a storage system for a web application that allows users to upload large data files to be analyzed by a business intelligence workflow. The files should be stored in a high-availability storage system. File system functionality is not required. Which storage system in Google Cloud Platform should be used?
   - **A.** Block storage
   - **B.** Object storage
   - **C.** Cache
   - **D.** Network File System

5. All block storage systems use what block size?
   - **A.** 4KB
   - **B.** 8KB
   - **C.** 16KB
   - **D.** Block size can vary.

6. You have been asked to set up network security in a virtual private cloud. Your company wants to have multiple subnetworks and limit traffic between the subnetworks. Which network security control would you use to control the flow of traffic between subnets?
   - **A.** Identity access management
   - **B.** Router
   - **C.** Firewall
   - **D.** IP address table

7. When you create a machine learning service to identify text in an image, what type of servers should you choose to manage compute resources?
   - **A.** VMs
   - **B.** Clusters of VMs
   - **C.** No servers; specialized services are serverless
   - **D.** VMs running Linux only

8. Investing in servers for extended periods of time, such as committing to use servers for three to five years, works well when?
   - **A.** A company is just starting up
   - **B.** A company can accurately predict server need for an extended period of time
   - **C.** A company has a fixed IT budget
   - **D.** A company has a variable IT budget

9. Your company is based in X and will be running a virtual server for Y. What factor determines the unit per minute cost?
   - **A.** The time of day the VM is run
   - **B.** The characteristics of the server
   - **C.** The application you run
   - **D.** None of the above

10. You plan to use Cloud Vision to analyze images and extract text seen in the image. You plan to process between 1,000 and 2,500 images per hour. How many VMs should you allocate to meet peak demand?
    - **A.** 1
    - **B.** 10
    - **C.** 25
    - **D.** None; Cloud Vision is a serverless service.

11. You have to run a number of services to support an application. Which of the following is a good deployment model?
    - **A.** Run on a large, single VM
    - **B.** Use containers in a managed cluster

C. Use two large VMs, making one of them read only

D. Use a small VM for all services and increase the size of the VM when CPU utilization exceeds 90 percent

12. You have created a VM. Which of the following system administration operations are you allowed to perform on it?

A. Configure the file system

B. Patch operating system software

C. Change file and directory permissions

D. All of the above

13. Cloud Filestore is based on what file system technology?

A. Network File System (NFS)

B. XFS

C. EXT4

D. ReiserFS

14. When setting up a network in GCP, your network the resources in it are treated as what?

A. Virtual private cloud

B. Subdomain

C. Cluster

D. None of the above

15. You need to store data for X and therefore you are using a cache for Y. How will the cache affect data retrieval?

A. A cache improves the execution of client-side JavaScript.

B. A cache will continue to store data even if power is lost, improving availability.

C. Caches can get out of sync with the system of truth.

D. Using a cache will reduce latency, since retrieving from a cache is faster than retrieving from SSDs or HDDs.

16. Why can cloud providers offer elastic resource allocation?

A. Cloud providers can take resources from lower-priority customers and give them to higher-priority customers.

B. Extensive resources and the ability to quickly shift resources between customers enables public cloud providers to offer elastic resource allocation more efficiently than can be done in smaller data centers.

C. They charge more the more resources you use.

D. They don't.

17. What is not a characteristic of specialized services in Google Cloud Platform?
    - **A.** They are serverless; you do not need to configure servers or clusters.
    - **B.** They provide a specific function, such as translating text or analyzing images.
    - **C.** They require monitoring by the user.
    - **D.** They provide an API to access the functionality of the service.

18. Your client's transactions must access a drive attached to a VM that allows for random access to parts of files. What kind of storage does the attached drive provide?
    - **A.** Object storage
    - **B.** Block storage
    - **C.** NoSQL storage
    - **D.** Only SSD storage

19. You are deploying a new relational database to support a web application. Which type of storage system would you use to store data files of the database?
    - **A.** Object storage
    - **B.** Data storage
    - **C.** Block storage
    - **D.** Cache

20. A user prefers services that require minimal setup; why would you recommend Cloud Storage, App Engine, and Cloud Functions?
    - **A.** They are charged only by time.
    - **B.** They are serverless.
    - **C.** They require a user to configure VMs.
    - **D.** They can only run applications written in Go.

Chapter 2

Google Cloud Computing Services

THIS CHAPTER COVERS THE FOLLOWING OBJECTIVES OF THE GOOGLE ASSOCIATE CLOUD ENGINEER CERTIFICATION EXAM:

- ✓ **2.2 Planning and configuring compute resources, including selecting appropriate compute choices for a given workload**
- ✓ **3.4 Deploying and implementing data solutions, including initializing data systems with products**

Official Google Cloud Certified: Associate Cloud Engineer: Study Guide
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Google Cloud Platform (GCP) is made up of almost 40 services that meet a variety of computing, storage, and networking needs. This chapter provides an overview of the most important GCP services and describes some important use cases for these services.

Computing Components of Google Cloud Platform

Google Cloud Platform is a suite of cloud computing services that includes compute, storage, and networking services designed to meet the needs of a wide range of cloud computing customers. Small businesses may be attracted to virtual machines (VMs) and storage services. Large businesses and other sizable organizations may be more interested in access to highly scalable clusters of VMs, a variety of relational and NoSQL databases, specialized networking services, and advanced artificial intelligence and machine learning capabilities.

This chapter provides an overview of many of GCP's services. The breadth of services available in the GCP continues to grow. By the time you read this, Google may be offering additional services. Most of the services can be grouped into several core categories.

- Computing resources
- Storage resources
- Databases
- Networking services
- Identity management and security
- Development tools
- Management tools
- Specialized services

A Google-certified Associate Cloud Engineer should be familiar with the services in each category, how they are used, and the advantages and disadvantages of the various services in each category.

Computing Resources

Public cloud services provide a range computing services options. At one end of the spectrum, customers can create and manage VMs themselves. This model gives the cloud user the greatest control of all the computing services. Users can choose the operating system to run, which packages to install, and when to back up and perform other maintenance operations. This type of computing service is typically referred to as infrastructure as a service (IaaS).

An alternative model is called platform as a service (PaaS), which provides a runtime environment to execute applications without the need to manage underlying servers, networks, and storage systems.

GCP's IaaS computing product is called Compute Engine, and the PaaS offerings are App Engine and Cloud Functions. In addition, Google offers Kubernetes Engine, which is a service for managing containers in a cluster; this type of service is an increasingly popular alternative to managing individual sets of VMs.

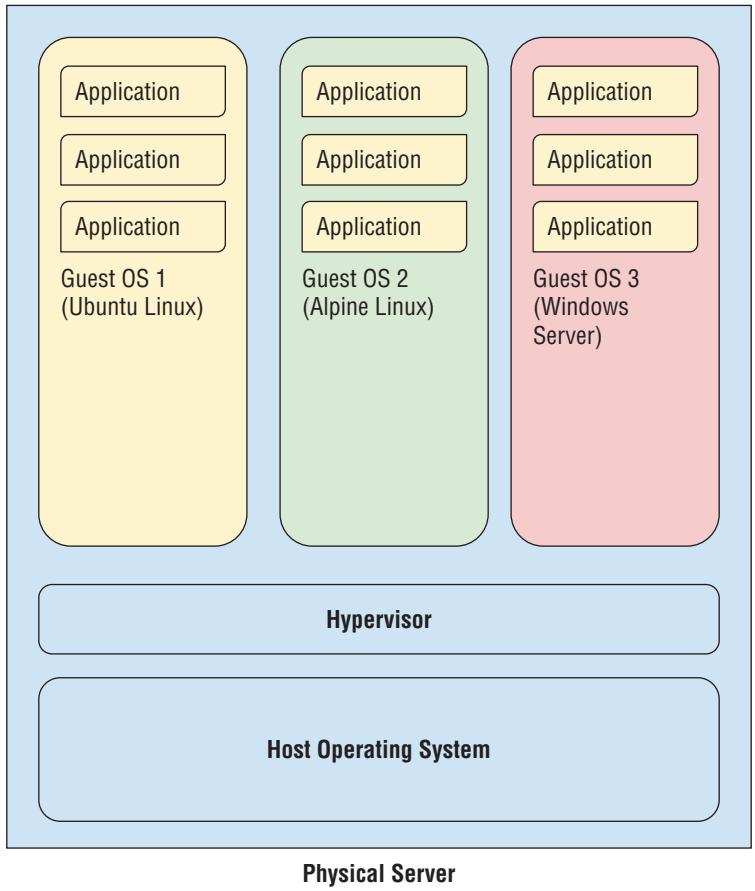
Compute Engine

Compute Engine is a service that allows users to create VMs, attach persistent storage to those VMs, and make use of other GCP services, such as Cloud Storage.

VMs are abstractions of physical servers. They are essentially programs that emulate physical servers and provide CPU, memory, storage, and other services that you would find if you ran your favorite operating system on a server under your desk or in a data center. VMs run within a low-level service called a *hypervisor*. GCP uses a security hardened version of the KVM hypervisor. KVM stands for Kernel Virtual Machine and provides virtualization on Linux systems running on x86 hardware.

Hypervisors run on an operating system like Linux or Windows Server. Hypervisors can run multiple operating systems, referred to as *guest operating systems*, while keeping the activities of each isolated from other guest operating systems. Each instance of an executing guest operating system is a VM instance. Figure 2.1 shows the logical organization of VM instances running on a physical server.

FIGURE 2.1 VM instances running within a hypervisor



VMs come in a range of predefined sizes, but you can also create a customized configuration. When you create an instance, you can specify a number of parameters, including the following:

- The operating system
- Size of persistent storage
- Adding graphical processing units (GPUs) for compute-intensive operations like machine learning
- Making the VM preemptible

The last option, making a VM preemptible, means you may be charged significantly less for the VM than normal (around 80 percent less), but your VM could be shut down at any time by Google. It will frequently be shut down if the preemptible VM has run for at least 24 hours.

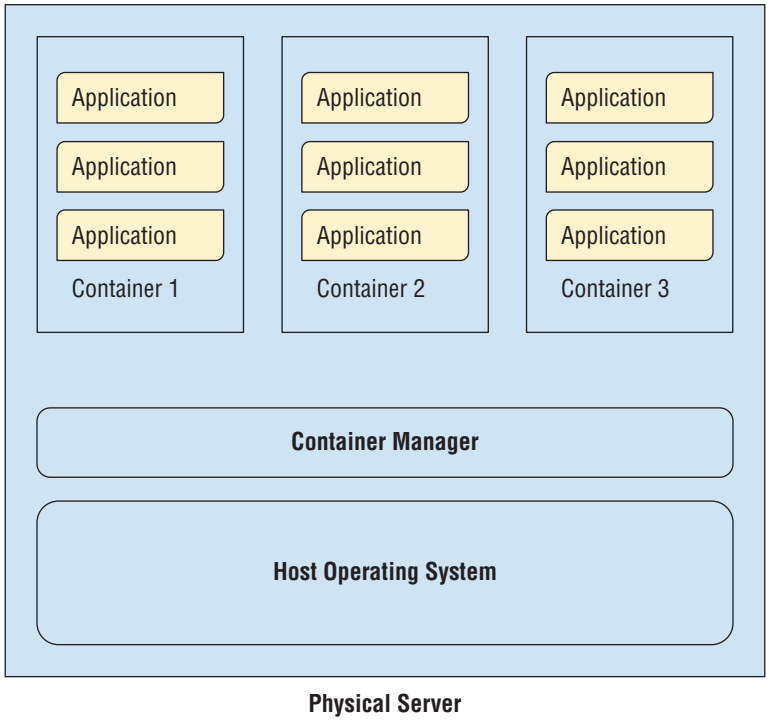
Chapter 4 will introduce the details of managing Compute Engine VMs. To explore Compute Engine, log into the Google Cloud Console, navigate to the main menu on the left, and select Compute Engine.

Kubernetes Engine

Kubernetes Engine is designed to allow users to easily run containerized applications on a cluster of servers. Containers are often compared to VMs because they are each used for isolating computing processing and resources. Containers take a different approach than VMs for isolating computing processes.

As mentioned, a VM runs a guest operating system on a physical server. The physical server runs an operating system as well, along with a hypervisor. Another approach to isolating computing resources is to use features of the host operating system to isolate processes and resources. With this approach, there is no need for a hypervisor; the host operating system maintains isolation. Instead, a container manager is used. That is, a single container manager coordinates containers running on the server. No additional, or guest, operating systems run on top of the container manager. Instead, containers make use of host operating system functionality, while the operating system and container manager ensure isolation between the running containers. Figure 2.2 shows the logical structure of containers.

FIGURE 2.2 Containers running on a physical server



Kubernetes Engine is a GCP product that allows users to describe the compute, storage, and memory resources they'd like to run their services. Kubernetes Engine then provisions the underlying resources. It's easy to add and remove resources from a Kubernetes cluster using a command-line interface or a graphical user interface.

In addition, Kubernetes monitors the health of servers in the cluster and automatically repairs problems, such as failed servers. Kubernetes Engine also supports autoscaling, so if the load on your applications increases, Kubernetes Engine will allocate additional resources.

Chapter 7 will describe the details of planning and managing Kubernetes Engine. To explore Kubernetes Engine, log into the Google Cloud Console, navigate to the main menu on the left, and select Kubernetes Engine.

App Engine

App Engine is GCP's compute PaaS offering. With App Engine, developers and application administrators don't need to concern themselves with configuring VMs or specifying Kubernetes clusters. Instead, developers create applications in a popular programming language such as Java, Go, Python, or Node.js and deploy that code to a serverless application environment.

App Engine manages the underlying computing and network infrastructure. There is no need to configure VMs or harden networks to protect your application. App Engine is well suited for web and mobile backend applications.

App Engine is available in two types: standard and flexible.

In the standard environment, you run applications in a language-specific sandbox, so your application is isolated from the underlying server's operating system as well as from other applications running on that server. The standard environment is well suited to applications that are written in one of the supported languages and do not need operating system packages or other compiled software that would have to be installed along with the application code.

In the flexible environment, you run Docker containers in the App Engine environment. The flexible environment works well in cases where you have application code but also need libraries or other third-party software installed. As the name implies, the flexible environment gives you more options, including the ability to work with background processes and write to local disk.

Chapter 9 will introduce details for using and managing App Engine. To explore App Engine, log into the Google Cloud Console, navigate to the main menu on the left, and select App Engine.

Cloud Functions

Google Cloud Functions is a lightweight computing option that is well suited to event-driven processing. Cloud Functions runs code in response to an event, like a file being uploaded to Cloud Storage or a message being written to a message queue. The code that executes in the Cloud Functions environment must be short-running—this computing service is not designed to execute long-running code. If you need to support long-running applications or jobs, consider Compute Engine, Kubernetes Engine, or App Engine.

Cloud Functions is often used to call other services, such as third-party application programming interfaces (APIs) or other GCP services, like a natural language translation service.

Like App Engine, Cloud Functions is a serverless product. Users only need to supply code; they do not need to configure VMs or create containers. Cloud Functions will automatically scale as load increases.

In addition to the four main computing products, GCP offers a number of storage resources.

Chapter 10 will describe the details of using and managing Cloud Functions. To explore Cloud Functions, log into the Google Cloud Console, navigate to the main menu on the left, and select Cloud Functions.

Storage Components of Google Cloud Platform

Applications and services that run in the cloud have to meet a wide range of requirements when it comes to storage.

Storage Resources

Sometimes an application needs fast read and write times for moderate amounts of data. Other times, a business application may need access to petabytes of archival storage but can tolerate minutes and even hours to retrieve a document. GCP has several storage resources for storing objects and files.

Cloud Storage

Cloud Storage is GCP's object storage system. Objects can be any type of file or binary large object. Objects are organized into buckets, which are analogous to directories in a file system. It is important to remember that Cloud Storage is not a file system. It is a service that receives, stores, and retrieves files or objects from a distributed storage system. Cloud Storage is not part of a VM in the way an attached persistent disk is. Cloud Storage is accessible from VM (or any other network device with appropriate privileges) and so complements file systems on persistent disks.

Each stored object is uniquely addressable by a URL. For example, a `.pdf` version of this chapter, called `chapter1.pdf`, that is stored in a bucket named *ace-certification-exam-prep* would be addressable as follows:

```
https://storage.cloud.google.com/ace-certification-exam-prep/chapter1.pdf
```

GCP users and others can be granted permission to read and write objects to a bucket. Often, an application will be granted privileges through IAM roles to enable the application to read and write to buckets.

Cloud Storage is useful for storing objects that are treated as single units of data. For example, an image file is a good candidate for object storage. Images are generally read and written all at once. There is rarely a need to retrieve only a portion of the image. In general, if you write or retrieve an object all at once and you need to store it independently of servers that may or may not be running at any time, then Cloud Storage is a good option.

There are different classes of cloud storage. Regional storage keeps copies of objects in a single Google Cloud *region*. Regions are distinct geographic areas that can have multiple *zones*, or deployment areas. A zone is considered a single failure domain, which means that if all instances of your application are running in a zone and there is a failure, then all instances of your application will be inaccessible. Regional storage is well suited for applications that run in the same region and need low latency access to objects in Cloud Storage.

Cloud Storage has some useful advanced features, such as support for multiple regions. This provides for storing replicas of objects in multiple Google Cloud regions, which is important for high availability, durability, and low latency.

Real World Scenario

Real-World Scenario

If there was an outage in region us-east1 and your objects were stored only in that region, then you would not be able to access those objects during the outage. However, if you enabled multiregion storage, then your objects stored in us-east1 would be stored in another region, such as us-west1, as well.

In addition to high availability and durability, multiregion storage allows for faster access to data when users or applications are distributed across regions.

Sometimes data needs to be kept for extended periods of time but is rarely accessed. In those cases, nearline storage is a good option because it costs less than regional or multiregional storage and is optimized for infrequent access.

The cold storage class is low-cost archival storage designed for high durability and infrequent access. This class of storage is suitable for data that is accessed less than once per year.

A useful feature of Cloud Storage is the set of lifecycle management policies that can automatically manage objects based on policies you define. For example, you could define a policy that moves all objects more than 60 days old in a bucket to nearline storage or deletes any object in a coldline storage bucket that is older than five years.

Persistent Disk

Persistent disks are storage service that are attached to VMs in Compute Engine or Kubernetes Engine. Persistent disks provide block storage on solid-state drives (SSDs) and hard disk drives (HDDs). SSDs are often used for low-latency applications where persistent disk performance is important. SSDs cost more than HDDs, so applications that require

large amounts of persistent disk storage but can tolerate longer read and write times can use HDDs to meet their storage requirements.

An advantage of persistent disks on the Google Cloud Platform is that these disks support multiple readers without a degradation in performance. This allows for multiple instances to read a single copy of data. Disks can also be resized as needed while in use without the need to restart your VMs.

Persistent disks can be up to 64TB in size using either SSDs or HDDs.

Cloud Storage for Firebase

Mobile app developers may find Cloud Storage for Firebase to be the best combination of cloud object storage and the ability to support uploads and downloads from mobile devices with sometimes unreliable network connections.

The Cloud Storage for Firebase API is designed to provide secure transmission as well as robust recovery mechanisms to handle potentially problematic network quality. Once files, like photos or music recordings, are uploaded into Cloud Storage, you can access those files through the Cloud Storage command-line interface and software development kits (SDKs).

Cloud Filestore

Sometimes, developers need to have access to a file system housed on network-attached storage. For these use cases, the Cloud Filestore service provides a shared file system for use with Compute Engine and Kubernetes Engine.

Filestore can provide high numbers of input-output operations per second (IOPS) as well as variable storage capacity. File system administrators can configure Cloud Filestore to meet their specific IOPS and capacity requirements.

Filestore implements the Network File System (NFS) protocol so system administrators can easily mount shared file systems on virtual servers.

Storage systems like the ones just described are used to store coarse-grained objects, like files. When data is more finely structured and has to be retrieved using query languages that describe the subset of data to return, then it is best to use a database management system.

Chapter 11 describes details and guidance for planning storage services. To explore storage options, log into the Google Cloud Console, navigate to the main menu on the left, and select Storage or Filestore.

Databases

GCP provides several database options. Some are relational databases, and some are NoSQL databases. Some are serverless and others require users to manage clusters of servers. Some provide support for atomic transactions, and others are better suited for applications with less stringent consistency and transaction requirements. GCP users must understand their application requirements before choosing a service, and this is especially important when choosing a database, which often provides core storage services in the application stack.

Cloud SQL

Cloud SQL is GCP's managed relational database service that allows users to set up MySQL or PostgreSQL databases on VMs without having to attend to database administration tasks, such as backing up databases or patching database software. Cloud SQL is available in a number of configurations:

- First-generation MySQL databases use MySQL 5.5 or 5.6 and can have up to 16GB of RAM and 500GB of data storage.
- Second-generation MySQL databases use MySQL 5.6 or 5.7 and can have up to 416GB of RAM along with 10TB of data storage. Second-generation MySQL databases can be configured to automatically add storage as needed.
- PostgreSQL 9.6 runs on the second-generation platform and can be configured with up to 64 CPUs, 416GB of RAM, and up to 10TB of storage. Cloud SQL PostgreSQL also supports common extensions such as PostGIS, cubes for analytic processing, and hstore for storing key-value pairs in a single PostgreSQL value.

This database service includes management of replication and allows for automatic failover, providing for highly available databases.

Relational databases are well suited to applications with relatively consistent data structure requirements. For example, a banking database may track account numbers, customer names, addresses, and so on. Since virtually all records in the database will need the same information, this application is a good fit for a relational database.

Cloud Bigtable

Cloud Bigtable is designed for petabyte-scale applications that can manage up to billions of rows and thousands of columns. It is based on a NoSQL model known as a *wide-column data model*, and unlike Cloud SQL that supports relational databases. Bigtable is suited for applications that require low-latency write and read operations. It is designed to support millions of operations per second.

Bigtable integrates with other Google Cloud services, such as Cloud Storage, Cloud Pub/Sub, Cloud Dataflow, and Cloud Dataproc. It also supports the Hbase API, which is an API for data access in the Hadoop big data ecosystem. Bigtable also integrates with open source tools for data processing, graph analysis, and time-series analysis.

Cloud Spanner

Cloud Spanner is Google's globally distributed relational database that combines the key benefits of relational databases, such as strong consistency and transactions, with the ability to scale horizontally like a NoSQL database. Spanner is a high availability database with a 99.999 percent availability Service Level Agreements (SLA), making it a good option for enterprise applications that demand scalable, highly available relational database services.

Cloud Spanner also has enterprise-grade security with encryption at rest and encryption in transit, along with identity-based access controls.

Cloud Spanner supports ANSI 2011 standard SQL.

Cloud Datastore

Cloud Datastore is a NoSQL document database. This kind of database uses the concept of a document, or collection of key-value pairs, as the basic building block. Documents allow for flexible schemas. For example, a document about a book may have key-value pairs listing author, title, and date of publication. Some books may also have information about companion websites and translations into other languages. The set of keys that may be included does not have to be defined prior to use in document databases. This is especially helpful when applications must accommodate a range of attributes, some of which may not be known at design time.

Cloud Datastore is accessed via a REST API that can be used from applications running in Compute Engine, Kubernetes Engine, or App Engine. This database will scale automatically based on load. It will also *shard*, or partition, data as needed to maintain performance. Since Cloud Datastore is a managed service, it takes care of replication, backups, and other database administration tasks.

Although it is a NoSQL database, Cloud Datastore supports transactions, indexes, and SQL-like queries.

Cloud Datastore is well suited to applications that demand high scalability and structured data and do not always need strong consistency when reading data. Product catalogs, user profiles, and user navigation history are examples of the kinds of applications that use Cloud Datastore.

Cloud Memorystore

Cloud Memorystore is an in-memory cache service. Other databases offered in GCP are designed to store large volumes of data and support complex queries, but Cloud Memorystore is a managed Redis service for caching frequently used data in memory. Caches like this are used to reduce the time needed to read data into an application. Cloud Memorystore is designed to provide submillisecond access to data.

As a managed service, Cloud Memorystore allows users to specify the size of a cache while leaving administration tasks to Google. GCP ensures high availability, patching, and automatic failover so users don't have to.

Cloud Firestore

Cloud Firestore is another GCP-managed NoSQL database service designed as a backend for highly scalable web and mobile applications. A distinguishing feature of Cloud Firestore is its client libraries that provide offline support, synchronization, and other features for managing data across mobile devices, IoT devices, and backend data stores. For example, applications on mobile devices can be updated in real time as data in the backend changes.

Cloud Firebase includes a Datastore mode, which enables applications written for Datastore to work with Cloud Firebase as well. When running in Native mode, Cloud Firestore provides real-time data synchronization and offline support.

Cloud Firestore is currently in beta release.

Chapter 12 delves into details of how to create various types of databases, as well as how to load, delete, and query data. Each of the databases can be accessed from the main menu of the Google Cloud Console. From there you can begin to explore how each works and begin to see the differences.

Networking Components of Google Cloud Platform

In this section, we will review the major networking components. Details on setting up networks and managing them are described in Chapters 14 and 15.

Networking Services

Google Cloud Platform provides a number of networking services designed to allow users to configure virtual networks within Google's global network infrastructure, link on-premise data centers to Google's network, optimize content delivery, and protect your cloud resources using network security services.

Virtual Private Cloud

When an enterprise operates its own data center, it controls what is physically located in that data center and connected to its network. Its infrastructure is physically isolated from those of other organizations running in other data centers. When an organization moves to a public cloud, it shares infrastructure with other customers of that public cloud. Although multiple enterprises will use the same cloud infrastructure, each enterprise can logically isolate its cloud resources by creating a virtual private cloud (VPC).

A distinguishing feature of GPC is that a VPC can span the globe without relying on the public Internet. Traffic from any server on a VPC can be securely routed through the Google global network to any other point on that network. Another advantage of the Google network structure is that your backend servers can access Google services, such as machine learning or IoT services, without creating a public IP address for backend servers.

VPCs in the Google Cloud can be linked to on-premise virtual private networks using Internet Protocol Security (IPSec).

Although a VPC is global, enterprises can use separate projects and billing accounts to manage different departments or groups within the organization. Firewalls can be used to restrict access to resources on a VPC as well.

Cloud Load Balancing

Google provides global load balancing to distribute workloads across your cloud infrastructure. Using a single multicast IP address, Cloud Load Balancing can distribute the workload within and across regions, adapt to failed or degraded servers, and autoscale your compute resources to accommodate changes in workload. Cloud Load Balancing also supports internal load balancing, so no IP addresses need to be exposed to the Internet to get the advantages of load balancing.

Cloud Load Balancing is a software service that can load-balance HTTP, HTTPS, TCP/SSL, and UDP traffic.

Cloud Armor

Services exposed to the Internet can become targets of distributed denial-of-service (DDoS) attacks. Cloud Armor is a Google network security service that builds on the Global HTTP(s) Load Balancing service. Cloud Armor features include the following:

- Ability to allow or restrict access based on IP address
- Predefined rules to counter cross-site scripting attacks
- Ability to counter SQL injection attacks
- Ability to define rules at both level 3 (network) and level 7 (application)
- Allows and restricts access based on the geolocation of incoming traffic

Cloud CDN

With content delivery networks (CDNs), users anywhere can request content from systems distributed in various regions. CDNs enable low-latency response to these requests by caching content on a set of endpoints across the globe. Google currently has more than 90 CDN endpoints that are managed as a global resource, so there is no need to maintain region-specific configurations.

CDNs are especially important for sites with large amounts of static content and a global audience. News sites, for example, could use the Cloud CDN service to ensure fast response to requests from any point in the world.

Cloud Interconnect

Cloud Interconnect is a set of GCP services for connecting your existing networks to the Google network. Cloud Interconnect offers two types of connections: interconnects and peering.

Interconnect with direct access to networks uses the Address Allocation for Private Internets standard (RFC 1918) to connect to devices in your VPC. A direct network connection is maintained between an on-premise or hosted data center and one of Google's colocation facilities, which are located in North America, South America, Europe, Asia,

and Australia. Alternatively, if an organization cannot achieve a direct interconnect with a Google facility, it could use Partner Interconnect. This service depends on a third-party network provider to provide connectivity between the company's data center and a Google facility.

For organizations that do not require the bandwidth of a direct or peered interconnect, Google offers VPN services that enable traffic to transmit between data centers and Google facilities using the public Internet.

Cloud DNS

Cloud DNS is a domain name service provided in GCP. Cloud DNS is a high availability, low-latency service for mapping from domain names, such as `example.com`, to IP addresses, such as 74.120.28.18.

Cloud DNS is designed to automatically scale so customers can have thousands and millions of addresses without concern for scaling the underlying infrastructure. Cloud DNS also provides for private zones that allow you to create custom names for your VMs if you need those.

Identity Management

GCP's Cloud Identity and Access Management (IAM) service enables customers to define fine-grained access controls on resources in the cloud. IAM uses the concepts of users, roles, and privileges.

Identities are abstractions about users of services, such as a human user. After an identity is authenticated by logging in or some other mechanism, the authenticated user can access resources and perform operations based on the privileges granted to that identity. For example, a user may have the privilege to create a bucket in Cloud Storage or delete a VM running in Compute Engine.

Users often need similar sets of permissions. Someone who has the ability to create a VM will likely want to be able to modify or delete those VMs. Groups of related permissions can be bundled into roles. Roles are sets of permissions that can be assigned to an identity.

As a Google Certified Associate Cloud Engineer, you will become familiar with identities, roles, and permissions and how to administer them across organizations and projects.

You can find identity management tools under the IAM and admin menu in the Google Cloud Console. Chapter 17 provides details on identity, roles, and best practices for their management.

Development Tools

Google Cloud Platform is an excellent choice for developers and software engineers because of the easy access to infrastructure and data management services, but also for the tools it supports.

Cloud SDK is a command-line interface for managing GCP resources, including VMs, disk storage, network firewalls, and virtually any other resource you might deploy in GCP. In addition to a command-line interface, Cloud SDK has client libraries for Java, Python, Node.js, Ruby, GO, .NET, and PHP.

GCP also supports deploying applications to containers with Container Registry, Cloud Build, and Cloud Source Repositories.

Google has also developed plug-ins to make it easy to work with popular development tools. These include the following:

- Cloud Tools for IntelliJ
- Cloud Tools for PowerShell
- Cloud Tools for Visual Studio
- Cloud Tools for Eclipse
- App Engine Gradle Plugin
- App Engine Maven Plugin

Of course, applications move from development to production deployment, and GCP follows that flow with additional management tools to help monitor and maintain applications after they are deployed.

Additional Components of Google Cloud Platform

Management tools are designed for DevOps professionals who are responsible for ensuring the reliability, availability, and scalability of applications.

Management Tools

The following are some of the most important tools in the management tools category:

Stackdriver This is a service that collects metrics, logs, and event data from applications and infrastructure and integrates the data so DevOps engineers can monitor, assess, and diagnose operational problems.

Monitoring This extends the capabilities of Stackdriver by collecting performance data from GCP, AWS resources, and application instrumentation, including popular open source systems like NGINX, Cassandra, and Elasticsearch.

Logging This service enables users to store and analyze and alert on log data from both GCP and AWS logs.

Error Reporting This aggregates application crash information for display in a centralized interface.

Trace This is a distributed tracing service that captures latency data about an application to help identify performance problem areas.

Debugger This enables developers to inspect the state of executing code, inject commands, and view call stack variables.

Profiler This is used to collect CPU and memory utilization information across the call hierarchy of an application. Profiler uses statistical sampling to minimize the impact of profiling on application performance.

The combination of management tools provides insights into applications as they run in production, enabling more effective monitoring and analysis of operational systems.

Specialized Services

In addition to IaaS and PaaS offerings, GCP has specialized services for APIs, data analytics, and machine learning.

Apigee API Platform

The Apigee API platform is a management service for GCP customers providing API access to their applications. The Apigee platform allows developers to deploy, monitor, and secure their APIs. It also generates API proxies based on the Open API Specification.

It is difficult to predict load on an API, and sometimes spikes in use can occur. For those times, the Apigee API platform provides routing and rate-limiting based on policies customers can define.

APIs can be authenticated using either OAuth 2.0 or SAML. Data is encrypted both in transit and at rest in the Apigee API platform.

Data Analytics

GCP has a number of services designed for analyzing big data in batch and streaming modes. Some of the most important tools in this set of services include the following:

- BigQuery, a petabyte-scale analytics database service for data warehousing
- Cloud Dataflow, a framework for defining batch and stream processing pipelines
- Cloud Dataproc, a managed Hadoop and Spark service
- Cloud Dataprep, a service that allows analysts to explore and prepare data for analysis

Often, data analytics and data warehousing projects use several of these services together.

AI and Machine Learning

Google is a leader in AI and machine learning, so it is no surprise that GCP includes several AI services. Specialized services in this area include the following:

Cloud AutoML This is a tool that allows developers without machine learning experience to develop machine learning models.

Cloud Machine Learning Engine This is a platform for building and deploying scalable machine learning systems to production.

Cloud Natural Language Processing This tool is for analyzing human languages and extracting information from text.

Cloud Vision This is an image analysis platform for annotating images with metadata, extracting text, or filtering content.

Exam Essentials

Understand the differences between Compute Engine, Kubernetes Engine, App Engine, and Cloud Functions. Compute Engine is Google's VM service. Users can choose CPUs, memory, persistent disks, and operating systems. They can further customize a VM by adding graphics processing units for compute-intensive operations. VMs are managed individually or in groups of similar servers.

Kubernetes Engine manages groups of virtual servers and applications that run in containers. Containers are lighter weight than VMs. Kubernetes is called an *orchestration service* because it distributes containers across clusters, monitors cluster health, and scales as proscribed by configurations.

App Engine is Google's PaaS. Developers can run their code in a language-specific sandbox when using the standard environment or in a container when using the flexible environment. App Engine is a serverless service, so customers do not need to specify VM configurations or manage servers.

Cloud Functions is a serverless service that is designed to execute short-running code that responds to events, such as file uploads or messages being published to a message queue. Functions may be written in Node.js or Python.

Understand what is meant by serverless. Serverless means customers using a service do not need to configure, monitor, or maintain the computing resources underlying the service. It does not mean there are no servers involved—there are always physical servers that run applications, functions, and other software. Serverless only refers to not needing to manage those underlying resources.

Understand the difference between object and file storage. Object stores are used to store and access file-based resources. These objects are referenced by a unique identifier, such as a URL. Object stores do not provide block or file system services, so they are not suitable for database storage. Cloud Storage is GCP's object storage service.

File storage supports block-based access to files. Files are organized into directories and subdirectories. Google's Filestore is based on the NFS.

Know the different kinds of databases. Databases are broadly divided into relational and NoSQL databases.

Relational databases support transactions, strong consistency, and the SQL query languages. Relational databases have been traditionally difficult to horizontally scale. Cloud Spanner is a global relational database that provides the advantages of relational databases with the scalability previously found only in NoSQL databases.

NoSQL databases are designed to be horizontally scalable. Other features, such as strong consistency and support for standard SQL, are often sacrificed to achieve scalability and low-latency query responses. NoSQL databases may be key-value stores like Cloud Memorystore, document databases like Cloud Datastore, or wide-column databases such as Cloud Bigtable.

Understand virtual private clouds. A VPC is a logical isolation of an organization's cloud resources within a public cloud. In GCP, VPCs are global; they are not restricted to a single zone or region. All traffic between GCP services can be transmitted over the Google network without the need to send traffic over the public Internet.

Understand load balancing. Load balancing is the process of distributing a workload across a group of servers. Load balancers can route workload based on network-level or application-level rules. GCP load balancers can distribute workloads globally.

Understand developer and management tools. Developer tools support common workflows in software engineering, including using version control for software, building containers to run applications and services, and making containers available to other developers and orchestration systems, such as Kubernetes Engine.

Management tools, such as Stackdriver, Monitoring, and Logging, are designed to provide systems administration information to developers and operators who are responsible for ensuring applications are available and operating as expected.

Know the types of specialized services offered by Google Cloud Platform. GCP includes a growing list of specialized services for data analytics, and AI and machine learning.

Know the main differences between on-premises and public cloud computing. On-premise computing is computing, storage, networking, and related services that occur on infrastructure managed by a company or organization for its own use. Hardware may be located literally on the premises in a company building or in a third-party colocation facility. Colocation facilities provide power, cooling, and physical security, but the customers of the colocation facility are responsible for all the setup and management of the infrastructure.

Public cloud computing uses infrastructure and services provided by a cloud provider such as Google, AWS, or Microsoft. The cloud provider maintains all physical hardware and facilities. It provides a mix of services, such as VMs that are configured and maintained by customers and serverless offerings that enable customers to focus on application development-while the cloud provider takes on more responsibility for maintaining the underlying compute infrastructure.

Review Questions

You can find the answers in the Appendix.

1. You are planning to deploy a SaaS application for customers in North America, Europe, and Asia. To maintain scalability, you will need to distribute workload across servers in multiple regions. Which GCP service would you use to implement the workload distribution?
   - **A.** Cloud DNS
   - **B.** Cloud Spanner
   - **C.** Cloud Load Balancing
   - **D.** Cloud CDN

2. You have decided to deploy a set of microservices using containers. You could install and manage Docker on Compute Engine instances, but you'd rather have GCP provide some container management services. Which two GCP services allow you to run containers in a managed service?
   - **A.** App Engine standard environment and App Engine flexible environment
   - **B.** Kubernetes Engine and App Engine standard environment
   - **C.** Kubernetes Engine and App Engine flexible environment
   - **D.** App Engine standard environment and Cloud Functions

3. Why would an API developer want to use the Apigee API platform?
   - **A.** To get the benefits of routing and rate-limiting
   - **B.** Authentication services
   - **C.** Version control of code
   - **D.** A and B
   - **E.** All of the above

4. You are deploying an API to the public Internet and are concerned that your service will be subject to DDoS attacks. Which GCP service should you consider to protect your API?
   - **A.** Cloud Armor
   - **B.** Cloud CDN
   - **C.** Cloud IAM
   - **D.** VPCs

5. You have an application that uses a Pub/Sub message queue to maintain a list of tasks that are to be processed by another application. The application that consumes messages from the Pub/Sub queue removes the message only after completing the task. It takes approximately 10 seconds to complete a task. It is not a problem if two or more VMs perform the same task. What is a cost-effective configuration for processing this workload?
   A. Use preemptible VMs
   B. Use standard VMs
   C. Use DataProc
   D. Use Spanner

6. Your department is deploying an application that has a database backend. You are concerned about the read load on the database server and want to have data available in memory to reduce the time to respond to queries and to reduce the load on the database server. Which GCP service would you use to keep data in memory?
   A. Cloud SQL
   B. Cloud Memorystore
   C. Cloud Spanner
   D. Cloud Datastore

7. The Cloud SDK can be used to configure and manage resources in which of the following services?
   A. Compute Engine
   B. Cloud Storage
   C. Network firewalls
   D. All of the above

8. What server configuration is required to use Cloud Functions?
   A. VM configuration
   B. Cluster configuration
   C. Pub/Sub configuration
   D. None

9. You have been assigned the task of consolidating log data generated by each instance of an application. Which of the Stackdriver management tools would you use?
   A. Monitoring
   B. Trace
   C. Debugger
   D. Logging

10. Which specialized services are most likely to be used to build a data warehousing platform that requires complex extraction, transformation, and loading operations on batch data as well as processing streaming data?
    - **A.** Apigee API platform
    - **B.** Data analytics
    - **C.** AI and machine learning
    - **D.** Cloud SDK

11. Your company has deployed 100,000 Internet of Things (IoT) sensors to collect data on the state of equipment in several factories. Each sensor will collect and send data to a data store every 5 seconds. Sensors will run continuously. Daily reports will produce data on the maximum, minimum, and average value for each metric collected on each sensor. There is no need to support transactions in this application. Which database product would you recommend?
    - **A.** Cloud Spanner
    - **B.** Cloud Bigtable
    - **C.** Cloud SQL MySQL
    - **D.** Cloud SQL PostgreSQL

12. You are the lead developer on a medical application that uses patients' smartphones to capture biometric data. The app is required to collect data and store it on the smartphone when data cannot be reliably transmitted to the backend application. You want to minimize the amount of development you have to do to keep data synchronized between smartphones and backend data stores. Which data store option should you recommend?
    - **A.** Cloud Firestore
    - **B.** Cloud Spanner
    - **C.** Cloud Datastore
    - **D.** Cloud SQL

13. A software engineer comes to you for a recommendation. She has implemented a machine learning algorithm to identify cancerous cells in medical images. The algorithm is computationally intensive, makes many mathematical calculations, requires immediate access to large amounts of data, and cannot be easily distributed over multiple servers. What kind of Compute Engine configuration would you recommend?
    - **A.** High memory, high CPU
    - **B.** High memory, high CPU, GPU
    - **C.** Mid-level memory, high CPU
    - **D.** High CPU, GPU

14. You are tasked with mapping the authentication and authorization policies of your on-premises applications to GPC's authentication and authorization mechanisms. The GCP documentation states that an identity must be authenticated in order to grant privileges to that identity. What does the term *identity* refer to?

A. VM ID

B. User

C. Role

D. Set of privileges

15. A client is developing an application that will need to analyze large volumes of text information. The client is not expert in text mining or working with language. What GCP service would you recommend they use?

A. Cloud Vision

B. Cloud ML

C. Cloud Natural Language Processing

D. Cloud Text Miner

16. Data scientists in your company want to use a machine learning library available only in Apache Spark. They want to minimize the amount of administration and DevOps work. How would you recommend they proceed?

A. Use Cloud Spark

B. Use Cloud Dataproc

C. Use Bigquery

D. Install Apache Spark on a cluster of VMs

17. Database designers at your company are debating the best way to move a database to GCP. The database supports an application with a global user base. Users expect support for transactions and the ability to query data using commonly used query tools. The database designers decide that any database service they choose will
need to support ANSI 2011 and global transactions. Which database service would you recommend?

A. Cloud SQL

B. Cloud Spanner

C. Cloud Datastore

D. Cloud Bigtable

18. Which specialized service supports both batch and stream processing workflows?

A. Cloud Dataproc

B. Bigquery

C. Cloud Datastore

D. AutoML

19. You have a Python application you'd like to run in a scalable environment with the least amount of management overhead. Which GCP product would you select?

A. App Engine flexible environment

B. Cloud Engine

C. App Engine standard environment

D. Kubernetes Engine

20. A product manager at your company reports that customers are complaining about the reliability of one of your applications. The application is crashing periodically, but developers have not found a common pattern that triggers the crashes. They are concerned that they do not have good insight into the behavior of the application and want to perform a detailed review of all crash data. Which Stackdriver tool would you use to view consolidated crash information?

A. DataProc

B. Monitoring

C. Logging

D. Error Reporting

Chapter

3

Projects, Service Accounts, and Billing

THIS CHAPTER COVERS THE FOLLOWING OBJECTIVES OF THE GOOGLE ASSOCIATE CLOUD ENGINEER CERTIFICATION EXAM:

- ✓ **1.1 Setting up cloud projects and accounts**
- ✓ **1.2 Managing billing configuration**

Official Google Cloud Certified: Associate Cloud Engineer: Study Guide
By Dan Sullivan
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Before delving into computing, storage, and networking services, we need to discuss how Google Cloud Platform (GCP) organizes resources and links the use of those resources to a billing system. This chapter introduces the GCP organizational hierarchy, which consists of organizations, folders, and projects. It also discusses service accounts, which are ways of assigning roles to compute resources so they can carry out functions on your behalf. Finally, the chapter briefly discusses billing.

How GCP Organizes Projects and Accounts

When you use GCP, you probably launch virtual machines or clusters, maybe create buckets to storage objects, and make use of serverless computing services such as App Engine and Cloud Functions. The list of resources you use can grow quickly. They can also change in dynamic, unpredicable ways as autoscaling services respond to workload.

If you run a single application or a few services for your department, you might be able to track all resources by viewing lists of resources in use. As the scope of your GCP use grows, you will probably have multiple departments, each with its own administrators who need different privileges. GCP provides a way to group resources and manage them as a single unit. This is called the *resource hierarchy*. The access to resources in the resource hierarchy is controlled by a set of policies that you can define.

GCP Resource Hierarchy

The central abstraction for managing GCP resources is the resource hierarchy. It consists of three levels:

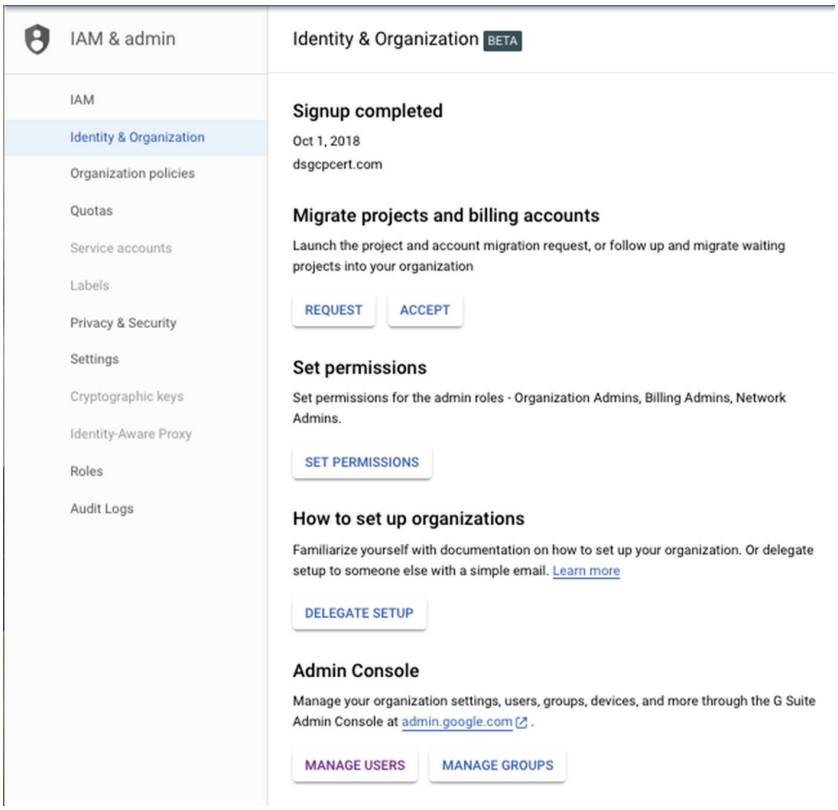
- Organization
- Folder
- Project

Let's describe how these three components relate to each other.

Organization

An organization is the root of the resource hierarchy and typically corresponds to a company or organization. G-suite domains and a Cloud Identity accounts map to GCP organizations. G Suite is Google's office productivity suite, which includes Gmail, Docs, Drive, Calendar, and other services. If your company uses G Suite, you can create an organization in your GCP hierarchy. If your company does not use G Suite, you can use Cloud Identity, Google's identity as a service (IDaaS) offering (Figure 3.1).

FIGURE 3.1 You can create Cloud Identity accounts and manage G Suite users from the Identity & Organization form.



A single cloud identity is associated with at most one organization. Cloud identities have super admins, and those super admins assign the role of Organization Administrator Identity and Access Management (IAM) role to users who manage the organization. In addition, GCP will automatically grant Project Creator and Billing Account Creator IAM roles to all users in the domain. This allows any user to create projects and enable billing for the cost of resources used.

The users with the Organization Administrator IAM role are responsible for the following:

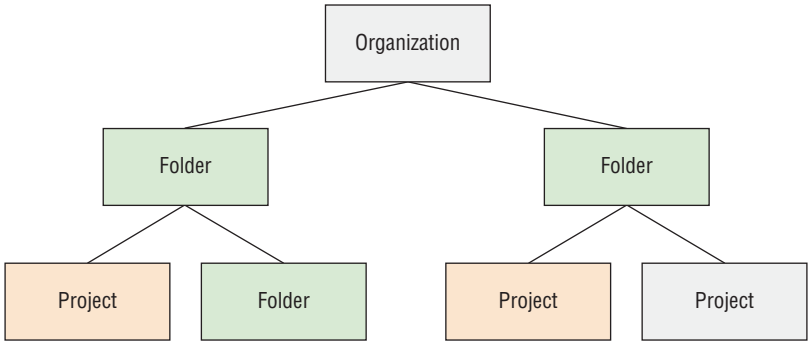
- Defining the structure of the resource hierarchy
- Defining identity access management policies over the resource hierarchy
- Delegating other management roles to other users

When a member of a G Suite organization / Cloud Identity account creates a billing account or project, GCP will automatically create an organization resource. All projects and billing accounts will be children of the organization resource. In addition, when the organization is created, all users in that organization are granted Project Creator and Billing Account Creator roles. From that point on, G Suite users will have access to GCP resources.

Folder

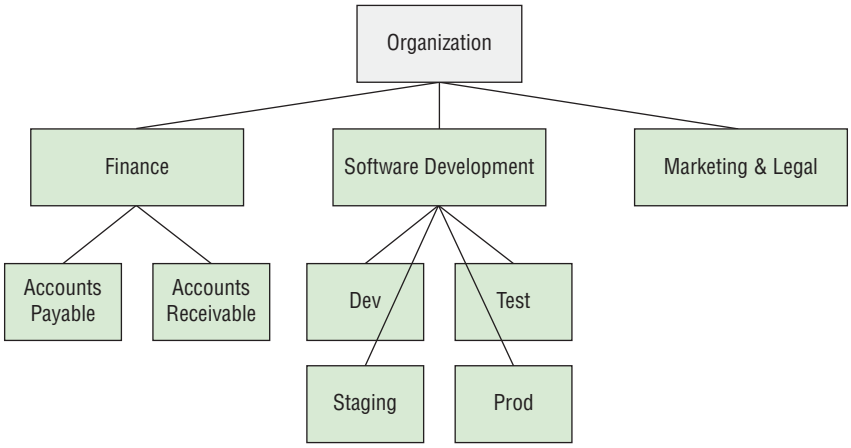
Folders are the building blocks of multilayer organizational hierarchies. Organizations contain folders. Folders can contain other folders or projects. A single folder may contain both folders and projects (see Figure 3.2). Folder organization is usually built around the kinds of services provided by resources in the contained projects and the policies governing folders and projects.

FIGURE 3.2 Generic organization folder project



Consider an example resource hierarchy. An organization has four departments: finance, marketing, software development, and legal. The finance department has to keep its accounts receivable and accounts payable resources separate, so the administrator creates two folders within the Finance folder: Accounts Receivable and Accounts Payable. Software development uses multiple environments, including Dev, Test, Staging, and Production. Access to each of the environments is controlled by policies specific to that environment, so it makes sense to organize each environment into its own folder. Marketing and legal can have all of their resources shared across members of the department, so a single folder is sufficient for both of those departments. Figure 3.3 shows the organization hierarchy for this organization.

FIGURE 3.3 Example organization folder project



Now that we have an organization defined and have set up folders that correspond to our departments and how different groups of resources will be accessed, we can create projects.

Project

Projects are in some ways the most important part of the hierarchy. It is in projects that we create resources, use GCP services, manage permissions, and manage billing options.

The first step in working with a project is to create one. Anyone with the `resourcemanager.projects.create` IAM permission can create a project. By default, when an organization is created, every user in the domain is granted that permission.

Your organization will have a quota of projects it can create. The quota can vary between organizations. Google makes decisions about project quotas based on typical use, the customer's usage history, and other factors. If you reach your limit of projects and try to create another, you will be prompted to request an increase in the quota. You'll have to provide information such as the number of additional projects you need and what they will be used for.

After you have created your resource hierarchy, you can define policies that govern it.

Organization Policies

GCP provides an Organization Policy Service. This service controls access to an organization's resources. The Organization Policy Service complements the IAM service. The IAM lets you assign permissions so users or roles can perform specific operations in the cloud. The Organization Policy Service lets you specify limits on the ways resources can be

used. One way to think of the difference is that IAM specifies who can do things, and the Organization Policy Service specifies what can be done with resources.

The organization policies are defined in terms of constraints on a resource.

Constraints on Resources

Constraints are restrictions on services. GCP has list constraints and Boolean constraints.

List constraints are lists of values that are allowed or disallowed for a resource. The following are some types of list constraints:

- Allow a specific set of values
- Deny a specific set of values
- Deny a value and all its child values
- Allow all allowed values
- Deny all values

Boolean constrains evaluate to true or false and determine whether the constraint is applied or not. For example, if you want to deny access to serial ports on VMs, you can set `constraints/compute.disableSerialPortAccess` to `TRUE`.

Policy Evaluation

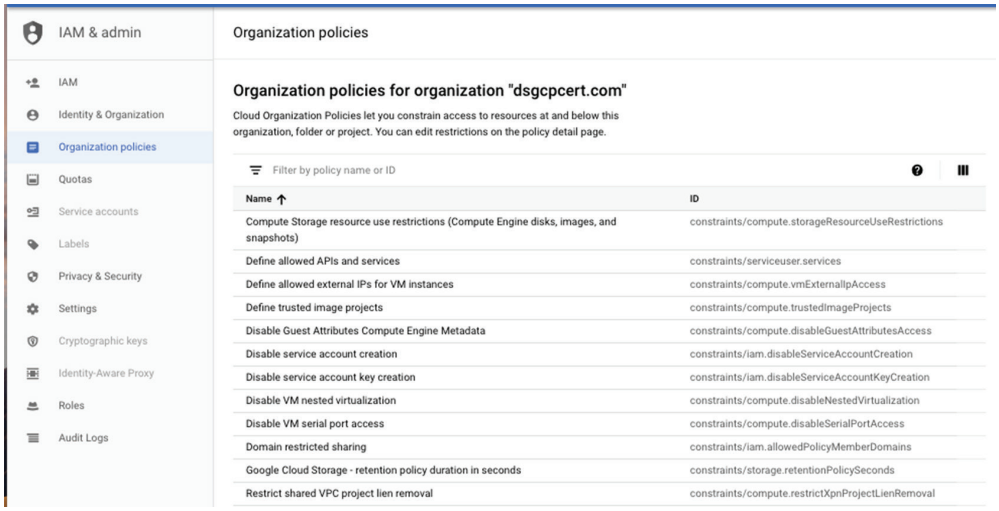
Organizations may have standing policies to protect data and resources in the cloud. For example, there may be rules dictating who in the organization can enable a service API or create a service account. Your InfoSec department may require that all VMs disable serial port access. You could implement controls on each individual VM, but that is inefficient and prone to error. A better approach is to define a policy that constrains what can be done and attach that policy to an object in the resource hierarchy.

For example, since InfoSec wants all VMs to disable serial port access, you could specify a policy that constrains serial port access and then attach it to the organization. All folders and projects below the organization will inherit that policy. Since policies are inherited and cannot be disabled or overridden by objects lower in the hierarchy, this is an effective way to apply a policy across all organizational resources.

Policies are managed through the Organization Policies form in the IAM & admin form. Figure 3.4 shows an example set of policies.

Multiple policies can be in effect for a folder or project. For example, if the organization had a policy on serial port access and a folder containing a project had a policy limiting who can create service accounts, then the project would inherit both policies and both would constrain what could be done with resources in that project.

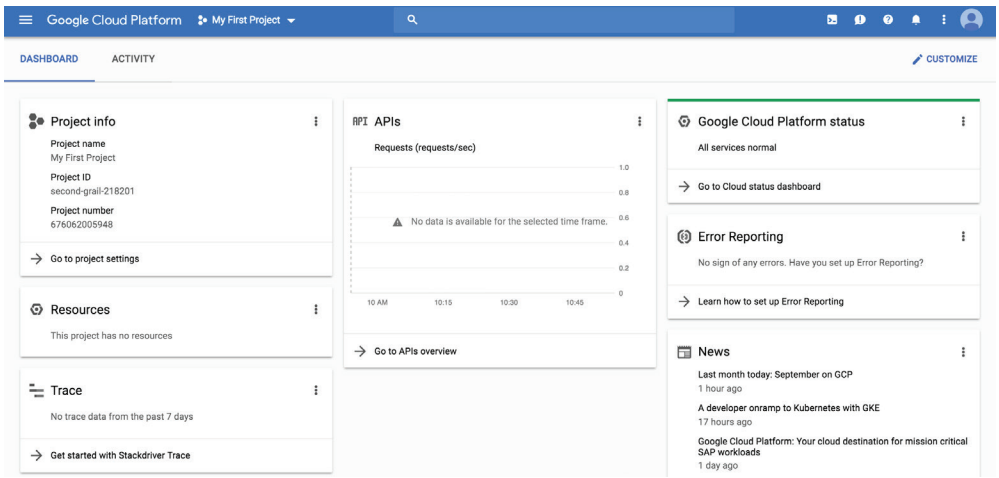
FIGURE 3.4 Organizational policies are managed in the IAM & admin console.



Managing Projects

One of the first tasks you will perform when starting a new cloud initiative is to set up a project. This can be done with the Google Cloud Console. Assuming you have created an account with GCP, navigate to the Google Cloud Console at `https://console.cloud.google.com` and log in. You will see the home page, which looks something like Figure 3.5.

FIGURE 3.5 Home page console



From the Navigation menu in the upper-left corner, select IAM & admin and then select Manage Resources (see Figure 3.6 and Figure 3.7).

FIGURE 3.6 Navigation menu

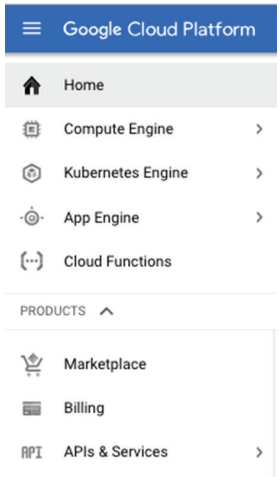
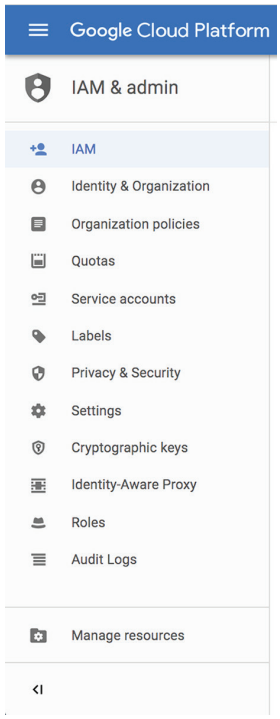


FIGURE 3.7 Select Manage Resources.



From there, you can click Create Project, which displays the Create Project dialog. You can enter the name of a project and select an organization in this dialog (Figure 3.8 and Figure 3.9).

FIGURE 3.8 Click Create Project.

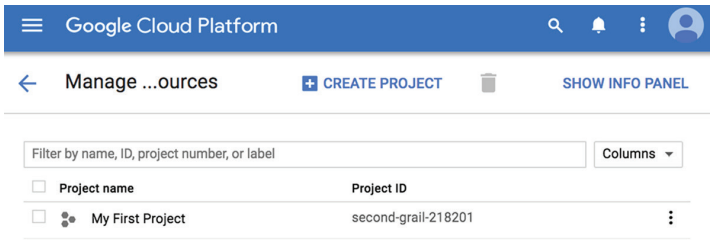
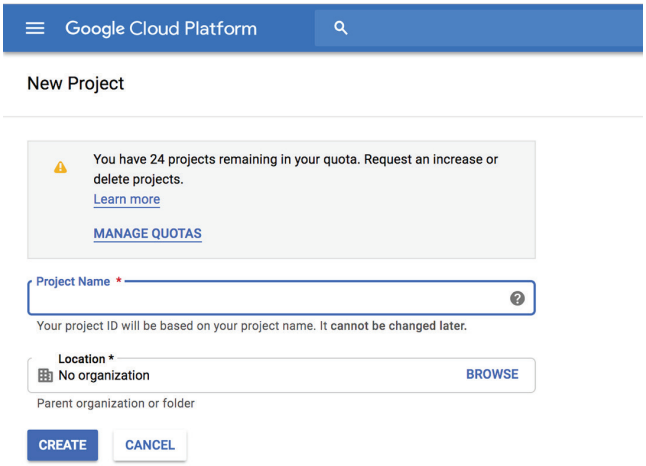


FIGURE 3.9 Create Project dialog



Note that when you create a project, your remaining quota of projects is displayed. If you need additional projects, click the Manage Quotas link to request an increase in your quota.

Roles and Identities

In addition to managing resources, as a cloud engineer you will have to manage access to those resources. This is done with the use of roles and identities.

Roles in GCP

A *role* is a collection of permissions. Roles are granted to users by binding a user to a role. When we talk of identities, we mean the record we use to represent a human user or service

account in GCP. For example, Alice is a software engineer developing applications in the cloud (the human user), and she has an identity with a name such as `alice@example.com`. Roles are assigned to `alice@example.com` within GCP so that Alice can create, modify, delete, and use resources in GCP.

There are three types of roles in Google Cloud Platform:

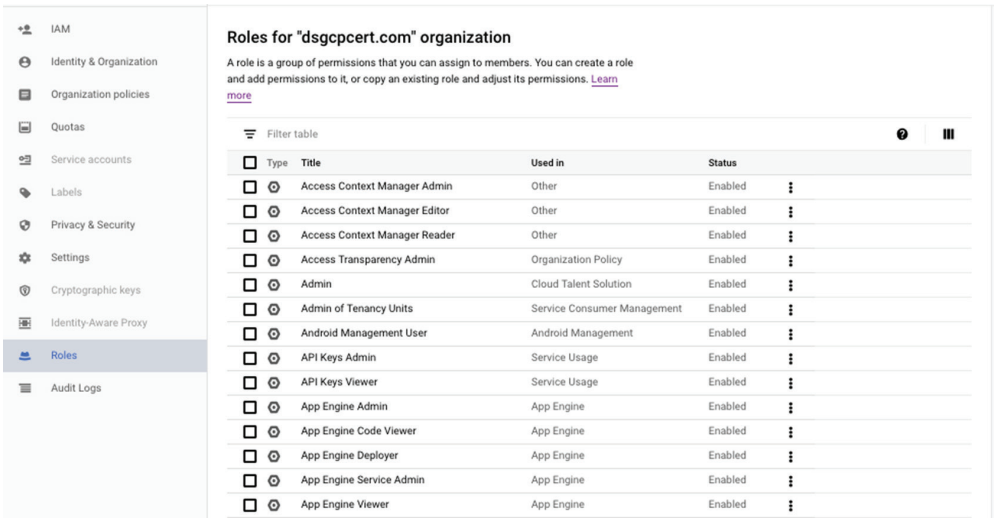
- Primitive roles
- Predefined roles
- Custom roles

Primitive roles include Owner, Editor, and Viewer. These are basic privileges that can be applied to most resources. It is a best practice to use predefined roles instead of primitive roles when possible. Primitive roles grant wide ranges of permissions that may not always be needed by a user. By using predefined roles, you can grant only the permissions a user needs to perform their function. This practice of only assigning permissions that are needed and no more is known as the *principle of least privilege*. It is one of the fundamental best practices in information security.

Predefined roles provide granular access to resources in GCP, and they are specific to GCP products. (See Figure 3.10.) For example, App Engine roles include the following:

- `appengine.appAdmin`, which grants identities the ability to read, write, and modify all application settings
- `appengine.ServiceAdmin`, which grants read-only access to application settings and write-level access to module-level and version-level settings
- `appengine.appViewer`, which grants read-only access to applications.

FIGURE 3.10 A sample list of roles in GCP



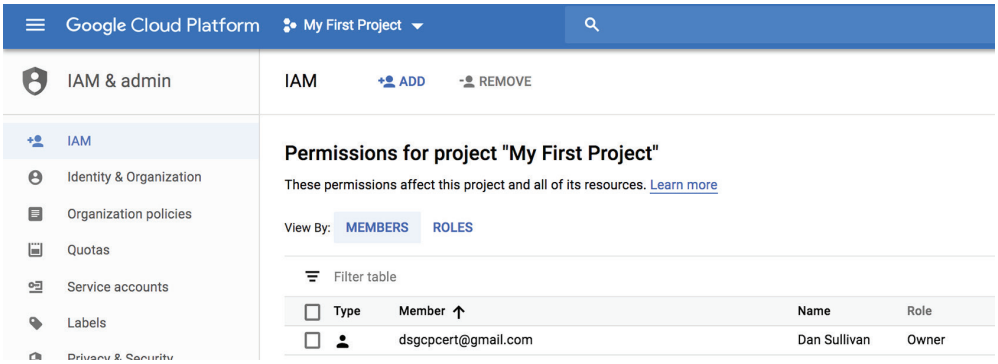
Custom roles allow cloud administrators to create and administer their own roles. Custom roles are assembled using permissions defined in IAM. While you can use most permissions in a custom role, some, such as `iam.ServiceAccounts.getAccessToken`, are not available in custom roles.

Granting Roles to Identities

Once you have determined which roles you want to provide to users, you can assign roles to users through the IAM console. It is important to know that permissions cannot be assigned to users. They can be assigned only to roles. Roles are then assigned to users.

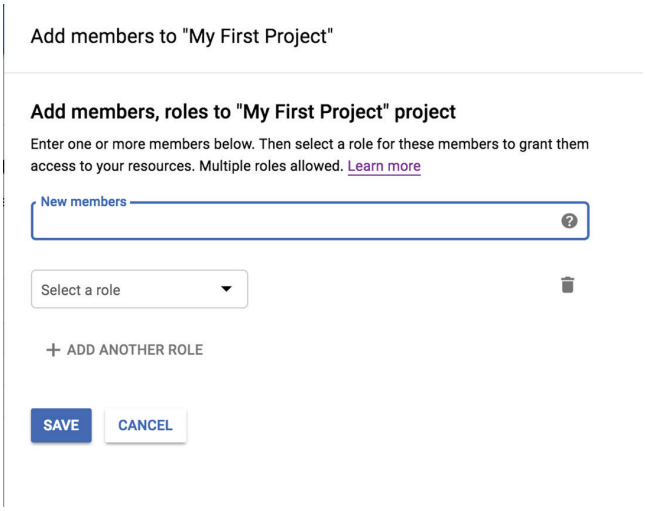
From the IAM console, you can select a project that will display a permission interface, such as in Figure 3.11.

FIGURE 3.11 IAM permissions



From there, select the Add option to display another dialog that prompts for usernames and roles (see Figure 3.12).

FIGURE 3.12 Adding a user



Service Accounts

Identities are usually associated with individual users. Sometimes it is helpful to have applications or VMs act on behalf of a user or perform operations that the user does not have permission to perform.

For example, you may have an application that needs to access a database, but you do not want to allow users of the application to access the database directly. Instead, all user requests to the database should go through the application. A service account can be created that has access to the database. That service account can be assigned to the application so the application can execute queries on behalf of users without having to grant database access to those users.

Service accounts are somewhat unusual in that we sometimes treat them as resources and sometime as identities. When we assign a role to a service account, we are treating it as an identity. When we give users permission to access a service account, we are treating it as a resource.

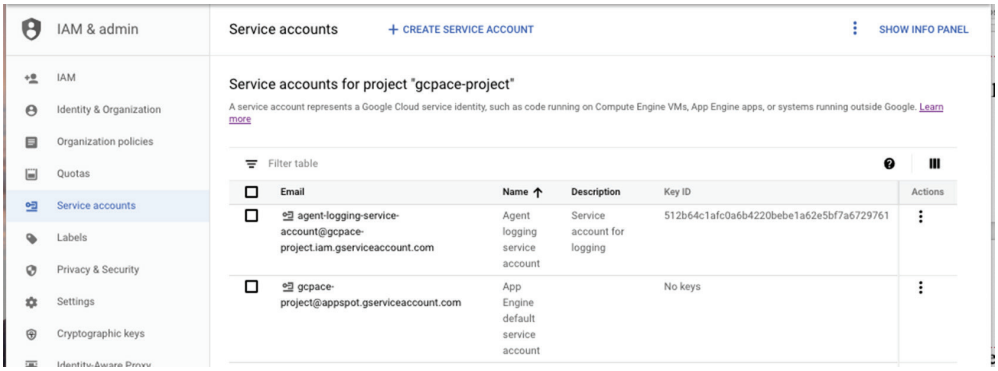
There are two types of service accounts, user-managed service accounts and Google-managed service accounts. Users can create up to 100 service accounts per project. When you create a project that has the Compute Engine API enabled, a Compute Engine service account is created automatically. Similarly, if you have an App Engine application in your project, GCP will automatically create an App Engine service account. Both the Compute Engine and App Engine service accounts are granted editor roles on the projects in which they are created. You can also create custom service accounts in your projects.

Google may also create service accounts that it manages. These accounts are used with various GCP services.

Service accounts can be managed as a group of accounts at the project level or at the individual service account level. For example, if you grant `iam.serviceAccountUser` to a user for a specific project, then that user can manage all service accounts in the project. If you prefer to limit users to manage only specific service accounts, you could grant `iam.serviceAccountUser` for a specific service account.

Service accounts are created automatically when resources are created. For example, a service account will be created for a VM when the VM is created. There may be situations in which you would like to create a service account for one of your applications. In that case, you can navigate to the IAM & admin console and select Service Accounts. From there you can click Create Service Account at the top, as shown in Figure 3.13.

FIGURE 3.13 Service accounts listing in the IAM & admin console



This brings up a form that prompts for the information needed to create a service account.

Billing

Using resources such as VMs, object storage, and specialized services usually incurs charges. The GCP Billing API provides a way for you to manage how you pay for resources used.

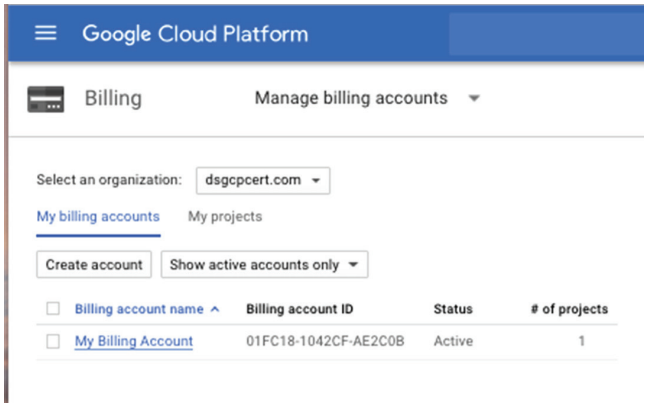
Billing Accounts

Billing accounts store information about how to pay charges for resources used. A billing account is associated with one or more projects. All projects must have a billing account unless they use only free services.

Billing accounts can follow a similar structure to the resource hierarchy. If you are working with a small company, you may have only a single billing account. In that case, all resource costs are charged to that one account. If your company is similar to the example from earlier in the chapter, with finance, marketing, legal, and software development departments, then you may want to have multiple billing accounts. You could have one billing account for each department, but that may not be necessary. If finance, marketing, and legal all pay for their cloud services from the same part of your company's budget, then they could use a single billing account. If software development services are paid from a different part of your company's budget, then it could use a different billing account.

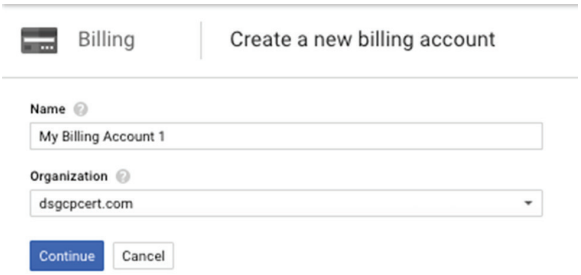
From the main Google Cloud Console, you can navigate to the Billing console (see Figure 3.14), which lists existing billing accounts.

FIGURE 3.14 The main Billing form listing existing billing accounts



From here, you can create a new billing account, as shown in Figure 3.15.

FIGURE 3.15 The form to create a new billing account



From the Billing overview page, you can view and modify projects linked to billing accounts.

There are two types of billing accounts: self-serve and invoiced. Self-serve accounts are paid by credit card or direct debit from a bank account. The costs are charged automatically. The other type is an invoiced billing account, in which bills or invoices are sent to customers. This type of account is commonly used by enterprises and other large customers.

Several roles are associated with billing. It is important to know them for the exam. The billing roles are as follows:

- Billing Account Creator, which can create new self-service billing accounts
- Billing Account Administrator, which manages billing accounts but cannot create them
- Billing Account User, which enables a user to link projects to billing accounts
- Billing Account Viewer, which enables a user to view billing account cost and transactions

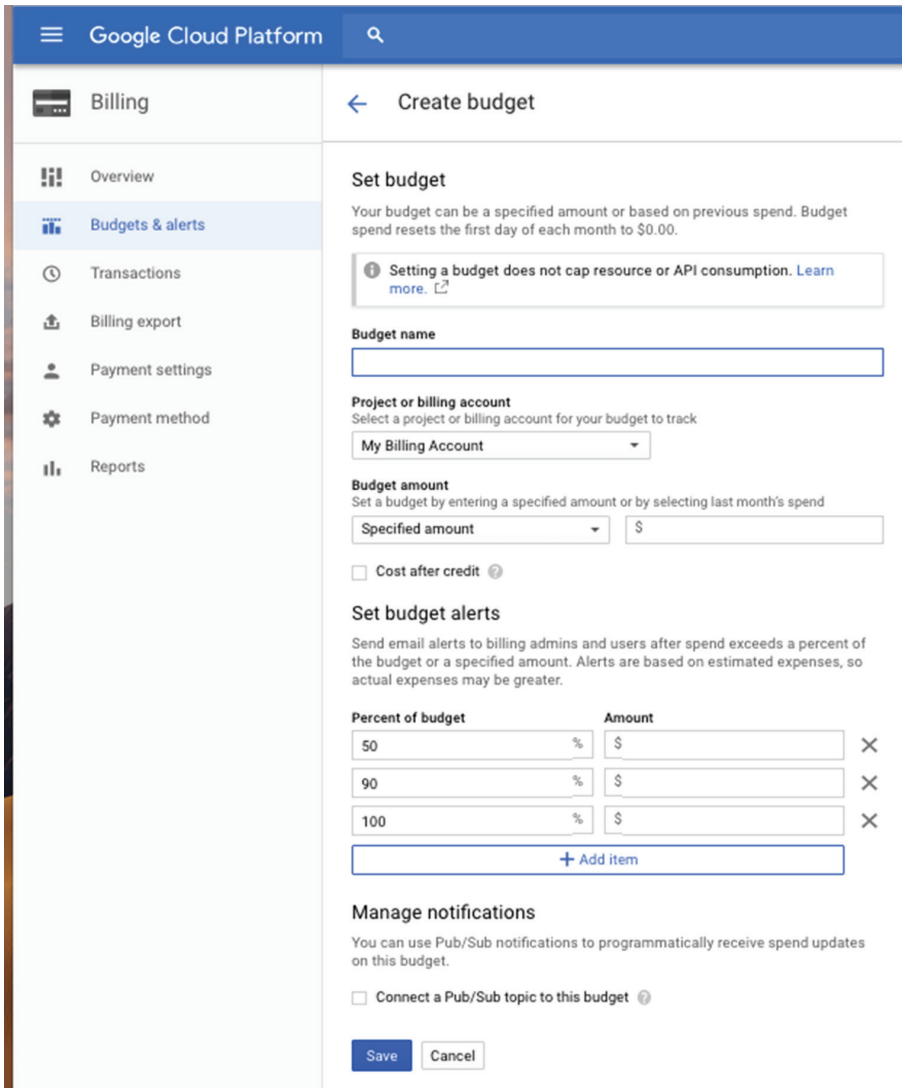
Few users will likely have Billing Account Creator, and those who do will likely have a financial role in the organization. Cloud admins may have Billing Account Administrator to manage the accounts. Any user who can create a project should have Billing Account User so new projects can be linked to the appropriate billing account. Billing Account

Viewer is useful for some, like an auditor who needs to be able to read billing account information but not change it.

Billing Budgets and Alerts

The GCP Billing service includes an option for defining a budget and setting billing alerts. You can navigate to the budget form from the main console menu, selecting Billing and then Budgets & alerts (see Figure 3.16).

FIGURE 3.16 The budget form enables you to have notices sent to you when certain percentages of your budget have been spent in a particular month.



In the budget form, you can name your budget and specify a billing account to monitor. Note that a budget is associated with a billing account, not a project. One or more projects can be linked to a billing account, so the budget and alerts you specify should be based on what you expect to spend for all projects linked to the billing account.

You can specify a particular amount or specify that your budget is the amount spent in the previous month.

With a budget, you can set three alert percentages. By default, three percentages are set: 50 percent, 90 percent, and 100 percent. You can change those to percentages that work best for you. If you'd like more than three alerts, you can click Add Item in the Set Budget Alerts section to add additional alert thresholds.

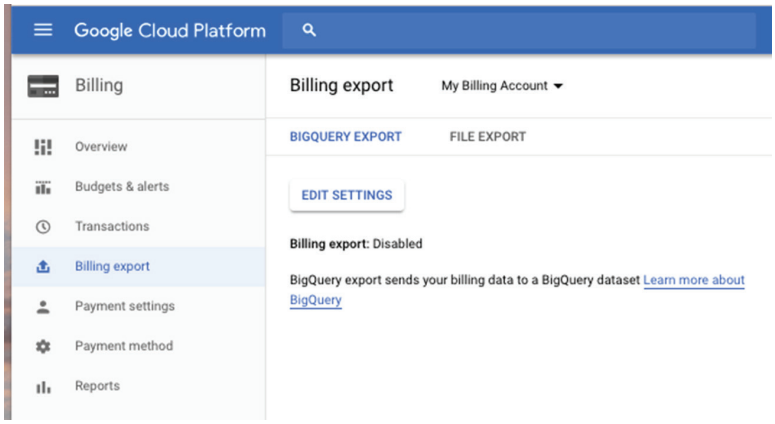
When that percentage of a budget has been spent, it will notify billing administrators and billing account users by email. If you would like to respond to alerts programmatically, you can have notifications sent to a Pub/Sub topic by checking the appropriate box in the Manage Notification sections.

Exporting Billing Data

You can export billing data for later analysis or for compliance reasons. Billing data can be exported to either a BigQuery database or a Cloud Storage file.

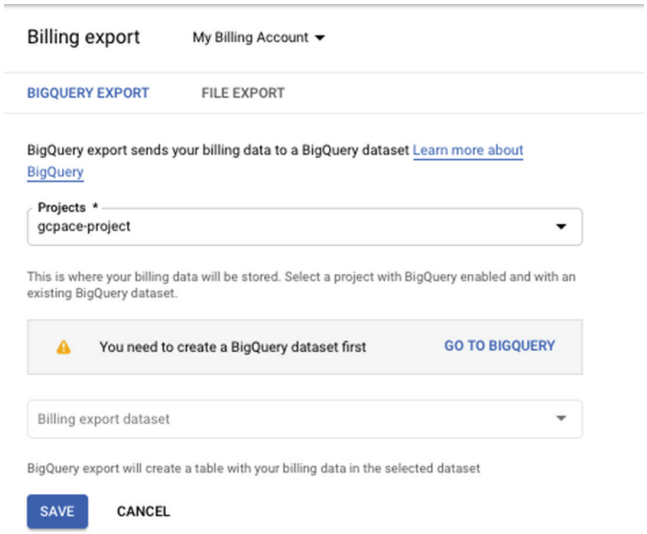
To export billing data to BigQuery, navigate to the Billing section of the console and select Billing export from the menu. In the form that appears, select the billing account you would like to export and choose either BigQuery Export or File Export (see Figure 3.17).

FIGURE 3.17 Billing export form



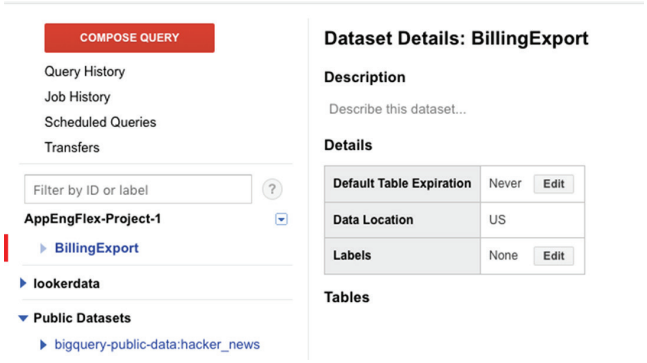
For BigQuery, click Edit Setting. Select the projects you want to include. You will need to create a BigQuery data set to hold the data. Click Go To BigQuery to open a BigQuery form. This will create a Billing export data set, which will be used to hold exported data. (See Figure 3.18.) For additional information on using BigQuery, see Chapter 12.

FIGURE 3.18 Exporting to BigQuery



Alternatively, you can export billing data to a file stored in Cloud Storage. From the Billing Export form, select the File Export tab to display a form as shown in Figure 3.19.

FIGURE 3.19 Exporting billing data to a file



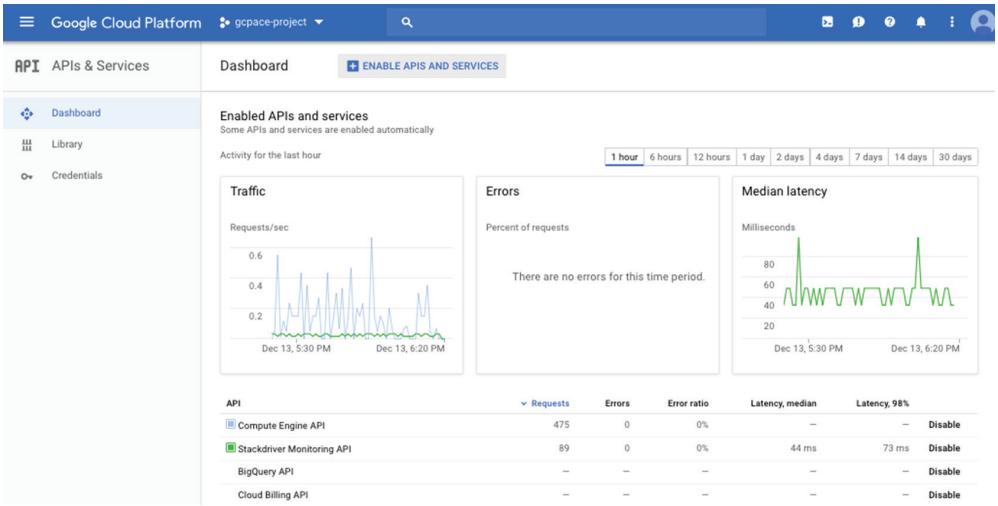
When exporting to a file, you will need to specify a bucket name and a report prefix. You have the option of choosing either the CSV or JSON file format. There may be questions about available file format options, so remember these two options.

Enabling APIs

GCP uses APIs to make services programmatically accessible. For example, when you use a form to create a VM or a Cloud Storage bucket, behind the scenes, API functions are executed to create the VM or bucket. All GCP services have APIs associated with them. Most, however, are not enabled by default in a project.

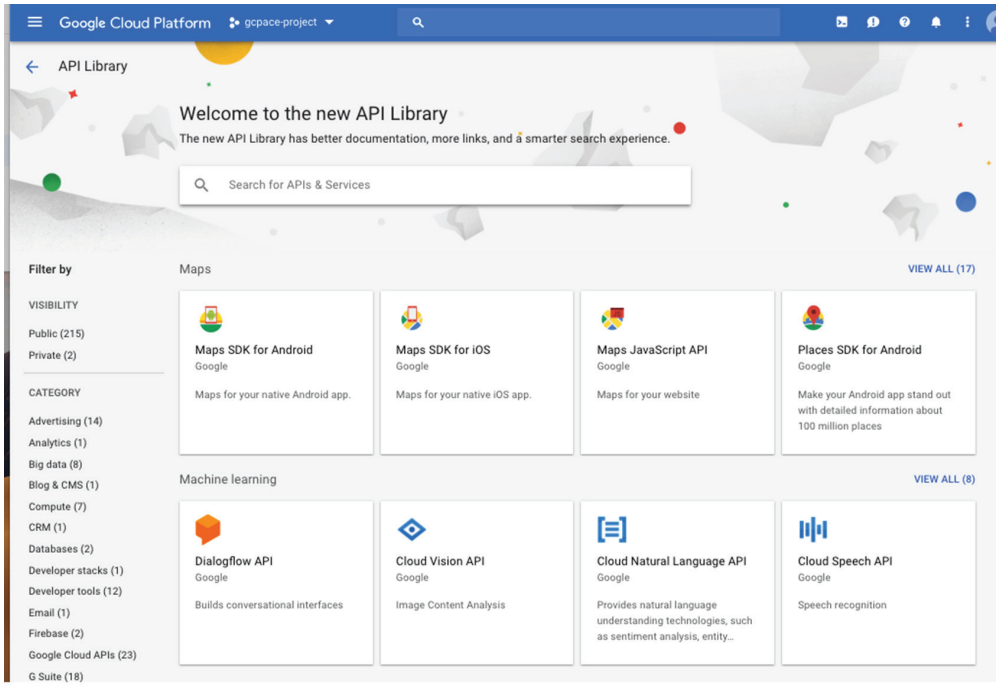
To enable service APIs, you can select APIs & Services from the main console menu. This will display a dashboard, as shown in Figure 3.20.

FIGURE 3.20 An example API services dashboard



If you click the Enable APIs and Services link, you will see a list of services that you can enable, as shown in Figure 3.21.

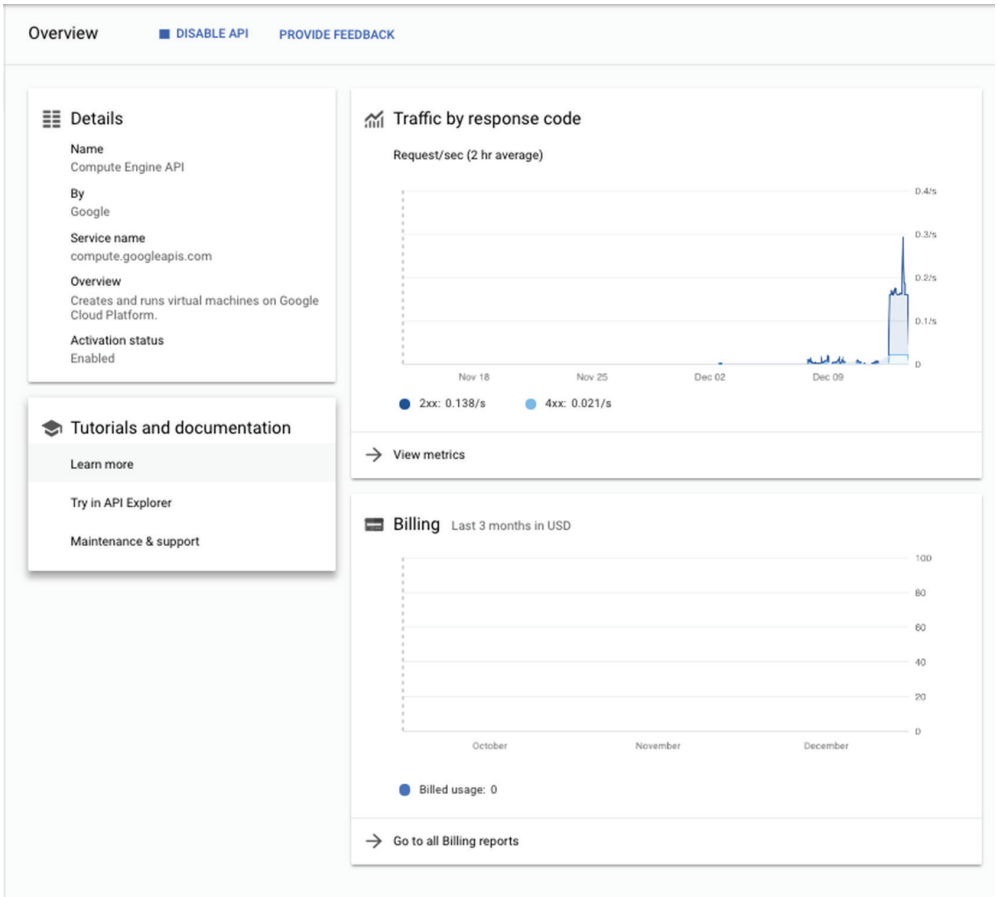
FIGURE 3.21 Services that can have their APIs enabled



This form is a convenient way to enable APIs you know you will need. If you attempt an operation that requires an API that is not enabled, you may be prompted to decide if you want to enable the API.

Also, note in Figure 3.20 the list of APIs and their status. Enabled APIs will have a Disable option. You can click that to disable the API. You can also click the name of an API in the list to drill down into details about API usage, as shown in Figure 3.22.

FIGURE 3.22 Details about API usage

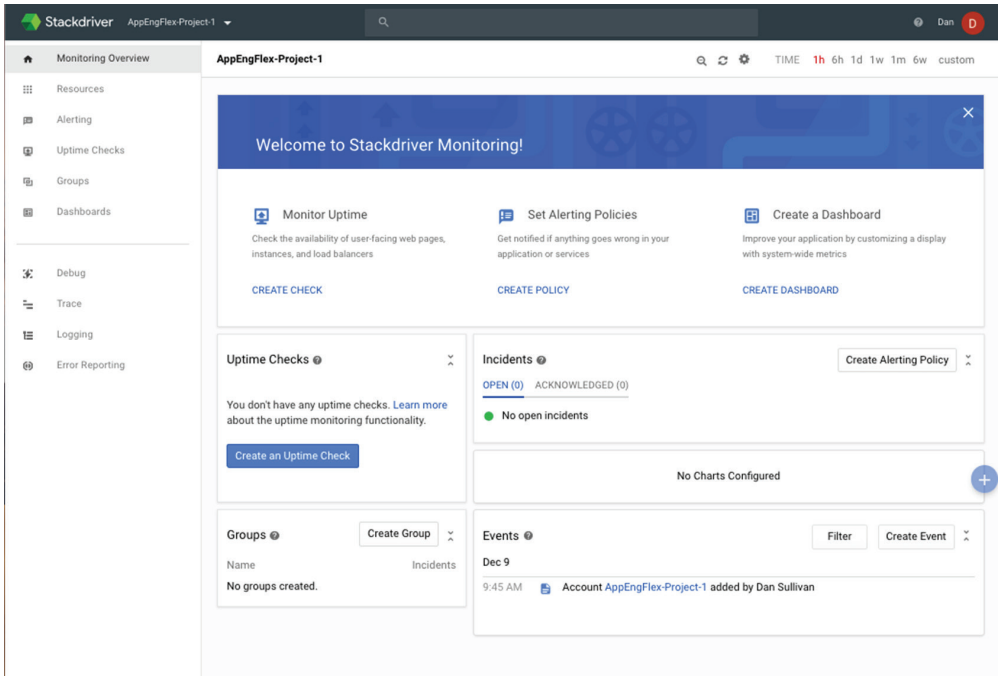


Provisioning Stackdriver Workspaces

When you are setting up organizations and projects, you will spend time on the tasks outlined in this chapter, such as creating identities, assigning roles, and setting up billing accounts. Another thing you should do is create a Stackdriver Workspaces. (These were formerly called Stackdriver accounts, so you may see that term sometimes.)

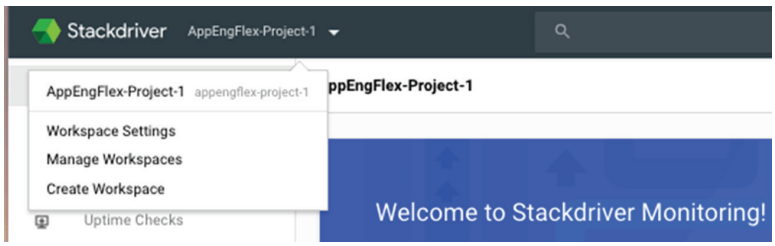
Stackdriver is a set of services for monitoring, logging, tracing, and debugging applications and resources (see Figure 3.23). For monitoring and logging data to be saved into Stackdriver, you need to create a workspace to save it. You can do this by selecting Stackdriver from the main console menu.

FIGURE 3.23 The main Stackdriver dashboard



At the top of the dashboard, the name of the current project is displayed. Click the drop-down icon next to the name of the project to display a list of administrative options. One of them is Create Workspace (See Figure 3.24).

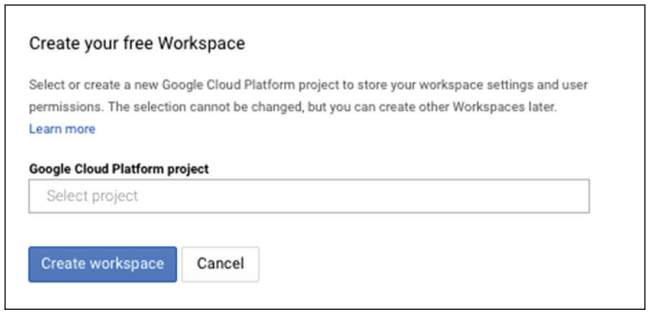
FIGURE 3.24 Administrative functions for managing Stackdriver workspaces



If you click Create Workspace, you will see a form like that in Figure 3.25. Select a project from the list that appears when you click in the Google Cloud Platform project box and then click Create Workspace. This will create a workspace and associate it with the project. You will now be able to use monitoring, logging, and other Stackdriver services with your project.

You can find more details on Stackdriver in Chapter 18.

FIGURE 3.25 Create Workspace dialog



Exam Essentials

Understand the GCP resource hierarchy. All resources are organized within your resource hierarchy. You can define the resource hierarchy using one organization and multiple folders and projects. Folders are useful for grouping departments, and other groups manage their projects separately. Projects contain resources such as VMs and cloud storage buckets. Projects must have billing accounts associated with them to use more than free services.

Understand organization policies. Organization policies restrict resources in the resource hierarchy. Policies include constraints, which are rules that define what can or cannot be done with a resource. For example, a constraint can be set to block access to the serial port on all VMs in a project. Also, understand the policy evaluation process and how to override inherited policies.

Understand service accounts and how they are used. Service accounts are identities that are not associated with a specific user but can be assigned to a resource, like a VM. Resources that are assigned a service account can perform operations that the service account has permission to perform. Understand service accounts and how to create them.

Understand GCP Billing. GCP Billing must be enabled to use services and resources beyond free services. Billing associates a billing method, such as a credit card or invoicing information, with a project. All costs associated with resources in a project are billed to the project's billing account. A billing account can be associated with more than one project. You manage your billing through the Billing API.

Know how to enable APIs and create Stackdriver Workspaces. A convenient form lets you enable APIs you know you will need. You can also show a list of APIs and their status. Stackdriver is a set of services for monitoring, logging, tracing, and debugging applications and resources. To monitor and log data to save into Stackdriver, you need to create a workspace.

Review Questions

You can find the answers in the Appendix.

1. You are designing cloud applications for a healthcare provider. The records management application will manage medical information for patients. Access to this data is limited to a small number of employees. The billing department application will have insurance and payment information. Another group of employees will have access billing information. In addition, the billing system will have two components: a private insurance billing system and a government payer billing system. Government regulations require that software used to bill the government must be isolated from other software systems. Which of the following resource hierarchies would meet these requirements and provide the most flexibility to adapt to changing requirements?
   A. One organization, with folders for records management and billing. The billing folder would have private insurer and government payer folders within it. Common constraints would be specified in organization-level policies. Other policies would be defined at the appropriate folder.
   B. One folder for records management, one for billing, and no organization. Policies defined at the folder level.
   C. One organization, with folders for records management, private insurer, and government payer below the organization. All constraints would be specified in organization-level policies. All folders would have the same policy constraints.
   D. None of the above.

2. When you create a hierarchy, you can have more than one of which structure?
   A. Organization only
   B. Folder only
   C. Folder and project
   D. Project only

3. You are designing an application that uses a series of services to transform data from its original form into a format suitable for use in a data warehouse. Your transformation application will write to the message queue as it processes each input file. You don't want to give users permission to write to the message queue. You could allow the application to write to the message queue by using which of the following?
   A. Billing account
   B. Service account
   C. Messaging account
   D. Folder

4. Your company has a number of policies that need to be enforced for all projects. You decide to apply policies to the resource hierarchy. Not long after you apply the policies, an engineer finds that an application that had worked prior to implementing policies is no longer working. The engineer would like you to create an exception for the application. How can you override a policy inherited from another entity in the resource hierarchy?
   - **A.** Inherited policies can be overridden by defining a policy at a folder or project level.
   - **B.** Inherited policies cannot be overridden.
   - **C.** Policies can be overridden by linking them to service accounts.
   - **D.** Policies can be overridden by linking them to billing accounts.

5. Constraints are used in resource hierarchy policies. Which of the following are types of constraints allowed?
   - **A.** Allow a specific set of values
   - **B.** Deny a specific set of values
   - **C.** Deny a value and all its child values
   - **D.** Allow all allowed values
   - **E.** All of the above

6. A team with four members needs you to set up a project that needs only general permissions for all resources. You are granting each person a primitive role for different levels of access, depending on their responsibilities in the project. Which of the following are not included as primitive roles in Google Cloud Platform?
   - **A.** Owner
   - **B.** Publisher
   - **C.** Editor
   - **D.** Viewer

7. You are deploying a new custom application and want to delegate some administration tasks to DevOps engineers. They do not need all the privileges of a full application administrator, but they do need a subset of those privileges. What kind of role should you use to grant those privileges?
   - **A.** Primitive
   - **B.** Predefined
   - **C.** Advanced
   - **D.** Custom

8. An app for a finance company needs access to a database and a Cloud Storage bucket. There is no predefined role that grants all the needed permissions without granting some permissions that are not needed. You decide to create a custom role. When defining custom roles, you should follow which of the following principles?
   - **A.** Rotation of duties
   - **B.** Least principle

C. Defense in depth

D. Least privilege

9. How many organizations can you create in a resource hierarchy?

A. 1

B. 2

C. 3

D. Unlimited

10. You are contacted by the finance department of your company for advice on how to automate payments for GCP services. What kind of account would you recommend setting up?

A. Service account

B. Billing account

C. Resource account

D. Credit account

11. You are experimenting with GCP for your company. You do not have permission to incur costs. How can you experiment with GCP without incurring charges?

A. You can't; all services incur charges.

B. You can use a personal credit card to pay for charges.

C. You can use only free services in GCP.

D. You can use only serverless products, which are free to use.

12. Your DevOps team has decided to use Stackdriver monitoring and logging. You have been asked to set up Stackdriver workspaces. When you set up a Stackdriver workspace, what kind of resource is it associated with?

A. A Compute Engine instance only

B. A Compute Engine instance or Kubernetes Engine cluster only

C. A Compute Engine instance, Kubernetes Engine cluster, or App Engine app

D. A project

13. A large enterprise is planning to use GCP across a number of subdivisions. Each subdivision is managed independently and has its own budget. Most subdivisions plan to spend tens of thousands of dollars per month. How would you recommend they set up their billing account(s)?

A. Use a single self-service billing account.

B. Use multiple self-service billing accounts.

C. Use a single invoiced billing account.

D. Use multiple invoiced billing accounts.

14. An application administrator is responsible for managing all resources in a project. She wants to delegate responsibility for several service accounts to another administrator. If additional service accounts are created, the other administrator should manage those as well. What is the best way to delegate privileges needed to manage the service accounts?
    - **A.** Grant `iam.serviceAccountUser` to the administrator at the project level.
    - **B.** Grant `iam.serviceAccountUser` to the administrator at the service account level.
    - **C.** Grant `iam.serviceProjectAccountUser` to the administrator at the project level.
    - **D.** Grant `iam.serviceProjectAccountUser` to the administrator at the service account level.

15. You work for a retailer with a large number of brick and mortar stores. Every night the stores upload daily sales data. You have been tasked with creating a service that verifies the uploads every night. You decide to use a service account. Your manager questions the security of your proposed solution, particularly about authenticating the service account. You explain the authentication mechanism used by service accounts. What authentication mechanism is used?
    - **A.** Username and password
    - **B.** Two-factor authentication
    - **C.** Encrypted keys
    - **D.** Biometrics

16. What objects in GCP are sometimes treated as resources and sometimes as identities?
    - **A.** Billing accounts
    - **B.** Service accounts
    - **C.** Projects
    - **D.** Roles

17. You plan to develop a web application using products from the GCP that already include established roles for managing permissions such as read-only access or the ability to delete old versions. Which of the following roles offers these capabilities?
    - **A.** Primitive roles
    - **B.** Predefined roles
    - **C.** Custom roles
    - **D.** Application roles

18. You are reviewing a new GCP account created for use by the finance department. An auditor has questions about who can create projects by default. You explain who has privileges to create projects by default. Who is included?
    - **A.** Only project administrators
    - **B.** All users
    - **C.** Only users without the role `resourcemanager.projects.create`
    - **D.** Only billing account users

19. How many projects can be created in an account?

A. 10

B. 25

C. There is no limit.

D. Each account has a limit determined by Google.

20. You are planning how to grant privileges to users of your company's GCP account. You need to document what each user will be able to do. Auditors are most concerned about a role called Organization IAM roles. You explain that users with that role can perform a number of tasks, which include all of the following except which one?

A. Defining the structure of the resource hierarchy

B. Determining what privileges a user should be assigned

C. Defining IAM policies over the resource hierarchy

D. Delegating other management roles to other users

Chapter

4

Introduction to Computing in Google Cloud

THIS CHAPTER COVERS THE FOLLOWING OBJECTIVES OF THE GOOGLE ASSOCIATE CLOUD ENGINEER CERTIFICATION EXAM:

✓ **2.2 Planning and configuring compute resources**

Official Google Cloud Certified: Associate Cloud Engineer: Study Guide
By Dan Sullivan
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In this chapter, you will learn about each of the compute options available in Google Cloud Platform (GCP) and when to use them. We will also discuss preemptible virtual machines and when they can help reduce your overall computing costs.

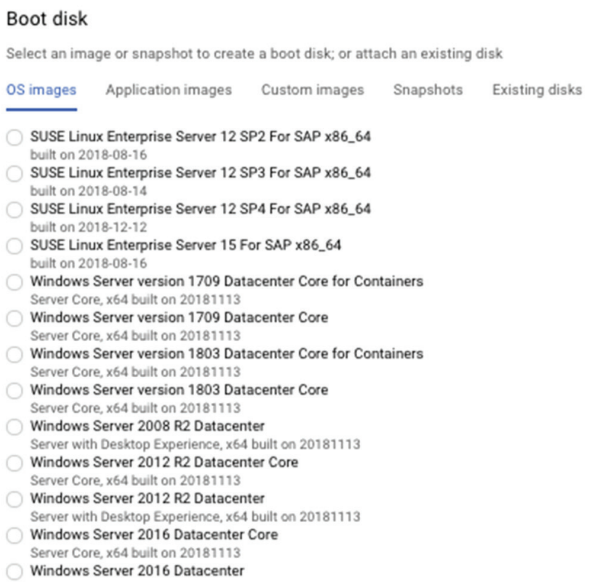
Compute Engine

Compute Engine is a service that provides VMs that run on GCP. We usually refer to a running VM as an *instance*. When you use Compute Engine, you create and manage one or more instances.

Virtual Machine Images

Instances run images, which contain operating systems, libraries, and other code. You may choose to run a public image provided by Google (Figure 4.1). Both Linux and Windows images are available. In addition to the images maintained by Google, there are other public images provided by open source projects or third-party vendors.

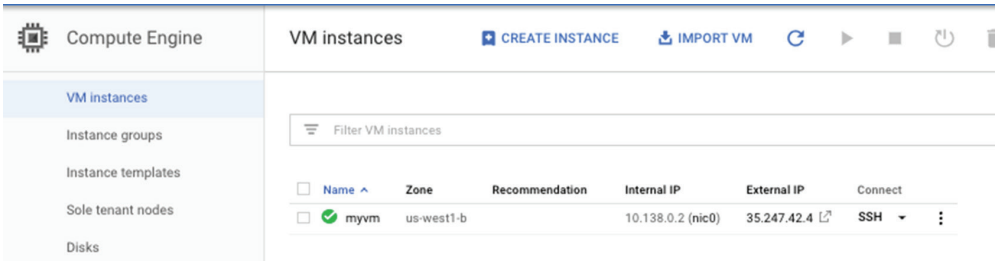
FIGURE 4.1 A subset of operating system images available in Compute Engine



The public images include a range of operating systems, such as CentOS, Container Optimized OS from Google, Debian, Red Hat Enterprise Linux, SUSE Enterprise Linux Server, Ubuntu, and Windows Server.

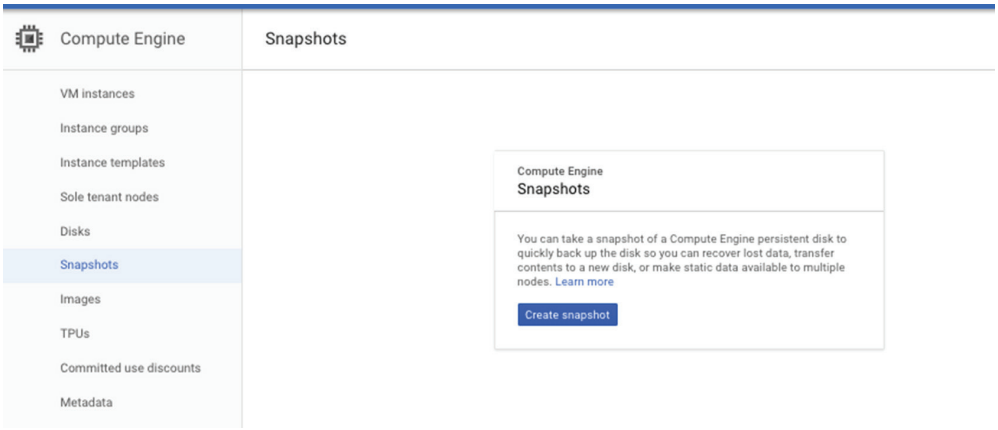
If there is no public image that meets your needs, you can create a custom image from a boot disk or by starting with another image. To create a VM from the console, navigate to Compute Engine and then to VM Instances. You will see a screen similar to Figure 4.2.

FIGURE 4.2 Creating a VM in Compute Engine



From there, click Create Instance to create a VM. Choose an image that is close to what you need and create the VM. Then make any changes you need to the image, such as installing libraries or other software packages. Once you have created the VM and made any changes you'd like, navigate to the Compute Engine menu in Google Cloud Console and select Snapshots, as shown in Figure 4.3.

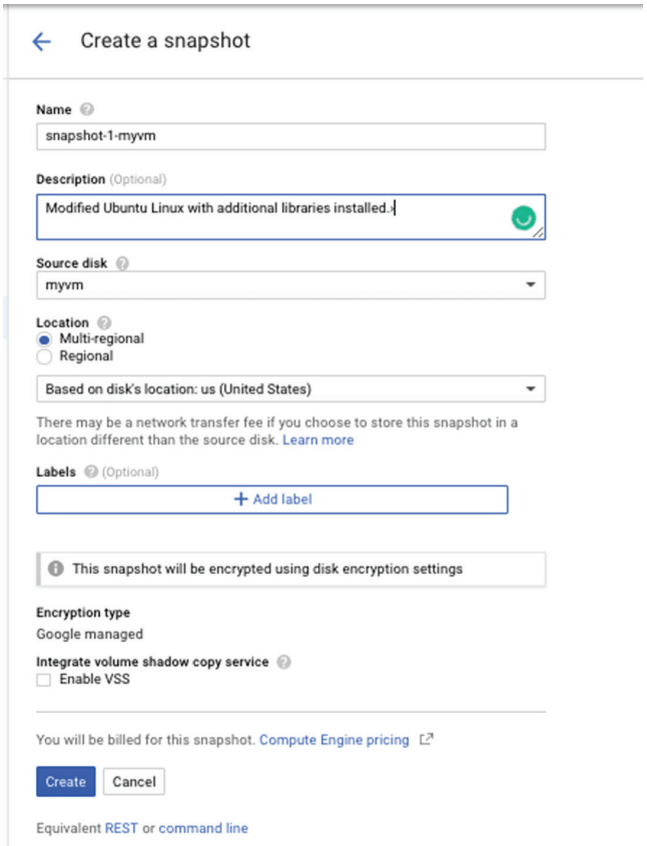
FIGURE 4.3 The first step in creating a snapshot



Click Create Snapshot. In the form that appears, you can specify a name for your snapshot, a description, and, most importantly, the disk that is the source for the snapshot. In Figure 4.4, the boot disk from a VM called `myvm` is selected. After selecting

options, click the Create button to save the snapshot, which can then be used as the image for other VMs.

FIGURE 4.4 Creating a snapshot in Compute Engine



Custom images are especially useful if you have to configure an operating system and install additional software on each instance of a VM that you run. Instead of repeatedly configuring and installing software for each instance, you could configure and install once and then create a custom image from the boot disk of the instance. You then specify that custom image when you start other instances, which will have the configuration and software available without any additional steps.

There may be cases where you have a custom image in your local environment or data center. You can import such an image using the virtual disk import tool provided by Google. This utility is part of the `gcloud` command-line tool, which will be described in more detail in the next chapter.

Custom images must be compatible with GCP. At the time of writing, the following base operating systems are available to build custom images that will run in Compute Engine:

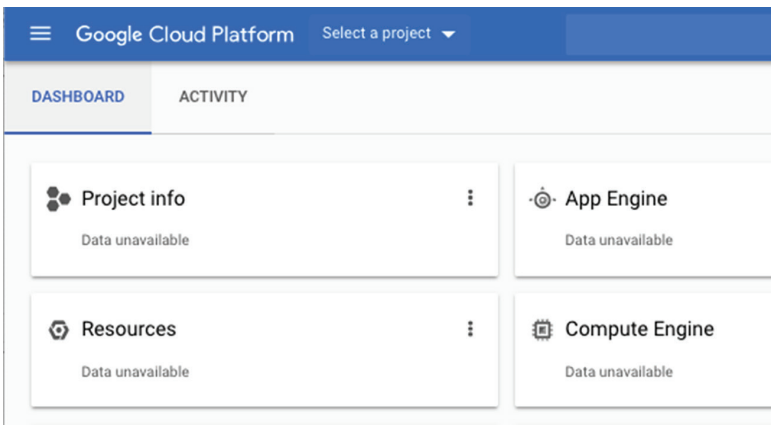
- Linux operating systems
  - CentOS 6
  - CentOS 7
  - Debian 8
  - Debian 9
  - Red Hat Enterprise Linux 6
  - Red Hat Enterprise Linux 7
  - Ubuntu 14.04 LTS
  - Ubuntu 15.04 LTS
- Windows operating systems
  - Windows Server 2008 R2
  - Windows Server 2012 R2
  - Windows Server 2012 R2 Core
  - Windows Server 2016
  - Windows Server 2016 Core

Virtual Machines Are Contained in Projects

When you create an instance, you specify a project to contain the instance. As you may recall, projects are part of the GCP resource hierarchy. Projects are the lowest-level structure in the hierarchy. Projects allow you to manage related resources with common policies.

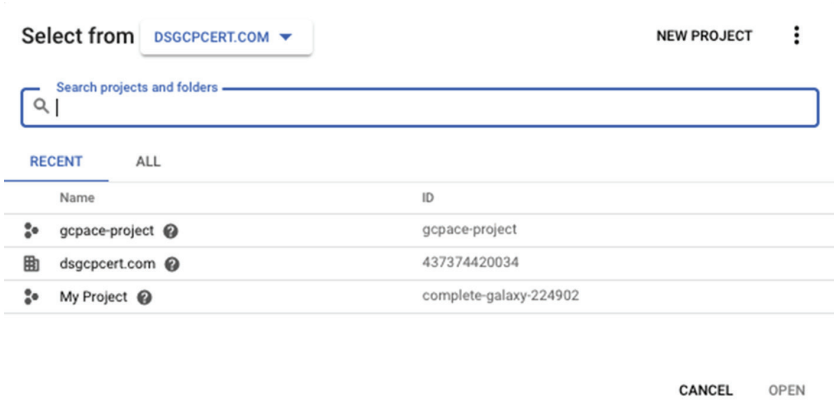
When you open Google Cloud Console, you will notice at the top of the form either the name of a project or the phrase Select A Project, as shown in Figure 4.5.

FIGURE 4.5 The current project name or the option to select one is displayed in Google Cloud Console.



When you choose Select a Project, a form like that in Figure 4.6 appears. From there, you can select the project you want to store your resources, including VMs.

FIGURE 4.6 Choosing a project from existing projects in an account

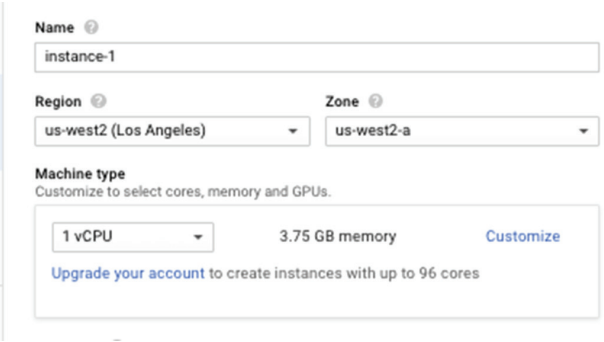


Virtual Machines Run in a Zone and Region

In addition to having a project, VM instances have a zone assigned. Zones are data center–like resources, but they may be comprised of one or more closely coupled data centers. They are located within regions. A *region* is a geographical location, such as asia-east1, europe-west2, and us-east4. The zones within a region are linked by low-latency, high-bandwidth network connections.

You specify a region and a zone when you create a VM. As you can see in Figure 4.7, the Create VM form includes drop-down lists from which you can select the region and zone.

FIGURE 4.7 Selecting a region and zone in the Create VM form



You may want to consider several factors when choosing where to run your VM, including the following:

- Cost, which can vary between regions.
- Data locality regulations, such as keeping data about European Union citizens in the European Union.
- High availability. If you are running multiple instances, you may want them in different zones and possibly different regions. If one of the zones or regions become inaccessible, the instances in other zones and regions can still provide services.
- Latency, which is important if you have users in different parts of the world. Keeping instances and data geographically close to application users can help reduce latency.
- Need for specific hardware platforms, which can vary by region. For example, at the time of writing europe-west1 has Intel Xeon E5, also known as Sandy Bridge, platforms, but Europe-west2 does not.

Users Need Privileges to Create Virtual Machines

To create Compute Engine resources in a project, users must be team members on the project or a specific resource and have appropriate permissions to perform specific tasks. Users can be associated with projects as follows:

- Individual users
- A Google group
- A G Suite domain
- A service account

Once a user or set of users is added to a project, you can assign permissions by granting roles to the user or set of users. This process is explained in detail in Chapter 17. Predefined roles are especially useful because they group permissions that are often needed together for a user to carry out a set of tasks. Here are some examples of predefined roles:

Compute Engine Admin Users with this role have full control over Compute Engine instances.

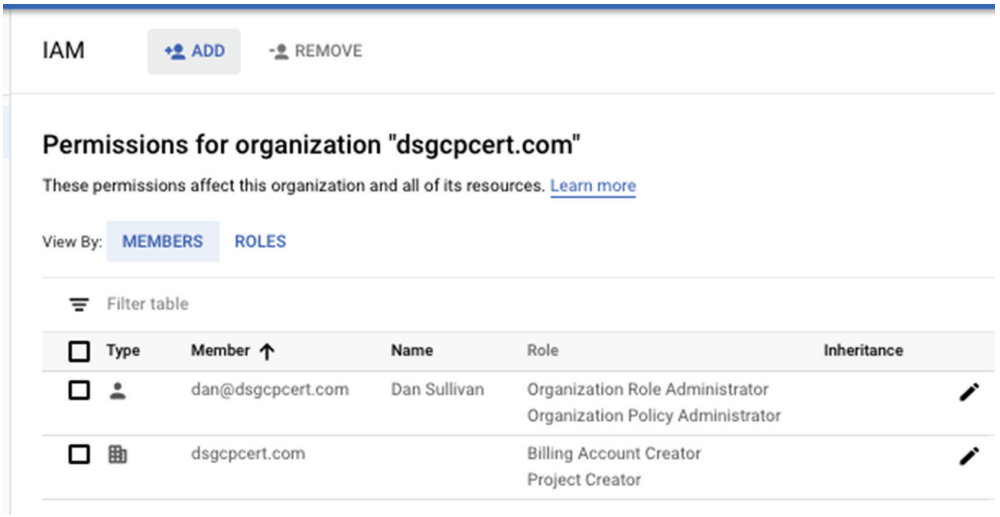
Compute Engine Network Admin Users with this role can create, modify, and delete most networking resources, and it provides read-only access to firewall rules and SSL certifications. This role does not give the user permission to create or alter instances.

Compute Engine Security Admin Users with this role can create, modify, and delete SSL certificates and firewall rules.

Compute Engine Viewer Users with this role can get and list Compute Engine resources but cannot read data from those resources.

When privileges are granted to users at the project level, then those permissions apply to all resources within a project. For example, if a user is granted the Compute Engine Admin role at the project level, then that person can administer all Compute Engine instances in the project. Figure 4.8 shows an example listing of users and roles.

FIGURE 4.8 An example listing of users and roles



An alternative way to grant permissions is to attach IAM policies directly to resources. In this way, privileges can be tailored to specific resources instead of for all resources in a project. For example, you could specify that user Alice has the Compute Engine Admin role on one instance and Bob has the same role on another instance. Alice and Bob would be able to administer their own VM instances, but they could not administer other instances.

Preemptible Virtual Machines

Consider if you have a workload that is the opposite of needing high availability. Preemptible VMs are short-lived compute instances suitable for running certain types of workloads—particularly for applications that perform financial modeling, rendering, big data, continuous integration, and web crawling operations. These VMs offer the same configuration options as regular compute instances and persist for up to 24 hours. If an application is fault-tolerant and can withstand possible instance interruptions (with a 30 second warning), then using preemptible VM instances can reduce Google Compute Engine costs significantly.

Real World Scenario

Reformatting Images

A mobile application that allows users to upload photos also reformats those images into a variety of formats. While it is important for the original image to upload quickly, there is no pressing need to have the other formats created quickly. If it were to take several

minutes, that would still meet the application requirements. This is a good use case for preemptible machines.

When a file is uploaded, it triggers a cloud function (described in detail in Chapter 10), which starts the reformatting process on a preemptible VM. When the reformatting is complete, the reformatted image is written to storage. If the machine shuts down while reformatting an image, that image could be reformatted again when another VM starts up. When the reformatting application starts, it checks for any images that do not have all reformatted versions. If some images are missing some reformatted options, it can start reformatting those. This process can run at regular intervals to check whether any images have not been reformatted. In this way, we can use preemptible VMs and still meet the service-level objectives.

Some big data analysis jobs run on clusters of servers running software like Hadoop and Spark. The platforms are designed to be resilient to failure. If a node goes down in the middle of a job, the platform detects the failure and moves workload to other nodes in the server. You may have analytic jobs that are well served by a combination of reliable VMs and preemptible VMs. With some percentage of reliable VMs, you know you can get your jobs processed within your time constraints, but if you add low-cost, preemptible VMs, you can often finish your jobs faster and at lower overall cost.

Limitations of Preemptible Virtual Machines

As you decide where to use preemptible VMs, keep in mind their limitations and differences compared to conventional VM instances in GCP. Preemptible VMs have the following characteristics:

- May terminate at any time. If they terminate within 10 minutes of starting, you will not be charged for that time.
- Will be terminated within 24 hours.
- May not always be available. Availability may vary across zones and regions.
- Cannot migrate to a regular VM.
- Cannot be set to automatically restart.
- Are not covered by any service level agreement (SLA).

Custom Machine Types

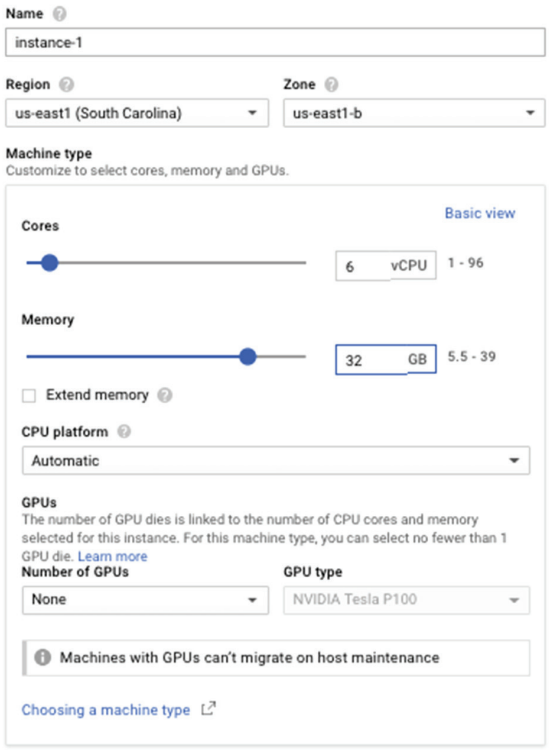
Compute Engine has more than 25 predefined machine types grouped into standard types, high-memory machines, high-CPU machines, shared core type, and memory-optimized machines. These predefined machine types vary in the number of virtual CPUs (vCPUs) and amount of memory. Here are some examples:

- n1-standard-1 has 1 vCPU and 3.75GB of memory.
- n1-standard-32 has 32 vCPUs and 120GB of memory.
- n1-highmem-32 has 32 vCPUs and 208GB of memory.
- n1-highcpu-32 has 32 vCPUs and 28.8GB of memory.

The predefined options for VMs will meet the needs of many use cases, but there may be times where your workload could run more cost effectively and faster on a configuration that is not already defined. In that case, you may want to use a custom machine type.

To create a custom image, select the Create VM option in the console. Click the Customize link in the Machine Type section. This expands the Machine Type section, as shown in Figure 4.9. From there you can adjust the sliders to increase or decrease the number of CPUs and the amount of memory you require.

FIGURE 4.9 Customizing a VM by adjusting the number of CPUs and the amount of memory



Custom machine types can have between 1 and 64 vCPUs and up to 6.5GB of memory per vCPU. The price of a custom configuration is based on the number of vCPUs and the memory allocated.

Use Cases for Compute Engine Virtual Machines

Compute Engine is a good option when you need maximum control over VM instances. With Compute Engine, you can do the following:

- Choose the specific image to run on the instance.
- Install software packages or custom libraries.
- Have fine-grained control over which users have permissions on the instance.
- Have control over SSL certificates and firewall rules for the instance.

Relative to other computing services in GCP, Google Compute Engine provides the least amount of management. Google does provide public images and a set of VM configurations, but you as an administrator must make choices about which image to use, the number of CPUs, the amount of memory to allocate, how to configure persistent storage, and how to configure network configurations.

In general, the more control over a resource you have in GCP, the more responsibility you have to configure and manage the resource.

App Engine

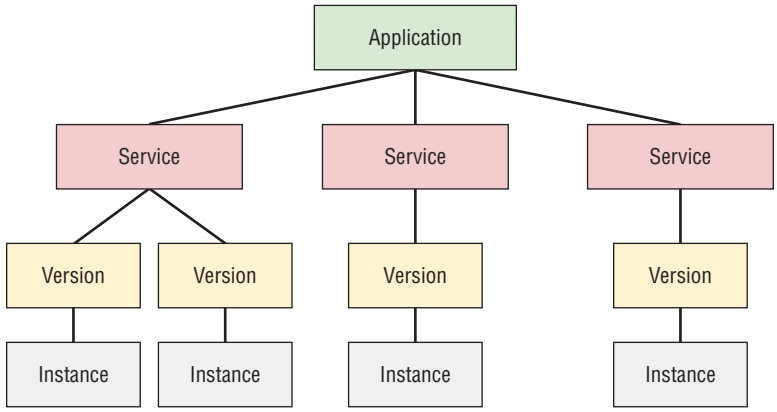
App Engine is a PaaS compute service that provides a managed platform for running applications. When you use App Engine, your focus is on your application and not on the VMs that run the application. Instead of configuring VMs, you specify some basic resource requirements along with your application code, and Google will manage the resources needed to run the code. This means that App Engine users have less to manage, but they also have less control over the compute resources that are used to execute the application.

Like VM instances, applications in App Engine are created within a project.

Structure of an App Engine Application

App Engine applications have a common structure, and they consist of services. Services provide a specific function, like computing sales tax in a retail web application or updating inventory as products are sold on a site. Services have versions, and this allows multiple versions to run at one time. Each version of a service runs on an instance that is managed by App Engine (see Figure 4.10).

FIGURE 4.10 The structure of an App Engine application



The number of instances used to provide an application depends on your configuration for the application and the current load on the application. As the load increases, Google can add more instances to meet the need. Similarly, if the load lessens, instances can be shut down to save on the cost of unutilized instances. This kind of autoscaling is available with dynamic instances.

In addition to dynamic instances, App Engine also provides resident instances. These instances run continually. You can add or remove resident instances manually.

When the number of deployed instances changes frequently, it can be difficult to estimate the costs of running instances. Fortunately, GCP allows users to set up daily spending limits as well as create budgets and set alarms.

App Engine Standard and Flexible Environments

App Engine provides two types of runtime environments: standard and flexible. The standard environment provides language runtimes, while the flexible environment is a more generalized container execution platform.

App Engine Standard Environment

The standard environment is the original App Engine environment. It consists of a preconfigured, language-specific runtime. There are currently two generations of the standard environment. The second generation improves on the performance of the first generation and has fewer limitations.

Currently, App Engine standard environment users can choose from the following supported languages:

First Generation

- Python 2.7
- PHP 5.5
- Go 1.9

Second Generation

- Java 8
- Python 3.7 (beta)
- PHP 7.2 (beta)
- Node.js 8 (beta) and 10 (beta)
- Go 1.11 (beta)

With the second-generation standard environment, developers can use any language extension, but in the first generation only a select set of whitelisted extensions and libraries are allowed. Network access is restricted in the first generation, but users have full network access in the second generation.

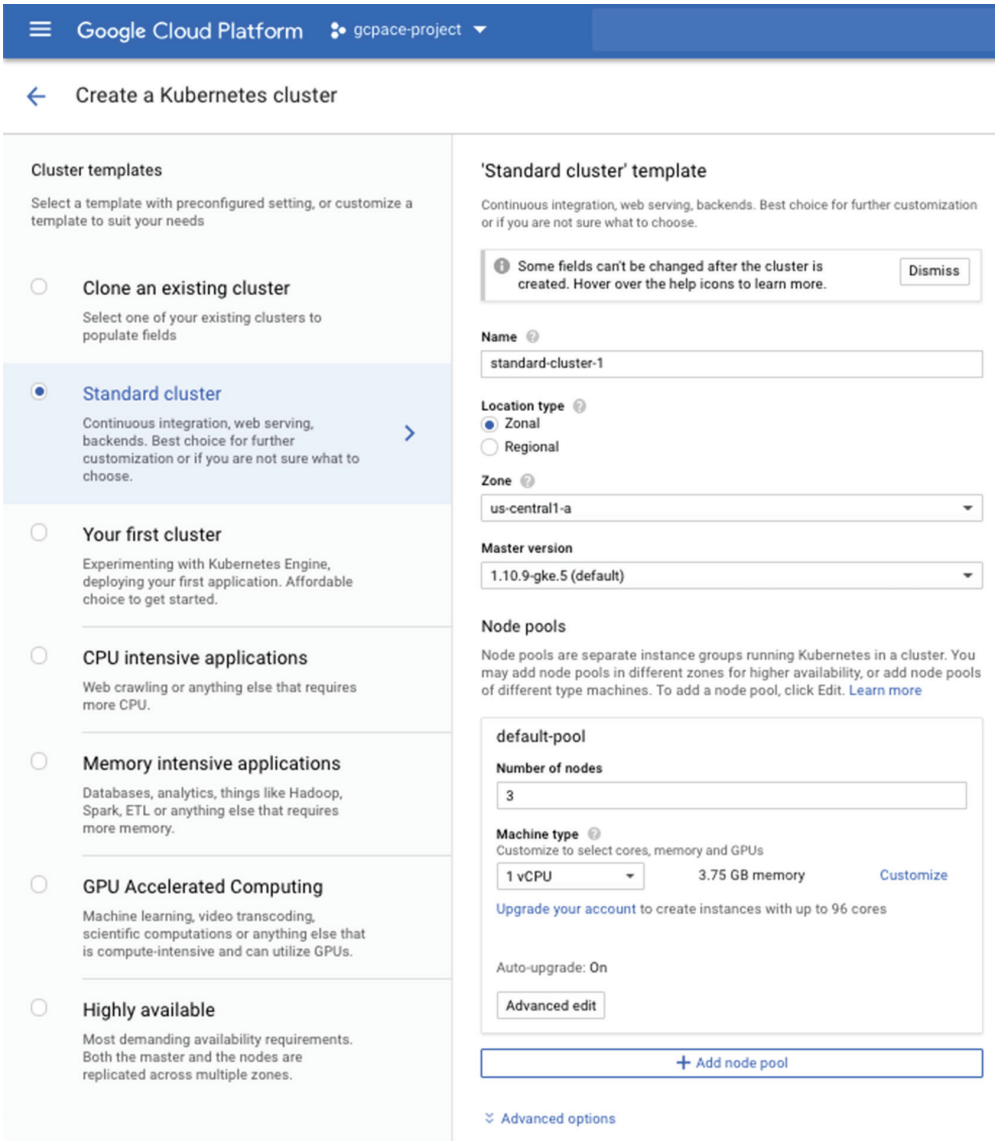
App Engine Flexible Environment

The App Engine flexible environment provides more options and control to developers who would like the benefits of a platform as a service (PaaS) like App Engine, but without the language and customization constraints of the App Engine standard environment (Figure 4.11).

The App Engine flexible environment uses containers as the basic building block abstraction. Users can customize their runtime environments by configuring a container. The flexible environment uses Docker containers, so developers familiar with Docker files can specify base operating system images, additional libraries and tools, and custom tools. It also has native support for Java 8, Eclipse Jetty 9, Python 2.7 and Python 3.6, Node.js, Ruby, PHP, .NET core, and Go.

In some ways, the App Engine flexible environment is similar to the Kubernetes Engine, which will be discussed in the next section. Both of these Google products can run customized Docker containers. The App Engine flexible environment provides a fully managed PaaS and is a good option when you can package your application and services into a small set of containers. These containers can then be autoscaled according to load. Kubernetes Engine, as we will see shortly, is designed to manage containers executing in a cluster that you control. With Kubernetes Engine you have control over your cluster but must monitor and manage that cluster using tools such as Stackdriver monitoring and autoscaling. With the App Engine flexible environment, the health of App Engine servers is monitored by Google and corrected as needed without any intervention on your part.

FIGURE 4.11 Interface to create a Kubernetes cluster in Kubernetes Engine



Use Cases for App Engine

The App Engine product is a good choice for a computing platform when you have little need to configure and control the underlying operating system or storage system. App Engine manages underlying VMs and containers and relieves developers and DevOps

professionals of some common system administration tasks, like patching and monitoring servers.

When to Use App Engine Standard Environment

The App Engine standard environment is designed for applications written in one of the supported languages. The standard environment provides a language-specific runtime that comes with its own constraints. The constraints are fewer in the second-generation App Engine standard environment.

If you are starting a new development effort and plan to use the App Engine standard environment, then it is best to choose second-generation instances. First-generation instances will continue to be supported, but that kind of instance should be used only for applications that already exist and were designed for that platform.

When to Use App Engine Flexible Environment

The App Engine flexible environment is well suited for applications that can be decomposed into services and where each service can be containerized. For example, one service could use a Django application to provide an application user interface, another could embed business logic for data storage, and another service could schedule batch processing of data uploaded through the application. If you need to install additional software or run commands during startup, you can specify those in the Dockerfile. For example, you could add a `run` command to a Dockerfile to run `apt-get update` to get the latest version of installed packages. Docker files are text files with commands for configuring a container, such as specifying a base image to start with and specifying package manager commands, like `apt-get` and `yum`, for installing packages.

The App Engine standard environment scales down to no running instances if there is no load, but this is not the case with the flexible environment. There will always be at least one container running with your service, and you will be charged for that time even if there is no load on the system.

Kubernetes Engine

Compute Engine allows you to create and manage VMs either individually or in groups called *instances groups*. Instance groups let you manage similar VMs as a single unit. This is helpful if you have a fleet of servers that all run the same software and have the same operational lifecycle. Modern software, however, is often built as a collection of services, sometimes referred to as *microservices*. Different services may require different configurations of VMs, but you still may want to manage the various instances as a single resource, or cluster. You can use Kubernetes Engine for that.

Kubernetes is an open source tool created by Google for administering clusters of virtual and bare-metal machines. (Kubernetes is sometimes abbreviated K8s.) Kubernetes is a container orchestration service that helps you. It allows you to do the following:

- Create clusters of VMs that run the Kubernetes orchestration software for containers
- Deploy containerized applications to the cluster
- Administer the cluster
- Specify policies, such as autoscaling
- Monitor cluster health

Kubernetes Engine is GCP's managed Kubernetes service. If you wanted, you could deploy a set of VMs, install Kubernetes on your VMs, and manage the Kubernetes platform yourself. With Kubernetes Engine you get the benefits of Kubernetes without the administrative overhead.

Kubernetes Functionality

Kubernetes is designed to support clusters that run a variety of applications. This is different from other cluster management platforms that provide a way to run one application over multiple servers. Spark, for example, is a big data analytics platform that runs Spark services on a cluster of servers. Spark is not a general-purpose cluster management platform like Kubernetes.

Kubernetes Engine provides the following functions:

- Load balancing across Compute Engine VMs that are deployed in a Kubernetes cluster
- Automatic scaling of nodes (VMs) in the cluster
- Automatic upgrading of cluster software as needed
- Node monitoring and health repair
- Logging
- Support for node pools, which are collections of nodes all with the same configuration

Kubernetes Cluster Architecture

A Kubernetes cluster includes a cluster master node and one or more worker nodes. These are referred to as the *master* and *nodes*, respectively.

The master node manages the cluster. Cluster services, such as the Kubernetes API server, resource controllers, and schedulers, run on the master. The Kubernetes API Server is the coordinator for all communications to the cluster. The master determines what containers and workloads are run on each node.

When a Kubernetes cluster is created from either Google Cloud Console or a command line, a number of nodes are created as well. These are Compute Engine VMs. The default

VM type is n1-standard-1 (1 vCPU and 3.75GB memory), but you can specify a different machine type when creating the cluster.

Kubernetes deploys containers in groups called *pods*. Containers within a single pod share storage and network resources. Containers within a pod share an IP address and port space. A pod is a logically single unit for providing a service. Containers are deployed and scaled as a unit.

It is important to note that some overhead is dedicated to running Kubernetes software on nodes. Some amount of CPU and memory is allocated for Kubernetes and therefore is not available for workload processing. Kubernetes Engine reserves memory resources as follows:

- 25 percent of the first 4GB of memory
- 20 percent of the next 4GB of memory, up to 8GB
- 10 percent of the next 8GB of memory, up to 16GB
- 6 percent of the next 112GB of memory, up to 128GB
- 2 percent of any memory above 128GB

CPU resources are reserved as follows:

- 6 percent of the first core
- 1 percent of the next core (up to two cores)
- 0.5 percent of the next two cores (up to four cores)
- 0.25 percent of any cores above four cores

Kubernetes High Availability

One way Kubernetes maintains cluster health is by shutting down pods that become starved for resources. Kubernetes supports something called *eviction policies* that set thresholds for resources. When a resource is consumed beyond the threshold, then Kubernetes will start shutting down pods.

Another way Kubernetes provides for high reliability is by running multiple identical pods. A group of running identical pods is called a *deployment*. The identical pods are referred to as *replicas*.

When deployments are rolled out, they can be in one of three states.

- Progressing, which means the deployment is in the process of performing a task
- Completed, which means the rollout of containers is complete and all pods are running the latest version of containers
- Failed, which indicates the deployment process encountered a problem it could not recover from

There are additional considerations when running stateful applications versus stateless applications. Those issues will be addressed in Chapter 7.

Kubernetes Engine Use Cases

Kubernetes Engine is a good choice for large-scale applications that require high availability and high reliability. Kubernetes Engine supports the concept of pods and deployment sets, which allow application developers and administrators to manage services as a logical unit. This can help if you have a set of services that support a user interface, another set that implements business logic, and a third set that provides backend services. Each of these different groups of services can have different lifecycles and scalability requirements. Kubernetes helps to manage these at levels of abstraction that make sense for users, developers, and DevOps professionals.

Cloud Functions

Cloud Functions is a serverless computing platform designed to run single-purpose pieces of code in response to events in the GCP environment. There is no need to provision or manage VMs, containers, or clusters when using Cloud Functions. Code that is written in Node.js 6, Node.js 8, or Python 3.7 can run in Cloud Functions.

Cloud Functions is not a general-purpose computing platform like Compute Engine or App Engine. Cloud Functions provides the "glue" between services that are otherwise independent.

For example, one service may create a file and upload it to Cloud Storage, and another service has to pick up those files and perform some processing on the file. Both of these services can be developed independently. There is no need for either to know about the other. However, you will need some way to detect that a new file has been written to Cloud Storage, and then the other application can begin processing it. We don't want to write applications in ways that make assumptions about other processes that may provide input or consume output. Services can change independently of each other. We should not have to keep track of dependencies between services if we can avoid it. Cloud Functions helps us avoid that situation.

Cloud Functions Execution Environment

GCP manages everything that is needed to execute your code in a secure, isolated environment. Of course, below the serverless abstraction, there are virtual and physical servers running your code, but you as a cloud engineer do not have to administer any of that infrastructure. Three key things to remember about Cloud Functions are the following:

- The functions execute in a secure, isolated execution environment.
- Compute resources scale as needed to run as many instances of Cloud Functions as needed without you having to do anything to control scaling.
- The execution of one function is independent of all others. The lifecycles of Cloud Functions are not dependent on each other.

There is an important corollary to these key points. That is, Cloud Functions may be running in multiple instances at one time. If two mobile app users uploaded an image file for processing at the same time, two different instances of Cloud Functions would execute at roughly the same time. You do not have to do anything to prevent conflicts between the two instances; they are independent.

Since each invocation of a Cloud Function runs in a separate instance, functions do not share memory or variables. In general, this means that Cloud Functions should be stateless. That means the function does not depend on the state of memory to compute its output. This is a reasonable constraint in many cases, but sometimes you can optimize processing if you can save state between invocations. Cloud Functions does offer some ways of doing this, which will be described in Chapter 11.

Cloud Functions Use Cases

Cloud Functions is well suited to short-running, event-based processing. If your workflows upload, modify, or otherwise alter files in Cloud Storage or use message queues to send work between services, then the Cloud Functions service is a good option for running code that starts the next step in processing. Some application areas that fit this pattern include the following:

- Internet of Things (IoT), in which a sensor or other device can send information about the state of a sensor. Depending on the values sent, Cloud Functions could trigger an alert or start processing data that was uploaded from the sensor.
- Mobile applications that, like IoT apps, send data to the cloud for processing
- Asynchronous workflows in which each step starts at some time after the previous steps completes, but there are no assumptions about when the processing steps will complete

Summary

GCP offers several computing options. The options vary in the level of control that you, as a user of GCP, have over the computing platform. Generally, with more control comes more responsibility and management overhead. Your objective when choosing a computing platform is to choose one that meets your requirements while minimizing DevOps overhead and cost.

Compute Engine is the GCP service that lets you provision VMs. You can choose from predefined configurations, or you can create a custom configuration with the best combination of virtual CPUs and memory for your needs. If you can tolerate some disruption in VM functioning, you can save a significant amount of money by using preemptible VMs.

App Engine is Google's PaaS offering. This is one of the serverless options. You provide application code and, in the case of the App Engine flexible environment, a specification for a

Docker container to run your application. The App Engine standard environment is appropriate for applications that can run in language-specific sandboxes.

Modern software applications are built on multiple services that may have different computing requirements and change on different lifecycles. Kubernetes Engine runs clusters of servers that can be used to run a variety of services while efficiently allocating work to servers as needed. Kubernetes Engine also provides monitoring, scaling, and remediation when something goes wrong with a VM in the cluster.

Loosely coupled applications may be strung together to implement complex workflows. Often, we want each component to be independent of others. In such cases, we often need to execute "glue" code that moves workload from one stage to another. Cloud Functions is the serverless computing option designed to meet this need.

Exam Essentials

Understand how images are used to create instances of VMs and how VMs are organized in projects. Instances run images, which contain operating systems, libraries, and other code. When you create an instance, you specify a project to contain the instance.

Know that GCP has multiple geographic regions and regions have one or more zones. VMs run in zones. A region is a geographical location, such as asia-east1, europe-west2, and us-east4. The zones within a region are linked by low-latency, high-bandwidth network connections.

Understand what preemptible VMs are and when they are appropriate to use. Also understand when not to use them. GCP offers an option called a preemptible VM for workloads that can be disrupted without creating problems.

Understand the difference between the App Engine standard and flexible environments. The standard environment runs a language-specific platform, and the App Engine flexible environment allows you to run custom containers.

Know that Kubernetes is a container orchestration platform. It also runs containers in a cluster.

Understand Kubernetes. It provides load balancing, automatic scaling, logging, and node health checks and repair.

Understand Cloud Functions. This service is used to run programs in response to events, such as file upload or a message being added to a queue.

Review Questions

You can find the answers in the Appendix.

1. You are deploying a Python web application to GCP. The application uses only custom code and basic Python libraries. You expect to have sporadic use of the application for the foreseeable future and want to minimize both the cost of running the application and the DevOps overhead of managing the application. Which computing service is the best option for running the application?
   - **A.** Compute Engine
   - **B.** App Engine standard environment
   - **C.** App Engine flexible environment
   - **D.** Kubernetes Engine

2. Your manager is concerned about the rate at which the department is spending on cloud services. You suggest that your team use preemptible VMs for all of the following except which one?
   - **A.** Database server
   - **B.** Batch processing with no fixed time requirement to complete
   - **C.** High-performance computing cluster
   - **D.** None of the above

3. What parameters need to be specified when creating a VM in Compute Engine?
   - **A.** Project and zone
   - **B.** Username and admin role
   - **C.** Billing account
   - **D.** Cloud Storage bucket

4. Your company has licensed a third-party software package that runs on Linux. You will run multiple instances of the software in a Docker container. Which of the following GCP services could you use to deploy this software package?
   - **A.** Compute Engine only
   - **B.** Kubernetes Engine only
   - **C.** Compute Engine, Kubernetes Engine, and the App Engine flexible environment only
   - **D.** Compute Engine, Kubernetes Engine, the App Engine flexible environment, or the App Engine standard environment

5. You can specify packages to install into a Docker container by including commands in which file?
   - **A.** `Docker.cfg`
   - **B.** `Dockerfile`
   - **C.** `Config.dck`
   - **D.** `install.cfg`

6. How much memory of a node does Kubernetes require as overhead?
   - **A.** 10GB to 20GB
   - **B.** 1GB to 2GB
   - **C.** 1.5GB
   - **D.** A scaled amount starting at 25 percent of memory and decreasing to 2 percent of marginal memory as the total amount of memory increases.

7. Your manager is making a presentation to executives in your company advocating that you start using Kubernetes Engine. You suggest that the manager highlight all the features Kubernetes provides to reduce the workload on DevOps engineers. You describe several features, including all of the following except which one?
   - **A.** Load balancing across Compute Engine VMs that are deployed in a Kubernetes cluster
   - **B.** Security scanning for vulnerabilities
   - **C.** Automatic scaling of nodes in the cluster
   - **D.** Automatic upgrading of cluster software as needed

8. Your company is about to release a new online service that builds on a new user interface experience driven by a set of services that will run on your servers. There is a separate set of services that manage authentication and authorization. A data store set of services keeps track of account information. All three sets of services must be highly reliable and scale to meet demand. Which of the GCP services is the best option for deploying this?
   - **A.** App Engine standard environment
   - **B.** Compute Engine
   - **C.** Cloud Functions
   - **D.** Kubernetes Engine

9. A mobile application uploads images for analysis, including identifying objects in the image and extracting text that may be embedded in the image. A third party has created the mobile application, and you have developed the image analysis service. You both agree to use Cloud Storage to store images. You want to keep the two services completely decoupled, but you need a way to invoke the image analysis as soon as an image is uploaded. How should this be done?
   - **A.** Change the mobile app to start a VM running the image analysis service and have that VM copy the file from storage into local storage on the VM. Have the image service run on the VM.
   - **B.** Write a function in Python that is invoked by Cloud Functions when a new image file is written to the Cloud Storage bucket that receives new images. The function should submit the URL of the uploaded file to the image analysis service. The image analysis service will then load the image from Cloud Storage, perform analysis, and generate results, which can be saved to Cloud Storage.
   - **C.** Have a Kubernetes cluster running continuously, with one pod dedicated to listing the contents of the upload bucket and detecting new files in Cloud Storage and another pod dedicated to running the image analysis software.

D. Have a Compute Engine VM running and continuously listing the contents of the upload bucket in Cloud Storage to detect new files. Another VM should be continually running the image analysis software.

10. Your team is developing a new pipeline to analyze a stream of data from sensors on manufacturing devices. The old pipeline occasionally corrupted data because parallel threads overwrote data written by other threads. You decide to use Cloud Functions as part of the pipeline. As a developer of a Cloud Function, what do you have to do to prevent multiple invocations of the function from interfering with each other?

A. Include a check in the code to ensure another invocation is not running at the same time.

B. Schedule each invocation to run in a separate process.

C. Schedule each invocation to run in a separate thread.

D. Nothing. GCP ensures that function invocations do not interfere with each other.

11. A client of yours processes personal and health information for hospitals. All health information needs to be protected according to government regulations. Your client wants to move their application to Google Cloud but wants to use the encryption library that they have used in the past. You suggest that all VMs running the application have the encryption library installed. Which kind of image would you use for that?

A. Custom image

B. Public image

C. CentOS 6 or 7

12. What is the lowest level of the resource hierarchy?

A. Folder

B. Project

C. File

D. VM instance

13. Your company is seeing a marked increase in the rate of customer growth in Europe. Latency is becoming an issue because your application is running in us-central1. You suggest deploying your services to a region in Europe. You have several choices. You should consider all of the following factors except which one?

A. Cost

B. Latency

C. Regulations

D. Reliability

14. What role gives users full control over Compute Engine instances?

A. Compute Manager role

B. Compute Admin role

C. Compute Manager role

D. Compute Security Admin

15. Which of the following are limitations of a preemptible VM?

A. Will be terminated within 24 hours.

B. May not always be available. Availability may vary across zones and regions.

C. Cannot migrate to a regular VM.

D. All of the above

16. Custom VMs can have up to how many vCPUs?

A. 16

B. 32

C. 64

D. 128

17. When using the App Engine standard environment, which of the following language's runtime is not supported?

A. Java

B. Python

C. C

D. Go

18. Kubernetes reserves CPU resources in percentage of cores available. The percentage is what range?

A. 1 percent to 10 percent

B. 0.25 percent to 6 percent

C. 0.25 percent to 2 percent

D. 10 percent to 12 percent

19. Kubernetes deployments can be in what states?

A. Progressing, stalled, completed

B. Progressing, completed, failed

C. Progressing, stalled, failed, completed

D. Progressing, stalled, running, failed, completed

20. A client has brought you in to help reduce their DevOps overhead. Engineers are spending too much time patching servers and optimizing server utilization. They want to move to serverless platforms as much as possible. Your client has heard of Cloud Functions and wants to use them as much as possible. You recommend all of the following types of applications except which one?

A. Long-running data warehouse data load procedures

B. IoT backend processing

C. Mobile application event processing

D. Asynchronous workflows

Chapter 5

Computing with Compute Engine Virtual Machines

THIS CHAPTER COVERS THE FOLLOWING OBJECTIVES OF THE GOOGLE ASSOCIATE CLOUD ENGINEER EXAM:

✓ **1.3 Installing and configuring the command line interface (CLI), specifically Cloud SDK (e.g., setting the default project)**

✓ **2.2 Planning and configuring compute resources. Considerations include:**

- Selecting appropriate compute choices for a given workload (e.g., Compute Engine, Kubernetes Engine, App Engine)
- Using preemptible VMs and custom machine types as appropriate

Official Google Cloud Certified: Associate Cloud Engineer: Study Guide
By Dan Sullivan
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In this chapter, you will learn about Google Cloud Console, a graphical user interface for working with Google Cloud Platform (GCP). You will learn how to install Google Cloud SDK and use it to create virtual machine instances and how to use Cloud Shell as an alternative to installing Google Cloud SDK locally.

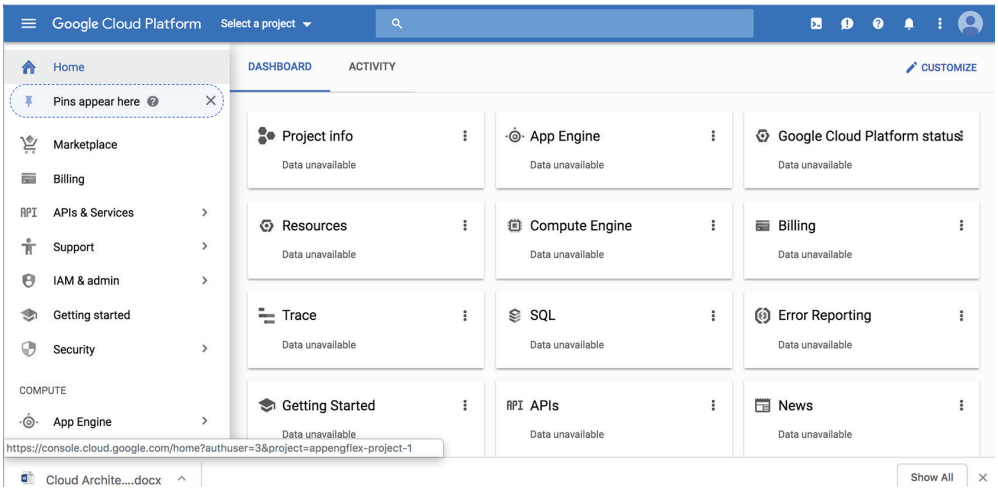
Creating and Configuring Virtual Machines with the Console

Let's create a VM in Compute Engine. We have three options for doing this: we can use Google Cloud Console, Google Cloud SDK, or Google Cloud Shell. Let's start with the console.

Google Cloud Console is a web-based graphical user interface for creating, configuring, and managing resources in Google Cloud. In this chapter, we will use it to create a VM.

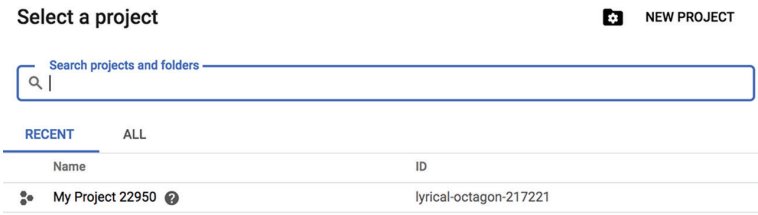
To open the console, navigate in your browser to `https://console.cloud.google.com` and log in. Figure 5.1 shows an example of the main form in the console.

FIGURE 5.1 The main starting form of Google Cloud Console



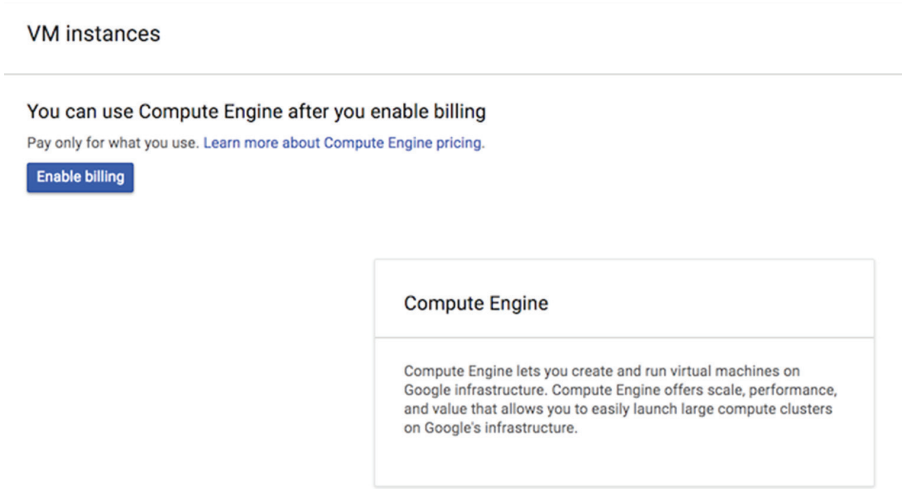
In the upper-left section of the form, click the Select A Project option to display the existing projects. You can also create a new project from this form, which is shown in Figure 5.2.

FIGURE 5.2 The Project form lets you choose the project to work with when creating VMs. You can also create a new project here.



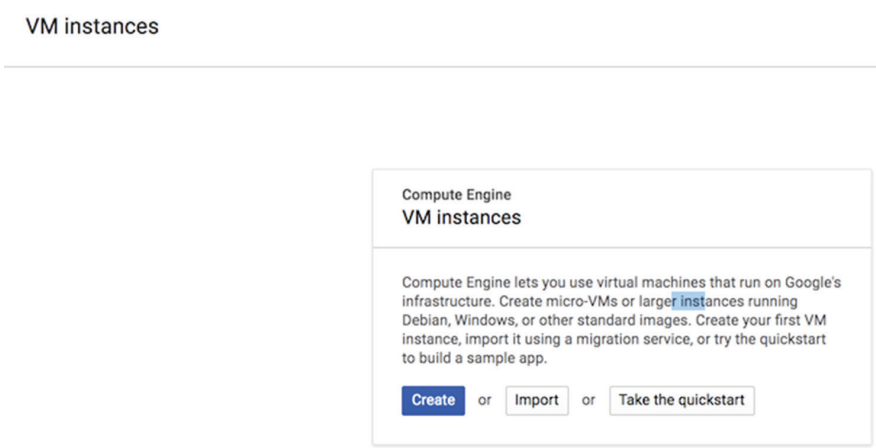
After you select an existing project or create a new project, you can return to the main console panel. The first time you try to work a VM you will have to create a billing account if one has not already been created. Figure 5.3 shows a message and button on the main panel for creating a billing account.

FIGURE 5.3 When a billing account does not exist for a project, you will be given the option to create a billing account when you try to create a VM.



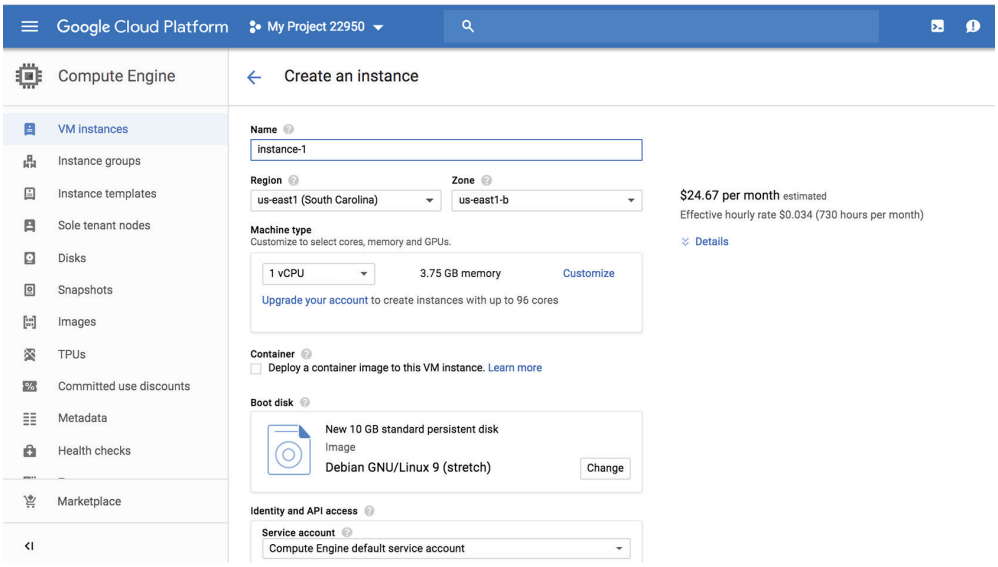
Click Enable Billing and fill in the billing information, such as name, address, and credit card. Once billing is enabled, you will return to the main panel (see Figure 5.4).

FIGURE 5.4 The starting panel for creating a VM



Click the Create button in the dialog box to bring up a VM configuration, as shown in Figure 5.5.

FIGURE 5.5 Part of the main configuration form for creating VMs in Compute Engine



Main Virtual Machine Configuration Details

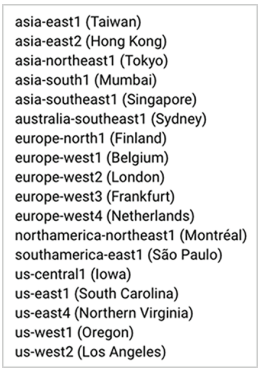
Within the console, you can specify all the needed details about the configuration of the VM that you are creating, including the following:

- Name of the VM
- Region and zone where the VM will run
- Machine type, which determines the number of CPUs and the amount of memory in the VM
- Boot disk, which includes the operating system the VM will run

You can choose the name of your VM. This is primarily for your use. Google Cloud uses other identifiers internally to manage VMs.

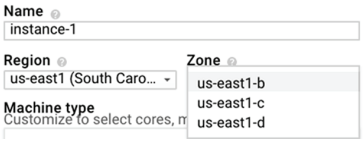
You will need to specify a region. Regions are major geographical areas. A partial list of regions is shown in Figure 5.6.

FIGURE 5.6 A partial list of regions providing Compute Engine services



After you select a region, you can select a zone. Remember, a zone is a data center–like facility within a region. Figure 5.7 shows an example list of zones available in the us-east-1 region.

FIGURE 5.7 A list of zones within the us-east-1 region

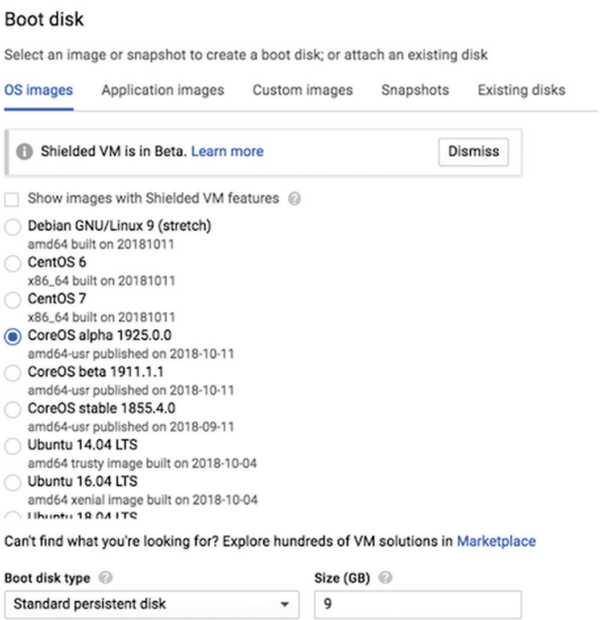


After you specify a region and zone, Google Cloud can determine the VMs available in that zone. Not all zones have the same availability. Figure 5.8 shows an example listing of machine types available in the us-east1-b zone.

FIGURE 5.8 A list of machine types available in the us-east1-b zone

The Boot Disk Option section lists a default configuration. Clicking the Change button brings up the Boot Disk Option dialog, as shown in Figure 5.9.

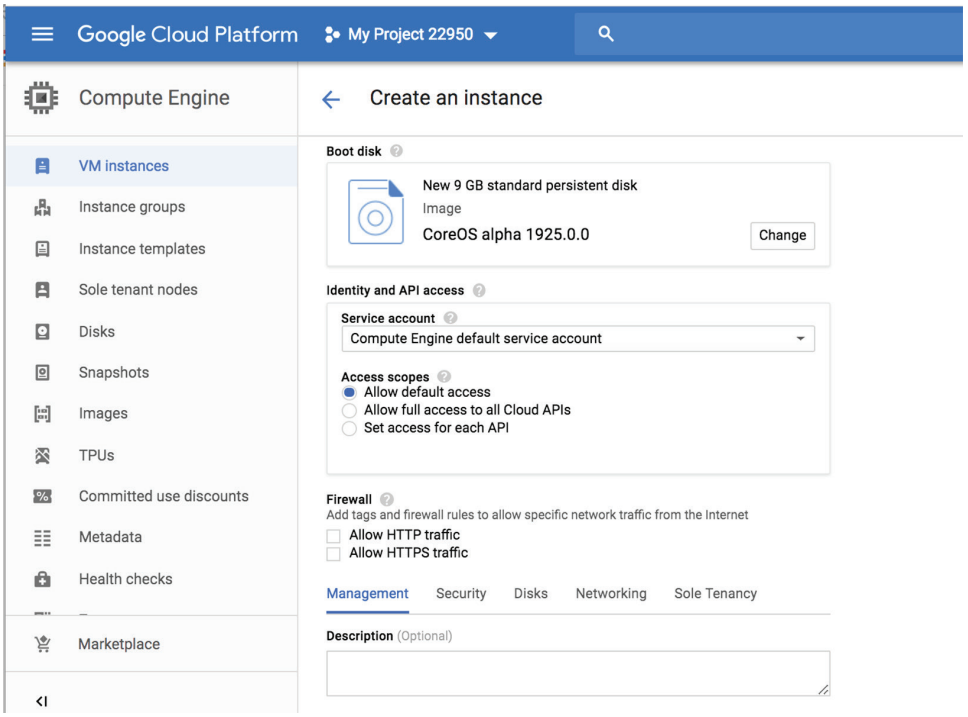
FIGURE 5.9 Dialog for configuring the boot disk of the VM



Here you can choose the operating system you want to use. You can also choose the boot disk type, which can be either Standard Persistent Disk or SSD Persistent Disk. You can also specify the size of the disk.

Following the Boot Disk section is the Identity and API Access section. Here you can specify a service account for the VM and set the scope of API access. If you want the processes running on this VM to use only some APIs, you can use these options to limit the VM's access to specific APIs.

FIGURE 5.10 Identity and API Access and Firewall configurations



In the next section, you can select if you want the VM to accept HTTP or HTTPS traffic.

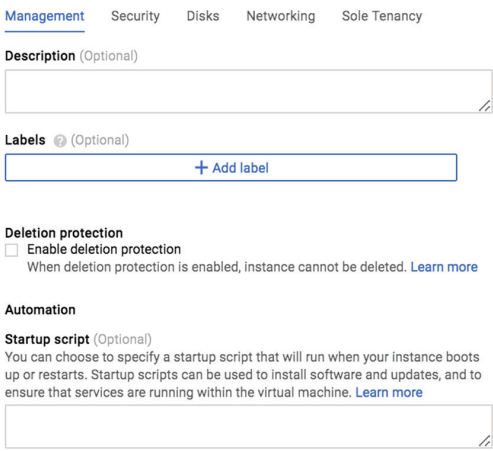
Additional Configuration Details

Click Management, Security, Disks, Networking, and Sole Tenancy to expose additional configuration options.

Management Tab

The Management tab of the form (Figure 5.11) provides a space where you can describe the VM and its use. You can also create labels, which are key-value pairs. You can assign any label you like. Labels and a general description are often used to help manage your VMs and understand how they are being used. Labels are particularly important when your number of servers grows. It is a best practice to include a description and labels for all VMs.

FIGURE 5.11 The first part of the Management tab of the VM creation form



If you want to force an extra confirmation before deleting an instance, you can select the deletion protection option. If someone tries to delete the instance, the operation will fail.

You can specify a startup script to run when the instance starts. Copy the contents of the startup script to the script text box. For example, you could paste a bash or Python script directly into the text box.

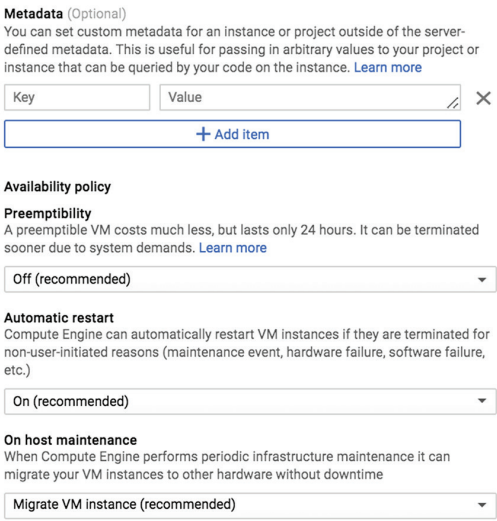
The Metadata section allows you to specify key-value pairs associated with the instance. These values are stored in a metadata server, which is available for querying using the Compute Engine API. Metadata tags are especially useful if you have a common script you want to run on startup or shutdown but want the behavior of the script to vary according to some metadata values.

The Availability Policy sets three parameters.

- Preemptibility, which when enabled allows Google to shut down the server with a 30-second notice. In return, the cost of a preemptible server is much lower than that of a nonpreemptible server.

- Automatic restart, which indicates if the server stops because of a hardware failure, maintenance event, or some other non-user–controlled event
- On host maintenance, which indicates whether the virtual server should be migrated to another physical server when a maintenance event occurs

FIGURE 5.12 The second part of the Management tab of the VM creation form

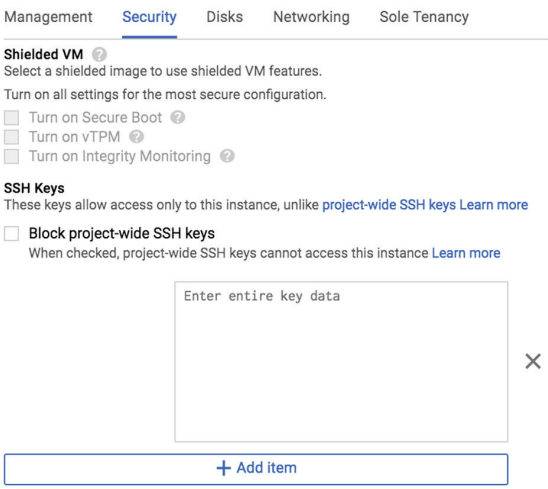


In the Security section, you can specify if you want to use Shielded VMs and Secure Shell (SSH) keys.

Shielded VMs are configured to have additional security mechanisms that you can choose to run. These include the following:

- Secure Boot, which ensures that only authenticated operating system software runs on the VM. It does this by checking the digital signatures of the software. If a signature check fails, the boot process will halt.
- Virtual Trusted Platform Module (vTPM), which is a virtualized version of a trusted platform module (TPM). A TPM is a specialized computer chip designed to protect security resources, like keys and certificates.
- Integrity Monitoring, which uses a known good baseline of boot measurements to compare to recent boot measurements. If the check fails, then there is some difference between the baseline measurement and the current measurements.

FIGURE 5.13 Additional security controls can be placed on VMs.

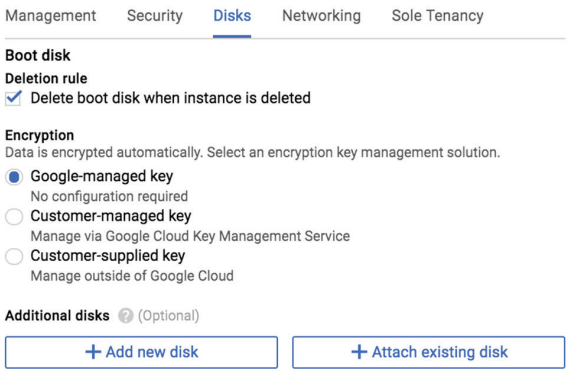


GCP supports the concept of project-wide SSH keys, which are used to give users project-wide access to VMs. You can block that behavior at the VM if you use project-wide SSH keys and do not want all project users to have access to this machine.

The next advanced tab is the Boot Disk tab. Here you can specify whether the boot disk should be deleted when the instance is deleted. You can also select how you would like to manage encryption keys for the boot disk. By default, Google manages those keys.

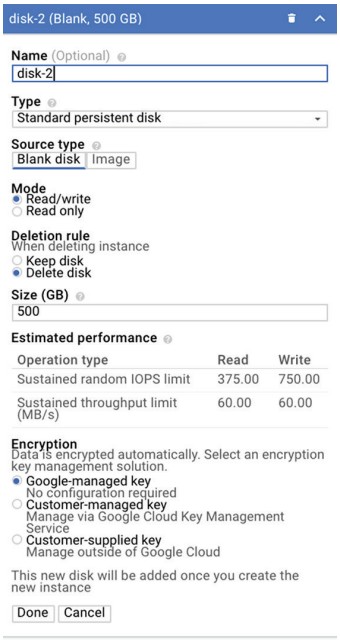
Within the Boot Disk configuration tab, you also have the option of adding a new disk or attaching an existing disk. Figure 5.14 shows the tab for adding a new disk.

FIGURE 5.14 Boot disk advanced configuration



When adding an existing disk, the dialog form appears, as in Figure 5.15. Note that the Disk drop-down has a list of existing disks you can choose from. You can make the disk read-only or read/write. You can also indicate if you want the disk deleted when the instance is deleted. Using an existing disk in read-only mode is a good way of replicating reference data across multiple instances of VMs.

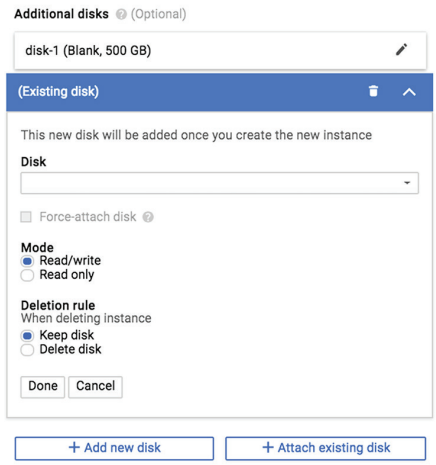
FIGURE 5.15 Dialog for adding an existing disk to a VM



You can also add a new disk using the dialog shown in Figure 5.16. When adding a new disk, you need to provide the following information:

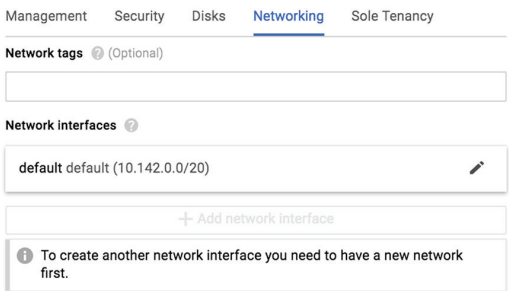
- Name of the disk
- Disk type, either standard or SSD Persistent disk
- Source image, if this is not a blank disk
- Indication of whether to delete the disk when the instance is deleted
- Size in gigabytes
- How the encryption keys will be managed

FIGURE 5.16 Dialog for adding a new disk to a VM



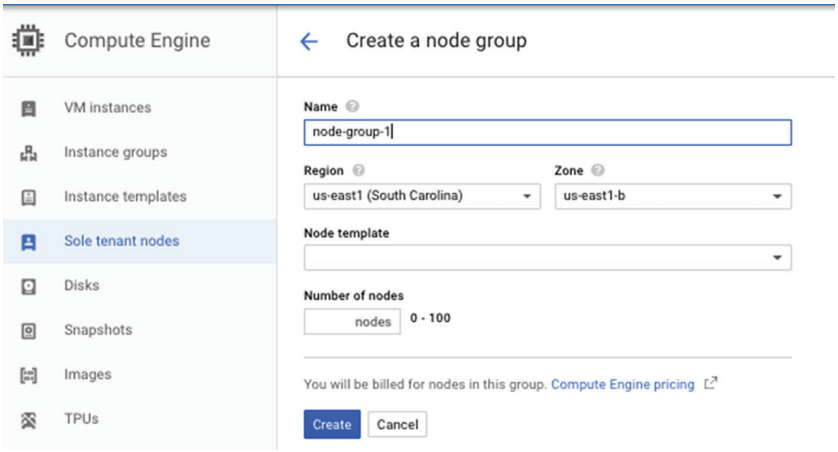
On the Networking tab, you can see the network interface information, including the IP address of the VM. If you have multiple networks, you have the option of adding another network interface to that other network. This use of dual network interfaces can be useful if you are running some type of proxy or server that acts as a control for flow of some traffic between the networks. In addition, you can also add network tags in this dialog (see Figure 5.17).

FIGURE 5.17 Dialog for network configuration of a VM



If you need to ensure that your VMs run on a server only with your other VMs, then you can specify sole tenancy. The Sole Tenancy tab allows you to specify labels regarding sole tenancy for the server (see Figure 5.18).

FIGURE 5.18 Sole Tenancy configuration form



Creating and Configuring Virtual Machines with Cloud SDK

A second way to create and configure VMs is with Google Cloud SDK, which provides a command-line interface. To use Cloud SDK, you will first need to install it on your local device.

Installing Cloud SDK

You have three options for interacting with Google Cloud resources:

- Using a command-line interface
- Using a RESTful interface
- Using the Cloud Shell

Before using either of the first two options from your local system, you will need to install Cloud SDK on your machine. Cloud Console is a graphical user interface you can access through a browser at `https://console.cloud.google.com`.

Cloud SDK can be installed on Linux, Windows, or Mac computers.

Installing Cloud SDK on Linux

If you are using Linux, you can install Cloud SDK using your operating system's package manager. Ubuntu and other Debian distributions use `apt-get` to install packages. Red Hat Enterprise, CentOS, and other Linux distributions use `yum`. For instructions on using `apt-get`, see `https://cloud.google.com/sdk/docs/quickstart-debian-ubuntu`. For instructions on installing on Red Hat Enterprise or CentOS, see `https://cloud.google.com/sdk/docs/quickstart-redhat-centos.Installing`.

Cloud SDK on Mac OS

Instructions for installing on a Mac and the installation file for Cloud SDK are available at `https://cloud.google.com/sdk/docs/quickstart-macos`. The first step is to verify that you have Python 2.7 installed. There are two versions of Cloud SDK, one for 32-bit macOS and one for 64-bit macOS.

Installing Cloud SDK on Windows

To install Cloud SDK on a Windows platform, you will need to download the appropriate installer. You can find instructions at `https://cloud.google.com/sdk/docs/quickstart-windows`.

Example Installation on Ubuntu Linux

The first step in installing Cloud SDK is to get the appropriate version of the package for your operating system. The following commands are for installing Cloud SDK on Ubuntu. See `https://cloud.google.com/sdk/docs/quickstart-debian-ubuntu` for any updates to this procedure.

You need to identify which version of the operating system you are using because the Google naming convention for Cloud SDK references the operating system name. The following command creates an environment variable with the name of the Cloud SDK package for the current operating system:

```
export CLOUD_SDK_REPO="cloud-sdk-$(lsb_release -c -s)"
```

Note that if you receive an error message that the `lsb_release` command is not found, you can install it with the following commands:

```
sudo apt-get update
sudo apt-get install lsb-core
```

You can see the value of the variable `CLOUD_SDK_REPO` using the following command:

```
echo $CLOUD_SDK_REPO
```

This will display a value such as `cloud-sdk-bionic`. Bionic is the code name for Ubuntu 18.04.

Next, you need to specify where to find Cloud SDK. We do this by adding the URL of the Cloud SDK package to the /etc/apt/sources.list.d/google-cloud-sdk.list file. Now apt-get will know where to find the package.

```
echo "deb http://packages.cloud.google.com/apt $CLOUD_SDK_REPO main" | sudo tee
-a /etc/apt/sources.list.d/google-cloud-sdk.list
```

You also need to import the GCP public key, which you do with this command:

```
curl https://packages.cloud.google.com/apt/doc/apt-key.gpg | sudo apt-key add -
```

Finally, you need to update the apt-get package list and then use apt-get to install Cloud SDK.

```
sudo apt-get update && sudo apt-get install google-cloud-sdk
```

Now Cloud SDK is installed and you can execute commands using it. The first step is to initialize Cloud SDK using the gcloud init command, as shown here:

```
gcloud init
```

When you receive an authentication link, copy it into your browser. You are prompted to authenticate with Google when you go to that URL. Next, a response code appears in your browser. Copy that to your terminal window and paste it in response to the prompt that should appear.

Next, you are prompted to enter a project. If projects already exist in your account, they will be listed. You also have the option of creating a new project at this point. The project you select or create will be the default project used when issuing commands through Cloud SDK.

Creating a Virtual Machine with Cloud SDK

To create a VM from the command line, you will use the gcloud command. You use this command for many cloud management tasks, including the following:

- Compute Engine
- Cloud SQL instances
- Kubernetes Engine
- Cloud Dataproc
- Cloud DNS
- Cloud Deployment

The gcloud command is organized into a hierarchy of groups, such as the compute group for Compute Engine commands. We'll discuss other groups in later chapters; the focus here is on Compute Engine.

A typical gcloud command starts with the group, as shown here:

```
gcloud compute
```

A subgroup is used in Compute Engine commands to indicate what type of compute resource you are working with. To create an instance, you use this command:

```
gcloud compute instances
```

And the action you want to take is to create an instance, so you would use this:

```
gcloud compute instances create ace-instance-1, ace-instance-2
```

If you do not specify additional parameters, such as a zone, Google Cloud will use your information from your default project. You can view your project information using the following gcloud command:

```
gcloud compute project-info describe
```

To create a VM in the us-central1-a zone, add the zone parameter like this:

```
gcloud compute instances create ace-instance-1 ace-instance-2 --zone
us-central1-a
```

You can list the VMs you've create using this:

```
gcloud compute instances list
```

Here are commonly used parameters with the create instance command:

- `--boot-disk-size` is the size of the boot disk for a new disk. Disk size may be between 10GB and 2TB.
- `--boot-disk-type` is the type of disk. Use `gcloud compute disk-types list` for a list of disk types available in the zone the VM is created in.
- `--labels` is the list of key-value pairs in the format of KEY=VALUE.
- `--machine-type` is the type of machine to use. If not specified, it uses n1-standard-1. Use `gcloud compute machine-types list` to view a list of machine types available in the zone you are using.
- `--preemptible`, if included, specifies that the VM will be preemptible.

For additional parameters, see the `glcoud compute instance create` documentation at `https://cloud.google.com/sdk/gcloud/reference/compute/instances/create`.

To create a standard VM with 8 CPUs and 30GB of memory, you can specify n1-standard-8 as the machine type.

```
gcloud compute instances create ace-instance-n1s8 --machine-type=n1-standard-8
```

If you want to make this instance preemptible, you add the preemptible parameter:

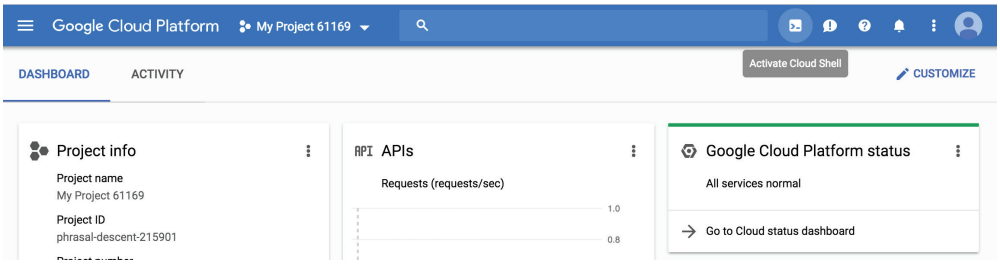
```
gcloud compute instances create --machine-type=n1-standard-8 --preemptible ace-
instance-1
```

Creating a Virtual Machine with Cloud Shell

An alternative to running gcloud commands locally is to run them in a cloud instance. Cloud Shell provides this capability. To use Cloud Shell, start it from Cloud

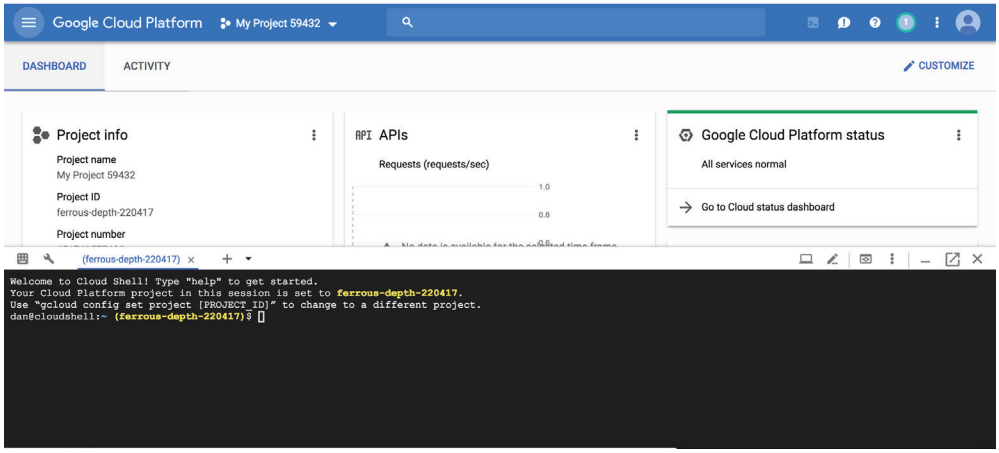
Console by clicking the shell icon in the upper-right corner of the browser, as shown in Figure 5.19.

FIGURE 5.19 Cloud Shell is activated through Cloud Console.



Cloud Shell provides a Linux command line, as shown in Figure 5.20, and Cloud SDK is already installed. All `gcloud` commands that you can enter on your local device with Cloud SDK installed can be used in Cloud Shell.

FIGURE 5.20 Cloud Shell opens a command-line window in the browser.



Basic Virtual Machine Management

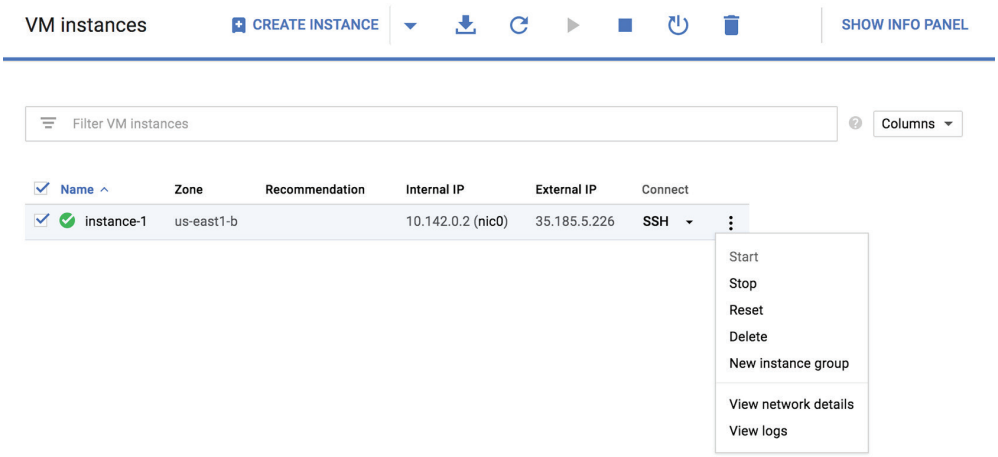
When VMs are running, you can perform basic management tasks by using the console or using `gcloud` commands.

Starting and Stopping Instances

In the console you view a list of instances by selecting Compute Engine and then VM Instances from the left-side panel of the console. You can then select a VM to operate on

and list command options by clicking the three dot icons on the right. Figure 5.21 shows an example.

FIGURE 5.21 Basic operations on VMs can be performed using a pop-up menu in the console.



Note that you can start a stopped instance using the `start` command that is enabled in the pop-up for stopped instances.

You can also use `gcloud` to stop an instance with the following command, where `INSTANCE-NAME` is the name of the instance:

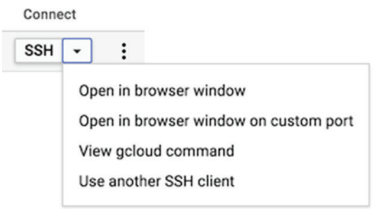
```
gcloud compute instances stop INSTANCE-NAME
```

Network Access to Virtual Machines

As a cloud engineer, you will sometimes need to log into a VM to perform some administration tasks. The most common way is to use SSH when logging into a Linux server or Remote Desktop Protocol (RDP) when logging into a Windows server.

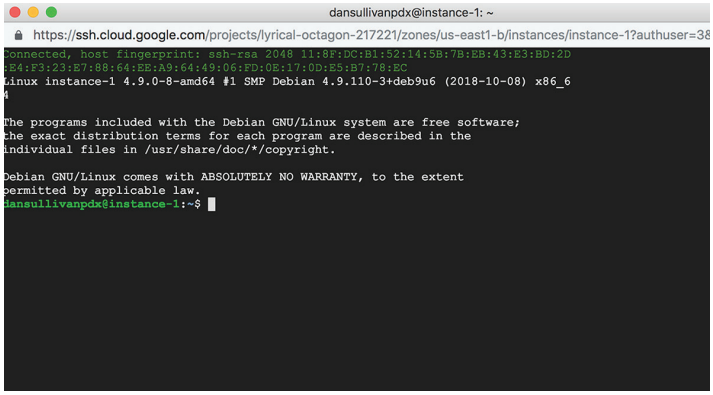
Figure 5.22 shows the set of options for using SSH from the console. This list of options appears when you click the SSH button associated with a VM.

FIGURE 5.22 From the console, you can start an SSH session to log into a Linux server.



Choosing the Open In Browser Window option will open a new browser window and display a terminal window for accessing the command line on the server.

FIGURE 5.23 A terminal window opens in a new browser window when using Cloud Shell.



Monitoring a Virtual Machine

While your VM is running you can monitor CPU, disk, and network load by viewing the Monitoring page in the VM Instance Details page.

To access monitoring information in the console, select a VM instance from the VM Instance page by clicking the name of the VM you want to monitor. This will show the Details page of the VM. Select the Monitoring option near the top of the page to view monitoring details.

Figures 5.24, 5.25, and 5.26 show the information displayed about CPU, network utilization, and disk operations.

FIGURE 5.24 The Monitoring tab of the VM Instance Details page shows CPU utilization.

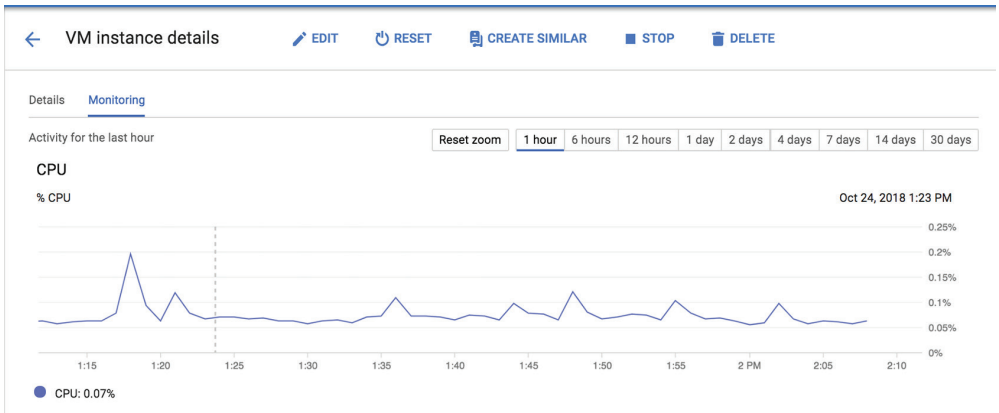


FIGURE 5.25 The Monitoring tab of the VM Instance Details page also shows network utilization.

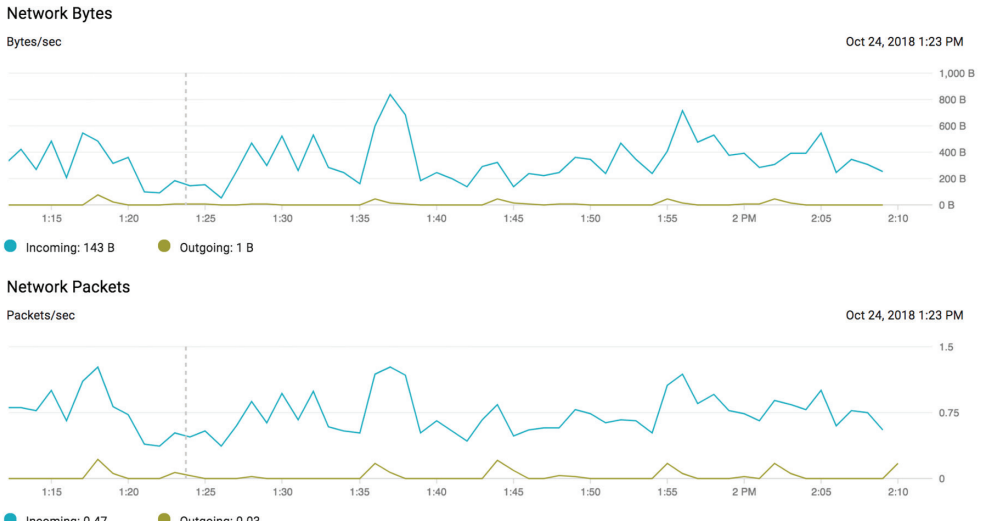
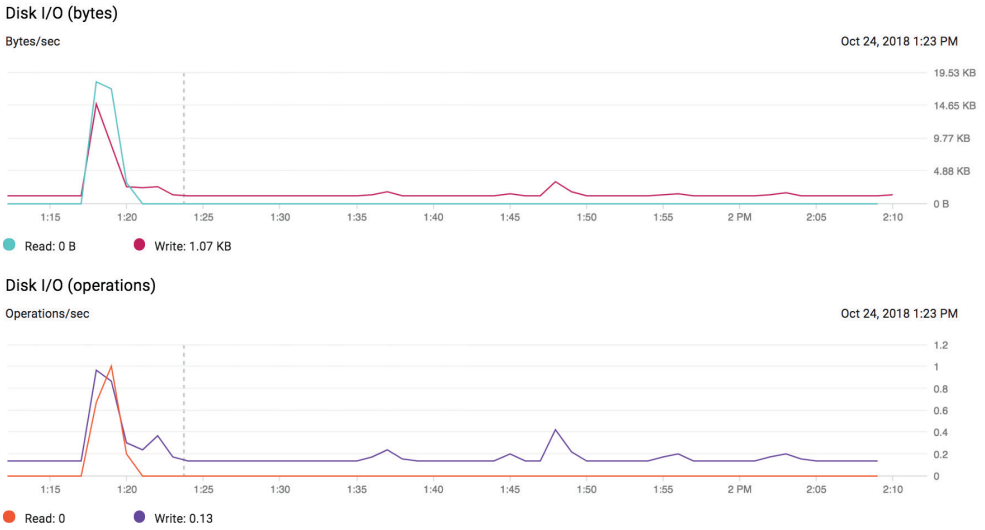


FIGURE 5.26 Disk utilization is included in the Monitoring tab of the VM Instance Details page.



Cost of Virtual Machines

Part of the basic management of a VM is tracking the costs of the instances you are running. If you want to track costs automatically, you can enable Cloud Platform billing and setup Billing Export. This will produce daily reports on the usage and cost of VMs.

The following are the most important things to remember about VM costs:

- VMs are billed in 1-second increments.
- The cost is based on machine type. The more CPUs and memory used, the higher the cost.
- Google offers discounts for sustained usage.
- VMs are charged for a minimum of 1 minute of use.
- Preemptible VMs can save you up to 80 percent of the cost of a VM.

Guidelines for Planning, Deploying, and Managing Virtual Machines

Consider the following guidelines to help with streamlining your work with VMs. These guidelines apply to working with a small number of VMs. Later chapters will provide additional guidelines for working with clusters and instance groups, which are sets of similarly configured VMs.

- Choose a machine type with the fewest CPUs and the smallest amount of memory that still meets your requirements, including peak capacity. This will minimize the cost of the VM.
- Use the console for ad hoc administration of VMs. Use scripts with `gcloud` commands for tasks that will be repeated.
- Use startup scripts to perform software updates and other tasks that should be performed on startup.
- If you make many modifications to a machine image, consider saving it and using it with new instances rather than running the same set of modifications on every new instance.
- If you can tolerate unplanned disruptions, use preemptible VMs to reduce cost.
- Use SSH or RDP to access a VM to perform operating system–level tasks.
- Use Cloud Console, Cloud Shell, or Cloud SDK to perform VM-level tasks.

Summary

Google Cloud Console is a web-based graphical user interface for managing GCP resources. Cloud SDK is a command-line package that allows engineers to manage cloud resources from the command line of their local device. Cloud Shell is a web-based terminal interface to VMs. Cloud SDK is installed in Cloud Shell.

When creating a VM, you have to specify a number of parameters, including a name for the VM, a region and zone where the VM will run, a machine type that specifies the number of vCPUs and the amount of memory, and a boot disk that includes an operating system.

`gcloud` is the top-level command of the hierarchical command structure in Cloud SDK.

Common tasks when managing VMs are starting and stopping instances, using SSH to access a terminal on the VM, monitoring, and tracking the cost of the VM.

Exam Essentials

Understand how to use Cloud Console and Cloud SDK to create, start, and stop VMs. Parameters that you will need to provide when creating a VM include name, machine type, region, zone, and boot disk. Understand the need to create a VM in a project.

Know how to configure a preemptible VM using Cloud Console and the `gcloud` commands. Know when to use a preemptible VM and when not to. Know that preemptible VMs cost up to 80 percent less than nonpreemptible VMs.

Know the purpose of advanced options, including Shielded VMs and advanced boot disk configurations. Know that advanced options provide additional security. Understand the kinds of protections provided.

Know how to use `gcloud` compute instance commands to list, start, and stop VMs. Know the structure of `gcloud` commands. `gcloud` commands start with `gcloud` followed by a service, such as `compute`, followed by a resource type, such as `instances`, followed by a command or verb, like `create`, `list`, or `describe`.

Understand how to monitor a VM. Know where to find CPU utilization, network monitoring, and disk monitoring in the VM Instances pages of the console. Know the difference between listing and describing instances with a `gcloud` command.

Know the factors that determine the cost of a VM. Know that Google charges by the second with a 1-minute minimum. Understand that the costs of a machine type may be different in different locations. Know that cost is based on the number of vCPUs and memory.