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Empowering Start-up success: Implementing Google Cloud solutions for business growth

Metropolia University of Applied Sciences

Bachelor of Engineering

Information and communication technology

Bachelor's Thesis

13 February 2024

Abstract

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Title:	Empowering Start-up success: Implementing Google Cloud solutions for business growth
Number of Pages:	39 pages
Date:	13 February 2024
Degree:	Bachelor of Engineering
Degree Programme:	Information and communication technology
Professional Major:	Software engineering
Supervisors:	Janne Salonen, Head of School in ICT

In a constantly changing and dynamic business environment, new companies offer the potential for innovation and change. However, such efforts often confront financial limitations and technological difficulties that may hold their expansion. This thesis aims out to investigate the application of cloud computing as the force behind startup success, focusing on using Google Cloud Platform's (GCP) features.

The goal of this study is to show how GCP solutions may support business expansion and to offer stakeholders and start-up entrepreneurs valuable data. Through providing a comprehensive analysis of actual case studies and realistic implementation scenarios, this research aims to explain the details of cloud integration and demonstrate how GCP may function as an essential partner for new businesses. Throughout a review into GCP's numerous components, this thesis highlights the strategic benefits it provides, such better data management, cost-effectiveness, and scalability. Additionally, it explores the business challenges and difficulties that new businesses may have in putting their plans into practice, providing a road map for effective adoption.

This thesis attempts to contribute an improvement to the growing field of cloud technology in the context of start-ups using extensive research and strategic analysis. Its goal is to empower business owners with the knowledge and understanding necessary to guide their businesses toward long-term success using the enormous potential of the Google Cloud Platform.

The overall objective of "Empowering Start-Up Success: Implementing Google Cloud Platform Solutions for Business Growth" is to address the knowledge gap between technology and entrepreneurship through putting light on how start-up businesses can apply the cloud's innovative possibilities.

Keywords: Empowering, Start-Up, Success, Implementing, Google Cloud Platform, Business Growth, Cloud Technology, Innovation, Transformation, Technical Challenges, Scalability, Cost-Efficiency, Data Management

Contents

List of Abbreviations

GCP: Google Cloud Platform

API: Application Programming Interface

BPaaS: Business Process as a Service

SaaS: Software as a Service

PaaS: Platform as a Service

IaaS: Infrastructure as a Service

ML: Machine Learning

AI: Artificial Intelligence

HTTP: Hypertext Transfer Protocol Secure

VM: Virtual Machine

VPC: Virtual Private Cloud

VPN: Virtual Private Network

IAM: Identity and Access Management

SQL: Structured Query Language

NoSQL: Not only SQL

GKE: Google Kubernetes Engine

CDN: Content Delivery Network

1   Introduction

Several start-up businesses, ready to take over industries and question conventional wisdom, have emerged in today's dynamic business environment thanks to the spirit of innovation and entrepreneurship. These initiatives are the ambitious dreams of creative people who want to turn concepts into meaningful reality. Unfortunately, there are many barriers in the way of a successful startup, from limited funds to innovative limitations. In the middle of this confusing scenery, cloud computing offers to be an element of hope, providing these young companies with the ability to change and expand in a sustainable way.

This thesis goes into the fascinating relationship between cloud innovation and start-up empowerment, emphasizing the benefits of Google Cloud Platform (GCP). Cloud technology is popular for delivering the flexibility, agility, and scalability that modern corporate environments require. Analyzing GCP's function inside the structure of startup companies, this paper wants to determine how utilizing its array of solutions might facilitate exceptional business development and originality.

Problem Statement:

Resource limitations and technological challenges are common obstacles faced by start-up businesses that prevent them from growing and prospering. Conventional IT infrastructure might not be able to keep up with the business's quick expansion and changing requirements. Using cloud technology becomes strategically essential in such circumstances. The issue is not only selecting the best cloud platform but also implementing its capabilities into practice efficiently to meet the demands of a business.

Objective:

This thesis' main goal is to investigate and clarify how Google Cloud Platform solutions may support business expansion and start-up success. Also, analyze the transformative effect of GCP on start-up operations using a combination of methods which involves case studies, data analysis, and a study of relevant literature. By doing this, this research hope to offer insightful analysis and practical suggestions that will help stakeholders and start-up business owners navigate the cloud environment and use GCP for long-term growth.

Significance of the Study:

In the context of contemporary entrepreneurship and technical innovation, this study is extremely important. The objective is to close the knowledge gap between cloud technology and start-up businesses by illuminating the strategic benefits of GCP. The research can help businesses manage the complexities of cloud adoption and deployment by providing them with a roadmap. Additionally, this study adds to the general conversation about how cloud computing will influence organizations in the future by showcasing its capacity to completely transform multiple industries.

The upcoming sections will look at the literature that already exists on cloud technology and start-up challenges, as well as the research methodology applied. Also, discuss and evaluate the data that was gathered and provide practical suggestions for using GCP solutions to accelerate start-up growth. Through this research journey is to provide information on how start-ups can effectively use cloud technology in the future to realize their goals and find long-term success.

2   Literature Review

2.1   Start-ups

A startup is a newly formed business with the mission to establish itself quickly in the market using modern ideas and a solid basis in technology. All these businesses main attribute is their ability to offer innovative solutions or to reinvent current ones using technology. The most profitable startups happen to be those that even discover a new market need.

Modern economies must have startups for several reasons. Firstly, they act as a vital driver of creating employment and economic expansion. Startups contribute to economic growth by generating revenue and jobs. Furthermore, they are an essential source of creativity and innovation. New businesses can come up with original and unique solutions to current problems by specializing on technological advancements and innovation. Second, the potential to contribute to the regional economy makes them significant. Plus have the potential to bring in capital from abroad and produce excellent jobs in the region. Finally, can also increase competition in the local market, which may benefit customers by bringing down costs and improving quality of products.

2.2   Challenges

New businesses or emerging companies, encounter numerous obstacles while trying to make a name for themselves in the marketplace. Lack of resources is one of the main issues these businesses deal with. Compared to larger companies, startups typically have a smaller budget and fewer resources available to them. This can make it challenging to invest in marketing and advertising, acquire technology, and hire qualified staff. Technological barriers are a major challenge for new businesses [4, p. 29]. For example, may find it challenging to come up with original ideas and to stay up to date with the latest advances in technology. Additionally, are likely to find it very difficult to compete with larger enterprises equipped with more ability and industry knowledge.

Regardless these struggles, there are plenty ways to get past these difficulties. Seeking outside funding from entrepreneur investors as a conventional plan. This can give newly formed companies the capital needed to invest in technology, hire skilled workers, and create fresh ways to solve problems. An alternative method is to emphasize being innovative and imaginative. Due to their smaller size, start-ups are more flexible and agile than major companies. They can come up with original and creative solutions to current issues by setting a priority on thinking outside the box.

2.3 Cloud Technology

The technology that's responsible for making it possible to provide computer services over the Internet is called cloud computing or cloud technology. Users can run programs straight from the Internet, saving space on their hard drive while optimizing the most possible use of their resources, instead of having to install them on their computer [1, p. 3].

For companies of all sizes, including start-ups, cloud computing has turned out to be revolutionary. Since it does not require costly hardware and software infrastructure, it guarantees flexibility, scalability, and cost savings. By ensuring that they have access to the most advanced technologies at an affordable price, cloud technology can help them in overcoming some of the obstacles they have [1, p. 4]. Additionally, it can enable to access its data and apps at any time and from any location, scaling up or down according to its needs. Cloud technology can help overcome its limitation by providing access to a wide range of computing services without having to invest in expensive infrastructure.
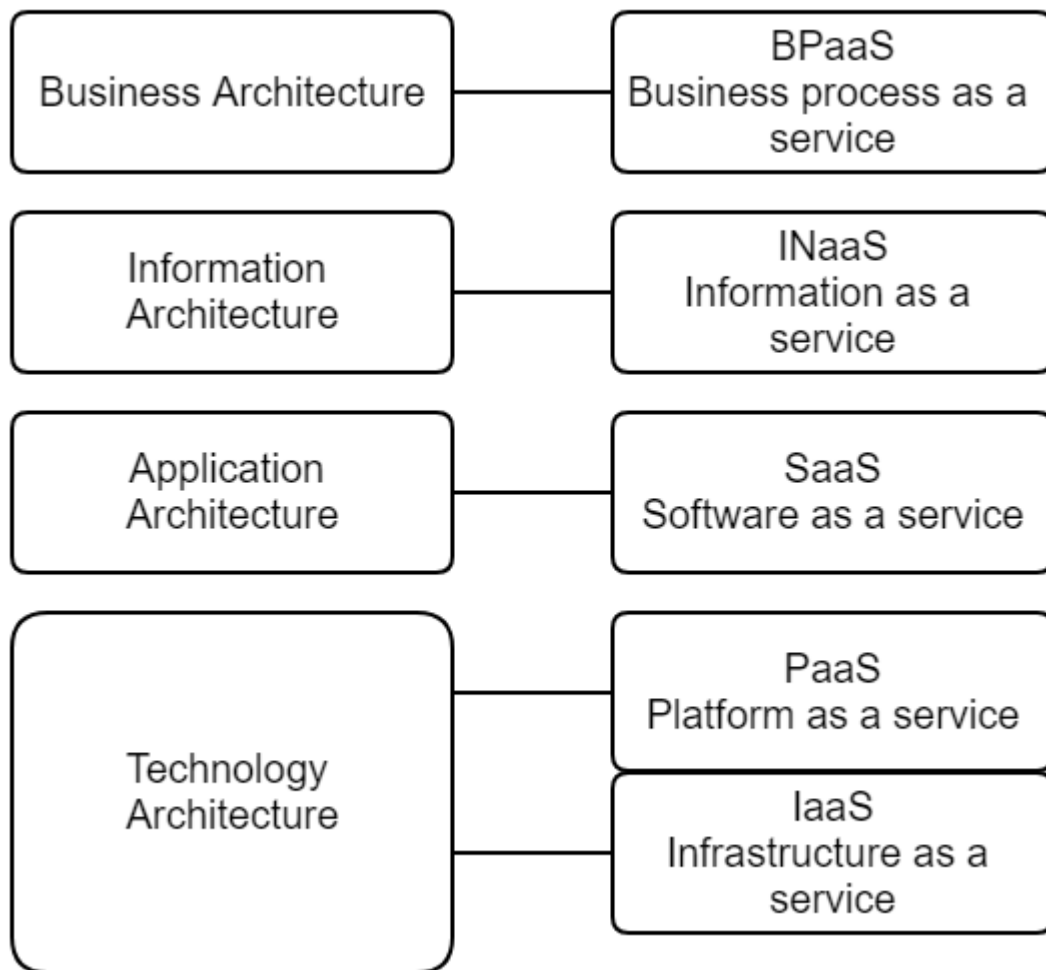
Figure 1. Cloud service models [1, p. 14].

Figure 1 shows how different types of cloud computing services can be aligned with different layers of enterprise architecture. Business architecture is a way of designing and organizing an organization's processes, information, applications, and technology to achieve its goals and strategy [1, p. 13]. Cloud computing is a way of delivering computing resources and services over the internet, without the need for owning or managing them on-premises.

There are two columns in the figure 1. Business architecture, information architecture, applications architecture, and technology architecture are the four levels of organizational architecture, listed from top to bottom in the left column. The five categories of cloud computing services are shown in the right column, going from top to bottom: information as a service (INaaS), software as a

service (SaaS), platform as a service (PaaS), business process as a service (BPaaS), and infrastructure as a service (IaaS).

Each type of cloud service may serve each level of the corporate architecture, as indicated by the arrows between the columns. For instance, BPaaS can offer pre-made business processes that are adaptable and can be combined with the company's current data and infrastructure. Data and analytics from an array of platforms and formats may be accessed via INaaS, avoiding the need for on-premises processing or storage. Software as a service (SaaS) can offer online apps that don't require setup or management on the devices. PaaS can offer an environment for creating, evaluating, and launching apps without requiring infrastructure management [1, p. 13]. The essential IT infrastructure, including servers, storage, and networks, may be selected, and expanded according using IaaS.

Figure 1 shows how, according to the needs and desires of the company, cloud computing could offer different degrees of abstraction, flexibility, and control. The cloud service has less influence over the organization and is more abstract and fluid the higher it is on the diagram. Also, has greater influence over the organization and is more concrete and particular the lower it is on the diagram [1, p. 14].

2.4 The Role of Cloud Technology

Startups can overcome resource constraints and achieve rapid scalability with the support of cloud technology. They have access to a variety of IT services through the cloud without having to spend a lot of money on infrastructure. This implies that cloud computing can help them to cut expenses and boost productivity [2, p. 4]. Businesses can expand their operations fast in response to consumer demand. As a result, startups can quickly adjust to changes in the market by reducing their processing capacity as needed. The ability for them to

access the latest tools and resources that help them develop original and creative solutions is another significant advantage of cloud computing.

2.4.1 Cost-Effective Solution

Cloud computing enables people to access computer resources like servers, storage, and apps through the Internet. The following is a discussion of some advantages of cloud computing:

Cost-effectiveness: Compared to conventional on-premises IT infrastructure, cloud computing may be more economical. Users with an Internet connection can access cloud services from any location, personalize apps, and scale services to meet their needs. Not only that, but business users can launch their apps faster without having to worry about underlying infrastructure or ongoing maintenance expenses [3, p. 13].

Flexibility: To support different workloads, cloud infrastructure can grow as needed. Depending on its security requirements and other factors, users can select between public, private, or hybrid storage options. As-a-service options allow organizations to decide how much control they want to have [3, p. 13]. Among these are platform as a service (PaaS), infrastructure as a service (IaaS), and software as a service (SaaS). Users can design a solution that meets their unique needs by choosing from a range of already developed tools and features [3, p. 14].

Accessibility: Data and apps hosted in the cloud can be accessed from almost any device with an Internet connection. Users can launch their apps into the market more swiftly with the help of cloud development. Because of network backups, data loss is prevented by hardware malfunctions. By utilizing remote resources, cloud computing helps businesses save money on servers and other equipment [3, p. 15].

3   Research Methodology

3.1   Google Cloud Platform: Using it as Business Transformation Accelerator

Developed by Google, GCP is a cloud computing platform that provides a broad range of services and resources to assist developers and businesses in creating, deploying, and managing scalable and effective cloud applications and services [4, p. 18]. Among GCP's primary attributes are:

Compute: Virtual machines, containers, Kubernetes Engine, App Engine, Cloud Functions, and many more options are available on GCP for compute. These services let users run workloads and apps in the cloud in a scalable and effective way [4, p. 99].

Storage: A multitude of storage solutions, including Cloud Storage, Cloud SQL, Cloud Bigtable, Cloud Spanner, and others, are available through GCP. These services enable scalable and effective cloud data management and storing for users [4, p. 107].

Data Analysis: BigQuery, Dataflow, Dataproc, Datalab, and many more options are available from GCP for data analysis. With the help of these services, users can quickly analyze huge data sets and obtain insightful knowledge that will benefit their company [5, p. 73].

Machine Learning: TensorFlow, AI Platform, AutoML, Kubeflow, and many other options are available for machine learning through GCP. Combining the

help of these services, users can create, develop, and implement machine learning frameworks in the cloud [5, p. 167].
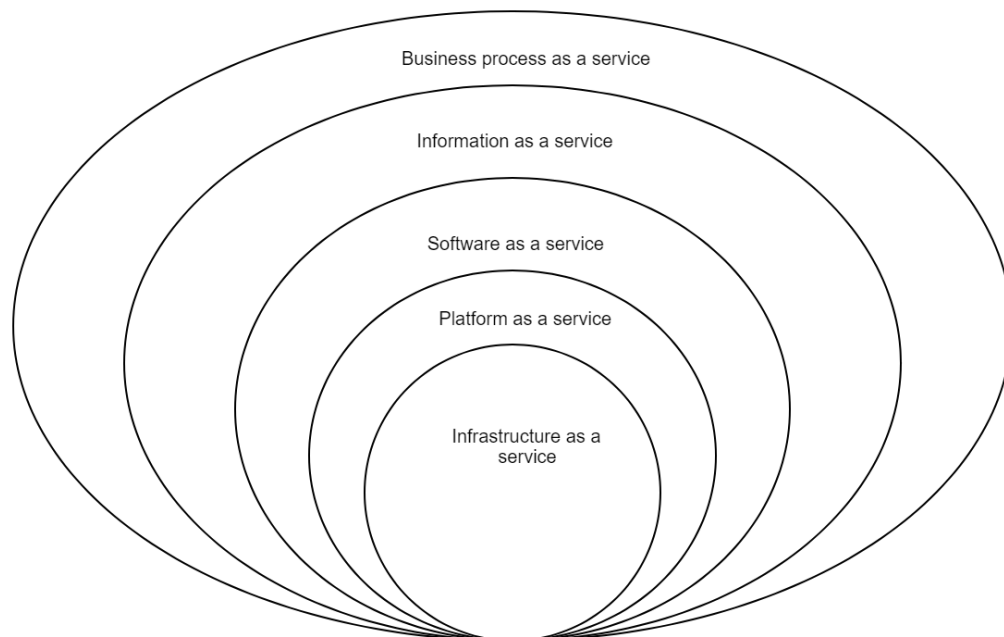
Figure 2. Types of cloud computing [1, p. 27].

Six concentric circles symbolize different levels of abstraction in the diagram. **"Business process as a service"** is stated in the outermost circle. This is the greatest degree of abstraction, where the user may access an entire business process as a service, such as payroll, accounting, or customer relationship management. The user has no concern about the service's deployment or management, and simply pays for the conclusion or result. Workday is an example of a business process as a service, as it generates human resource and financial management solutions.

"Information as a service" can be found in the next circle. This is the degree of abstraction at which the user may receive data and information as a service, such as analytics, reports, or insights. The user is not obligated for the collection, processing, or storage of data, but only for the access or use of the information. Google Analytics, which delivers online analytics and marketing insights, is an example of information as a service.

The next circle is marked as **"Software as a service."** This is the degree of abstraction at which the user can access software programs such as email, word processing, or spreadsheets as a service. The user does not need to worry about software installation, maintenance, or updates, just pays for the service subscription or license. Microsoft 365, a program that provides productivity and collaboration tools, is an example of software as a service.

"Platform as a service" is indicated in the next circle. This is the rate of abstraction at which a user could use a platform as a service, such as an operating system, a programming language, or a framework. The user is free of concerns about the platform's configuration, management, or scaling, and simply pays for the resources or time applied by the service. Google App Engine is an example of platform as a service, as it provides a cloud-based platform for developing and hosting websites.

"Infrastructure as a service" belongs in the lowest point area. This is the most basic level of abstraction, where the user may use fundamental infrastructure as a service, such as servers, storage, or networks. The user has the most power and responsibility over the infrastructure, but he or she also pays for the service's capacity or performance. Amazon Web Services, which supplies a range of cloud computing services, is an example of infrastructure as a service.

3.1.1 GCP for Start-ups

The Google Cloud for business program provides plenty of advantages to support new firms in expanding and scaling. Google Cloud credits, technical training, professional guidance, and access to a network of entrepreneurs, experts, investors, and partners are among the advantages. The program also provides special benefits for AI and Web3 organizations. New businesses may benefit from Google's open AI ecosystem, infrastructure, tools, and models. By designing applications, Web3 tools, and services, they may also focus on

innovation rather than infrastructure. The program includes financial rewards such as up to $200,000 in Google Cloud credits (up to $350,000 for AI businesses) and exclusive support services for entrepreneurs. Startups may also get professional assistance and training from webinars, online training seminars, and one-on-one counselling. The package also includes a results manager for entrepreneurs that may be used for training courses and research accelerator proposals [6].
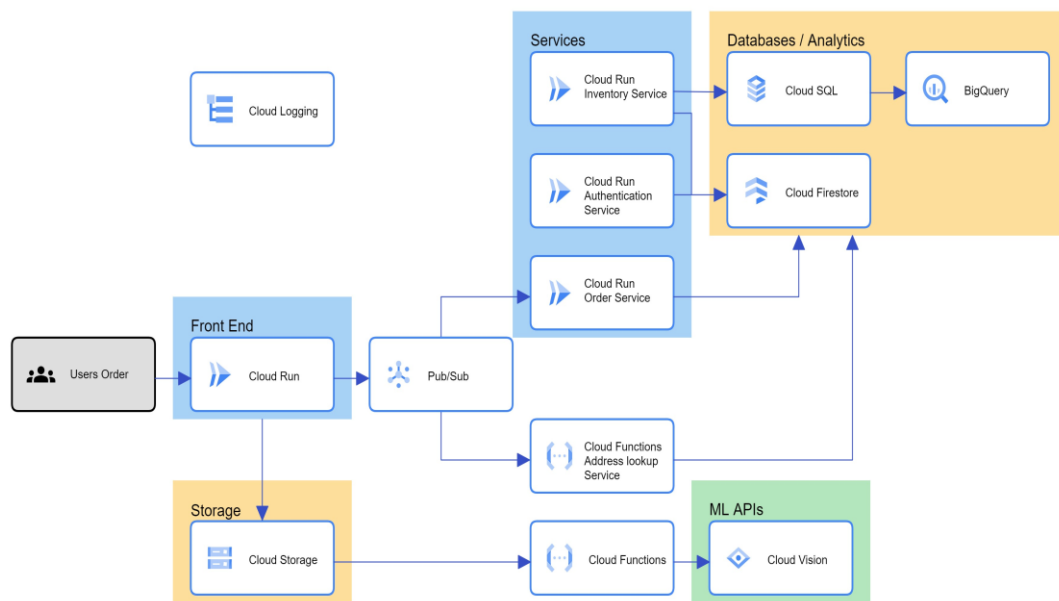

Figure 3. E-commerce application. Created from Google Cloud architecture diagramming tool.

This diagram describes a serverless microservices architecture for an e-commerce application built with Google Cloud Run. Google Cloud run as a service that enables execute code in a serverless environment without having to worry about servers, scalability, or infrastructure. Serverless indicates that just pay for the resources of use, and the service scales up or down automatically based on demand. Microservices are a method of developing software systems that divide them into smaller, self-contained components, each with its own role and responsibility.

Figure 3 displays how the e-commerce application is made up of numerous microservices, each of which runs on Cloud Run. HTTP requests and responses serve to communicate amongst the microservices. The graphic further illustrates the interactions of the microservices with other Google Cloud services such as databases, analytics, and machine learning APIs.

Front End, Services, Databases/Analytics, and ML APIs are the four components of the diagram. The Front-End part displays how consumers may utilize a web interface to order items from the e-commerce application. The web interface is hosted by Cloud Run Front End, a microservice that runs the interface for the application and its business logic. The Cloud Run Front End also interacts with other microservices, such as the Cloud Run Inventory Service, the Cloud Run Authentication Service, and the Cloud Run Order Service, to perform tasks such as checking product availability, verifying user identity, and processing orders.

The Services section reflects the three microservices with which the Cloud Run Front End connects. The Cloud Run Inventory Service is a microservice that handles product inventory, including quantity, price, and description. The Cloud Run Authentication Service is a microservice that authorizes users and delivers access tokens to them. The Cloud Run Order Service is a microservice that executes order processing, covering order development, modifications, and deactivation.

The Databases/Analytics section discusses the three Google Cloud services deployed through the microservices to store and analyze data. A fully sustained relational database, such as MySQL or PostgreSQL, is delivered by Cloud SQL. The Cloud Run Inventory Service and the Cloud Run Order Service uses Cloud SQL to store and query data about items and orders. BigQuery is a service that provides a scalable and serverless data warehouse in which SQL queries may be executed on massive and sophisticated datasets. The Cloud Run Inventory Service and the Cloud Run Order Service run BigQuery to perform data analytics and reporting. Cloud Spanner is a service that offers a globally

connected and continuously flexible relational database with high reliability and consistency. The Cloud Run Authentication Service exploits Cloud Spanner to store and query data about users and access tokens.

The Google Cloud service used by the microservices to deploy machine learning activities is shown in the ML APIs section. Cloud Vision is a service that provides a pre-trained and adaptable image analysis API to identify objects, faces, text, and other features in pictures. The Cloud Run Inventory Service use Cloud Vision to extract information from product photos, such as colour, size, and brand.

3.1.2 Spotify Case

With 248 million users worldwide, including 113 million subscribers, Spotify is a well-known audio streaming service available in 79 markets. It currently generates the most revenue for the music industry. With its late 2008 launch as a music-streaming service and current 248 million monthly active users across 79 markets with access to over 50 million songs and podcasts, Spotify is a prime example of the new era of scaling a business. Spotify has kept up its innovative offerings while following the tried-and-true policies for expanding and maintaining a profitable company. Since 2016, Spotify's growing success and diversification have been strengthened by Google Cloud. Spotify's teams could concentrate more on their core business by using developer-friendly, automated services on Google Cloud. Additionally, the company gained access to services like data analytics that would allow it to expand. The tech leaders at Spotify prioritize the significance of Pub/Sub and BigQuery, two Google Cloud data analysis tools, for accelerating the development of software applications. Dataflow has also proven to be very helpful for analyzing data in real time and past periods. By automating repetitive operations of approximately 20,000 data pipelines, Spotify's engineers upgraded their computing efficiency by nearly 300% and released up time for analysis and action. They fully utilized their customer-focused engineering talent and cloud-based data insight by selecting just one cloud [7].

Figure 4. Spotify's data visualization to GCP. Created from Google Cloud architecture diagramming tool.

The data visualization indicates Spotify's development from starting point to the present.

The timeline in the graphic has six points, each of which symbolizes a turning point or difficulty that Spotify overcame. The first point, "microservices" indicates that Spotify was built using a microservice architecture, which divides software systems into smaller, independent parts. As a result, teams at Spotify were able to work independently on various features and services, promoting an agile and flexible engineering culture. Continuous Integration and Delivery (CI/CD) was one of the many automation tools that Spotify used to facilitate the development and deployment process.

"Data center" is displayed on a computer screen at the second point. This indicates that Spotify processed and stored its data at four separate data centers. High availability and dependability were guaranteed by having an independent copy of the whole Spotify system in each data center. However, this also meant that Spotify had to deal with issues related to consistency and synchronization of data among the data centers. "Backend" is the third point, represented by a cloud. In other words, Spotify made the decision to keep its backend services and content delivery network (CDN) separated. A content delivery network (CDN) is a web-based system that distributes files, especially music, to users according to their location. By keeping the CDN and backend separate, Spotify was able optimize the user experience and decrease load and latency on its backend servers. Through a synch icon, the fourth point says, "Workflows." This indicates that Spotify operated thousands of data processing jobs and workflows every day through a sizable and complex data pipeline. These tasks and procedures served a variety of functions, including

personalization, analytics, recommendation, and experimentation. To address its big data challenges, Spotify employed a variety of technologies, including Hadoop, Spark, and Scio. A group of people is mentioned in the fifth point, which says, "Team." This indicates that a sizable and varied group of engineers, designers, product managers, and other professionals worked on various facets of the Spotify product. Using an efficient and progressive methodology, Spotify tested and validated its concepts and features on actual users, integrating user feedback and learning into the cycle of product development. The sixth point, which says, "Worldwide Product" indicates that Spotify's goal of becoming the greatest music service globally was both clear and ambitious. By providing an extensive variety of content, features, and customization choices, Spotify intended to give users the greatest possible music experience. Spotify aimed to generate value for various stakeholders in the music industry, including labels, artists, and others, by offering them tools, data, as well as knowledge to expand their audience and revenue [8].

3.1.3 Snapchat Case

The creators of Snapchat, Snap, decided to secure its cloud workloads with a robust Zero Trust architecture with Google Cloud's Beyond Corp Enterprise (BCE). Secure access to resources and applications from anywhere in the globe becomes possible by the Zero Trust access architecture known as BCE. Modern Zero Trust network access control is available by its device-attestation system, which combines context-aware access policy formulations, and a globally distributed policy enforcement engine. Identity-Aware Proxy (IAP), the access proxy provided by BCE, enables admins to execute custom claims in JSON Web Tokens (JWTs) and supports both programmatic and user-based resource access. Without using a VPN, BCE assisted Snap in enabling safe access to their internal services. Snap managed to implement access controls to tens of thousands of device objects and have visibility into thousands of corporate endpoints because of BCE's device inventory system [9].
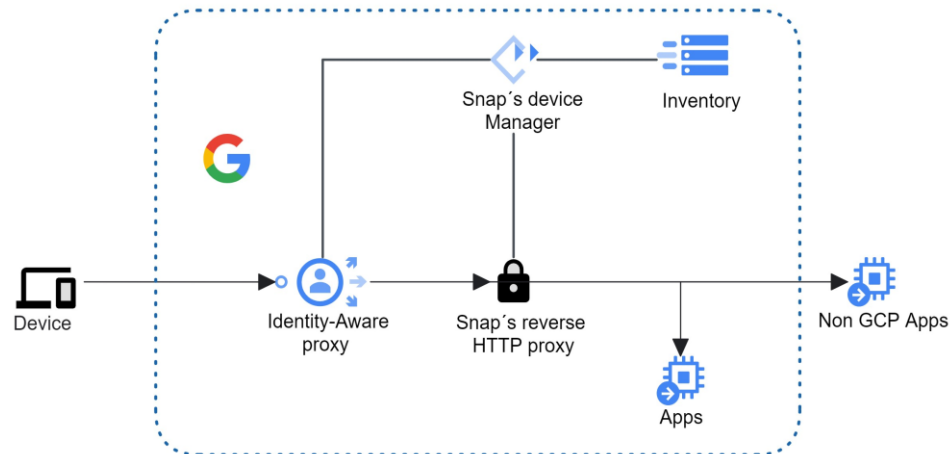
Figure 5. Snapchat secure device connectivity. Created from Google Cloud architecture diagramming tool.

The diagram explains the operation of Google Cloud. Figure 5 shows how a laptop or smartphone can use an identity-aware proxy to connect to Google Cloud, and then use a reverse HTTP proxy to access other apps. Before granting access to Google Cloud, the identity-aware proxy service confirms the identity of the user and the device. To make sure that only authorized people and devices can access the cloud resources, it makes use of Google's authentication and authorization system. Additionally, the identity-aware proxy protects against SQL injection and cross-site scripting online attacks.

A service that directs device requests to the relevant apps is known as a reverse HTTP proxy. Regardless of where the apps are hosted, it serves as a single point of entry for all of them. For the apps, the reverse HTTP proxy also includes load balancing, caching, and encryption.

The apps on Google Cloud are the programs that the user wishes to utilize. These could be third-party or company-owned apps. Applications like inventory control systems and customer relationship management systems, which are owned and operated by the user's organization, are referred to as company-owned apps. The applications that are offered by outside providers, like Google Workspace or Snap Device Manager, are known as third-party apps. The

applications may be hosted on Amazon Web Services (AWS), Microsoft Azure, or GCP, among other cloud computing platforms.

The reverse HTTP proxy and identity-aware proxy are two ways the device can access the apps, as seen in the diagram. For example, the device will first send a request to the identity-aware proxy, which will authenticate both the user and the device, for the user to use Google Workspace, a third-party app hosted on GCP. The request will then be forwarded by the identity-aware proxy to the reverse HTTP proxy, which will send it on to Google Workspace. Additionally, the Google Workspace response will be handled by the reverse HTTP proxy and sent back to the device [9].

3.1.4 Special Start-up services

GCP has some special features that set it apart from other cloud platforms like Microsoft Azure and AWS and can be helpful for startups.

To begin with, GCP provides a vast array of data analytics and machine learning tools that can assist companies in deriving insightful conclusions from their data. Second, GCP offers an open pricing structure that may help new businesses. When compared to other cloud platforms, GCP pricing is competitive, and users only pay for the resources they really use. Finally, security and regulatory compliance are top priorities for GCP. To assist businesses in securing their data and adhering to regulations, the platform provides an extensive range of security and compliance tools.

GCP provides the following machine learning and data analysis tools:

With generative AI, Google Cloud provides a service called **GenAI** that reduces lengthy emails, reports, or conversations to their essential information for rapid understanding. For those who require an improved method for finding, understanding, and extracting knowledge from enormous volumes of content, this service is helpful.

A log product in Cloud Logging may be summarized using **Duet AI**, an AI-powered collaborator in Google Cloud. When investigating into a problem, this service is helpful for analyzing activities in a log. Another Google Cloud service called **Document AI** enables users to construct a summarizer processor that compresses the information of documents. The output's length and format can be changed as needed. Those who need to take text out of a sample document and summarize it might benefit from this service.

Vertex AI is a fully managed machine learning platform that lets data scientists and developers create, train, and implement large-scale machine learning models. Additionally, offers tools for choosing models, preparing data, and assessing model performance.

BigQuery is a fully managed data analysis service that lets users use SQL to examine sizable data sets. Also comes with real-time analysis and data visualization tools.

Dataflow is a fully managed data processing service that makes use of **Apache Beam** to enable users to process massive data sets. Tools for data cleansing and transformation are also included in dataflow.

Regarding security measures, GCP provides an extensive selection of tools to assist businesses in protecting their information and adhering to legal requirements. Among them are the following tools:

Cloud Identity-Aware Proxy: This tool enables users to set identity-based restrictions that limit access to cloud-based apps.

Cloud data loss prevention helps businesses discover and safeguard sensitive data by automatically identifying and classifying it.

Cloud Security Command Center: Offers a consolidated view of GCP security status, enabling customers to identify and address issues promptly.

3.1.5 Considerations in Implementing GCP

Selecting what products and services are needed to meet the demands and objectives of a start-up is one of the barriers in setting up GCP for businesses. As a result, to choose the best and most affordable products and services to fulfil their goals and objectives must do in-depth research and analysis of their requirements, budget, and projected growth [5, p. 27].

Based on their planned development and deployment methodology, firms may choose to utilize Google App Engine, a serverless platform that grows and manages the application automatically, or **Google Kubernetes Engine**, a managed service for hosting containerized apps. In addition to their requirements for data format and consistency, they may also choose to utilize **Google Cloud SQL**, a fully managed relational database service, or Firestore, a scalable and adaptable NoSQL database.

Protecting the security and compliance of the data and apps housed in the cloud is another challenge while implementing GCP for startups. For the benefit in securing their data and applications against unwanted access, alteration, or deletion, GCP offers a range of security features and capabilities, including firewalls, identity and access control, encryption, audit logs, and security scanners. However, follow by the best practices and guidelines that Google and other authorities have established. These include creating strong passwords, transforming on multi-factor authentication, restricting user and service account access and permissions, and frequently patching and updating software and libraries [5, p. 29].

Additionally, must ensure that files and applications correspond to all applicable legal and regulatory standards and obligations, including GDPR, HIPAA, PCI DSS, and ISO 27001, that are specific to their industry and geographic area. To satisfy compliance standards, start-ups may be required to utilize services like **Google Cloud Key Management Service**, which enables them to manage their own encryption keys, or **Google Cloud Data Loss Prevention**, which assists in identifying and removing sensitive data.

Controlling expenses and maximizing cloud resource performance is a third difficulty for using GCP. To assist in cutting expenses and only paying for what they use, GCP provides a range of pricing models and reductions, including **pay-as-you-go**, sustained usage, committed use, and taking instances [4, p. 89].

Important to keep an eye on and evaluate how much they spend and how they use the cloud, and then modify setup and resource allocation to avoid running over or under budget. To track and optimize cloud usage and spending, they might want to use **Google Cloud Monitoring**, which offers visibility and insights into the health and performance of the cloud resources, or **Google Cloud Billing**, which offers extensive, customizable reports and alerts on the cloud costs [4, p. 31].

To improve the functionality and accessibility of their cloud infrastructure, startups might choose to use **Google Cloud Recommendations**, a service which provides recommendations and best practices on how to optimize the effectiveness and dependability of the cloud resources, or **Google Cloud Operations**, a collection of tools that assists in troubleshooting and incident resolution.

Discussion of strategies to overcome these challenges, such as change management, training, and support.

Here are some strategies that can help overcome the technical, organizational, and cultural challenges associated with adopting GCP:

Technical challenges: GCP adoption may require specialized technical skills that are not available in-house. Additionally, migrating applications and data to the cloud can be a complex process that requires careful planning.

Organizational challenges: Adopting GCP may require significant changes to existing organizational structure and processes. For example, IT teams may

need to be reorganized or new workflows established to take full advantage of cloud capabilities [5, p. 30].
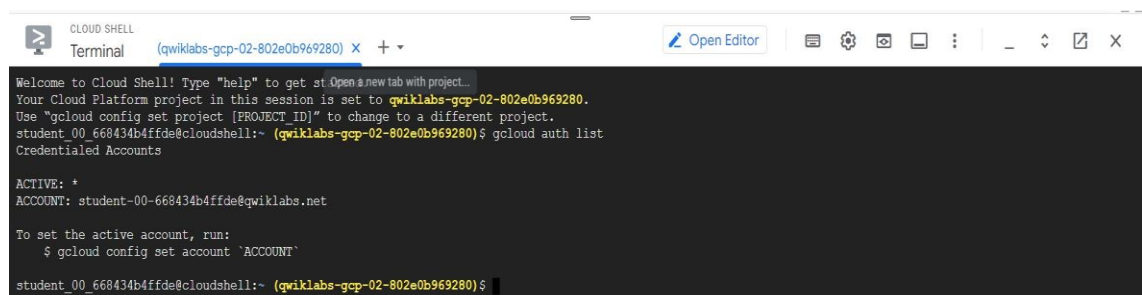
Cultural challenges: Adopting GCP may require a significant cultural change in the company. For example, it may be necessary to foster a culture of innovation and experimentation to take full advantage of cloud capabilities.

Training: Training is essential to ensure that employees have the technical skills necessary to work with GCP. This may include training in GCP-specific tools as well as general cloud skills [5, p. 29].

Support: Support is important to ensure that employees have access to the help they need when working with GCP. This may include technical support, sales support, and marketing support.

3.2 Cloud Shell

A browser-based command-line interface for controlling resources in a cloud context is offered by Cloud Shell, an online development and operations environment. In any location with a web browser and an internet connection can access it. Both the Microsoft Azure and Google Cloud platforms support Cloud Shell. An easy and safe approach to handle cloud resources is with Cloud Shell. also has a command-line interface for overseeing databases, virtual machines, and other cloud services. This can assist companies in streamlining their operations and performing tasks [10].

Figure 6. Cloud Shell terminal. Setting up account details.

The image's command and output are associated with the GCP Cloud Shell. In this case a welcome text message and ways to use Cloud Shell from the command prompt. A list of commands and a URL are also included in the command prompt. Google Chrome is the online browser that has the command prompt open. There are many tabs open in the online browser, and the bookmarks bar is visible.

The commands are listed as follows:
• To start a new project, use `gcloud config set project [PROJECT_ID]`.
• Run the active account with `gcloud auth list`.
• To switch accounts, type `gcloud`.

3.3 VPC Firewalls

Hosted inside a public cloud, a Virtual Private Cloud (VPC) is a private cloud that is segregated and safe. VPC clients have access to all the same features as regular private cloud users, with the exception that the private cloud is hosted remotely by a public cloud provider. They may execute code, store data, host websites, and perform other operations. Controlling access to and from a VPC network is done by means of a VPC firewall. The resources in a VPC network are shielded from unwanted access by means of this virtual firewall. Another degree of protection for their cloud architecture is offered by VPC firewalls [4, p. 183].

Businesses may limit access to critical data and apps by using VPC firewalls to manage resource access in a VPC network. By doing this, security problems and data breaches may be avoided. Furthermore, traffic within a VPC network may be monitored by VPC firewalls, which can be useful in detecting and correction of security risks.

```
Your active configuration is: [cloudshell-14203]
student_00_668434b4ffde@cloudshell:~ (qwiklabs-gcp-02-802e0b969280)$ gcloud compute networks create mynetwork --subnet-mode=auto
Created [https://www.googleapis.com/compute/v1/projects/qwiklabs-gcp-02-802e0b969280/global/networks/mynetwork].
NAME: mynetwork
SUBNET_MODE: AUTO
BGP_ROUTING_MODE: REGIONAL
IPV4_RANGE:
GATEWAY_IPV4:
```

Figure 7. Cloud Shell terminal. Setting up network environment.

In Figure 7, a new VPC network is created using the `gcloud compute networks create` command. The new network's name is specified by `mynetwork` option. The network's subnet mode will be specified with the `--subnet-mode` option, and the automatic subnet creation mode can be enabled with the `--subnet-mode=auto` setting. In this process, a single subnet is established in every Google Cloud area, and when more regions become available, new subnets are automatically added to the network.

```
student_00_668434b4ffde@cloudshell:~ (qwiklabs-gcp-02-802e0b969280)$ gcloud compute networks create privatenet \
--subnet-mode=custom
Created [https://www.googleapis.com/compute/v1/projects/qwiklabs-gcp-02-802e0b969280/global/networks/privatenet].
NAME: privatenet
SUBNET_MODE: CUSTOM
BGP_ROUTING_MODE: REGIONAL
IPV4_RANGE:
GATEWAY_IPV4:
```

Figure 8. Cloud Shell terminal. Private Custom network.

The GCP command `gcloud compute networks create privatenet --subnet-mode=custom` works to establish a new custom network. A new network called `privatenet` with a customized subnet mode is created by using this command. An individual subnet configuration will be used by the network, as indicated by the `--subnet-mode=custom` flag.

```
student_00_668434b4ffde@cloudshell:~ (qwiklabs-gcp-02-802e0b969280)$ gcloud compute networks subnets create privatesubnet \
--network=privatenet --region=us-central1 \
--range=10.0.0.0/24 --enable-private-ip-google-access
Created [https://www.googleapis.com/compute/v1/projects/qwiklabs-gcp-02-802e0b969280/regions/us-central1/subnetworks/privatesubnet].
NAME: privatesubnet
REGION: us-central1
NETWORK: privatenet
RANGE: 10.0.0.0/24
STACK_TYPE: IPV4_ONLY
IPV6_ACCESS_TYPE:
INTERNAL_IPV6_PREFIX:
EXTERNAL_IPV6_PREFIX:
```

Figure 9. Cloud Shell terminal. Entire subnet environment.

The command `gcloud compute networks subnets create privatesubnet --network=privatenet --region=us-central1 --range=10.0.0.0/24 -- enable-private-ip-google-access` is used to create a private subnet in GCP. The create keyword is used to create a new subnet. privatesubnet is the name of the new subnet that will be created. `--network=privatenet` specifies the network that the subnet will be created in. `--region=us-central1` specifies the region where the subnet will be created. `--range=10.0.0.0/24` specifies the IP address range for the subnet. `--enable-private-ip-google-access` enables private IP Google access for the subnet An IP address range that is assigned to a regional resource is called a subnet. Subnets and subnetworks are interchangeable in Google Cloud. Prior to being utilized, a network must have a minimum of one subnet. Subnets can be set either manually or automatically. A subnet with a route to an internet gateway but no route table association is called a private subnet. This indicates that instances inside the subnet are inaccessible over the internet.

Businesses could gain from creating a private subnet since it enables them to set up a private network for their services and applications. This can assist companies in maintaining the security and isolation of their apps and data from the public internet. Businesses may help prevent data breaches and other security risks by establishing a private subnet to shield their data from the internet. Furthermore, private subnets may be utilized to provide a secure testing and development environment, assisting companies in identifying and resolving issues before they become a problem.

4   Data Analysis and Results

4.1   Cloud with Dataflow

The design, development, management of real-time data processing and analysis systems are the focus of the discipline of data engineering for streaming data. Prompt decision-making and timely insights are the two main objectives of developing a real-time data system. Such solutions may be

developed with the support of Google Cloud's group of goods and services [5, p. 197]. Data is made more accessible, usable, and structured from the moment it is created, according to Google Cloud's literature on streaming analytics solutions. Data input via Pub/Sub, data processing via Dataflow, and data visualization via Looker and Data Studio comprise Google Cloud's end-to-end pipeline for handling streaming data.

4.1.1 BigQuery dataset

BigQuery is a cloud-based data warehouse that allows users to store, manage, and analyze large datasets. It is a fully managed, serverless solution that can handle petabyte-scale data analysis workloads [5, p. 197]. The Trip Record Data of the New York City Taxi and Limousine Commission (TLC) is one of the datasets that can be found on BigQuery. This includes details on taxi trips in New York City, such as the destinations for pickup and drop-off, the cost, and the total distance of the journey [11].

The following command generates the taxirides dataset in Cloud Shell:


```
student_01_a774401dddd4@cloudshell:~ (qwiklabs-gcp-01-4188540114aa)$ bq --location=us-central1 mk taxirides
/usr/lib/google-cloud-sdk/platform/bq/bq.py:17: DeprecationWarning: 'pipes' is deprecated and slated for removal in Python 3.13
  import pipes
Dataset 'qwiklabs-gcp-01-4188540114aa:taxirides' successfully created.
```

Figure 10. Cloud Shell terminal. Importing dataset.

This command down below creates a new table in Google BigQuery with the specified schema and time-based partitioning field.


```
student_01_a774401dddd4@cloudshell:~ (qwiklabs-gcp-01-4188540114aa)$ bq --location=us-central1 mk \
--time_partitioning_field timestamp \
--schema ride_id:string,point_idx:integer,latitude:float,longitude:float,\
timestamp:timestamp,meter_reading:float,meter_increment:float,ride_status:string,\
passenger_count:integer -t taxirides.realtime
/usr/lib/google-cloud-sdk/platform/bq/bq.py:17: DeprecationWarning: 'pipes' is deprecated and slated for removal in Python 3.13
  import pipes
Table 'qwiklabs-gcp-01-4188540114aa:taxirides.realtime' successfully created.
```

Figure 11. Cloud Shell terminal. Importing us-central dataset.

Figure 11 display a command-line instruction for creating a new table in Google
BigQuery. The `bq` command is used to interact with BigQuery. The `--location`
specifies the location of the dataset, and the `mk` command is used to create a
new table. The `--time_partitioning_field` specifies the field to use for
time-based partitioning, which is a feature that allows you to divide a large table
into smaller, more manageable pieces based on time. The `--schema` specifies
the schema of the new table, which includes the names and types of the
columns in the table. The `-t` specifies the name of the new table, and the
`taxirides.realtime` argument specifies the dataset and table name in the
format `dataset.table`.

In the subsequent step, a cloud storage bucket should be created to store a
large amount of data and retrieve archival data, as well as serve website
content. To create a cloud storage bucket, users can follow the instructions
provided by the cloud storage provider. For example, **Google Cloud Storage**
provides a simple process for creating a bucket. Users can navigate to the
Cloud Storage Buckets page in the Google Cloud console, click on the + Create
button, and enter the required information for the bucket, such as the name,
location, and storage class. Once the bucket is created, users can upload
objects into the bucket and manage them as needed.

Figure 12. Cloud Shell terminal. Cloud storage buckets.

4.1.2 Streaming pipeline

Continuing with the previous example this step is necessary to store data in real
time.

Figure 13. Cloud Shell terminal. Access to real time data.

Data processing pipelines may be created and managed in the cloud with **Dataflow API service**. Access the Dataflow interface inside the GCP dashboard to generate a task template.
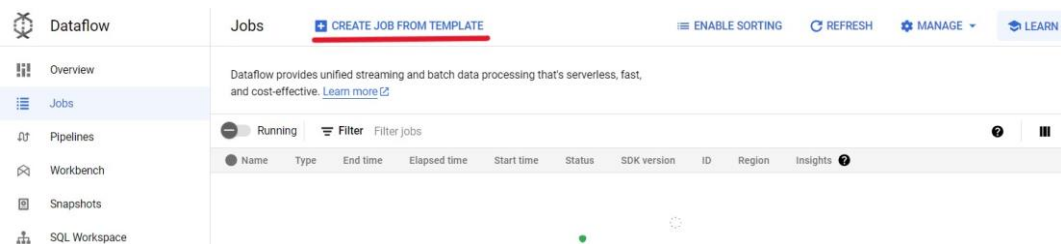
Figure 14. Dataflow dashboard.

Job name step

Regional step

Dataflow template step

Schema file step

Cloud Storage step

The fully qualified BigQuery table *
☑ qwiklabs-gcp-01-4188540114aa:taxirides.realtime   BROWSE

The Cloud Storage location of the text you'd like to process *
gs://qwiklabs-gcp-01-4188540114aa-bucket/tmp/rt_taxidata.csv

Example: gs://your-bucket/your-files/text.txt

Temporary directory for BigQuery loading process *
☑ gs:// qwiklabs-gcp-01-4188540114aa-bucket/tmp   BROWSE

Example: gs://your-bucket/your-files/temp_dir

Temporary location *
☑ gs:// qwiklabs-gcp-01-4188540114aa-bucket/tmp   BROWSE

Machine type step

| ✓ General purpose | Compute optimized | Memory optimized | GPUs |

Machine types for common workloads, optimized for cost and flexibility

Series
E2

CPU platform selection based on availability

Machine type
e2-medium (2 vCPU, 1 core, 4 GB memory)

vCPU	Memory
1-2 vCPU (1 shared core)	4 GB

Down below is the result once all the details are filled:
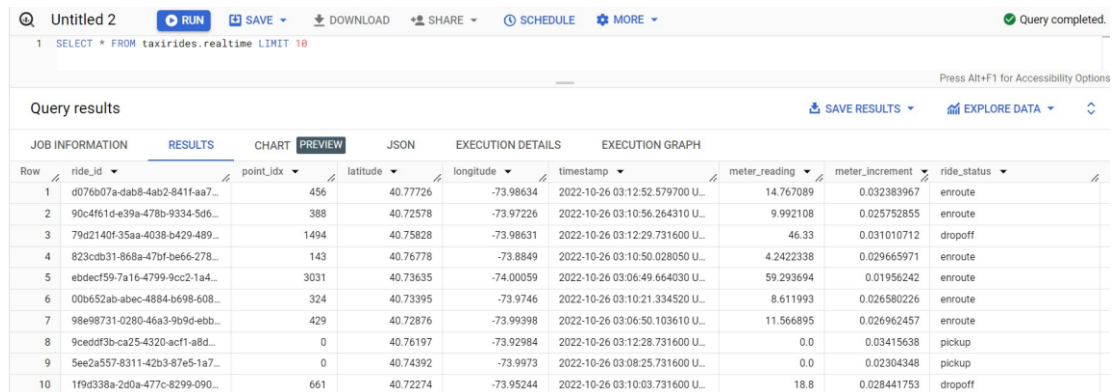
Job info

Job name	streaming-taxi-pipeline
Job ID	2023-11-30_14_45_54-2799510916068908379
Job type	Streaming
Job status	⟳ Running
SDK version	Apache Beam SDK for Java 2.51.0
Job region	us-central1
Worker location	us-central1
Current workers	0
Latest worker status	Starting a pool of 1 workers.
Straggler status	No active straggler
Start time	December 1, 2023 at 12:45:56 AM GMT+2
Elapsed time	1 min 30 sec
Encryption type	Google-managed
Dataflow Prime	Disabled
Runner v2	Disabled
Streaming Engine	Disabled
Vertical Autoscaling	Disabled

Figure 15. Dataflow execution.

At the query editor using SQL commands to filter and process data from database:

Figure 16. Cloud Shell editor.

Another example to process data from database using SQL commands:

Figure 17. Cloud Shell editor.

Result down below from the previous code:

Row	dashboard_sort	minute	total_rides	total_revenue	total_passengers
1	1	2022-10-26 03:13:00 UTC	2	0.0	2
2	2	2022-10-26 03:13:00 UTC	1	26.307207	1
3	3	2022-10-26 03:13:00 UTC	2	23.3	2
4	4	2022-10-26 03:13:00 UTC	1	8.120775	1
5	5	2022-10-26 03:13:00 UTC	3	18.599999	6
6	6	2022-10-26 03:13:00 UTC	1	11.025369	1
7	7	2022-10-26 03:13:00 UTC	1	32.15	1
8	8	2022-10-26 03:13:00 UTC	1	28.61771	2
9	9	2022-10-26 03:13:00 UTC	1	52.460243	6
10	10	2022-10-26 03:13:00 UTC	1	13.8	1
11	11	2022-10-26 03:13:00 UTC	1	6.346747	1
12	12	2022-10-26 03:13:00 UTC	1	22.118544	1
13	13	2022-10-26 03:13:00 UTC	2	14.8	2
14	14	2022-10-26 03:13:00 UTC	1	42.55505	3
15	15	2022-10-26 03:13:00 UTC	1	12.8	1
16	16	2022-10-26 03:13:00 UTC	1	2.622159	1
17	17	2022-10-26 03:13:00 UTC	1	13.3	1

Figure 18. Cloud Shell execution.

4.2 Python application on Kubernetes engine

A controlled environment called Google Kubernetes Engine (GKE) lets customers grow, manage, and launch containerized apps on Google infrastructure. Kubernetes Engine provides a clustered environment made up of several computers (particularly, Google Compute Engine instances) grouped together [4, p. 108].

The tools that users utilize to communicate with their cluster are provided by the open-source platform Kubernetes. To deploy and manage applications, carry out administrative duties, establish policies, and keep an eye on the wellbeing of deployed workloads, users can benefit from Kubernetes commands and resources [4, p. 109].

4.2.1 Using Python to launch a quiz app

This section will show Kubernetes best practices. Through google training program a git repository is available to deploy a quiz app.

Step 1

Figure 19. Cloud Shell terminal. Git repository extraction.

Right after the repo is completed the next step is to set up the environment and work directly with the application.

Step 2

Figure 20. Cloud Shell terminal. Configuring packages.

Basically, configure Kubernetes service account which is named `quiz-account`. The command `prepare_environment.sh` has successfully created the service account and generated an associated key of type JSON. Additionally, have updated the IAM policy for the project. The result of these actions will be that the `quiz-account` is now configured with specific permissions and roles as defined in the updated IAM policy, enabling it to interact with various resources within the GCP project.

Figure 21. Cloud Shell terminal. App environment is finished.

Step 3

The Cloud Shell Editor is a built-in code editor that allow to browse file directories, and view and edit files, with continued access to the Cloud Shell. The editor is available by default with every Cloud Shell instance.
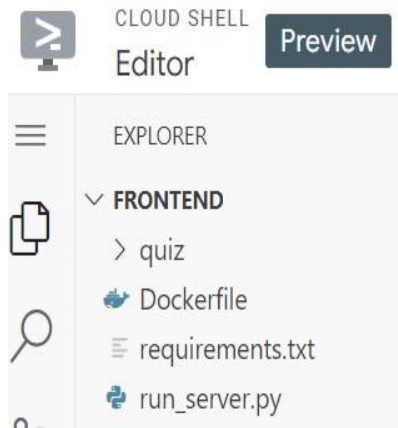

Figure 22. Cloud Shell editor.

The IDE is in the process of previewing a project structure under the "FRONTEND" directory. Within this directory, there is a sub-directory named "quiz," and three files: "Dockerfile," "requirements.txt," and "run_server.py." These files are working on a frontend application, involving a quiz feature, with Docker for containerization.
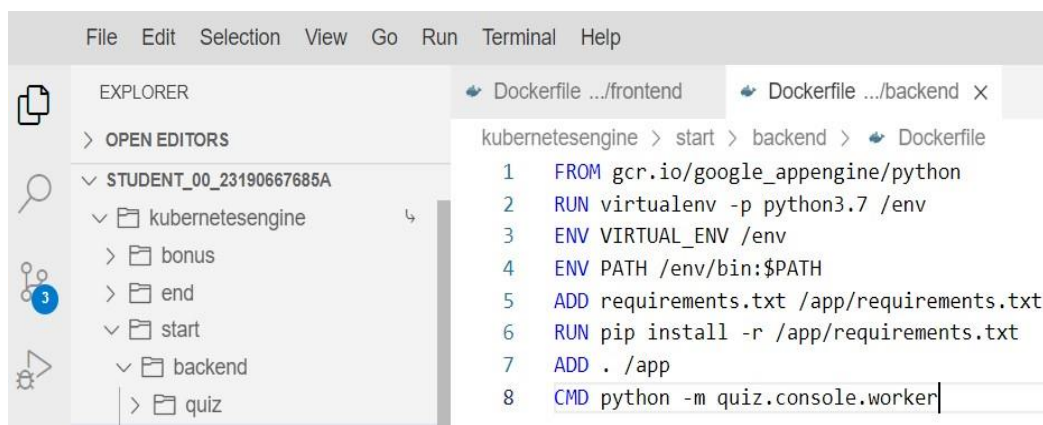

Figure 23. Cloud Shell editor. Configuring Dockerfiles.

On the right side of figure 23, a Dockerfile is open with instructions for creating a Docker container. The instructions include specifying a base image from

Google App Engine optimized for Python applications, setting up a virtual environment, installing requirements from a "requirements.txt" file, adding application files to the container, and specifying the command to run an application module named "quiz.console.worker".

Step 4

	Name ↑	Status	Type	Pods	Namespace	Cluster
☐	quiz-backend	✅ OK	Deployment	2/2	default	quiz-cluster
☐	quiz-frontend	✅ OK	Deployment	3/3	default	quiz-cluster

Figure 24. Application status.

Both deployments are in the "OK" status, indicating they are operational and healthy. The "Type" column specifies that these are "Deployment" types, a standard workload object in Kubernetes to manage applications. The "Pods" column shows the number of current pods compared to the desired state; both deployments have achieved their desired state (2/2 for quiz-backend and 3/3 for quiz-frontend).
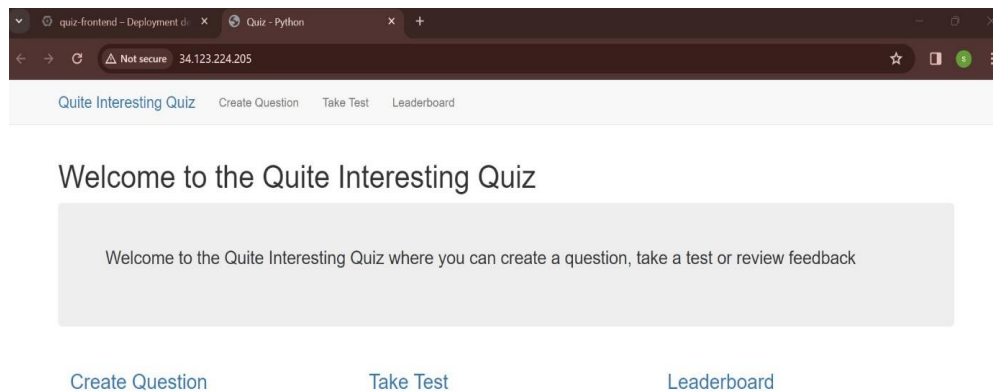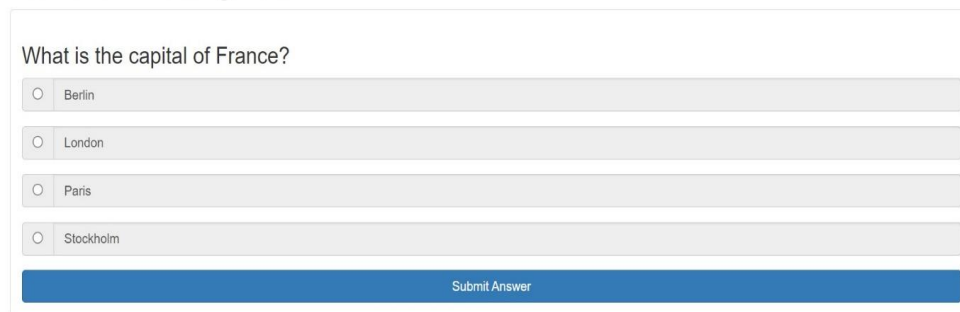

Figure 25. App interface.

Figure 26. Fully operational software.

The app has successfully been deployed via localhost. A load balancer is executed by the service to display the frontend deployment. The load balancer sends requests from users to all instances through the frontend component.

4.2.2 Managing Traffic with Cloud Run

Traffic management is an essential aspect of software development and deployment. It refers to the process of controlling the number and/or type of visitors to a website [10, p. 3]. This chapter, discuss traffic management with Cloud Run, a serverless computing platform offered by Google Cloud.

To use Cloud Run for traffic management, the first step is to enable the **Cloud Run API**. This can be done by navigating to the Google Cloud Console and selecting the project that you want to work with. From there, you can enable the Cloud Run API by clicking on the "APIs & Services" tab and searching for "Cloud Run API." Once you have enabled the API, you can proceed to deploy a Cloud Run service.

```
gcloud services enable run.googleapis.com.
```

This command enables the Google Cloud Run API. It allows the user to deploy and manage applications on a fully managed serverless platform*.*

```
gcloud config set compute/region us-central1.
```

Sets the compute region property in the configuration to `us-central1`. This means subsequent commands will be executed in this specified region unless overridden.

Deploying a Cloud Run service involves creating a container image of an application and deploying it to Cloud Run. Users can use the Cloud Console or the gcloud command-line tool to deploy any service [10, p. 3]. Once the service is deployed, users can assign tags to a revision. Tags are used to identify specific versions of a particular application.

```
gcloud run deploy product-service \
--image gcr.io/qwiklabs-gcp-01-0769a8d5142c/product-status:0.0.1
\
--tag test1 \
--region us-central1 \
--allow-unauthenticated
```

Deploys a new revision of a container to Cloud Run service named "product-service". The container image specified is pulled from **Google Container Registry**, tagged as `test1`, deployed to region `us-central1`, and is accessible without authentication.

After is assigned tags to a revision, this can migrate traffic to a revision. This involves specifying which revisions should receive traffic and the percentage of traffic that each revision should receive. Migrating traffic to a revision allows users to gradually roll out a revision, split traffic between multiple revisions, and rollback to a previous revision if necessary. Rolling back a revision involves routing all traffic to a previous revision. Therefore, Rolling back to a previous revision is useful if users encounter issues with a new revision and need to revert to a previous version [10, p. 3].

```
TEST1_PRODUCT_SERVICE_URL=$(gcloud run services describe product-
service --platform managed \
--region us-central1 --format="value(status.address.url)")
```

Assigns the URL of the deployed service "product-service" to an environment variable named `TEST1_PRODUCT_SERVICE_URL`. It retrieves this URL by describing the service and extracting its address URL.

```
curl $TEST1_PRODUCT_SERVICE_URL/help -w "\n".
```

Sends an HTTP request to the "/help" endpoint of the deployed service "product-service" `TEST1_PRODUCT_SERVICE_URL`.
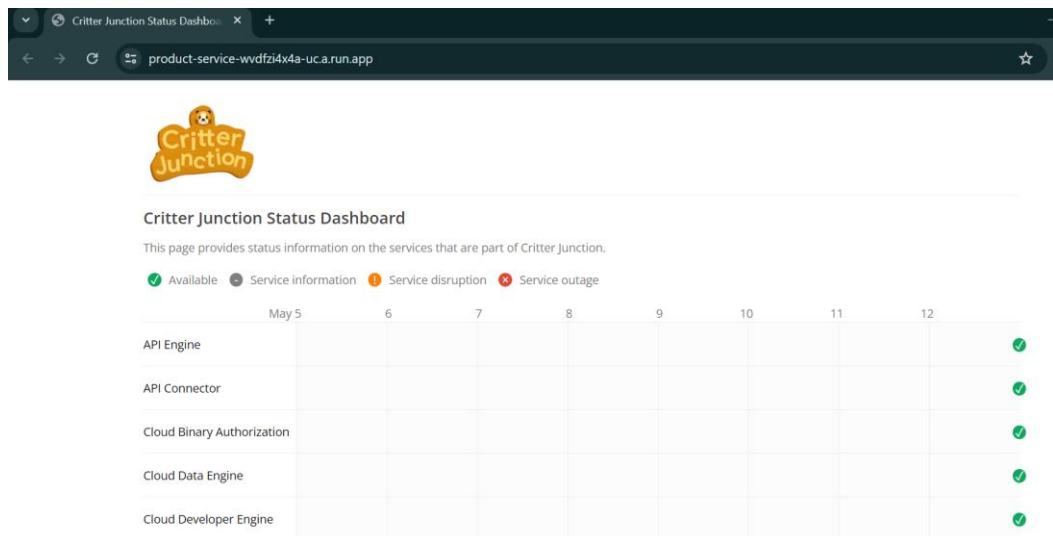
Response from the service:

Figure 27. Critter Junction Status.

Then is possible to test the server multiple times with the following code:

```
$for i in {1..10}; do curl $TEST1_PRODUCT_SERVICE_URL/help -w
"\n".
```

Figure 28. Loop Function.

This is a loop that executes a curl command ten times. Here, it sends requests to the URL stored in the variable `$TEST1_PRODUCT_SERVICE_URL/help`.
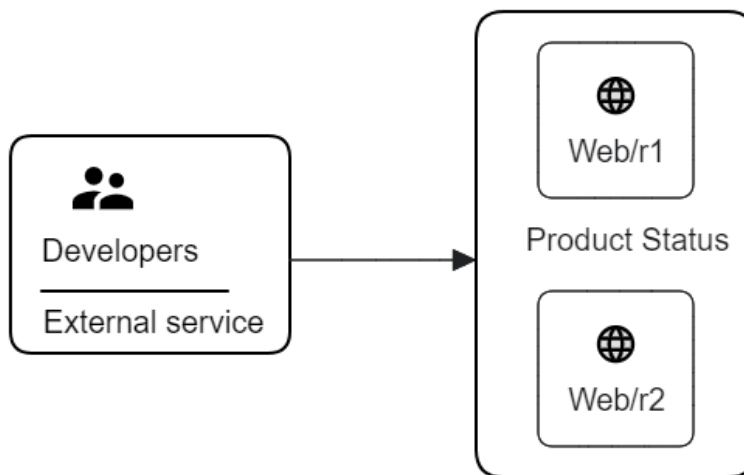

Figure 29. Developer Interaction with Product Status Interface.

To illustrate how traffic management with Cloud Run works, consider a scenario where a team of developers is working on two versions (r1 and r2) of a web application hosted on Cloud Run and utilizing serverless computing. The developers interact with external services to enhance functionality or performance. Traffic management ensures that updates, modifications, or testing do not impact the live application's performance or user experience. For instance, the team can assign tags to each revision (r1 and r2) and gradually migrate traffic to the new revision (r2) while monitoring the application's

performance. If any issues arise, the team can quickly rollback to the previous revision (r1) and investigate the issue.

5 Conclusion

In conclusion, it has been a great and interesting experience to study how Google Cloud products and services could become integrated to support start-up success. This study has shown that incorporating cloud technology especially Google Cloud solutions presents new businesses with many possibilities to grow, develop, and advance in a business environment that is becoming more and more competitive every day. The results of this study reflect the innovative potential in improving business growth for startups in a range of industries. They may improve their decision-making processes, streamline operations, and deliver higher-quality services for their consumers with GCP scalable infrastructure, powerful data analytics, and AI capabilities. On the other hand, extensive planning, clear strategy, and a dedication to continuing development and evolution are necessary for successful execution.

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