✅ What is GCP?

GCP (Google Cloud Platform) is **Google's cloud computing service** that provides tools and infrastructure over the internet — so you can run websites, apps, store data, use AI models, and much more **without needing your own servers**.

🧠 Basic Concept of GCP:

Instead of buying and managing your own hardware, you **rent computing resources from Google**, like:

Service Area	Example	What it does
Compute	Compute Engine (VMs)	Run virtual machines like servers
Storage	Cloud Storage, Bigtable	Store files, data, backups
Databases	Cloud SQL, Firestore	Use managed SQL/NoSQL databases
Networking	VPC, Load Balancer	Control traffic and network connections
AI & ML	Vertex AI, AutoML	Build and run machine learning models
DevOps & Tools	Cloud Build, Cloud Functions	Automate deployments, run serverless functions

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📒 Key Concepts:

1. **Pay-as-you-go**
   You pay only for what you use — no need to buy servers.
2. **Scalability**
   Easily scale your application up or down based on demand.
3. **Managed Services**
   Google handles updates, backups, security — you just use the services.
4. **Global Infrastructure**
   Your app can run in data centers across the world (fast & reliable).

BigQuery is **Google Cloud's serverless, highly scalable, and cost-effective data warehouse** designed for running fast SQL queries on large datasets.

🧠 Key Concepts:

Concept	Description
Serverless	No infrastructure management — Google handles resources, scaling, etc.
SQL-Based	You use standard SQL to query and analyze data
Scalable	Handles **petabytes** of data efficiently
Pay-as-you-go	You pay for **storage** and **query processing**

We enable the BigQuery API to allow our Google Cloud project to access and use BigQuery services programmatically. It must be enabled to run queries, manage datasets, or interact via tools like Python or gcloud.

PUB/SUB:

Pub/Sub stands for Publish/Subscribe, a messaging pattern used in distributed systems. It's used to send messages asynchronously between different components or services without them knowing about each other directly.

🔁 Basic Idea:

- A **Publisher** sends messages.

- A **Subscriber** receives messages.

- A **Broker** (middleware) sits in the middle to deliver messages.

✅ How It Works:

1. **Publishers** send messages to a **Topic**.

2. **Subscribers** subscribe to the **Topic**.

3. When a new message is published, all **Subscribers** to that topic receive the message.

📌 Topic

- A **named resource** to which **publishers** send messages.

- Think of it as a **channel** or **category**.

- Publishers **publish** messages to a topic.

- ◆ **Example**:
Topic: `news/sports`
A publisher sends a message: "Pakistan won the match!"

📫 Subscription

- A **subscription** is how **subscribers** receive messages from a topic.

- It is linked to a specific topic.

- It **pulls** or **pushes** messages from the topic to the subscriber.

- Multiple subscriptions can be attached to one topic.

- ◆ **Example**:
Subscriber A and B both subscribe to `news/sports`
Both will get the message: "Pakistan won the match!"

🔄 One-to-Many Flow:

1. Publisher ➡ Topic

2. Topic ➡ Subscription(s)

3. Subscription ➡ Subscriber(s)

📦 Correct Way to Think About It:

- The **publisher** sends a message to a **topic**.

- The **topic** forwards that message to all its **subscriptions**.

- Each **subscription stores the message** until a subscriber consumes (acknowledges) it.

- The **subscriber** connects to the **subscription** and either:

    - **Pulls** the message (pull subscription), or

    - Waits for it to be **pushed** to them (push subscription).
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🌐 What Are Cloud Data Solutions?

Cloud Data Solutions are services and tools provided by cloud platforms (like Google Cloud, AWS, Azure) to **collect**, **store**, **process**, and **analyze** large volumes of data — **without managing physical servers**.

Core Components

Component	Description
Data Ingestion	Collecting data from different sources into the cloud.
Data Storage	Storing structured/unstructured data at scale.
Data Processing	Transforming, cleaning, filtering, and aggregating the data.
Data Analysis	Applying analytics, machine learning, or BI tools to gain insights.
Data Security	Securing access to data using IAM, encryption, firewalls, etc.

GCS:

GCS (Google Cloud Storage) is an **object storage service** used to store data in the form of **objects**. It organizes these objects in **buckets**, which are like folders — and you can upload any type of file (text, images, CSV, logs, etc.) into them

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Dataflow – Data Processing (Stream + Batch)

- A **fully managed service** that processes data either **in real-time (stream)** or **scheduled (batch)**.

- Based on Apache Beam.

🧠 *Use it for:*

- Cleaning, filtering, aggregating, or transforming raw data

- Handling **event-driven processing** or large historical files

💡 *Stream:* Handle data from Pub/Sub (real-time clicks)
💡 *Batch:* Handle stored data from GCS (daily CSV uploads)

Dead Letter Queues

Dead Letter Queues (DLQs) are special queues used to store messages that cannot be processed successfully.

◆ **Example (in Google Pub/Sub):**

In **Pub/Sub**, if a subscriber fails to acknowledge a message after a configured number of delivery attempts, that message is sent to a **Dead Letter Topic** (DLQ).