

# **CLOUD COMPUTING**

## **(Undergraduate Course)**

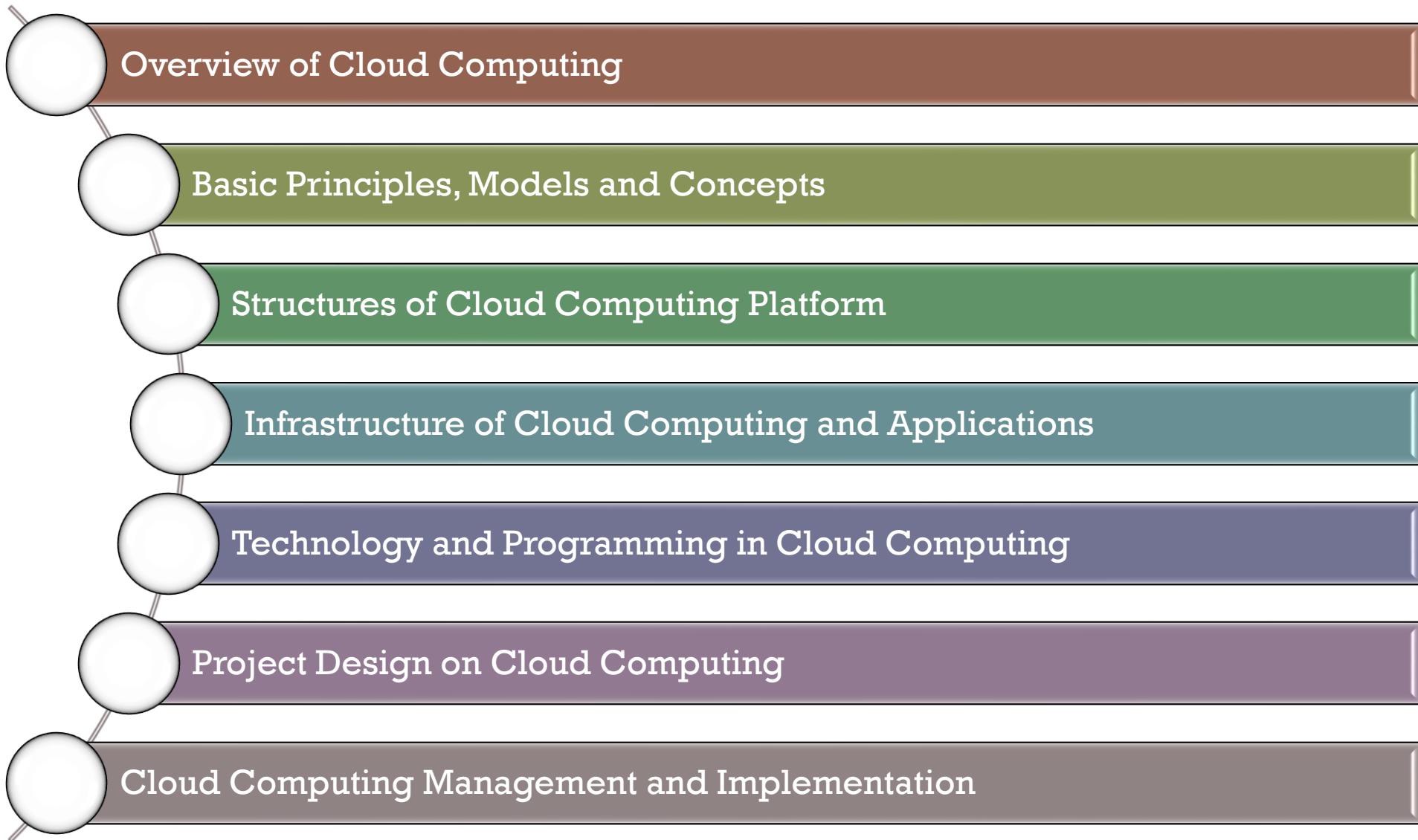
### **Chapter 5 – Cloud Technology and Application Programming**

**Presenter: Dr. Nguyen Dinh Long**

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Oct. 2022

# Outline



# References

Main:

- Thomas Erl, Zaigham Mahmood, and Ricardo Puttini. 2013. *Cloud Computing Concepts, Technology & Architecture*. Prentice Hall.
- Michael J. Kavis. 2014. *Architecting the Cloud: Design Decisions for Cloud Computing Service Models*. Wiley
- Arshdeep Bahga, and Vijay Madisetti. 2013. *Cloud Computing: A Hands-On Approach*. CreateSpace Independent Publishing Platform

More:

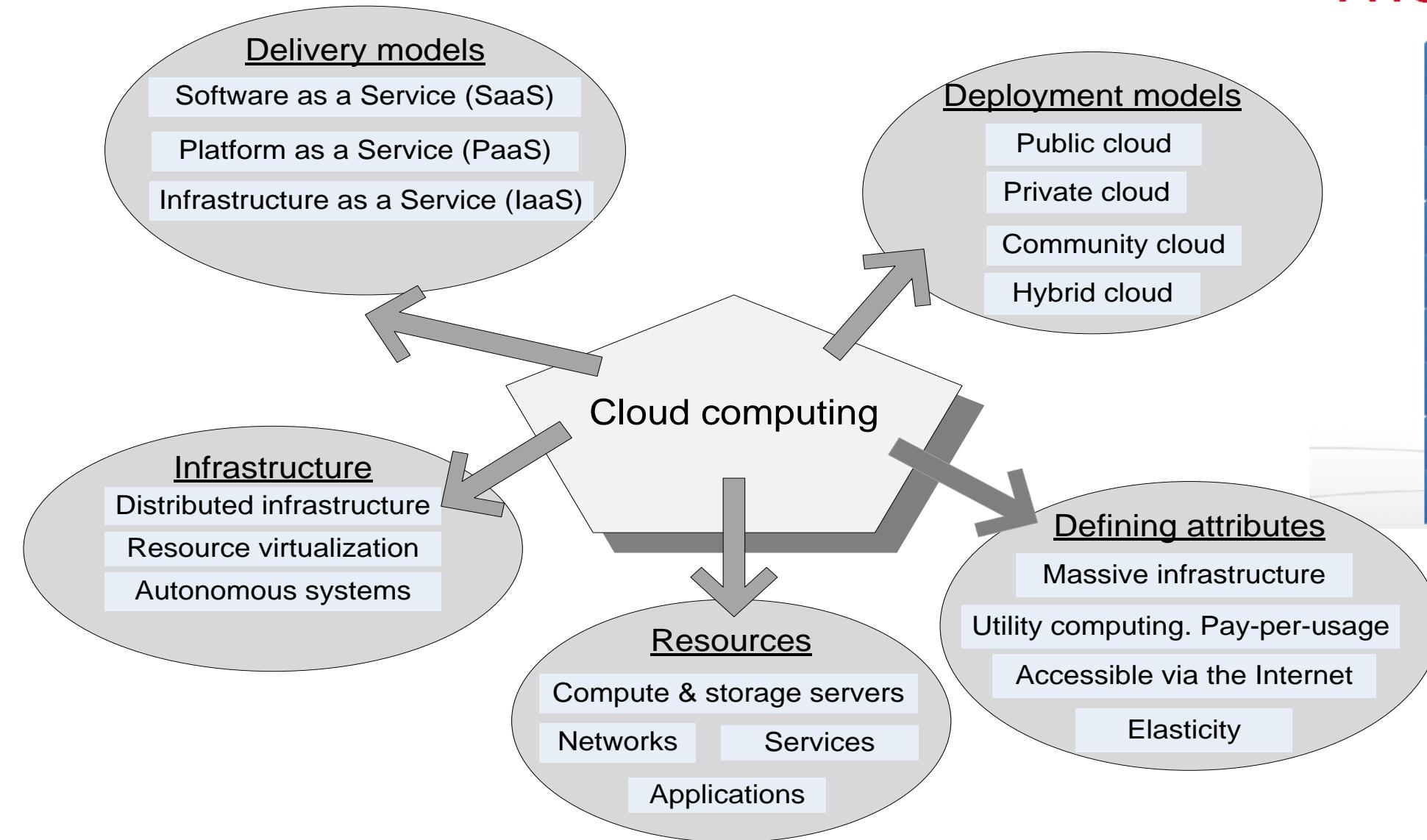
- Rajkuma Buyya, Jame Broberg and Andrzej Goscinski. 2011. *Cloud Computing –Principles and paradigms*, Wiley
- Nick Antonopoulos, and Lee Gillam. 2010. *Cloud Computing - Principles, Systems and Applications*, Springer-Verlag London Limited.
- Slides here are modified from several sources in Universities and Internet.

# Content of Chapter 5

1. Cloud technology and delivery models
2. Cloud application programming
3. Practice 1

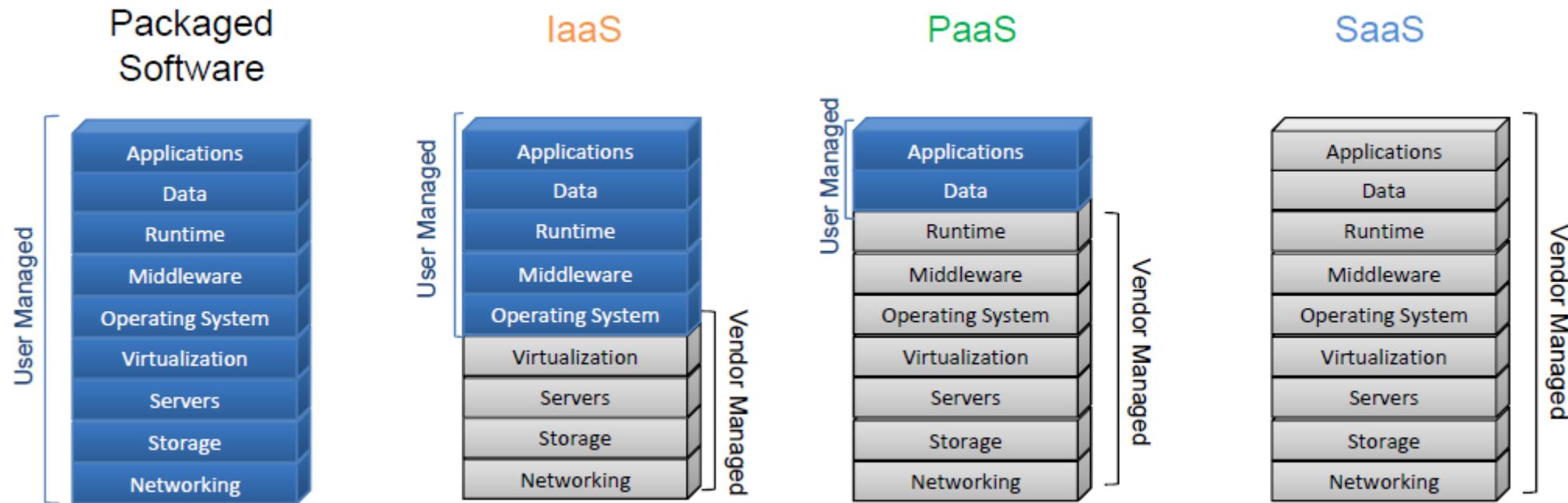
# CLOUD CONCEPTS AND PRINCIPLES

## The Cloud Stack



# Cloud Delivery Models

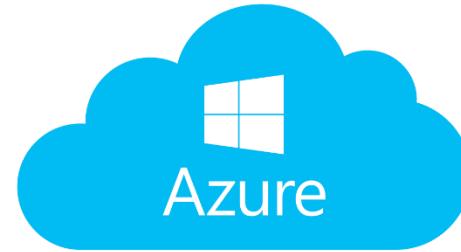
## □ Cloud Service Layers ...



# Cloud Infrastructure and Applications

## ❑ Application architectures:

- Compute services
- Storage services
- Database services



- Application services
- Content delivery services
- Analytics services
- Deployment and Management services
- Identity & Access management services



# Cloud Infrastructure and Applications

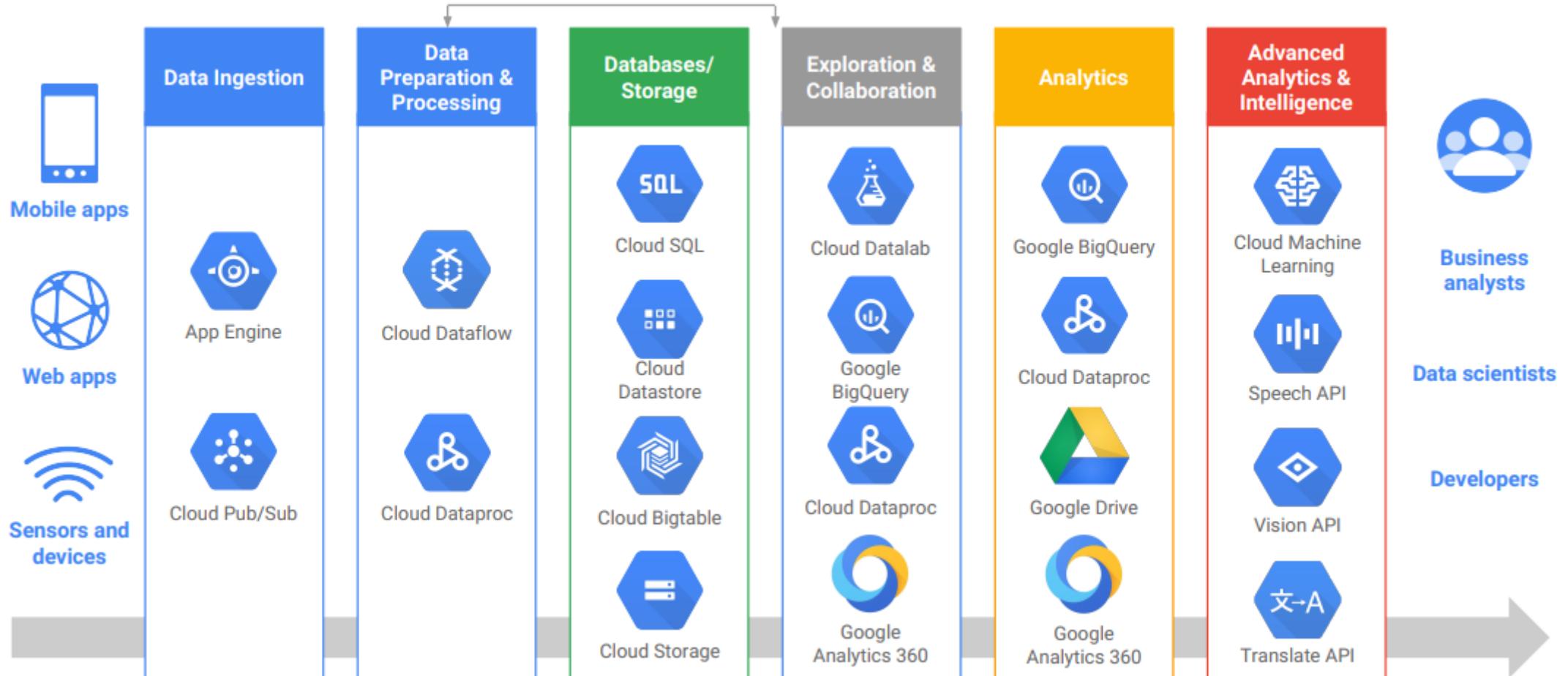
## ❑ Analytics services:

### Smart Analytics - A comprehensive platform



# Cloud Infrastructure and Applications

## ❑ Analytics services:



# Cloud Technology and Applications



Đa ứng dụng,  
phương tiện



Đa tương tác  
Low coding



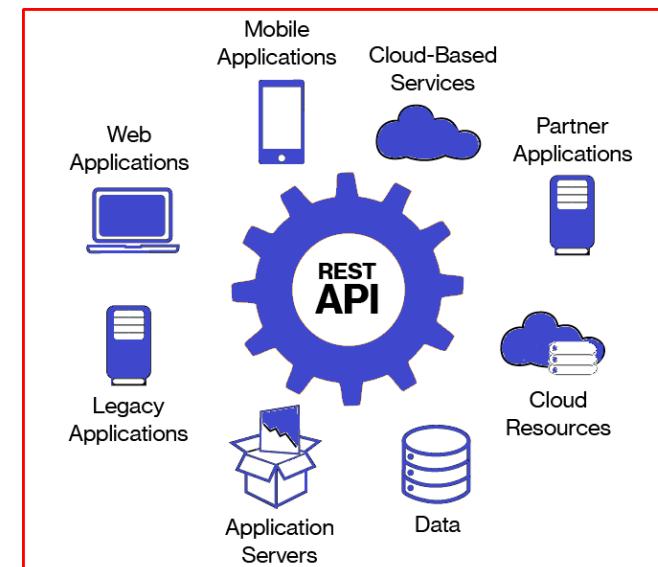
Cơ sở dữ liệu trực tuyến



# Cloud Technology and Applications

## □ REST, RESTfull:

- Imagine you were suddenly transported to a foreign city where you don't speak the language—in fact, every person you encounter speaks a different language, and you aren't even sure which one they are. That's the situation faced by many developers and users today as they try to integrate different software and systems.
- One of the greatest challenges of modern computing is its complexity. With millions of different software applications, services, and systems currently in use, each one is speaking its own "language." How can they ever hope to have meaningful communications by exchanging information with each other?
- So what can you do in the face of this spiraling complexity and lack of universal communication standards? The answer, for many organizations, is using a [REST API](#).



# Cloud Technology and Applications

## □ REST, REST API and Why:

- **Simplifies Development**

If APIs didn't exist, developers would have to write a separate communication protocol for each third-party software or service with which they wanted to communicate. Not only would this be time-consuming and technically complex, but it would also be highly brittle—if one of the systems changed, it could break the entire protocol and force developers to start from scratch.

- **Provides an Abstraction for Technical Details**

Even if everyone spoke the same “language,” communicating between two different systems would still be technically challenging without an API. Developers would have to dive deep into low-level concepts such as data formats and data transfer, making it more challenging and laborious—and preventing you from getting quick, easy access to the information you need.

APIs solve this problem by presenting a clean, smooth layer of abstraction over the messiness of the underlying technical implementation. Instead of working with low-level communications protocols, developers simply have to look up the syntax of how to send a high-level REST API request—a much easier task.

# Cloud Technology and Applications

## □ REST, REST API and Why:

- [Most Popular API Architecture](#)

REST is by far the predominant choice for building APIs. According to a 2017 report, 83% of APIs use the REST architecture, while 15% make use of SOAP (simple object access protocol). Meanwhile, just 2% rely on neither of these and instead use Microsoft's .NET architecture.

The status of REST as the most popular API architecture carries with it a number of valuable benefits. For example, it's easier to find tools and tutorials for working with REST APIs. Tech giants such as Google, Amazon, Microsoft, and Twitter all actively promote REST APIs for accessing and using their services.

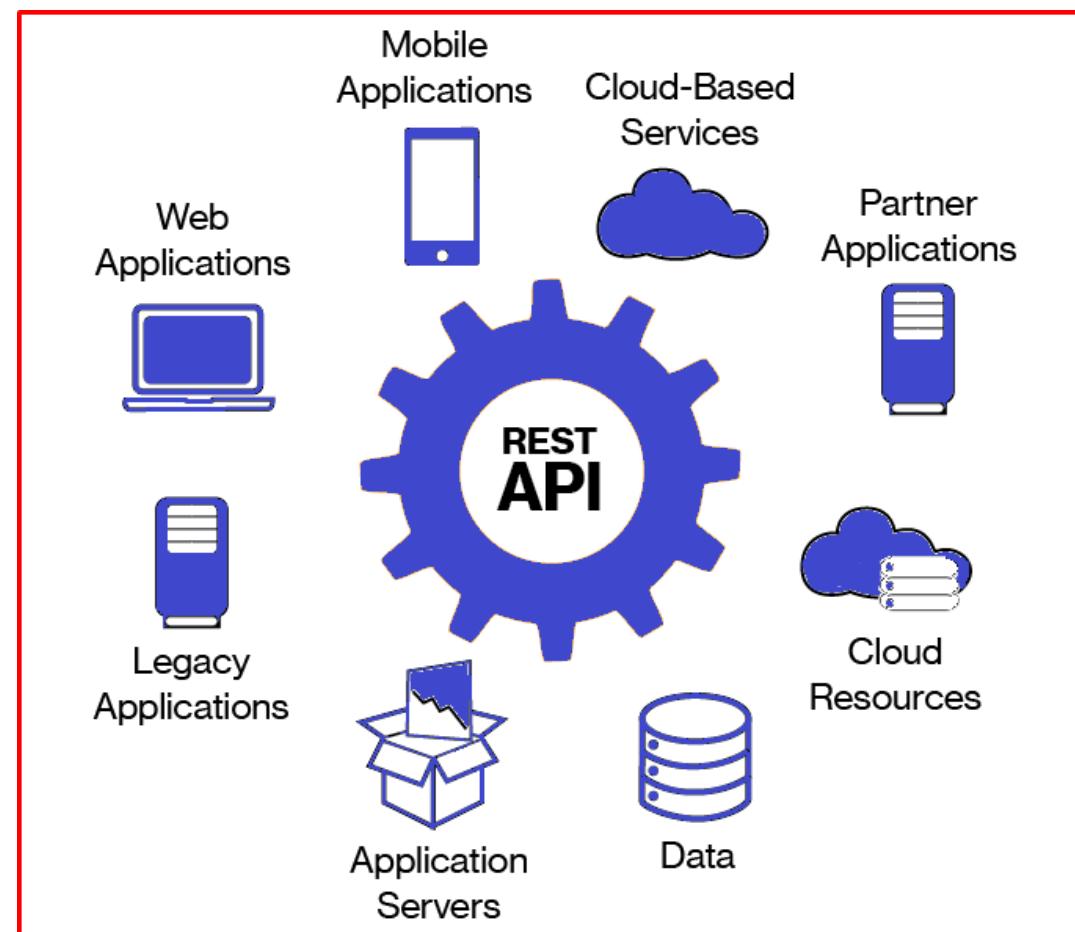
- [Technical Benefits](#)

Why is REST more widespread than SOAP and other API architectures in the first place? Much of its popularity has to do with the inherent technical advantages of the REST architecture. In fact, REST was created in part as an answer to some shortcomings of SOAP.

# Cloud Technology and Applications

## □ REST, RESTfull:

- REST ([Representational State Transfer](#)) is an API that defines a set of functions that programmers can use to send requests and receive responses using the HTTP protocol methods such as GET and POST.
- REST works over the HTTP protocol that provides communication between client-server. REST is a transfer method used in software based on service-oriented architecture.
- Rest services:
  - They are platform-independent.  
(It doesn't matter if the client is Windows, and the server is Linux)
  - They are language independent.
  - They work over HTTP.
  - They are flexible and can be extended very easily.



# Cloud Technology and Applications

## □ API, Cloud API:

- API ([Application Program Interface](#)) is an agreed way to send and receive data between computers.
- For example, if you want to display Google Maps on your site, but the maps are on Google's servers, you need a way to ask Google to provide you with the maps. The way to ask Google to send you the requested maps is through an API provided by Google that tells you to which web addresses should you send the requests to get the data. In a more formal language, you need to send a request to the remote server to get a response.

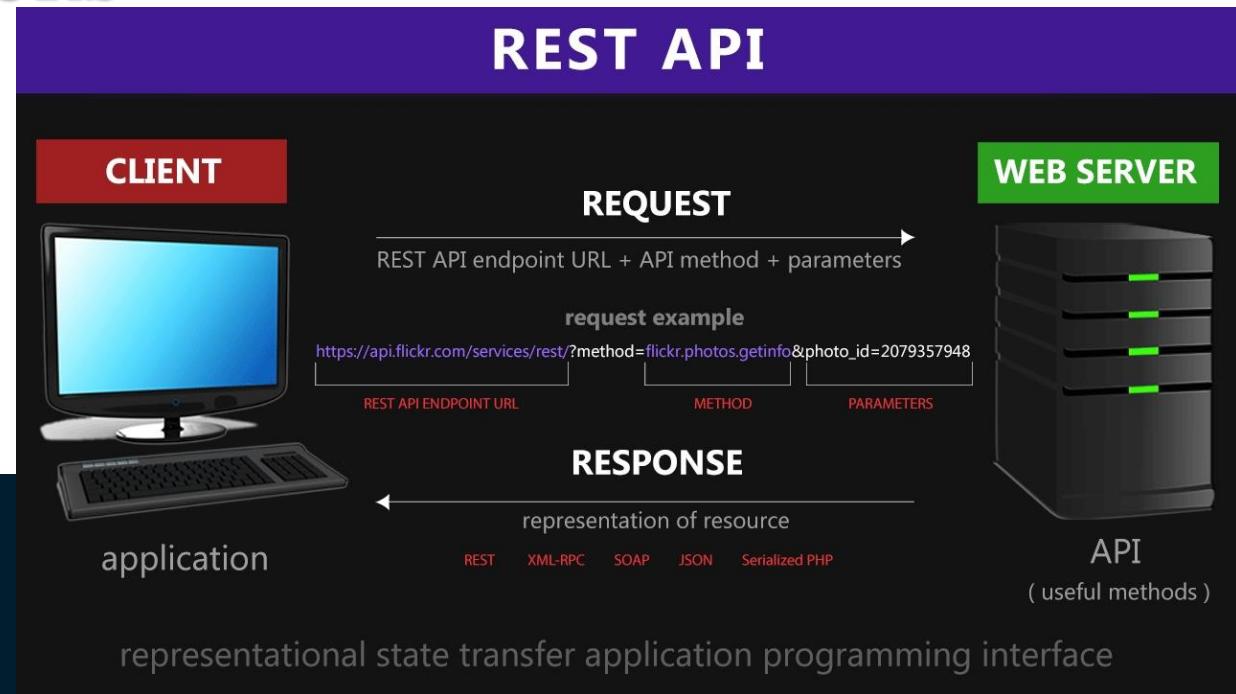
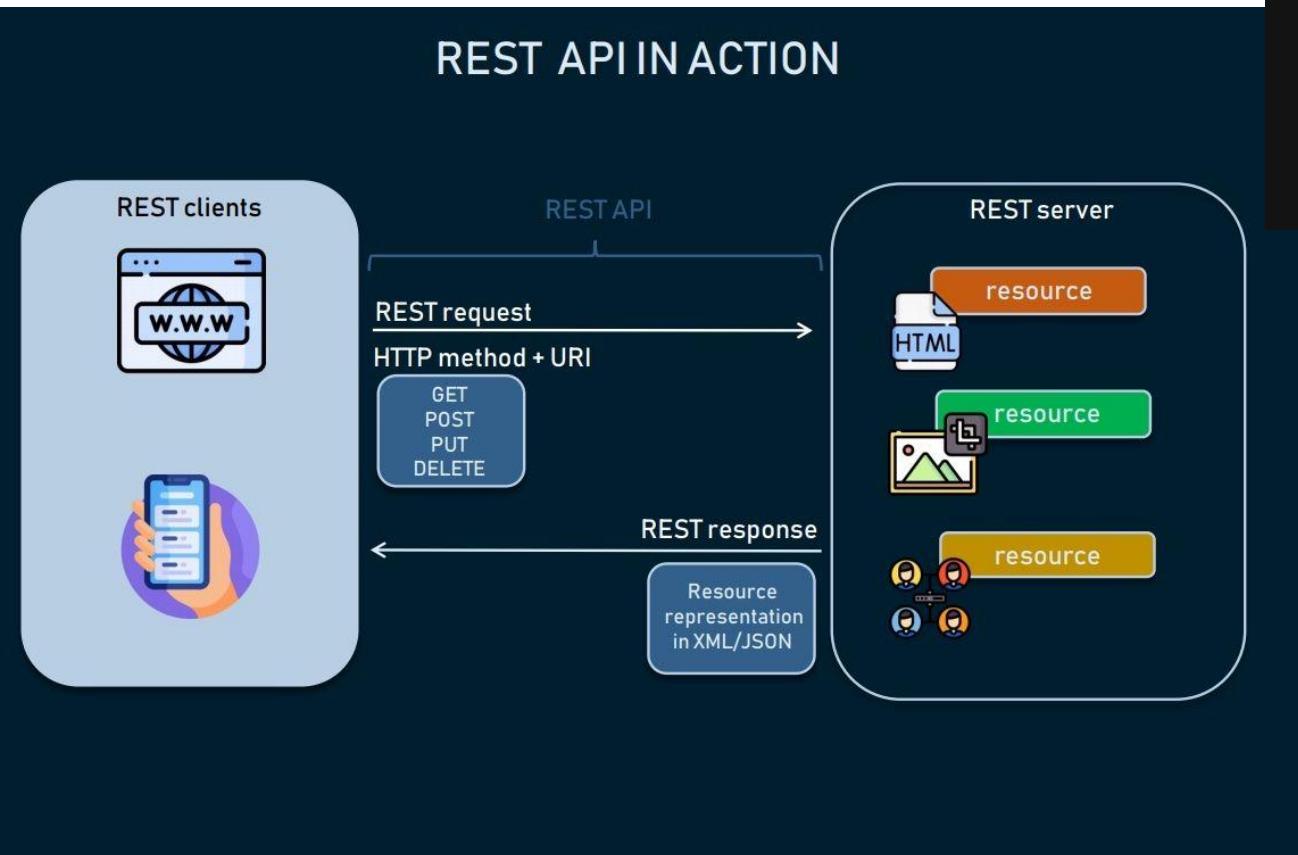
# Cloud Technology and Applications

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- REST ([Representational State Transfer](#)) is an API that defines a set of functions that programmers can use to send requests and receive responses using the HTTP protocol methods such as GET and POST.
- [REST API](#) can be used by any site or application no matter what language it is written in because the requests are based on the universal HTTP protocol, and the information is usually returned in the JSON format that almost all of the programming languages can read.

# Cloud Technology and Applications

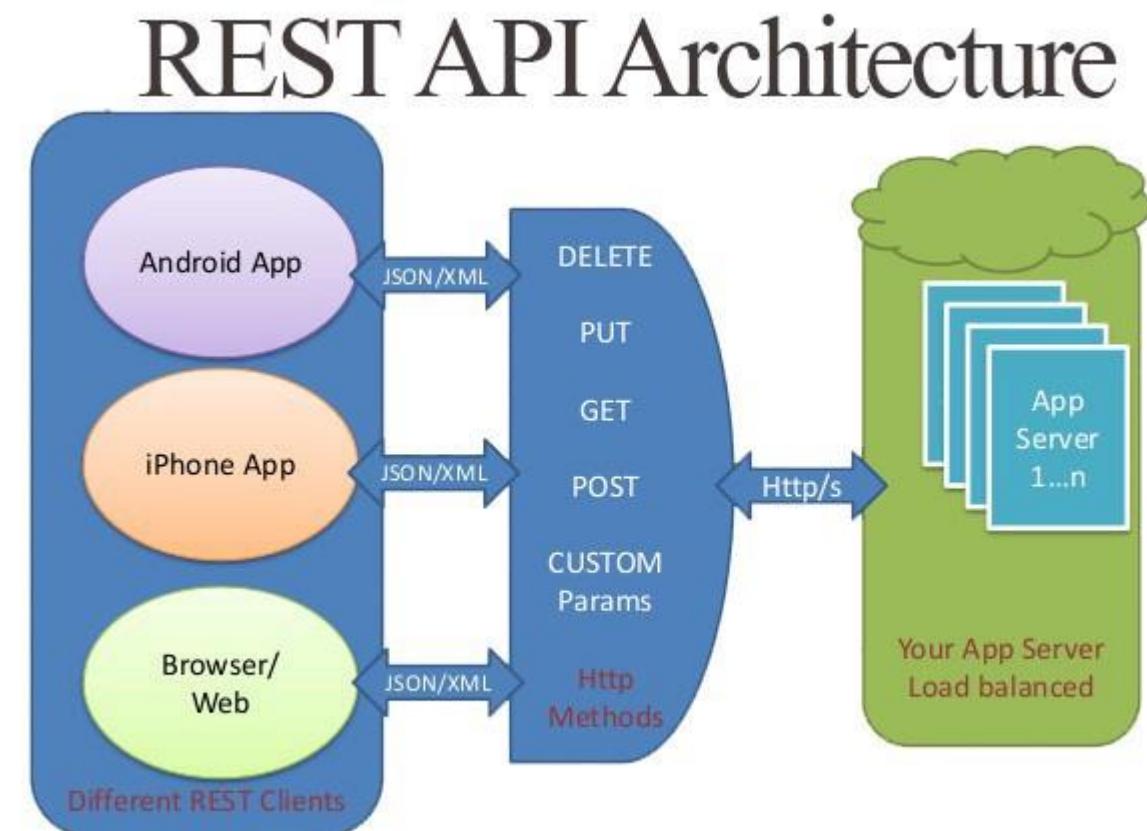
## □ REST, API, REST API:



# Cloud Technology and Applications

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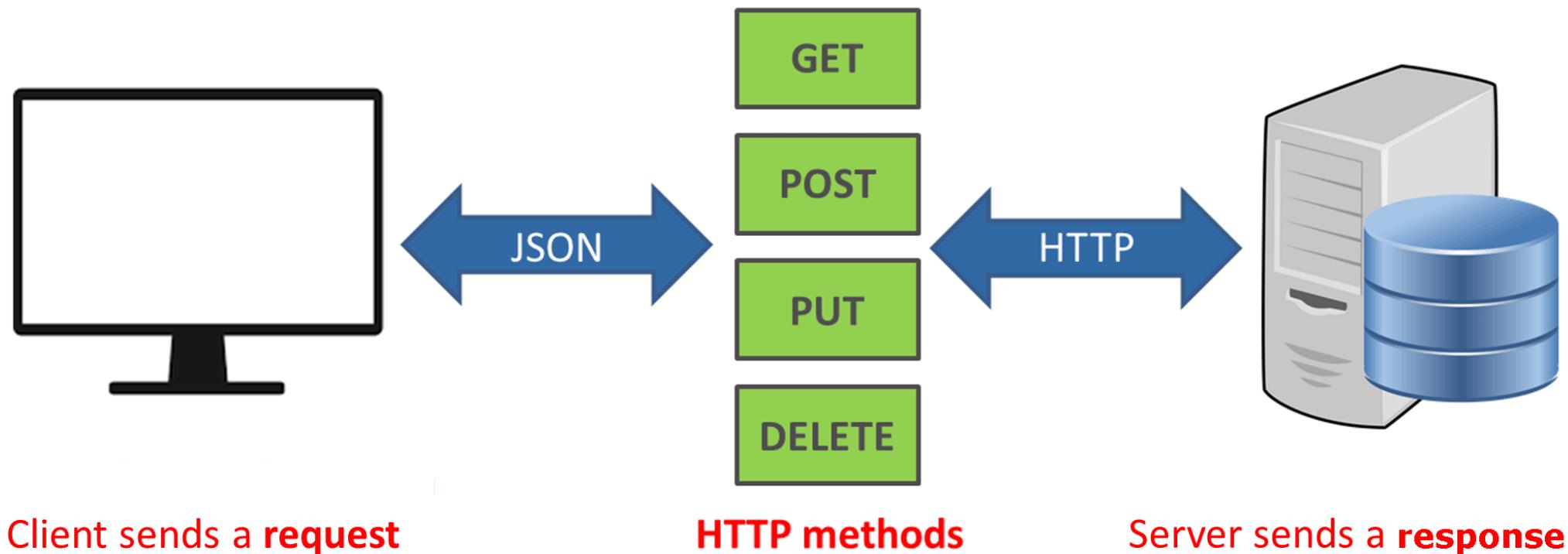
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# Cloud Technology and Applications

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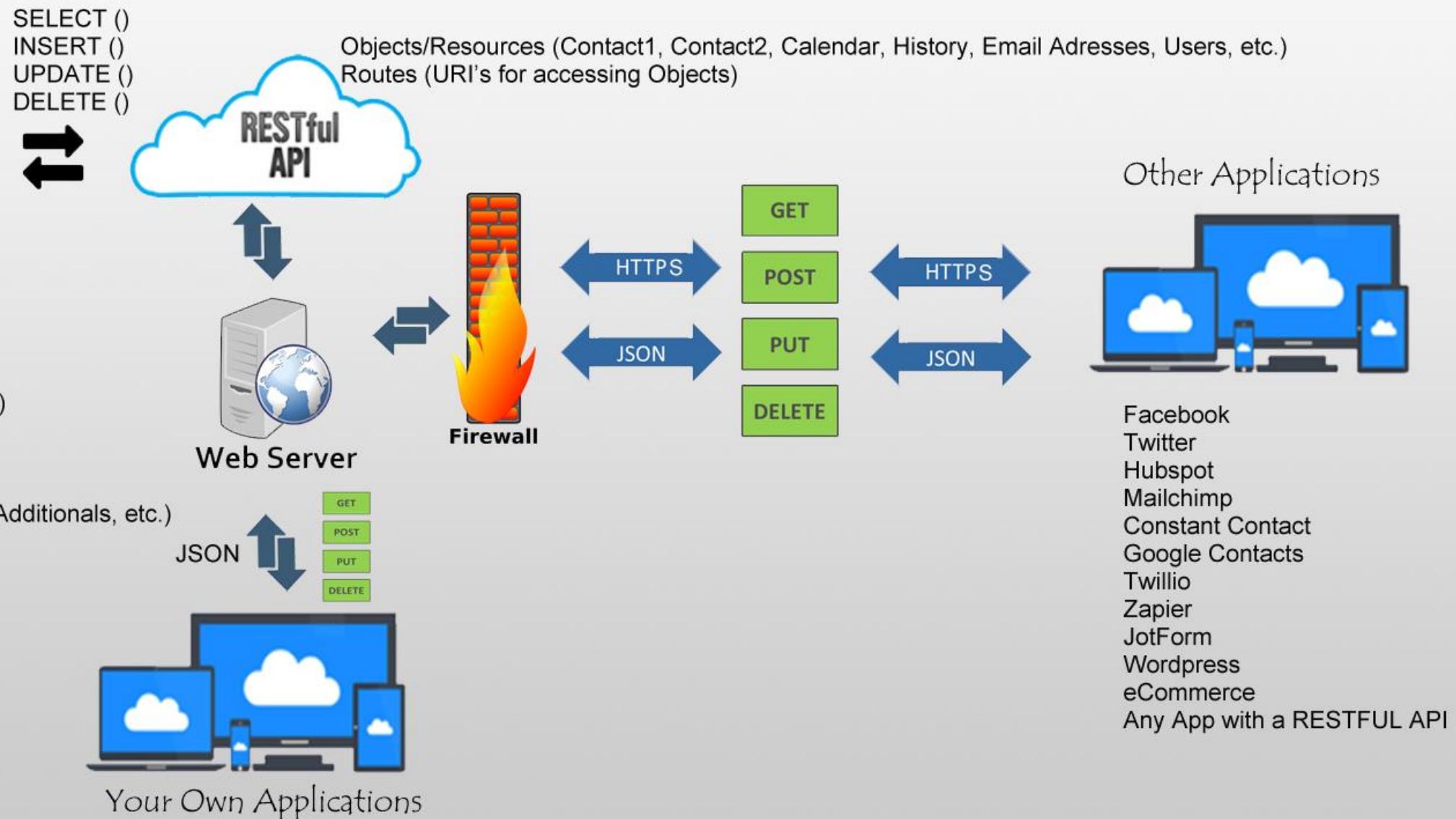
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# Cloud Technology and Applications



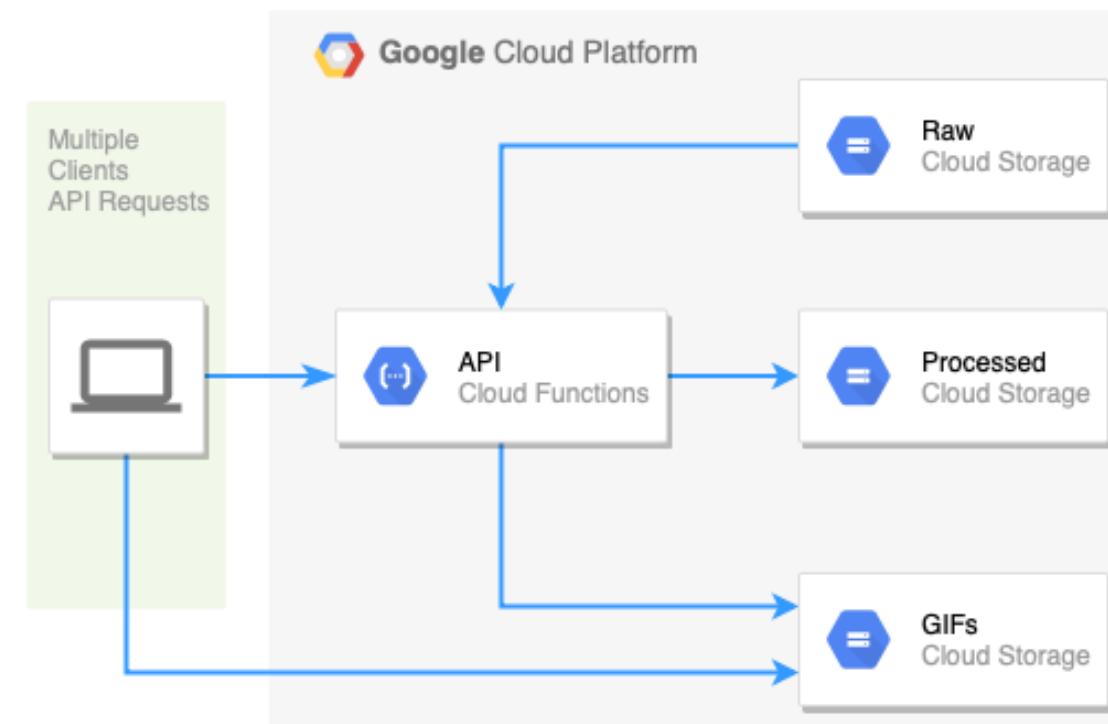
Contact1 (Primary Contacts)  
Contact2 (Custom fields)  
Cal (Calendar/Activities)  
ContHist (History)  
Contsupp (Emails, Details, Additionals, etc.)  
Cases  
Notes  
Mailbox (Email Messages)  
Lookup  
Users  
Logs  
Plus many more...



# Cloud Technology and Applications

## □ REST API in Google Cloud Platform:

- REST is a set of guidelines for API design. Its aim is to help developers create APIs which are accessible, usable, bug-free, and secure. It is based on six different principles.
- Client-Server: Your API should separate the data storage part of your application from the user interface. This lets you use the same datastore and API with multiple different front-ends.
- Stateless: Your API endpoints should not have to remember anything about the client between API calls that will allow it to function properly. Instead, each request to the API should contain all the information required to perform the task correctly.
- Cacheable: Data that can be cached should be cached so identical requests can return data from the cache instead of the primary data store.
- Uniform Interface: If your API is HTTP based, then be consistent in how you use the HTTP verbs (GET, POST, PUT, etc). It doesn't matter if they are used exactly as they are specified in their specification as long as they take on the same meaning between different uses in your API.
- Layered System: API components should follow the principle of least privilege, meaning endpoints should only have permissions to access the data they need to access.
- Code on Demand: This principle is optional to implement. APIs which do implement it can send executable code to the client upon request for the client to execute locally.



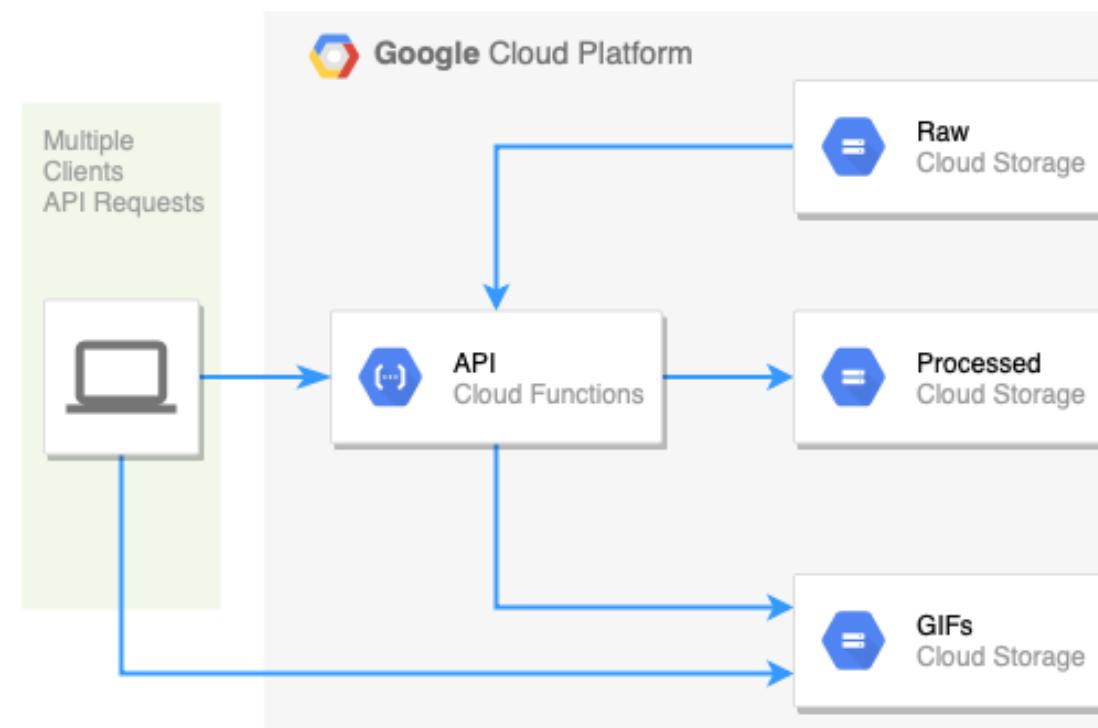
# Cloud Technology and Applications

## □ REST API in Google Cloud Platform:

- Google Cloud Platform (GCP) is the set of cloud solutions which Google provides. Depending on the needs of your application, you can use different resources that they offer.
- Google Cloud Storage(GCS): This is Google's solution for storing files in the cloud. Files are stored in a “bucket” which can contain both folders and files.
- Google Cloud Functions(GCF): These are serverless compute which are triggered to accomplish a single task.

Our API will only have two endpoints.

- When the user uploads an image to the “raw” folder in our Google Cloud Storage bucket, we will convert it to grayscale and save it to the “processed” folder in the bucket.
- The user can send a POST request with a list of image names and a frame rate and get back a GIF of the frames.



# Cloud Technology and Applications

## ❑ HTTP protocol:

- It sends requests from your personal computer and receives back data from remote servers. That's the internet in a nutshell. And it is feasible because all the computers that use the net speak in the same language, the same protocol with the name of HTTP.
- HTTP is the protocol on which the internet is based. It allows computers from anywhere in the world to send requests to remote servers, and get back responses that can be displayed in browsers.
- The following table summarizes the 4 most useful HTTP protocol methods:

GET	Retrieves data from a remote server. It can be a single resource or a list of resources.
POST	Creates a new resource on the remote server. *
PUT	Updates the data on the remote server.
DELETE	Deletes data from the remote server.

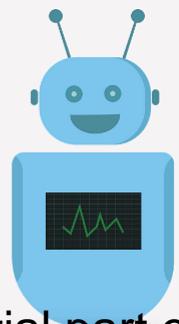
## Sample GCP Projects Ideas in 2022

*Explore this list of solved end-to-end GCP projects for students and professionals to take a step forward in your big data career.*

- Projects 1-5: Beginning
- Projects 6-10: Intermediate
- Projects 11-15: Advanced

# Cloud Technology and Applications

## 1. Web Chatbot Using Google Cloud Platform:



Web Chatbots have taken over the world in all fields. Be it any industry, chatbots have become an essential part of enhancing the user experience of any service or product. The entire Business to Customer segment has been sorted by the involvement of Web Chatbots on the Cloud.

The entire implementation of Web Chatbots using Google Cloud Platform is done with the help of a natural language processing technique called [Dialogflow](#). This processing technique is hosted on Google Cloud and provides a smooth conversational user interface. Dialog Flow can analyze various types of inputs, like text and video, to name a few, to ensure that the communication is bidirectional, and the response can be shared in multiple formats.

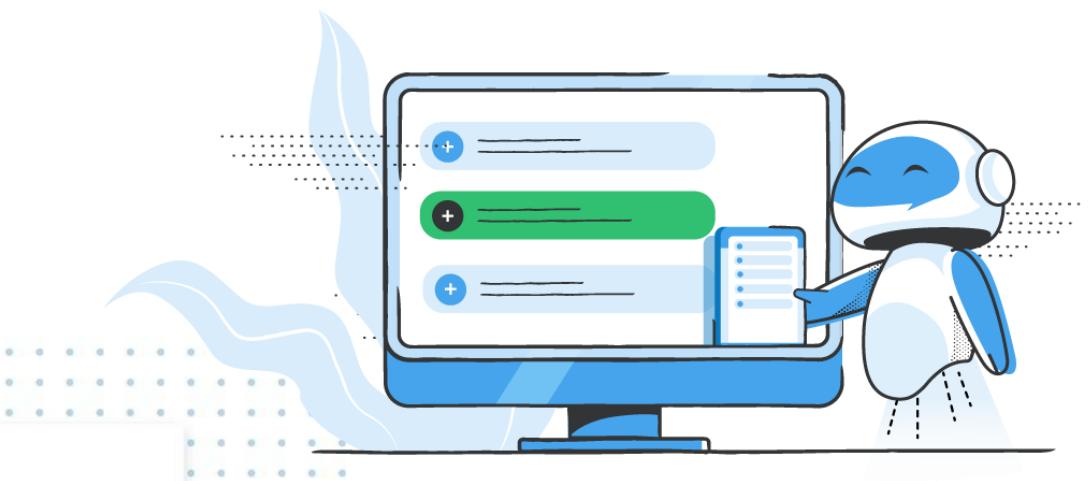
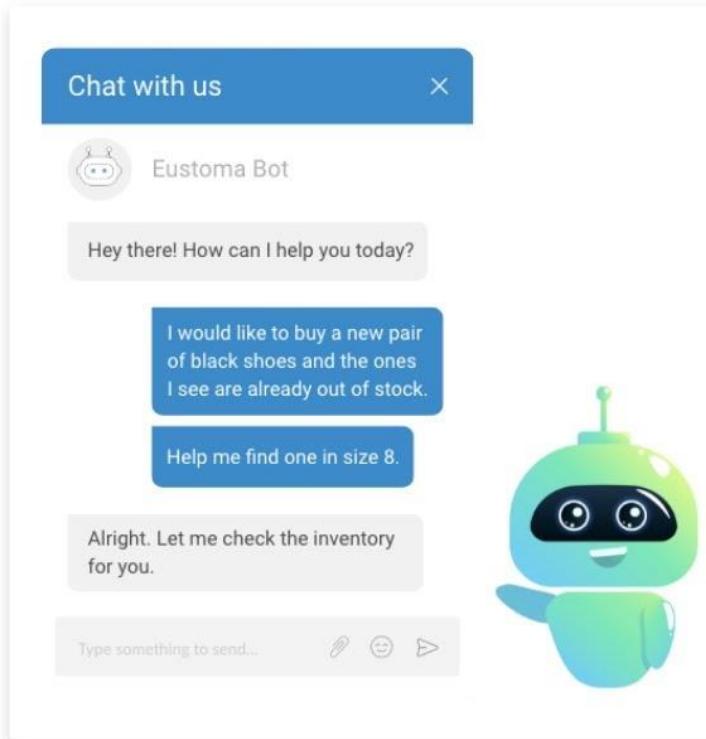
Dialogflow primarily uses two virtual agent services, namely [Dialog CX](#) and [Dialog ES](#). Each of them has its API, agent type, libraries, and functionalities. Dialog CX is an enhanced version used to solve complex problems, whereas Dialog ES is primarily used to solve the issues of simple agents.

# Cloud Technology and Applications

## 1. Web Chatbot Using Google Cloud Platform:

**ADDING  
A CHATBOT  
TO WEBSITE**

**ProProfs**

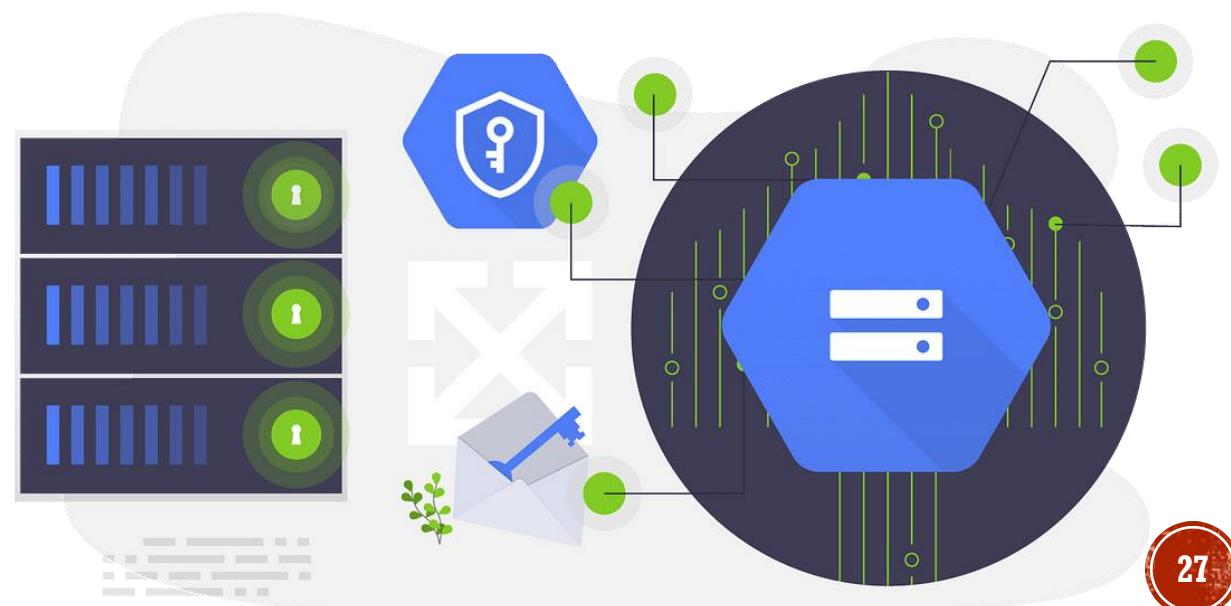


# Cloud Technology and Applications

## 2. Encryption Using Google Cloud Platform:

Data encryption has become important in all cloud services. **Encryption** is a technique to ensure that data is protected and secured with a unique key or highly protected passwords that are only known to the user. This entire process helps to keep a user's information private and avoid confidential information from getting leaked out.

Google Cloud Platform uses layers of encryption to protect data and stores it at **REST**. The encryption is not only limited to text but also includes synthetic data and videos. The entire data is split into chunks, and each chunk is managed using a highly protected **encryption key**. All these keys are used globally and distributed, and stored in Google's central **Key Management Service**. Google uses **AES256** as its storage level and also uses Tink technology as its cryptographic library.



# Cloud Technology and Applications

## 3. Shipping Management Using Google Cloud Platform:

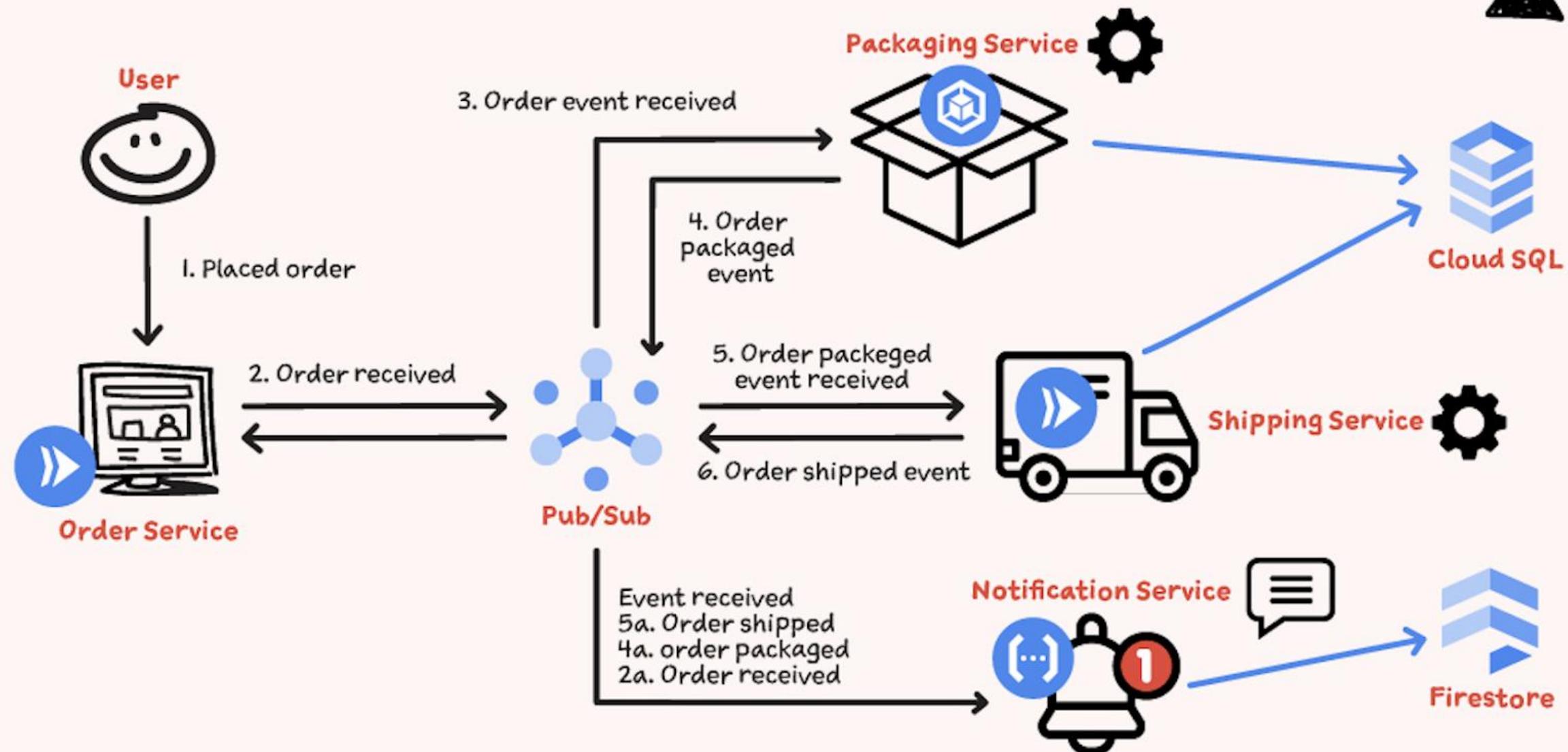
The shipping industry has also understood the advancement of cloud services and has adopted the Google Cloud Platform for digital advancement. This has also helped in increasing the operational efficiency of the shipping industry.

The shipping management industry needs to scale its [ERP systems](#) and [map the SAP systems](#) to Google Cloud Services. The industry uses [Google workspace](#) for its employee effectiveness. It also uses services like [Google Big Query](#) to generate actionable business insights and work in the right direction. With the implementation of Google Cloud, the entire management process will be smooth and automated at the same time.



# Cloud Technology and Applications

## EXAMPLE OF MICROSERVICES ARCHITECTURE IN GOOGLE CLOUD



# Cloud Technology and Applications

## 4. Cab Booking System Using Google Cloud Platform:

- Companies like Uber and Ola have resolved the commute problem of all citizens of the world. This mechanism is quite complex and uses a lot of components from Google Cloud Platform and its services.
- The Online Cab Booking System uses a lot of data stored in [Big Query](#) and then uses [Google maps](#) to understand the coordinates of the different cabs in a particular area. It primarily uses two functionalities. One is to create a preview using the App [Actions-use-start-test tool](#), and the other is user invocation from [Google Assistant](#). These two uses en-US, en-GB, en-CA, en-IN, en-BE, en-SG, en-AU, id-ID locales for implementation.

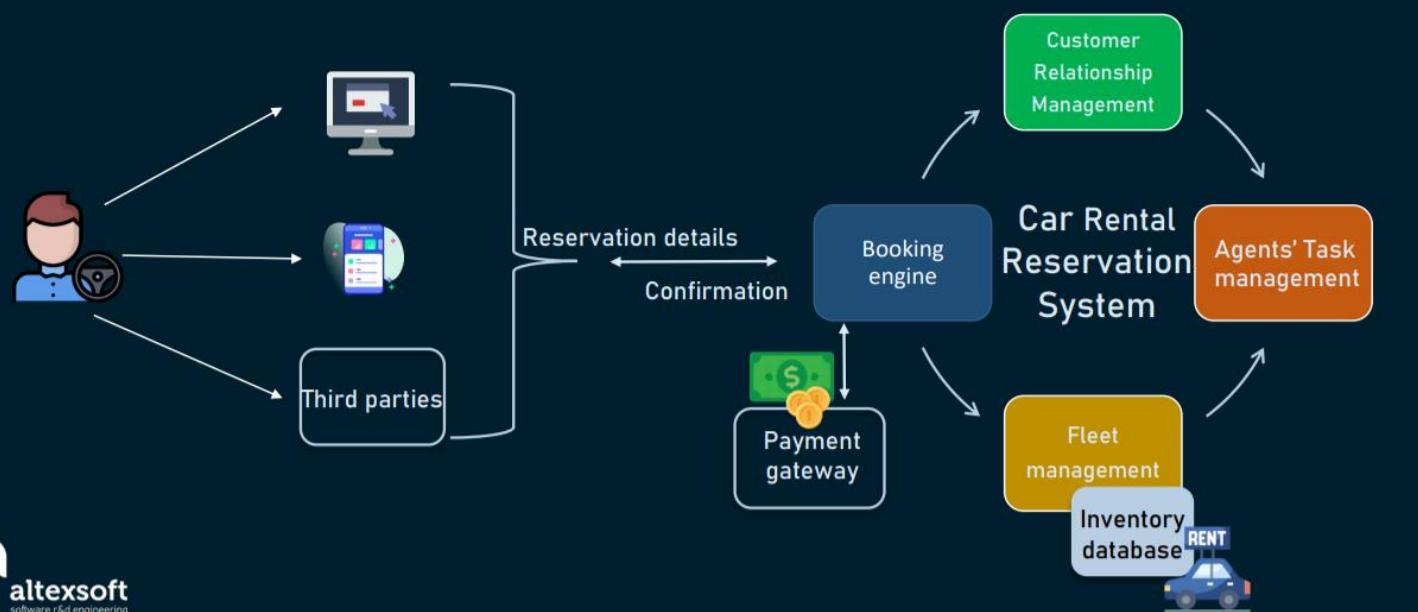


# Cloud Technology and Applications

## 4. Cab Booking System Using Google Cloud



### CAR RENTAL RESERVATION PROCESS

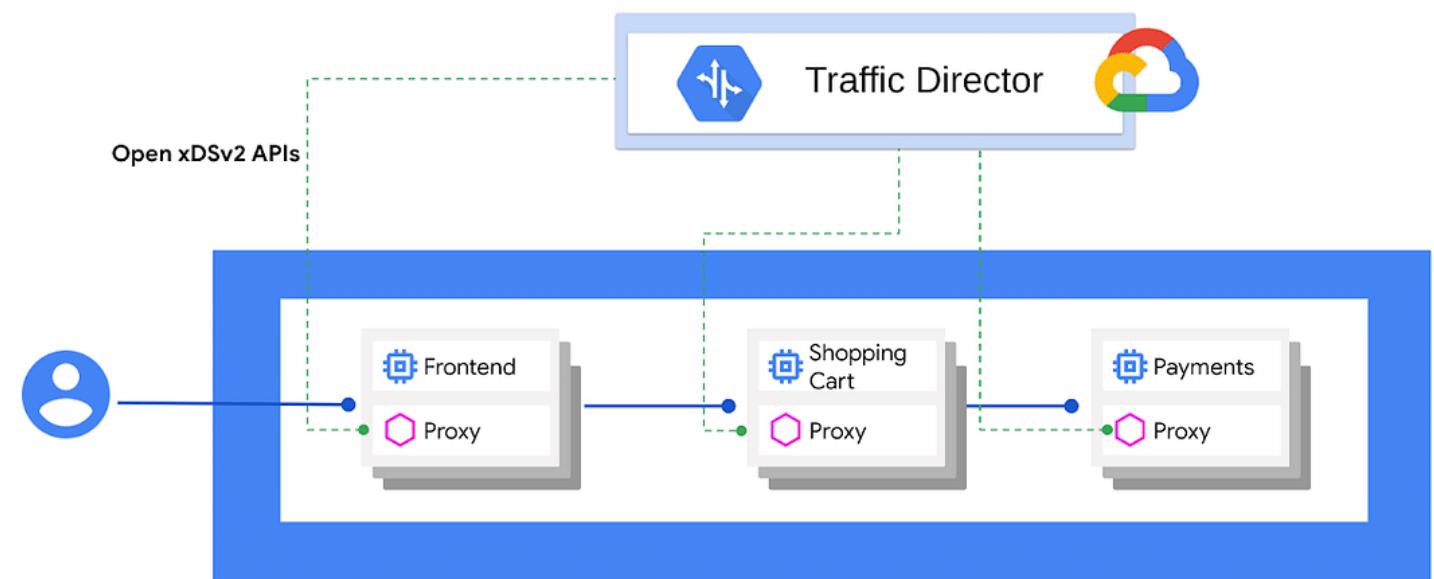


# Cloud Technology and Applications

## 5. Traffic Management using Google Cloud Platform:

Traffic is a huge concern all over the globe. The congestion, long queues have always been a problem for the traffic police to solve. So to fix this problem, one can use smart traffic management, which uses Google's infrastructure to store data and adhere to quick response time.

This GCP project involves collecting different and [real-time traffic data](#). This data is then analyzed and mined using business intelligence tools. On top of this dataset, a prediction model is built. Technologies like [SQL](#) are used on GCP. This is then [integrated into routing vehicles](#) which helps in more competent traffic management.

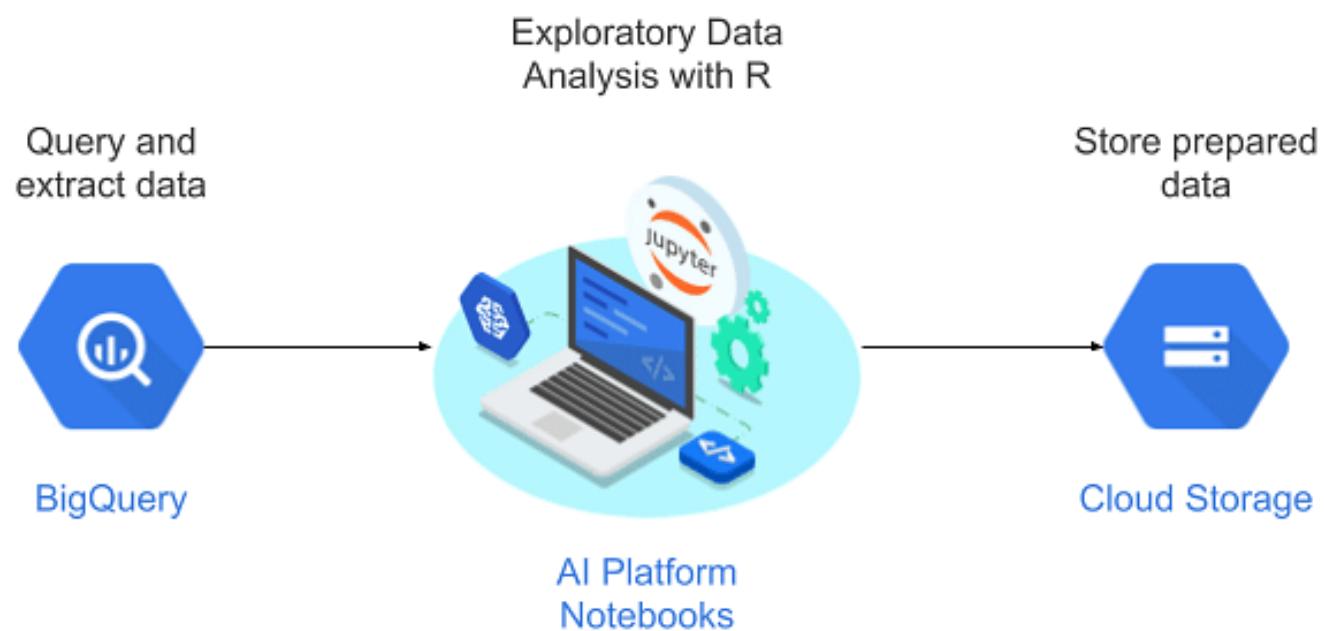


# Cloud Technology and Applications

## 6. Data Mining Applications using Google Cloud Platform:

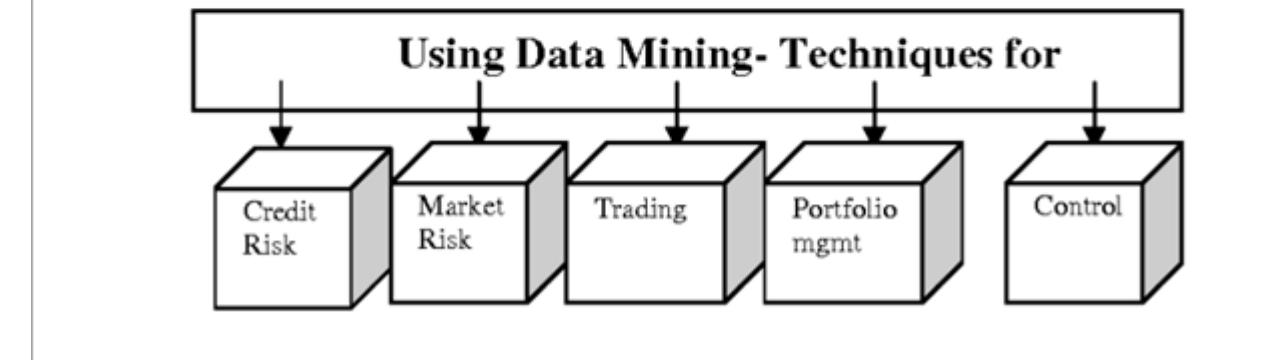
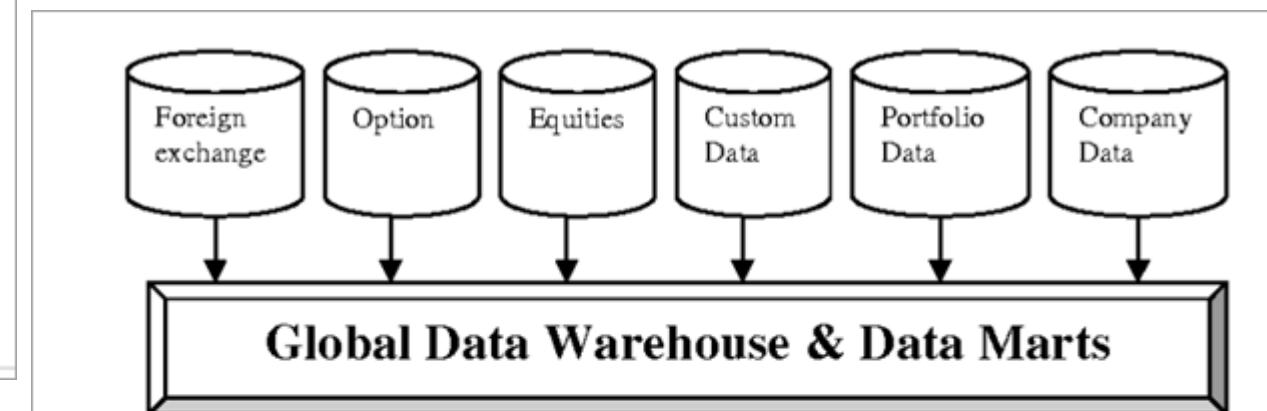
Data Mining Applications have become highly essential to solve different real-world problems. Google Cloud Platform offers a wide range of products that can be used to understand their analytics capabilities. It has services like Big Query, Cloud Data Fusion, Cloud Dataflow, Cloud BigTable, and Cloud Dataprep, to name a few.

Cloud [DataFlow](#) is used when a streamlined batch pipeline is a requirement. It can then be deployed in the [GCP AI Platform](#) for better usage. Cloud [DataPrep](#) is a data preparation tool that is serverless. All these services help in a better user interface, and with [Google Big Query](#), one can also upload and manage custom data sets..



# Cloud Technology and Applications

## 6. Data Mining Applications using Google Cloud Platform:

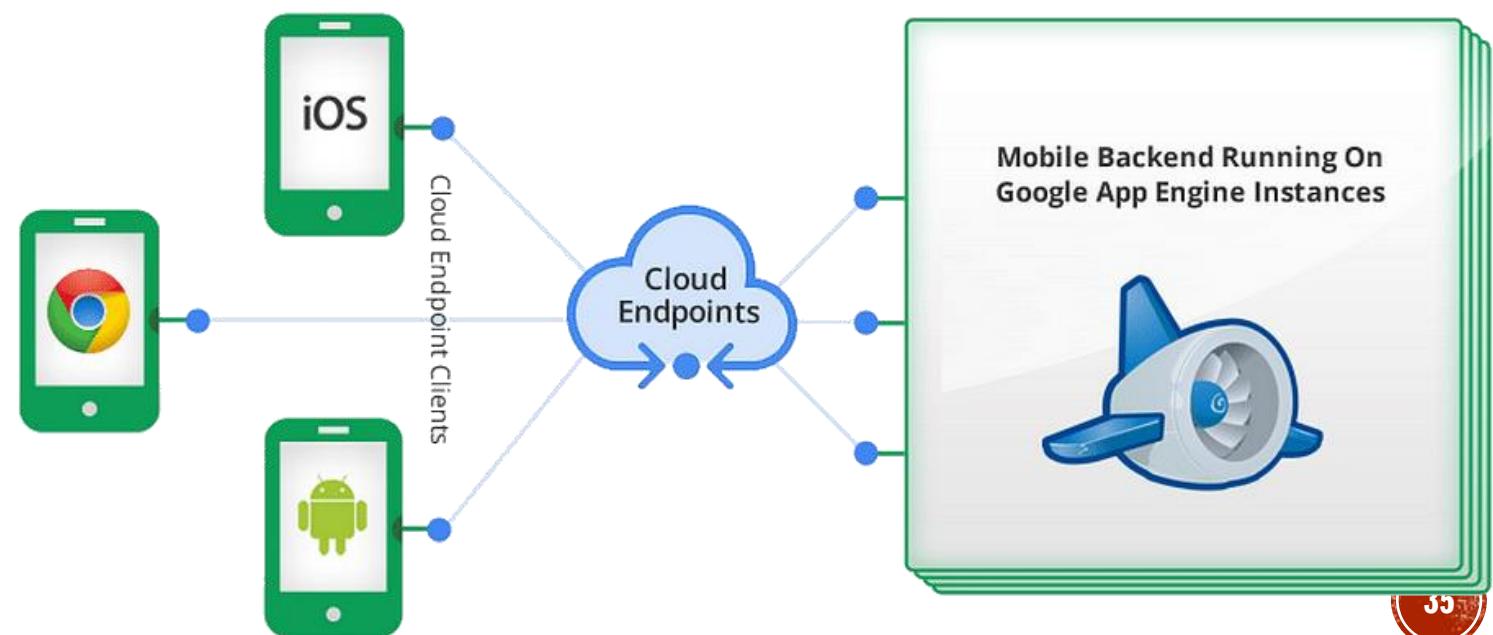


# Cloud Technology and Applications

## 7. Mobile App Backend using Google Cloud Platform:

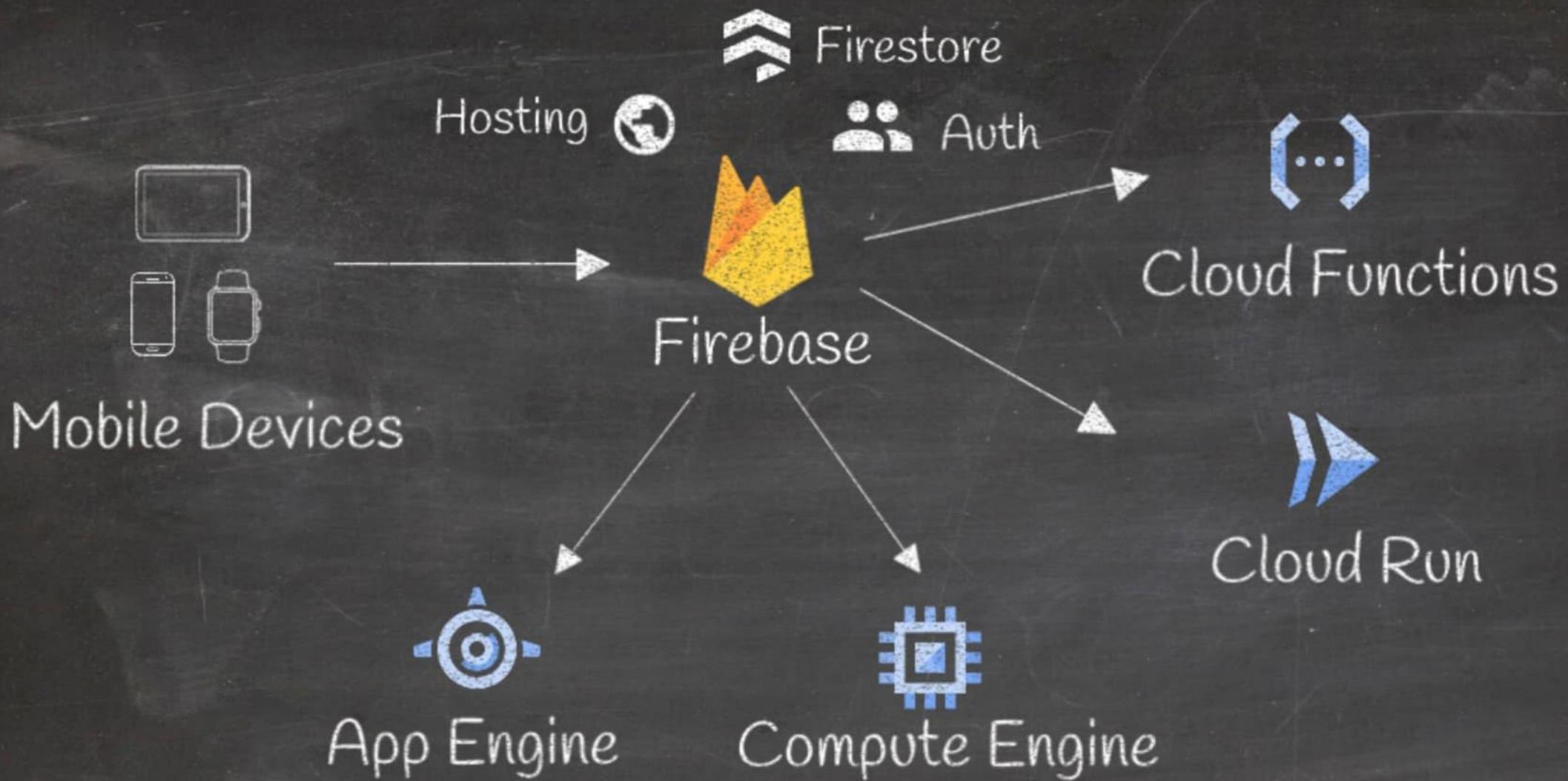
Building mobile apps is one of the most looked-after skills in the world of technology. The primary use cases to build a mobile app are send notifications, should be able to manage when offline, and should be able to integrate data across various devices.

[Firebase](#) platform is used for real-time handling of various problems. It also improves the automatic synchronization of data elements. The Firebase needs to work in line with the [Google App Engine](#) for scalability. Also, [Cloud Endpoints](#) are used, which help speed up the development, making smoother [API calls](#) for mobile app development.





# Mobile App Backend on Google Cloud



# Cloud Technology and Applications

## 8. Data Lake using Google Cloud Platform:

What is a Data Lake? Data Lake is a centralized area or repository for data storage. Here, data is stored, processed, and managed in its original format and can also be synthesized based on needs. Here, data can be structured, semi-structured, and unstructured as well. Data Lake is everything that a data warehouse can do, but it also has many additional capabilities.

Data Lake is highly used in [Financial services](#) where the data is highly confidential. It uses groundbreaking computing systems that are scalable and real-time at the same time. [Data Lake](#) uses various Google Cloud services to manage real-time risks and ensure that it is easily accessible. It also uses [Data Fusion](#) and [Composer tools](#) to create an advanced Data Lake architecture. The major [GCP components](#) required in this architecture are data integration, data storage, and data orchestration.

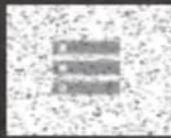


# Data Lake in Google Cloud => Cloud Storage

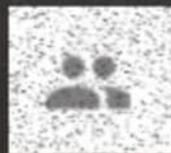
## Sources



Sensor



On-premise



User Activity



OLTP

Real Time →

Real Time

## Stream Processing



PubSub



Dataflow

Batch →



Transfer Application



Transfer Service



gsutil

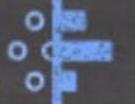
## Data lake



## Cloud Storage



AI Platform  
Notebooks



Dataprep

Real-time Store



AI Platform

## Data Warehouse



BigQuery

## Refined Data



Bigtable



Spanner

Predictions ↗

Hive, Spark, etc.



Dataproc



pvergadia

# Cloud Technology and Applications

## 9. Video Processing using Google Cloud Platform:

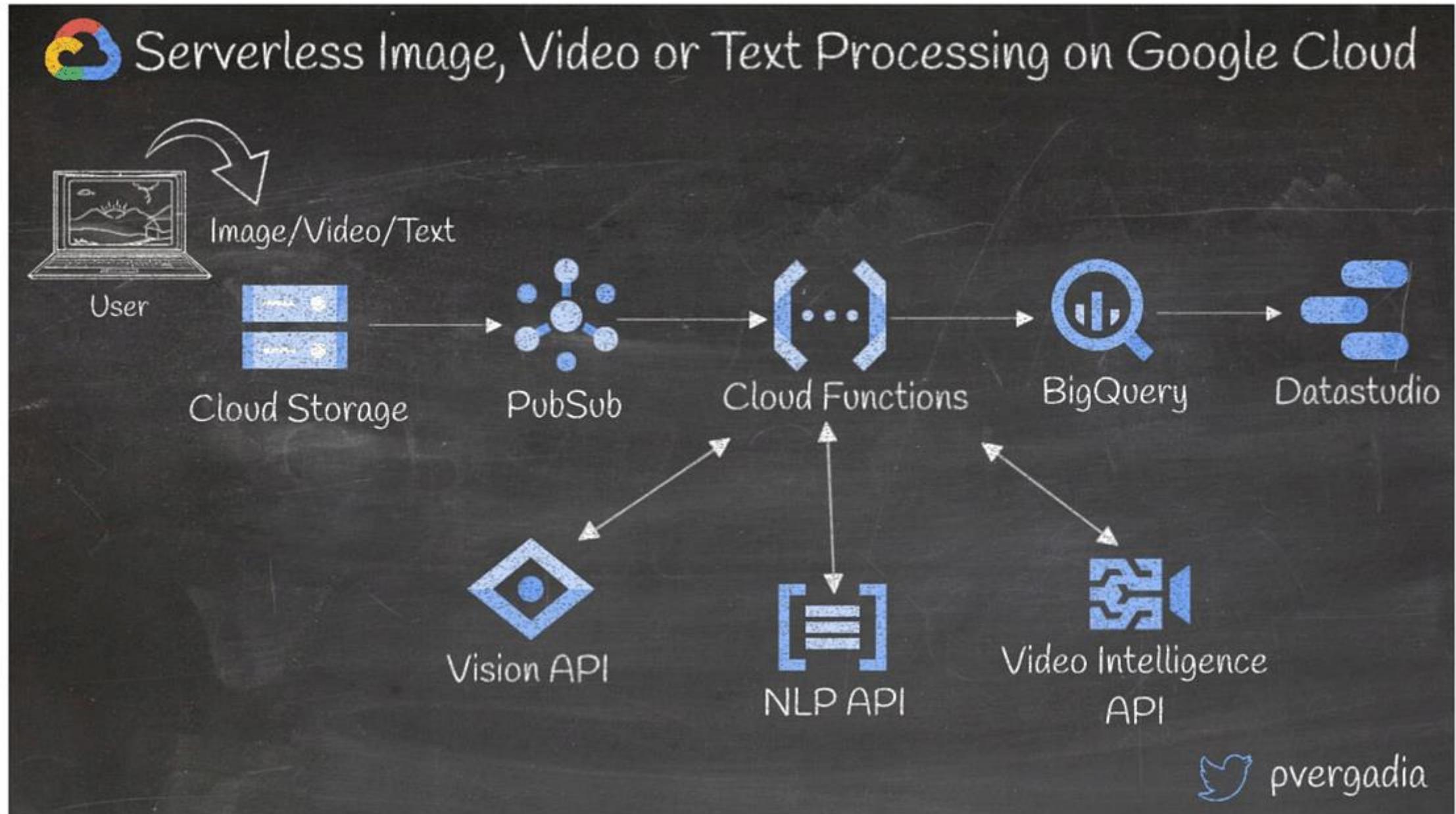
The use case here is to solve video processing and understanding using Google Cloud Services. There are a lot of videos on the internet, and simplifying them is a huge challenge that many industries are trying to tackle. The significant challenges in implementing this architecture are that it should be scalable with the evolution, it should be fast, and there should be no lag in its performance.

You can use GCP services like [Cloud Video Intelligence](#) and [Cloud Vision APIs](#) to overcome these challenges. Several storage services like [Cloud Spanner](#) and [Cloud Datastore](#) are used with different functions and [APIs](#) to solve the processing problem. GCP provides an intelligent and scalable platform that uses pre-trained [Machine Learning platforms](#) as its architecture.

It also uses [Cloud Pub/Sub](#) to receive notifications when data is uploaded in the [Cloud Storage Bucket](#). To increase the effectiveness of the back-end architecture the upload functionality is isolated from the processing functionality.

# Cloud Technology and Applications

9. Vid



# Cloud Technology and Applications

## 10. Continuous Integration and Continuous Deployment using Google Cloud Platform:

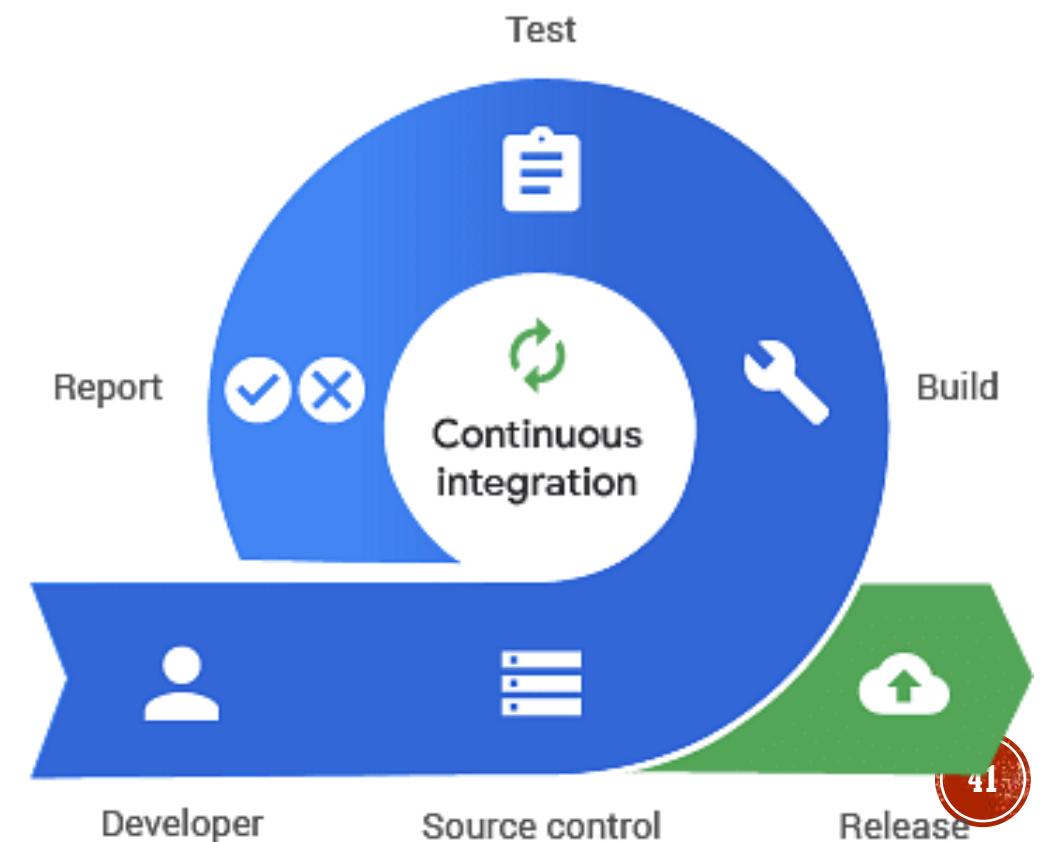
CI and CD pipelines bridge the gap between the development activities and deployment activities by automating development, testing, and other related activities.

How Google Cloud Platform or GCP can make this process a lot simpler is the next question? First of all, GCP enhances the efficiency and productivity of the process. It uses parallel builds and spends less time debugging through its connection to Google's high-performance global network.

Tools like [Maven](#) and [Bazel](#) can help you achieve flexibility.

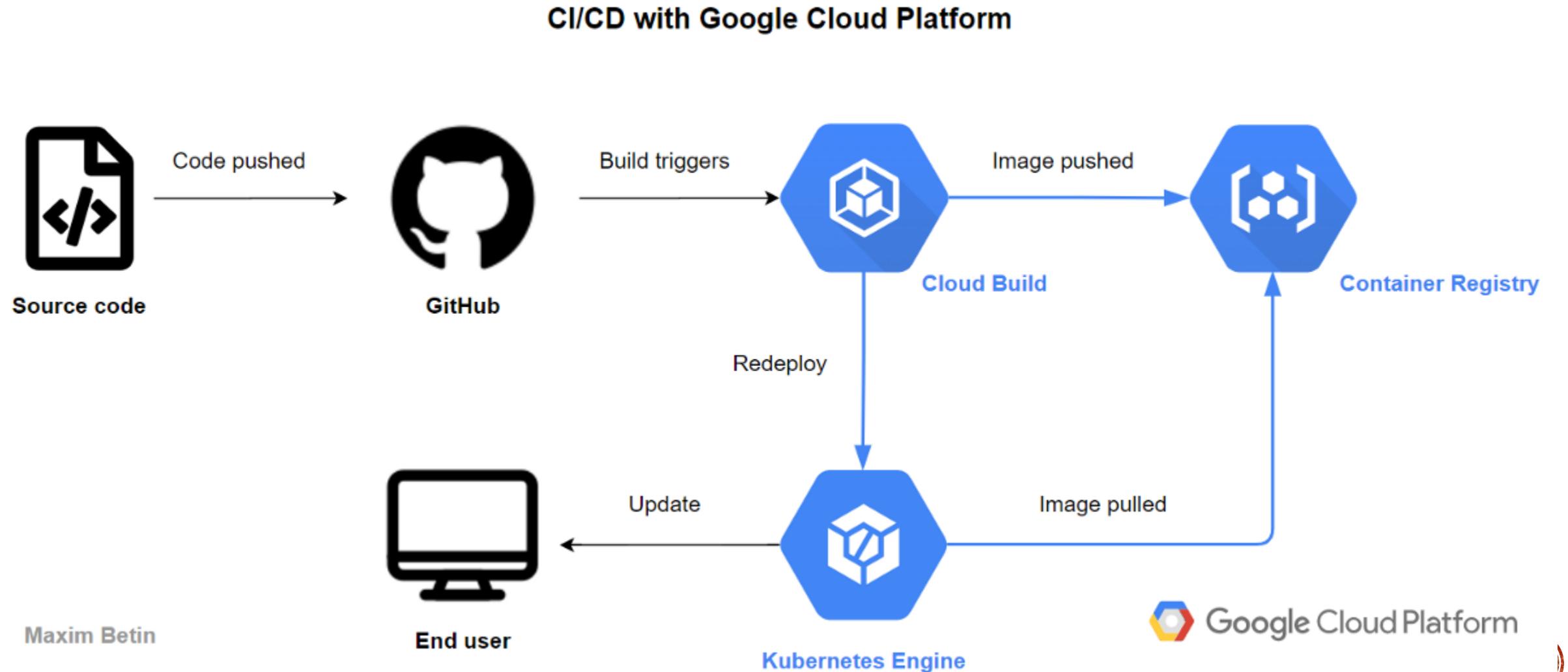
Tools like [Spinnaker](#) can automate and speed up the entire [CI/CD process](#) on Google Cloud.

You can also use administrative tools like [Jenkins](#), [Gitlab](#), [Packer](#), and [Terraform](#) to ensure the process runs smoothly and the security is up to the level expected.



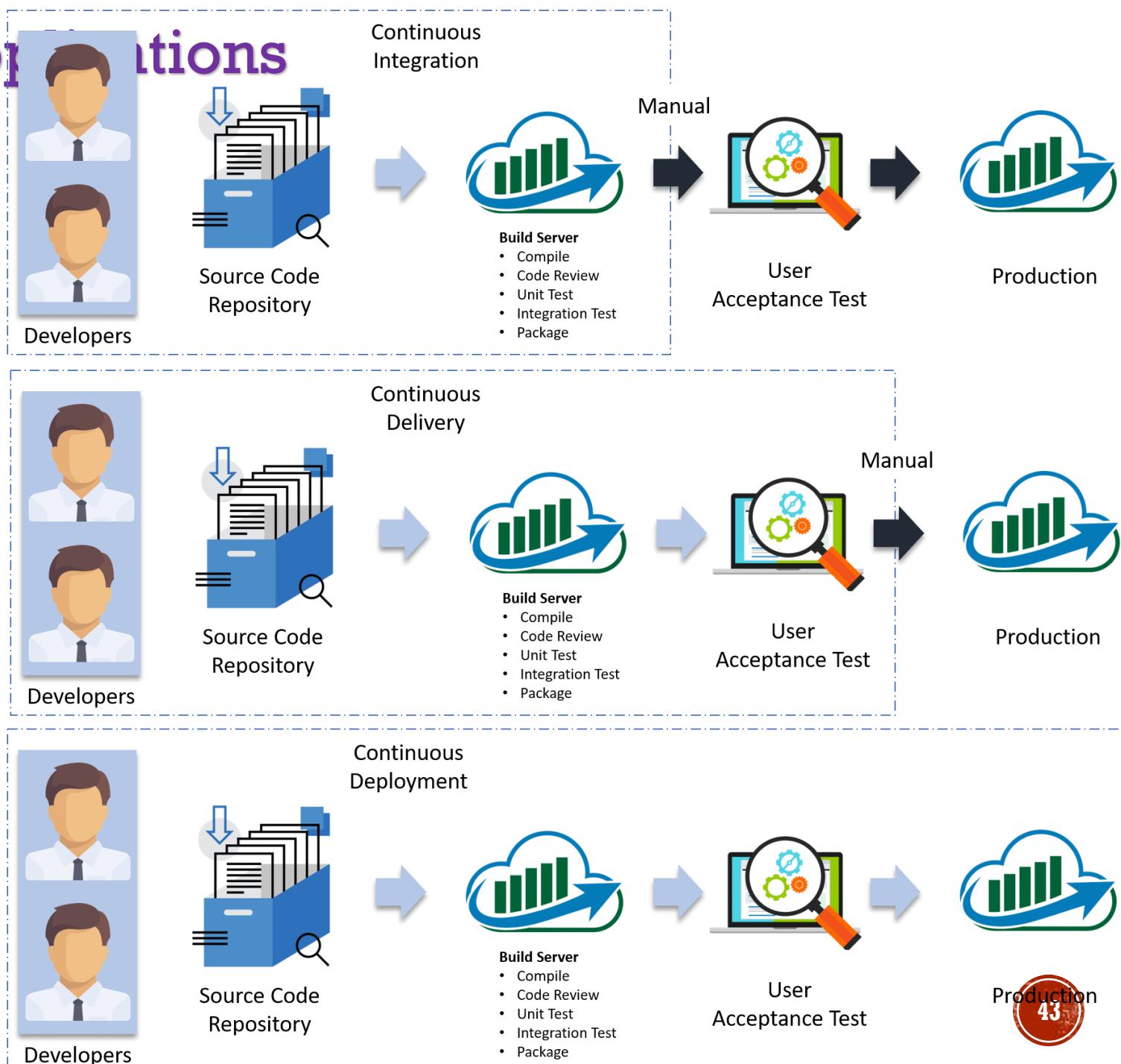
# Cloud Technology and Applications

## 10. Continuous Integration and Continuous Deployment using Google Cloud Platform:



# Cloud Technology and Applications

## 10. Continuous Integration ...



# Cloud Technology and Applications

## 11. Networking using Google Cloud Platform:

Networking in Google Cloud Services can be achieved through a [Virtual Private Cloud Network](#). This is done by using a network which is called Andromeda. This solving helps different VPNs connect, and then the traffic is distributed. There are three types of networks offered by Google Cloud Platform. The three are default network, auto network, and custom network.

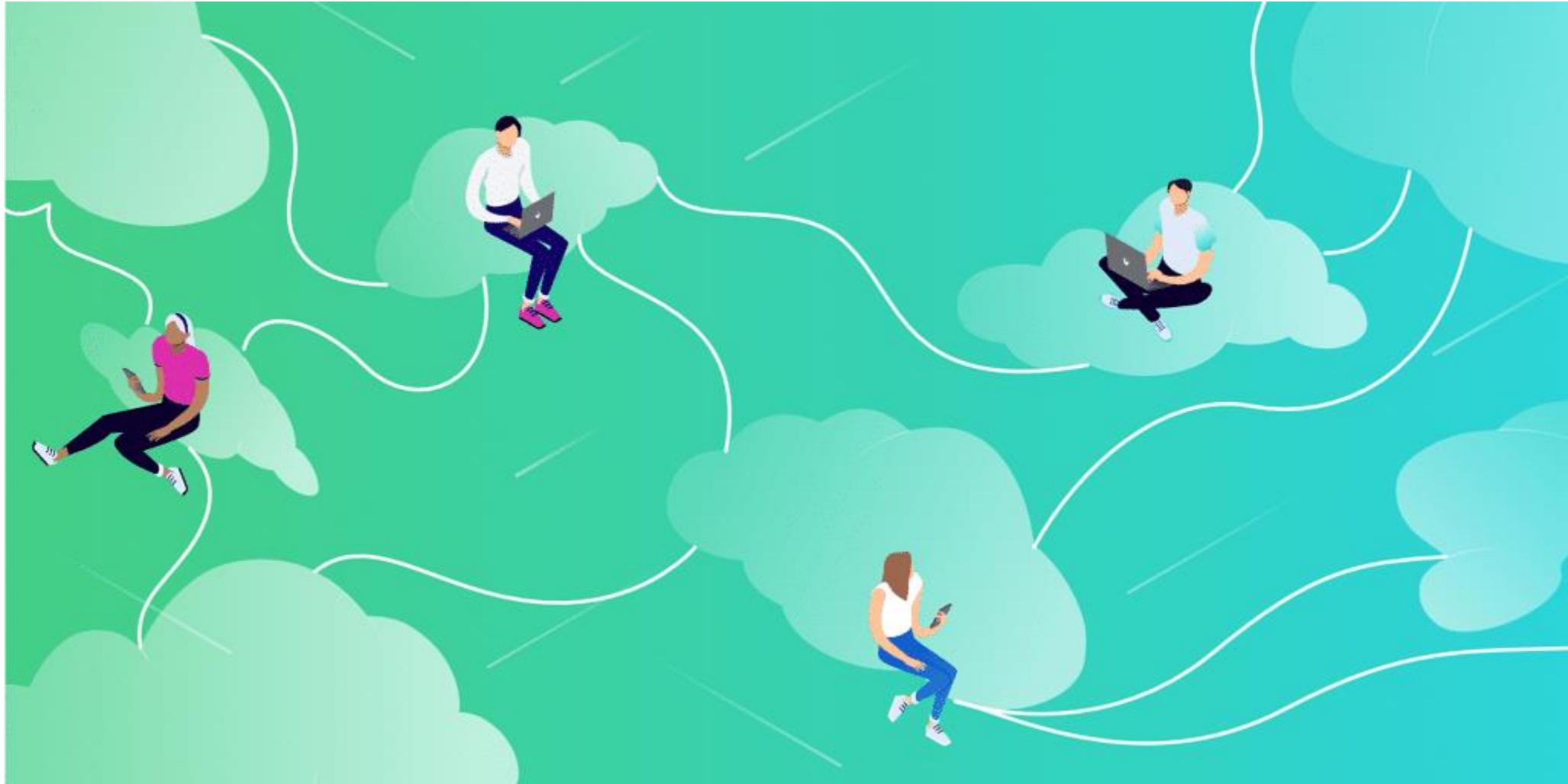
To create a network in GCP following steps need to be performed:

- Click on create [VPC network](#) from networks page in the cloud console
- Then one needs to give a name to the network and then [configure the network type](#)
- For [Subnet creation](#), one needs to choose the automatic network type
- Then select predefined firewalls to connect to [Virtual Machines](#)

The best way to learn about networking is to know how all network components work the access points, IP addresses, routers, firewalls, clients, servers, and switches primarily.

# Cloud Technology and Applications

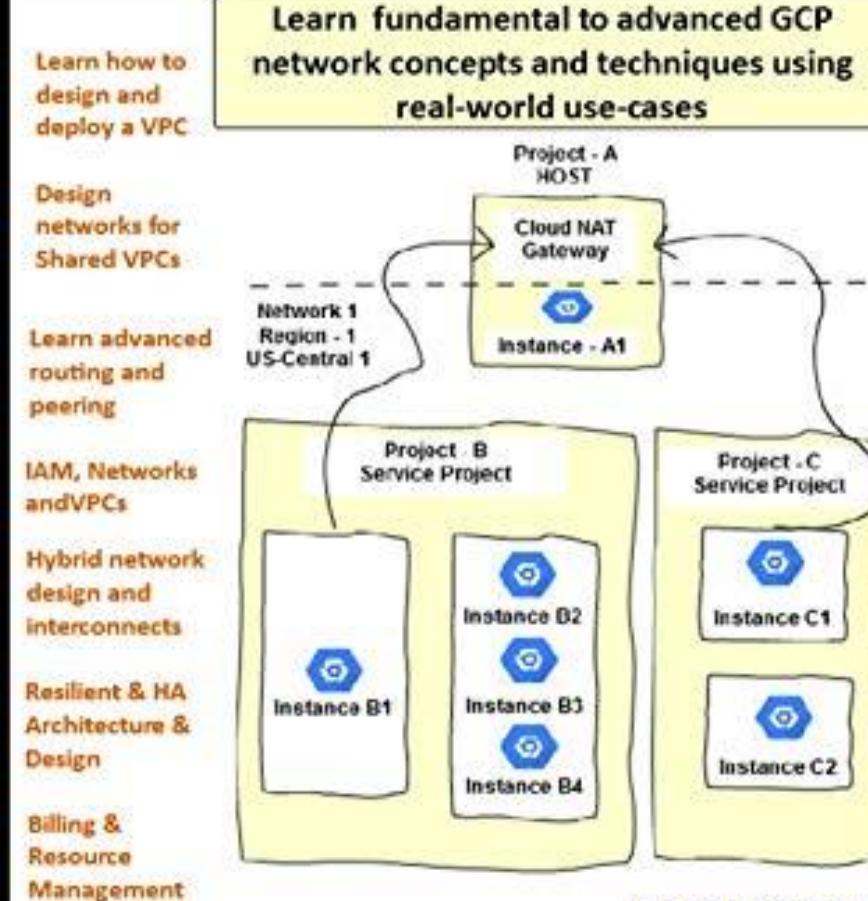
## 11. Networking using Google Cloud Platform:



# Cloud Technology and Applications

## 11. Networking using Google Cloud Platform:

### Google Cloud Platform Networking



Alasdair Gilchrist

Learn Networking in GCP  
Following Best Practices

# Cloud Technology and Applications

## 12. Remote Controlled Systems using Google Cloud Platform:

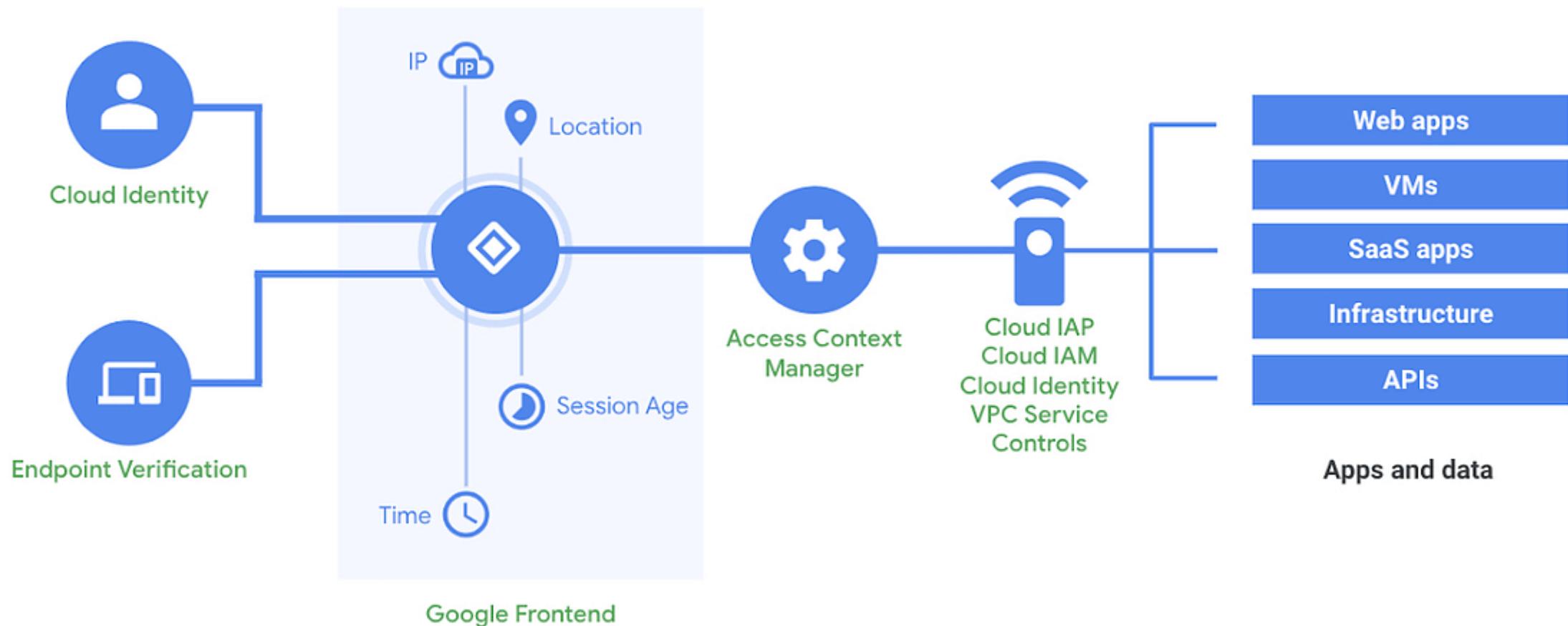
Remote Controlled Systems have become a necessity in all homes across the globe. With the advancement of the Internet of Things, such systems are widely available now. These systems are ingenious and can predict the time to time maintenance activities of any system.

It uses [AutoML Vision](#) and [Vision API](#) models to understand and process the activities. It makes it intelligent enough to give real-time insights. The same algorithms are used to build smart cities and buildings. Th Google Cloud services like [IOT core](#) and [Vertex AI](#) are used in such smart devices. This also helps in real-time asset tracking and also checks downtime risks.

# Cloud Technology and Applications

## 12. Remote Controlled Systems using Google Cloud Platform:

### Enabling BeyondCorp with context-aware access



# Cloud Technology and Applications

## 13. Healthcare Systems using Google Cloud Platform:

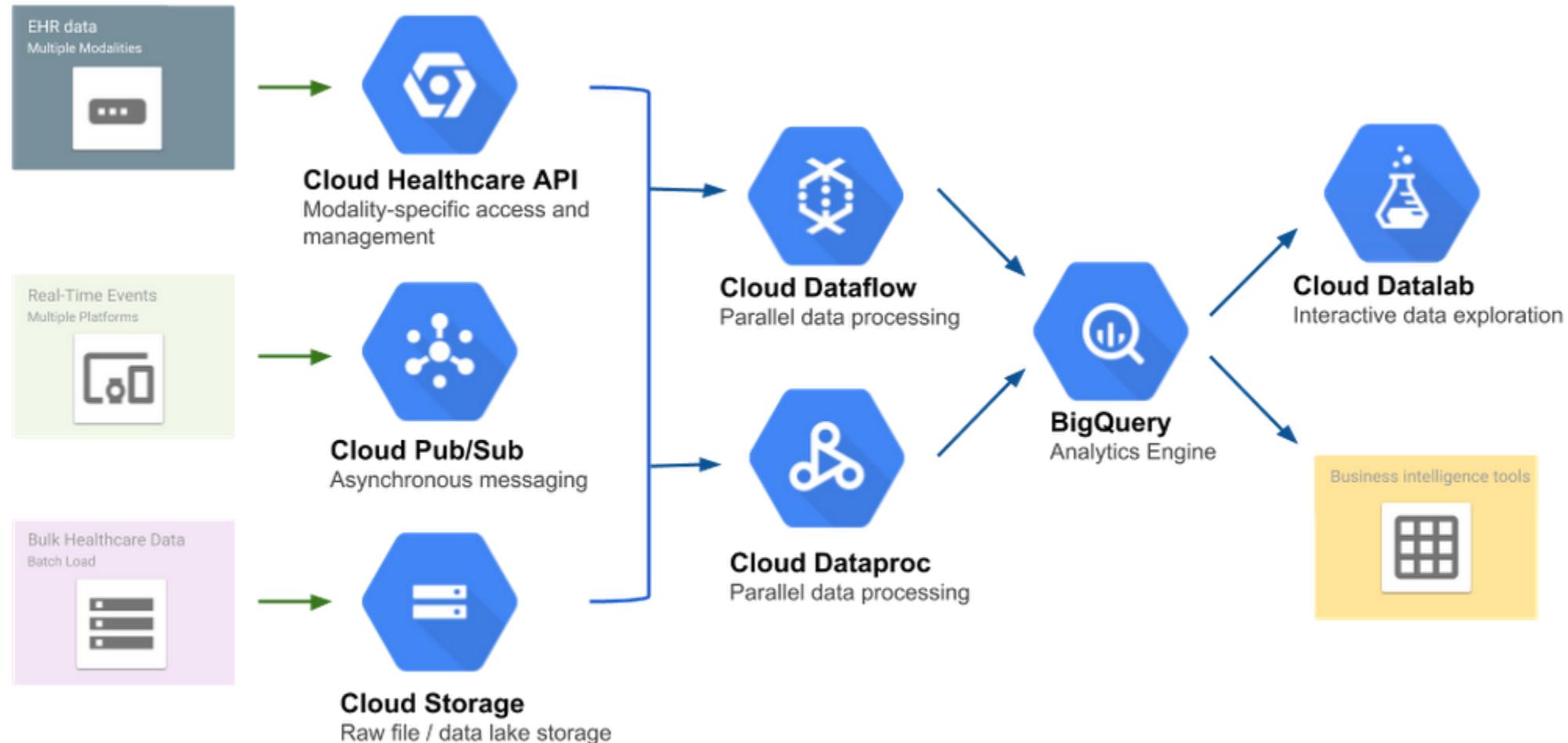
The Healthcare industry generates a lot of data and needs super-advanced analytics to solve real-world problems at a rapid pace. Google Cloud Platform uses [Healthcare Data Engine](#), which uses [Google Bigquery](#) power to store and process vast chunks of data.

The power and the [API](#) calls scale up the entire healthcare platform and manage different systems and their complex needs. It also uses several layers to ensure that all data is entirely confidential. [Healthcare Data Engine](#) uses 90% of [HL7v2](#) messages to [FHIR](#) across leading [EHRs](#) out of the box. This, in turn, enables services that come at lower costs and are also of high quality.



# Cloud Technology and Applications

## 13. Healthcare Systems using Google Cloud Platform:



# Cloud Technology and Applications

## 14. Data Integrity Management using Google Cloud Platform:

Maintaining Data Integrity is one of the most common problems that various industries across the globe are facing. You need shielded VM instances that can monitor data integrity and minimize risks and any system failures in the future.

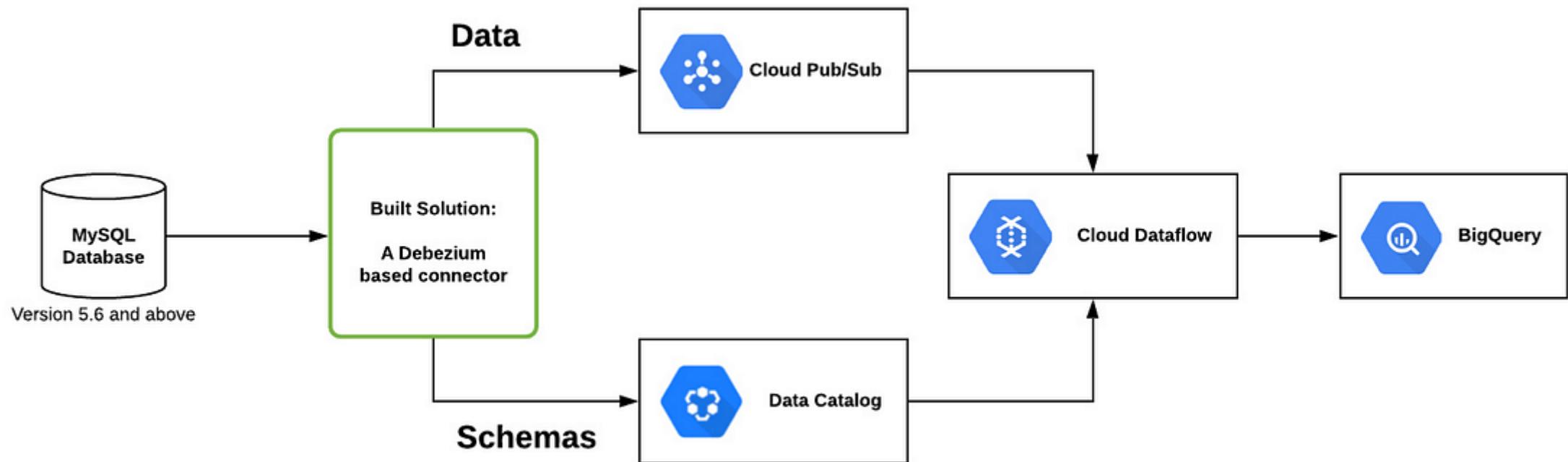
[Cloud Monitoring](#) is used to validate the integrity of the system, and [Cloud Logging](#) is used to review the details and procedures of each event. There are mainly two kinds of validation [Early Boot Validation](#) and [Late Boot Validation](#). Early Boot Validation shows the pass/fail status at an early stage of the process, and late boot validation shows pass/fail status at a late stage of the process. One can also update the integrity policy from time to time based on needs. One should use [set-Shielded-Instance-Integrity-Policy](#) permission to be able to update the integrity policy baseline.

Update the [VM instance's](#) integrity policy baseline by using the [update-Auto-Learn-Policy](#) request body item with the set-Shielded-Instance-Integrity-Policy method.

The following example resets the integrity policy baseline for a [VM instance](#).

# Cloud Technology and Applications

## 14. Data Integrity Management using Google Cloud Platform:



# Cloud Technology and Applications

## 15. Online Book Store System using Google Cloud Platform:

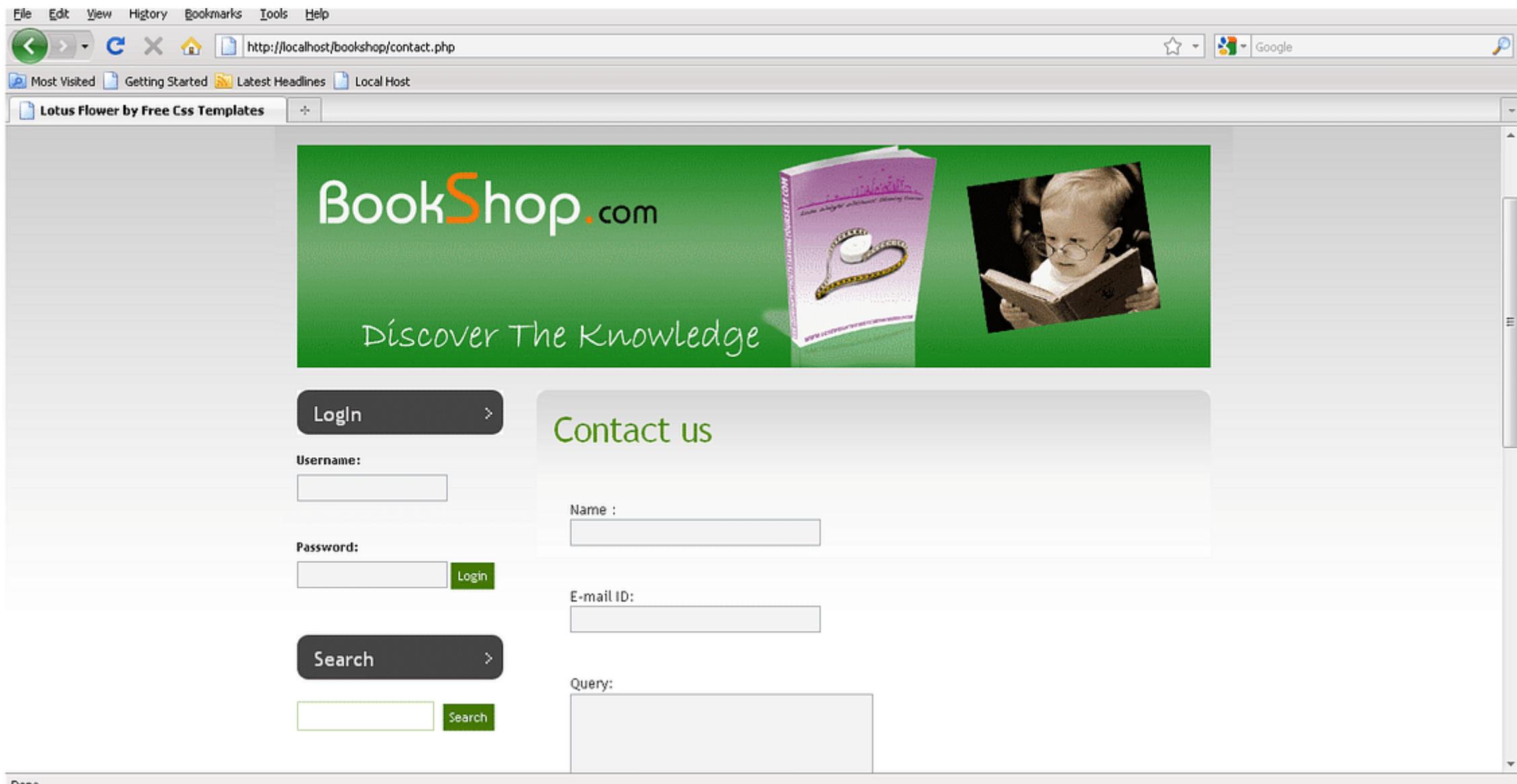
The system of purchasing books online has become a trend in the world of the internet. This can be done on the Google Cloud Platform and can be maintained with all the data security.

[SQL](#) is one of the languages used for this project. Here all notification systems are also built to ensure the users are updated from time to time on their bookings. All the details are stored in the database called [Google Bigquery](#) and can be easily available on their websites. This problem statement is a part of GCP projects for students.

The above GCP sample project ideas can be a great start to your career in mastering GCP. There is no better time than this to improve your GCP skills by working on real-world projects. Learn how ProjectPro's solved end-to-end big data projects can help you bridge the gap between theory and hands-on experience working with GCP. Leverage ProjectPro's GCP projects that come with reusable code, datasets, guided videos, and industry expert guidance to enhance your portfolio.

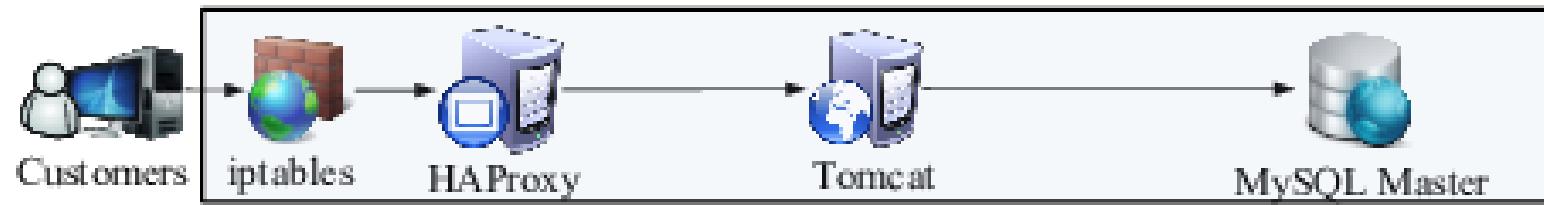
# Cloud Technology and Applications

## 15. Online Book Store System using Google Cloud Platform:

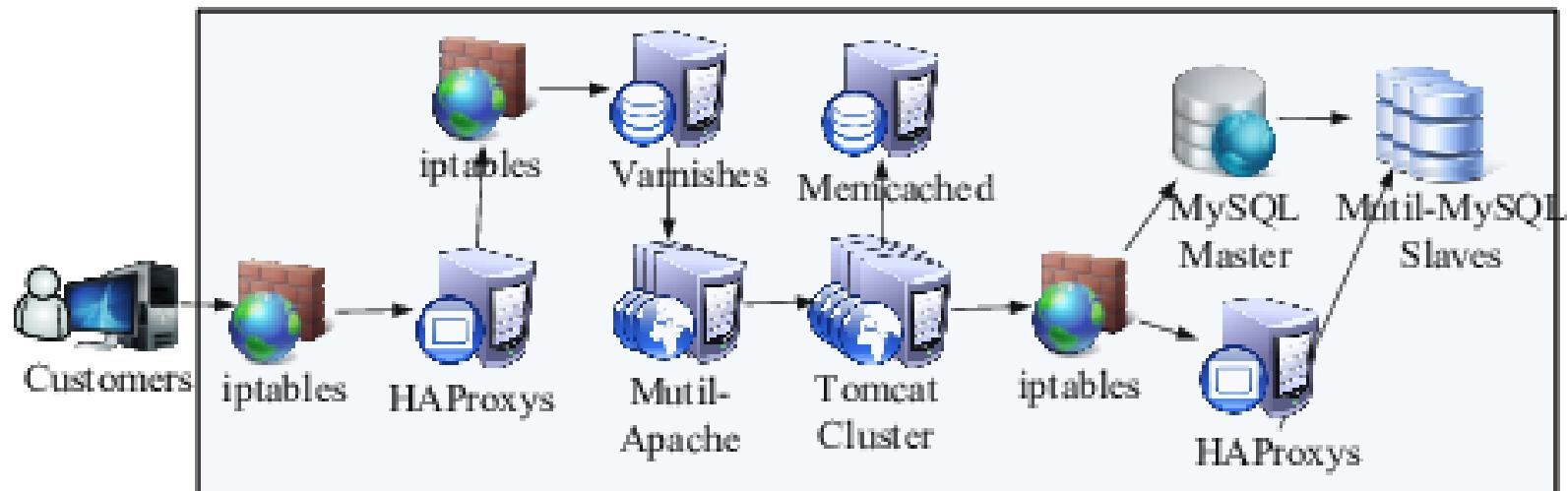


# Cloud Technology and Applications

## 15. Online Book Store System using Google Cloud Platform:



(a) A small-scale online bookstore deployment



(b) A large-scale online bookstore deployment

## Programming Languages in Cloud Platform

*How do you choose the cloud programming language  
that best suits your current and future needs?*

<https://www.techtarget.com/searchcloudcomputing/tip/11-cloud-programming-languages-developers-need-to-know>

# Cloud Application Programming

## □ Common Cloud programming languages:

Cloud computing programming takes many forms.

- For back-end developers, it might mean the development of a cloud-native app or the continuous delivery of an interconnected set of microservices.
- For administrators, it might mean the development of a script that automatically provisions cloud-based resources.
- For web developers, it might mean the development of an Angular or React app that consumes cloud-hosted resources.

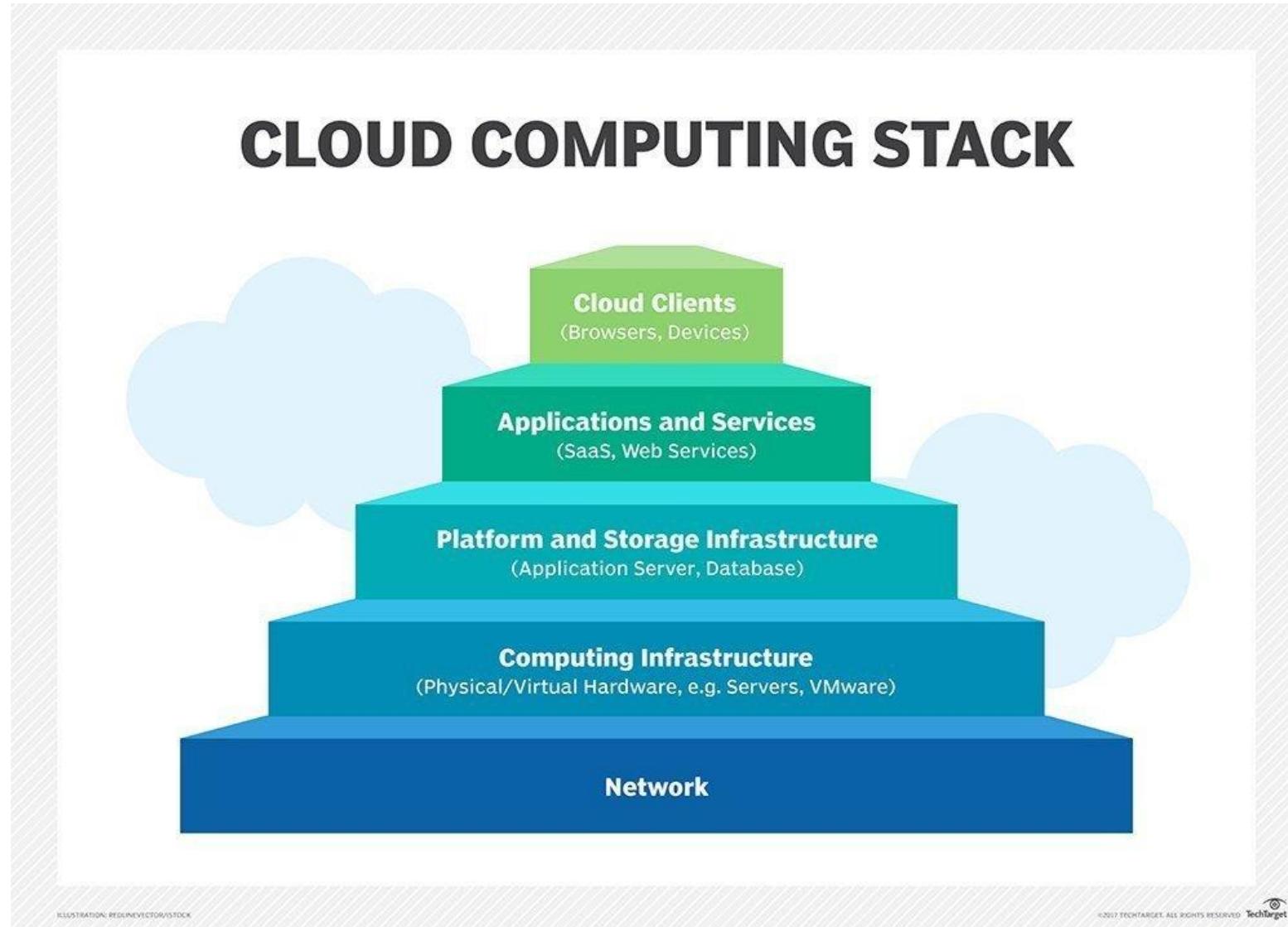
To choose the best cloud programming language for your needs, carefully consider the selection criteria below. Explore the details of some popular programming languages and their use cases.

Organizations should take these four factors into account when choosing a cloud programming language:

- cloud clients and services
- targeted cloud stack layer
- familiarity
- risk averseness

# Cloud Application Programming

## □ Cloud programming languages:



# Cloud Application Programming

## □ Cloud programming languages:

- **Cloud clients and services:** The first step to determine which programming language is right for you is to ask which types of clients you will create and which types of cloud-based services you will access.
- **Targeted cloud stack layer:** Another consideration is whether you need a general, all-purpose programming language that does a variety of things well, or one that targets a specific technology.
- **Familiarity:** IT and development teams don't always have to leave their comfort zone. Sometimes, it is best to tap into your existing knowledge of a given platform or framework. If you already have strong Java or .NET skills, for example, that is a compelling reason to choose Java or .NET.
- **Risk averseness:** Lastly, an organization must determine its comfort with risk. For example, Rust is a programming language that developers can use at almost every layer of the cloud stack. However, the Rust for Linux project has not yet integrated any code into an official kernel build, and software development kit (SDK) support from the predominant cloud vendors is not universal. If an enterprise wants to avoid risk, it is a better option to choose a more established language.

# Cloud Application Programming

## Cloud programming languages:

## Popular cloud programming languages and frameworks

<b>JavaScript</b> A dynamic programming language used for interactive web development	<b>Node.js</b> An open source JavaScript runtime environment ideal for microservices development and deployment	<b>C</b> A general-purpose, procedural programming language widely used to develop applications and OSes
<b>Python</b> A high-level, general-purpose programming language popular with data scientists and AI development teams	<b>Java</b> A class-based, object-oriented and server-side programming language popular for cloud-native applications, Android applications and IoT	<b>.NET</b> An open source and cross-platform development framework ideal for web and mobile apps, as well as microservices
<b>Go</b> An open source, compiled programming language used for back-end services, such as distributed networking	<b>Swift</b> A general-purpose programming language used for mobile application development, specifically iOS	<b>Unity</b> A development platform and game engine popular for game development and virtual reality applications
<b>Kotlin</b> A statically-typed, general-purpose programming language used for mobile application development, specifically Android	 An illustration showing two developers sitting at a desk, each working on a laptop. They are surrounded by floating code snippets and cloud icons, symbolizing cloud computing and programming.	
<b>Rust</b> A low-level, memory-efficient programming language often used for embedded and bare-metal development		



JavaScript

# Cloud Application Programming

## □ Cloud programming - JavaScript

- + For the development of rich, HTTP-based clients that need access to a swath of cloud services, such as Storage or secure authentication, client-side JavaScript is the best option.
- + JavaScript can interact directly with managed cloud services, eliminated the need to implement a complex, RESTful middleware layer.
- + Client-side JavaScript may be the only language they need. Every browser supports it, developers can render an application written in JavaScript on any laptop, phone, tablet, smart TV or desktop computer.
  
- JavaScript does have its limitations, such as security. A web browser's basic username and password authentication mechanism is not as trusted and secure as the cryptographic key handshake required by a secure shell (SSH) connection.
- Most organizations require access keys or SSH connections to provision cloud-based infrastructure programmatically.
- Client-side JavaScript is a good fit for the consumption of cloud-based resources. For automation and resource provisioning, a server-side language is required.

# Cloud Application Programming



## □ Cloud programming - Java

- + Java has long been at the top of developers' lists because it is cross-platform and object-oriented. It is a reliable and practical language to create cloud-native microservices. Java frameworks have standardized and simplified the development of cloud-native apps.
- + Java has been actively developed for so long that connectors and drivers exist for every server-side technology, such as a legacy database, mail server, document store or file-system driver. This makes Java the ideal choice to create applications that can glue together different parts of an enterprise architecture.
- Other languages may be even better suited for a developer who wants to "get into the weeds of data science".

# Cloud Application Programming



## □ Cloud programming - Node.js

- + Node.js and the Node package manager (npm) turned JavaScript into a viable cloud programming language.
- + Node.js is ideal for microservices development and deployment because npm provides a simple mechanism to add RESTful API support. Connectors to data-tier resources and utility libraries that simplify commonly performed tasks and functions.
- + Node.js makes it possible for organizations to unify client-side and server-side cloud tasks under one umbrella.
- + Node.js and its support for JavaScript is a good choice for organizations that want a single language that will work across many use cases.
  
- Code that runs on a VM, like the Chrome engine, will never perform as well as close-to-the-metal languages such as Go, Rust or C. In situations where every megabyte of memory counts, you might find Node.js applications lack the required runtime optimization.

## □ Cloud programming - Python

- + Python is popular with developers because it supports imperative programming → functional programming, this approach enables developers to write simple, succinct functions that perform complex logic.
- + With Python, developers can quickly write scripts that provision infrastructure with vendor SDKs. When cloud platforms release new features, the Python SDK is prioritized for updates.
- + Python is a favorite language among data scientists and AI development. For organizations that use AWS AI services or Google's ML tools, it makes sense to use Python-based SDKs to interact with cloud-based services.
  
- Languages like R or Julia may be even better suited for a developer who wants to "get into the weeds of data science."
- Perhaps, Python is not familiar who work with C, C++, JavaScript for many years.

# Cloud Application Programming



## ❑ Cloud programming – C/C++

- + C is fast and efficient. It interfaces with a CPU kernel directly without the need to move through abstraction layers languages, as with Java.
- + Operating systems, hardware drivers, hypervisors, GPUs that mine bitcoin, load balancers and virtualization tools are most commonly written in C and C++. C is a preferred choice when optimization and efficiency are top priorities.
- + All major cloud vendors provide full SDK support for C.
- + Developers primarily used C to write the behind-the-scenes software that supports the cloud.
  
- Perhaps, C/C++ is not familiar who work with other languages for many years.
- With C/C++, we need to write code for everything without not much library, modules.

# Cloud Application Programming



## □ Cloud programming - Go

- + Go has a syntax similar to C. Like C, it enables developers to compile it into abstraction-free binaries that communicate directly with a server's CPU or GPU.
- + Any developer who wishes to contribute to open source projects like Terraform, extend the OpenShift Container Platform or customize their Docker and Kubernetes implementations at the source-code level will need to know Go.
- + All of the major cloud vendors provide a Go SDK to interact with their IaaS APIs, so you can use Go to provision infrastructure and automate cloud-based management tasks. Developers can use a JavaScript conversion tool to create browser-based applications in Go.
- Other languages may be even better suited for a developer who wants to "get into the weeds of data science".

# Cloud Application Programming

## □ Cloud programming - .NET

- + Microsoft's .NET platform has competed on steady ground against the Java platform for more than 20 years. In terms of cloud, the .NET framework plays the same role as the Java platform, with the key difference being the target user is a Microsoft developer.
- + .NET is a well-proven middle-tier framework with connectors to every type of back-end resource. This makes it a great choice for the development of microservices and RESTful APIs that glue together various parts of an organization's infrastructure.
- .NET may be not suitable with some platform and environment.

# Cloud Application Programming



## □ Cloud programming - Unity

- + Unity is the best fit for developing VR applications that use ML and visual recognition technology to make gameplay in the metaverse lifelike.
- + IBM is the only cloud vendor with an SDK dedicated to the Unity platform for Watson, although you can expect more partnerships that link VR, AI, ML and the computational processing power of the cloud together into a single offering in the future..
- .NET may be not suitable with some platform and environment.

# Cloud Application Programming



## □ Cloud programming - Rust

- + Many core programming language in the Kernel development community think it's time for something new: Rust.
- + Rust is a close-to-the-metal programming language that can match the performance and efficiency of C.
- + "Rust tends to be popular at lower-level development, where speed of execution takes priority over flexibility or ease of use," Strechay said.
- + Amazon, Microsoft, Dropbox and Discord have all experimented with Rust. Google did an Android port of Rust and Amazon released an AWS Rust SDK preview in December of 2021.
- Languages like R or Julia may be even better suited for a developer who wants to "get into the weeds of data science".
- At current, Rust is not much real applications and environment support.