

# Module 1

## Digital Transformation with Google Cloud

### Lessons

- 01** Why cloud technology is transforming business
- 02** Fundamental cloud concepts
- 03** Cloud computing models and shared responsibility

Google Cloud

It's time to jump into module 1, "Digital Transformation with Google Cloud. In this section of the course, you'll explore why cloud technology is transforming business, fundamental cloud concepts, and cloud computing models and the shared responsibility model.

# Module 1

## Digital Transformation with Google Cloud

### Lessons

01 Why cloud technology is transforming business

02 Fundamental cloud concepts

03 Cloud computing models and shared responsibility

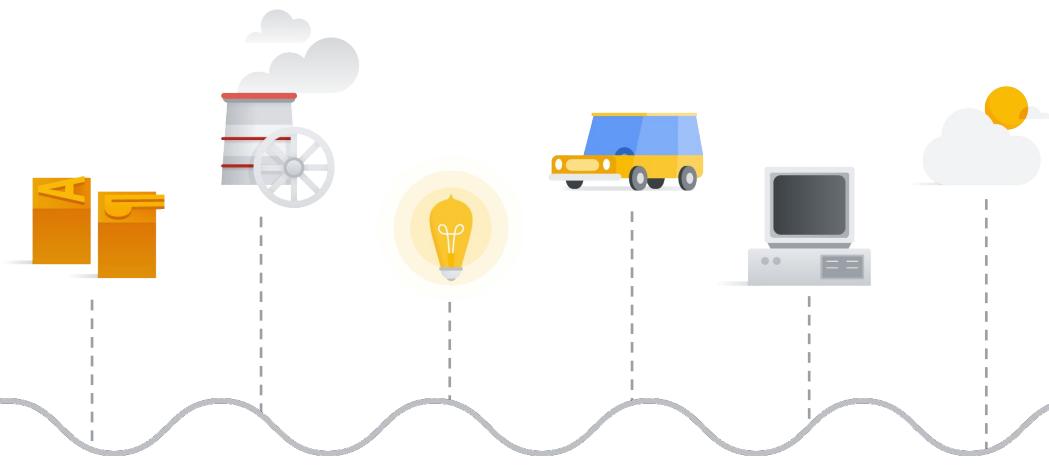
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Let's get started!



**Innovations, paradigm  
shifts, and digital  
transformation**

## Innovation over the ages



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Innovation doesn't come in a linear pattern. It comes in waves. And each of these waves is powered by a breakthrough technology. There was the age of the **printing press**, the steam engine, electricity, the transportation age, the first computers and, today, data and cloud infrastructure. Each of these inventions triggered thousands of innovations, changing what's possible in life and work.

Consider the invention of the printing press. It was revolutionary because it gave everyone access to books, encyclopedias, and even playing cards in their daily lives. It also led to a broader recognition of intellectual property through widely distributed patents, which in turn prepared the world for the first industrial revolution. There was no turning back!

Steam-powered engines brought us cars and trains, which then radically transformed the transportation industry; allowing businesses to produce and transport goods at scale.

The entire Industrial Revolution resulted from new technologies that came together and facilitated new ways of working.

In the same way, electricity brought us the light bulb, household appliances, and eventually the computer.

## Paradigm shift



A fundamental and irreversible change in the way that humans work and engage with the world

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What the printing press, the steam engine, and electricity all have in common is that they're examples of a paradigm shift: a fundamental and irreversible change in the way that humans work and engage with the world.

## Cloud technology

is transforming how...

 Organizations create value

 People work

 People live

is the catalyst for thousands of innovations that change how...

 We navigate the world

 We interact with media

 We diagnose illness

 We combat environmental issues

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Well, we're right in the middle of another paradigm shift: one of digital transformation. Cloud technology is transforming how organizations create value, how people work, and ultimately, how people live. It's the catalyst for thousands of innovations that change how we navigate the world, how we interact with media, how we diagnose illness, or how we combat environmental issues.

## Discussion

### What is a digital transformation?

How would you define this term?

Can you think of industries that have gone through digital transformation recently?



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Because this is an introduction to digital transformation, let's make sure we're using the same definition.

## Digital transformation

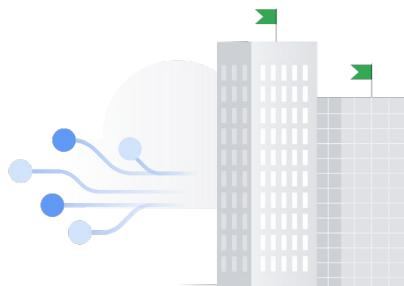
When an organization uses **new digital technologies**, such as public, private, and hybrid cloud platforms **to create or modify** business processes, culture, and customer experiences **to meet the needs** of changing business and market dynamics.

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Digital transformation, as a term, has become prominent over the past few years. But what are the key components of a digital transformation, how do they relate to the use of cloud technologies, and why do so many organizations pursue it?

At Google Cloud, we define digital transformation as when an organization uses new digital technologies, such as public, private, and hybrid cloud platforms to create or modify business processes, culture, and customer experiences to meet the needs of changing business and market dynamics.

## How does digital transformation help organizations?



- Change how they operate
- Redefine relationships
- Modernize applications
- Create services
- Deliver value

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Organizations choose digital transformation frameworks to foster innovation, generate new revenue streams, and adapt quickly to market changes and customer needs.

Digital transformation helps organizations change how they operate and redefine relationships with their customers, employees, and partners by modernizing their applications, creating new services, and delivering value.

For that reason, rapid advances in digital technology are redefining every industry.

- Many vehicles are now software-driven, and they receive regular updates much like a laptop or phone.
- In chemistry, big data and artificial intelligence (or AI) facilitates drug discovery.
- Financial service institutions use cloud's vast computing power to provide better insights than ever before.

“

50% of all IT spending will go toward digital transformation and innovation by 2024.

DC FutureScape: Worldwide IT Industry 2020 Predictions

“

By 2025, more than 90% of new enterprise apps will have AI embedded within them.

DC FutureScape: Worldwide IT Industry 2020 Predictions

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With smart analytics that are increasingly embedded in everything and devices that generate exponential amounts of data, traditional on-premises computing solutions can no longer suffice. As business innovation becomes more driven by software, the [IDC FutureScape report](#) predicts that over 50% of all IT spending will go toward digital transformation and innovation by 2024.

In fact, [IDC also predicts](#) that, by 2025, more than 90% of new enterprise apps will have AI embedded within them. Leading organizations will rely more heavily on AI to launch new business models, create more customized experiences, and optimize operations to reduce costs. Understanding the scale and power of the cloud is more critical than ever before.

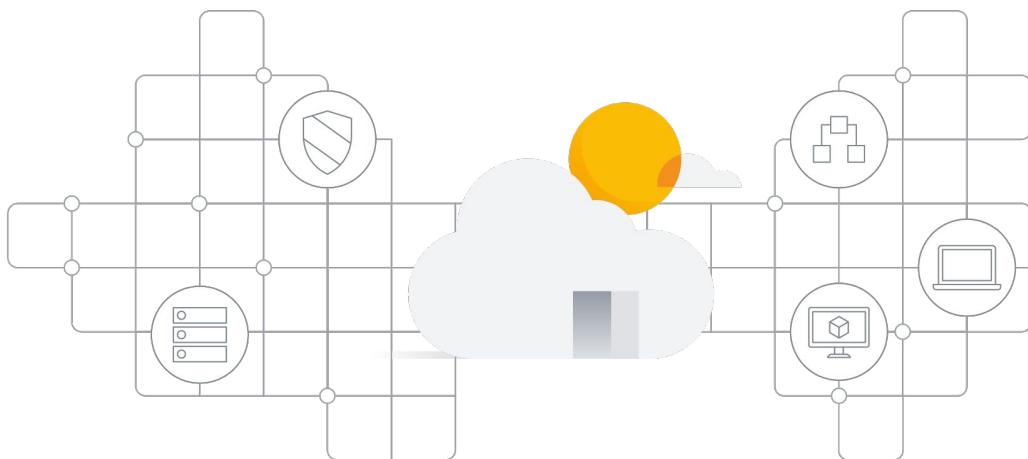


## What is cloud?

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So what is the cloud and cloud technology, exactly? And how does it support digital transformation?

## The cloud is a metaphor for the network of data centers



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The cloud is a metaphor for the network of data centers which store and compute information that's available through the internet.

Essentially, instead of describing a complex web of software, servers, computers, networks, and security systems, all of that has been combined into one word: "**cloud**." You may also hear the term 'cloud computing' which is the same thing, just specifying more the computing power and capabilities of the cloud, all the other hardware and software is still needed to support that computing work.

# IT infrastructure implementations

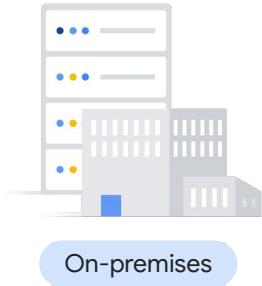


To better understand the cloud, it might help to explore the different ways organizations can implement their information technology (or IT) infrastructure.

The list includes:

- On-premises
- Private cloud
- Public cloud
- Hybrid cloud
- Multicloud

## On-premises



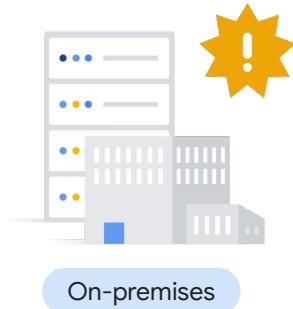
- Hosted on-site
- Located and operated in an organization's data center
- Traditional way of managing IT infrastructure
- Doesn't require third-party access
- Owners have physical control
- No payment for ongoing access

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**On-premises** IT infrastructure, which is often abbreviated to “on-prem,” refers to hardware and software applications that are hosted on-site, located and operated within an organization's data center to serve their unique needs. This implementation is the traditional way of managing IT infrastructure.

The benefit of on-premises is that it doesn't require third-party access, which gives owners physical control over the server hardware and software and doesn't require them to pay for ongoing access.

## On-premises drawbacks



- Require physical space
- Require a specialized room
- Require expert personnel
- Difficult to scale
- Acquire more computing resources than needed

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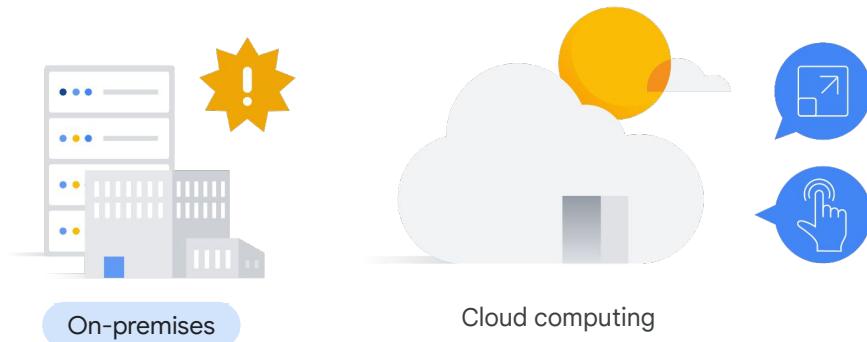
However, to have the computing power to run their required workloads, organizations must buy physical servers and other infrastructure through procurement processes that can take months.

These systems require physical space, typically a specialized room with sufficient power and cooling. After configuring and deploying the systems, businesses then need expert personnel to manage them.

This long process is difficult to scale when demand spikes or business expands.

Organizations often acquire more computing resources than they actually need, which results in low utilization and high overhead.

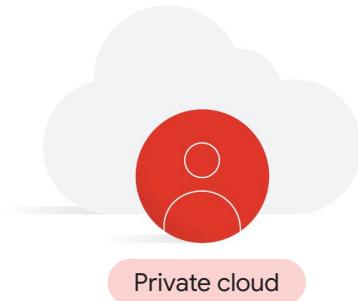
## On-premises vs cloud computing



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Cloud computing addresses these issues by offering computing resources as scalable, on-demand services.

## Private cloud



- Dedicated to a single organization
- Single-tenant or corporate cloud
- Same kind of ongoing maintenance and management as for traditional on-premises infrastructure
- Hosted within an organization's own private servers
- Benefits of a public cloud but with more customization available

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A **private cloud** is a type of cloud computing where the infrastructure is dedicated to a single organization instead of the general public. This type is also known as single-tenant or corporate cloud.

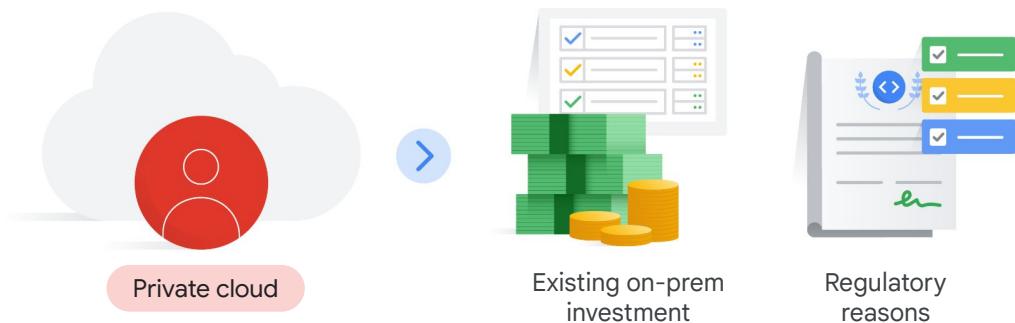
Typically, an organization has to perform the same kind of ongoing maintenance and management for a private cloud as it would for traditional on-premises infrastructure.

A private cloud is hosted within an organization's own private servers, either at an organization's own data center, at a third-party colocation facility, or by using a private cloud provider.

It is when an organization has virtualized servers in its own data centers, or those of a private cloud provider, to create its own private dedicated environment.

Private cloud computing gives businesses many of the benefits of a public cloud—including self-service, scalability, and elasticity—with more customization available from dedicated on-premises infrastructure.

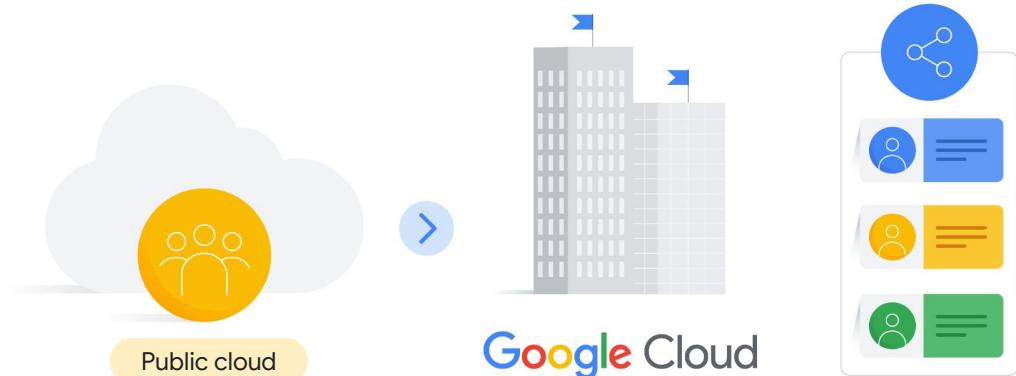
## Private cloud use cases



Organizations might use private cloud if they have already made significant investments in their own infrastructure or if, for regulatory reasons, data must be kept on-premises or hosted in a certain way.

On-premises servers are also often referred to as private clouds, but generally the distinction can be made that on-premises software runs in a local environment, whereas a private cloud is accessed through the internet.

## Public cloud

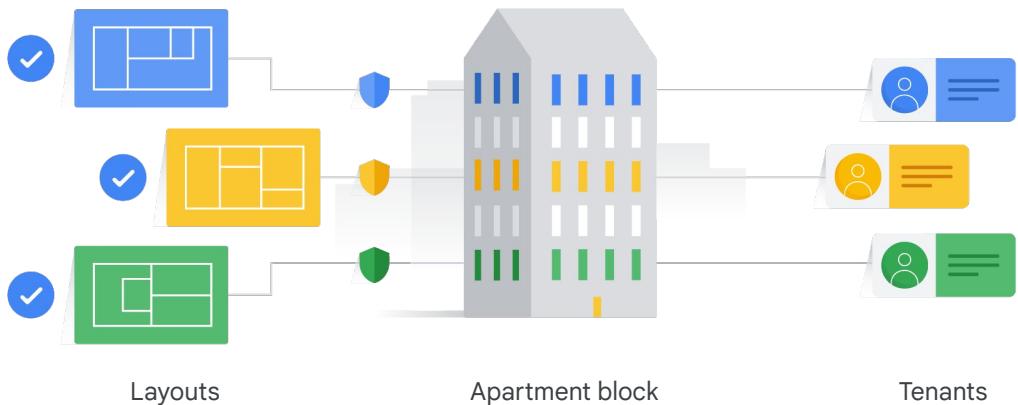


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The **public cloud** is where on-demand computing services and infrastructure are managed by a third-party provider, such as Google Cloud, and shared with multiple organizations or “tenants” through the public internet.

This sharing is why public cloud is known as multi-tenant cloud infrastructure, but each tenant’s data and applications running in the cloud are hidden from other tenants.

## Public cloud



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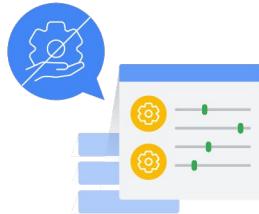
You can think of it like an apartment building that's maintained by a property management company. The building has many units and tenants. Each unit might have a slightly different layout, but still has all the amenities a tenant needs to live there. And each unit is locked and private to the tenant who pays for that space.

In these lessons, when we refer to "cloud," unless otherwise stated, we're talking about the public cloud.

## Public cloud benefits



On-demand availability  
of computing and  
infrastructure resources



No need to acquire,  
configure, or manage  
resources

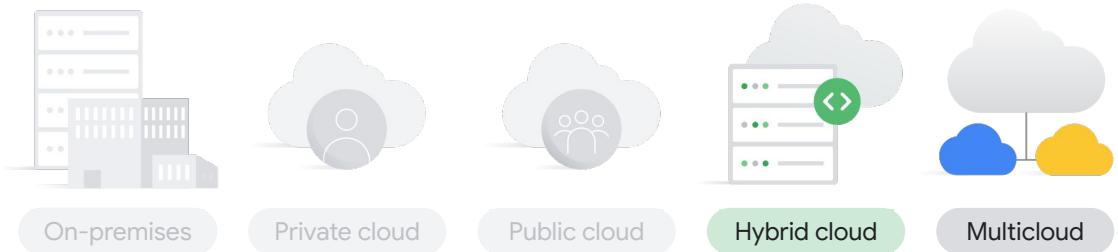


Pay only for  
what is used

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Because public cloud has on-demand availability of computing and infrastructure resources, organizations don't need to acquire, configure, or manage those resources themselves, and they only pay for what they use.

## Hybrid cloud and multicloud

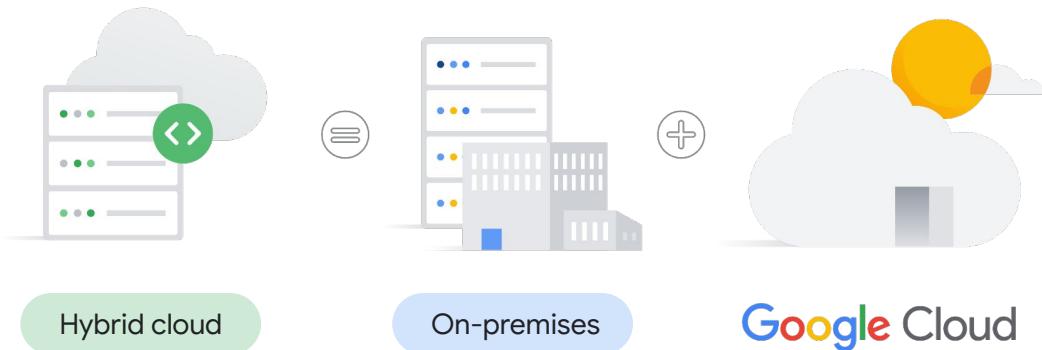


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The final two ways that organizations can implement IT infrastructure is hybrid cloud or multicloud.

Although they're not the same, these two terms are often used interchangeably, so let's take a moment to define them.

## Hybrid cloud



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In a **hybrid cloud**, applications run in a combination of different environments.

The most common hybrid cloud example is combining a public and private cloud environment, like an on-premises data center, and a public cloud computing environment, like Google Cloud.

It's not always possible, or necessary, for an organization to rely solely on the cloud. For example, requirements might call for on-premises infrastructure to work with public cloud services.

## Multicloud



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The term **multicloud** describes architectures that combine at least two public cloud providers, such as Google Cloud, Amazon Web Services, Microsoft Azure, or others. An organization might choose multicloud if they want to take advantage of the key strengths of different public cloud providers. Organizations might operate a combination of on-premises and multiple public cloud environments, therefore implementing both hybrid and multicloud simultaneously.

So, although hybrid cloud and multicloud are related, they aren't interchangeable terms.

## Today, most organizations embrace a multicloud strategy



89% of respondents  
have a multicloud strategy



80% of respondents  
have a hybrid strategy

Flexera 2022 State of the Cloud Report

Google Cloud

Today, most organizations embrace a multicloud strategy. According to the “Flexera 2022 State of the Cloud Report,” 89% of respondents reported having a multicloud strategy, and 80% of them take a hybrid approach by combining public and private cloud.

We'll talk about this in more detail later today.

## Discussion

**What are your current and future IT infrastructure implementations?**

- Why do you think the majority of organizations are implementing hybrid and/or multicloud?
- What cloud strategy are you using today?
- What was your goal for moving to the cloud?



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Let's pause for a quick discussion. I'm curious to hear about your current and future infrastructure implementations.

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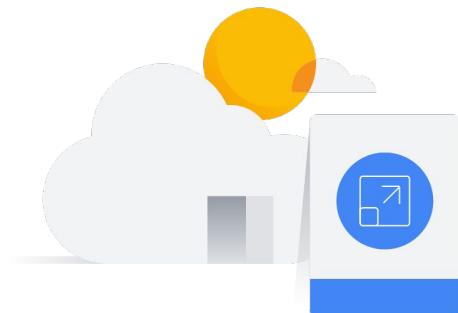


## The benefits of cloud computing

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So, what are the benefits of cloud computing compared to traditional on-premises infrastructure?

## Scalability



- Access to scalable resources
- Latest technology on-demand
- Accelerates deployment time

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It's **scalable**. Cloud computing gives organizations access to scalable resources and the latest technologies on-demand, so they don't need to worry about capital expenditures or limited fixed infrastructure. This can significantly accelerate infrastructure deployment time.

## Flexibility

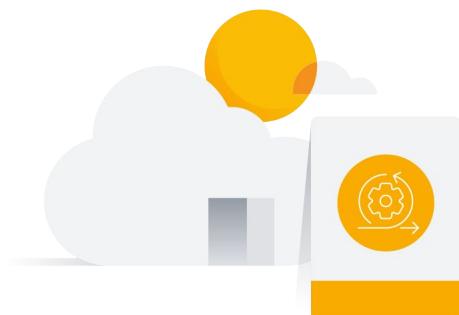


- ✓ Access services from anywhere
- ✓ Scale services up
- ✓ Scale services down

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It's **flexible**. Organizations and their users can access cloud services from anywhere with an internet connection; scaling services up or down as needed to meet business requirements.

# Agility

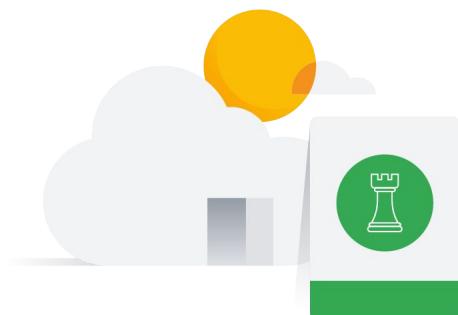


- ✓ Develop new applications
- ✓ Rapidly get them into production
- ✓ No infrastructure worries

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It's **agile**. Organizations can develop new applications and rapidly get them into production, without worrying about the underlying infrastructure.

## Strategic value

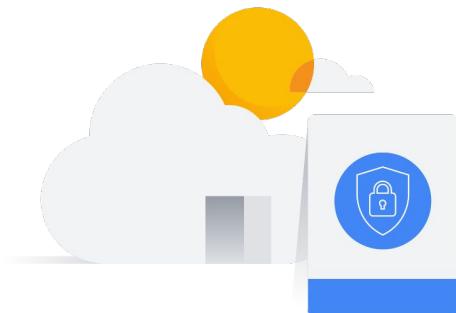


- Competitive advantages
- Higher return on investment
- Innovate and try new ideas

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It offers **strategic value**. Because cloud providers stay updated with the latest innovations and offer them as services to customers, organizations can get more competitive advantages—and a higher return on investment—than if they'd invested in soon-to-be obsolete technologies. This lets organizations innovate and try new ideas faster.

# Security



- Stronger than enterprise data centers
- Depth and breadth of mechanisms
- Dedicated teams

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It's **secure**. Cloud computing security is recognized as stronger than that in enterprise data centers, because of the depth and breadth of the security mechanisms and dedicated teams that cloud providers implement.

## Cost-effectiveness



- ✓ Pay for what is used
- ✓ No overbuilding data centers
- ✓ IT staff can work on strategic initiatives

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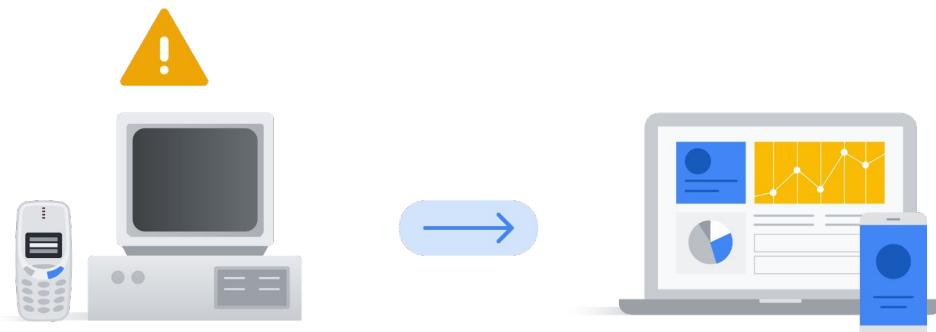
Finally, it's **cost-effective**. No matter which cloud computing service model organizations implement, they only pay for the computing resources they use. They don't need to overbuild data center capacity to handle sudden spikes in demand or business growth, and they can deploy IT staff to work on more strategic initiatives.



Real-world examples:  
**Why it's critical to  
transform and embrace  
new technology**

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## Not being open to change is risky for an organization

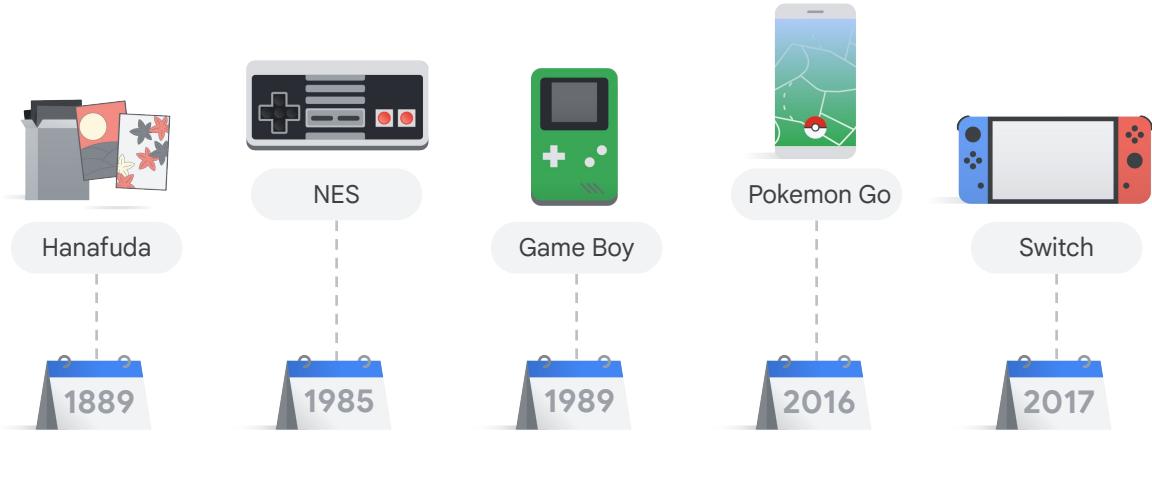


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As the world and business change, keeping technology the same instead of being open to transforming is risky for an organization.

Let's illustrate this by looking at two examples: one embraces new technology and uses it to their advantage, and the other doesn't.

## Nintendo



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First up is Nintendo. Nintendo has been creating games since 1889! They started with traditional Japanese playing cards, called **Hanafuda**, which were made possible by the printing press.

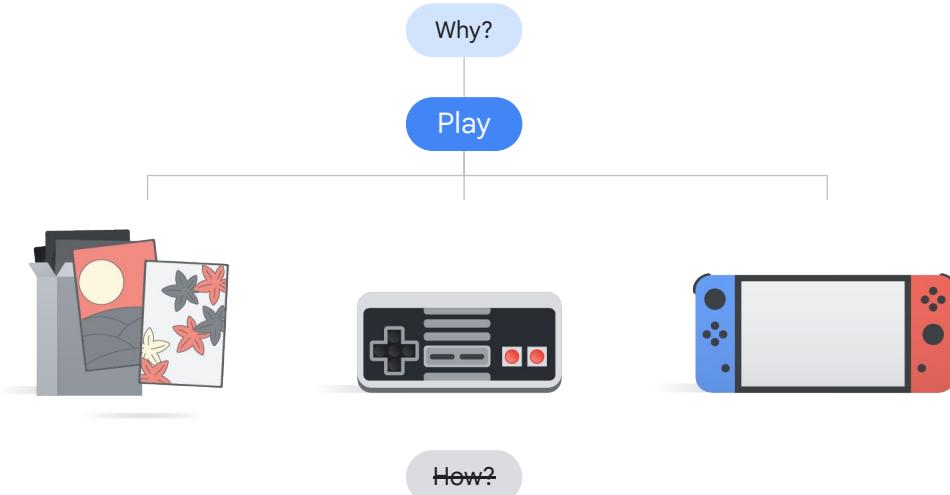
From there, they have consistently used new technology to transform their business, and become a leader in the gaming industry. They were even among the first to introduce gaming consoles and mobile gaming devices.

Still, they didn't just stop after these successes. Instead, they revolutionized mobile gaming when they launched **Pokemon Go** in 2016, and then the first cloud gaming console—**Nintendo Switch**—one year later in 2017.

At a time when most of their competitors were failing, Nintendo transformed by using one new technology after the next, consistently maintaining and even expanding its market share and customer base along the way.

More recently, Nintendo has been using Google Cloud to bring games to smartphones worldwide.

## What makes Nintendo so successful at transforming?



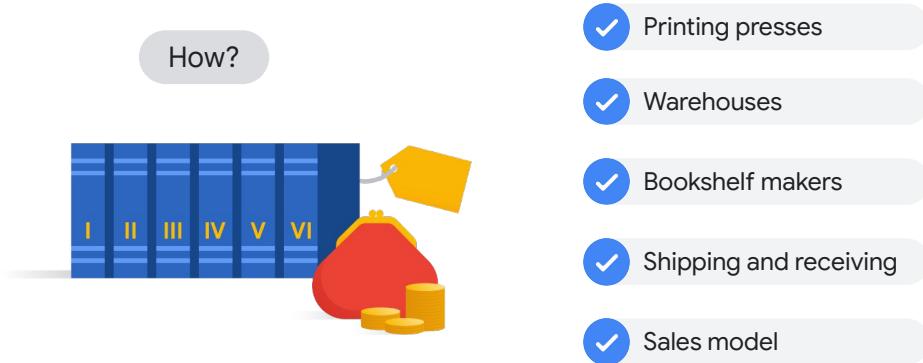
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So, what makes Nintendo so successful at transforming?

The answer is that they consistently focus on “why” they exist, not “how” they operate. They exist because they want people to play, and naturally, they’ll use any new technology as a resource to achieve this mission.

If they focused on liquid crystal displays, or LCDs, as the best tool for gaming, then each new technology would have posed a threat to them. Instead, they used LCDs for a while, and then quickly shifted as the next technology became available to continue motivating people to play.

## Encyclopaedia publishers focused on the ‘how’



- Printing presses
- Warehouses
- Bookshelf makers
- Shipping and receiving
- Sales model

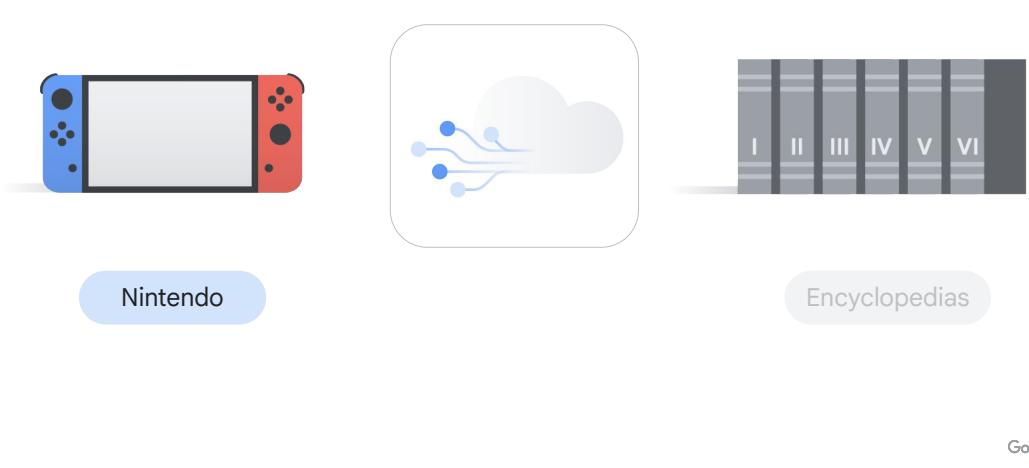
Google Cloud

By contrast, companies that sold encyclopedias, for example, all focused on “how” they operate—how to print and sell a specific set of books. And this was what they were proud of: a beautiful set of leather-bound books lined up on the shelves of the finest libraries. And because of their high cost, only a few scholars or the elite could afford them.

For businesses that made and sold encyclopedias, they needed printing presses, well-kept warehouses, bookshelf makers, a way to ship and receive heavy containers, and a good door-to-door sales model.

These companies were so focused on manufacturing books that they lost sight of their initial mission: **to capture, catalog, and share human knowledge.**

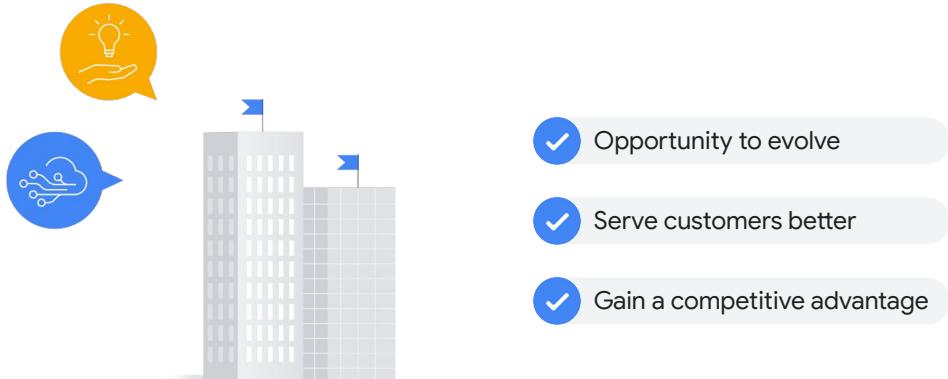
## Digital transformation is an ongoing process, not a one-time effort



Nintendo and encyclopedia companies were both born from the printing era; Nintendo began with traditional playing cards, and encyclopedias stemmed from hard copy books. Because they reacted to technological innovations differently, they experienced different outcomes.

The reality is that **digital transformation is an ongoing process, not a one-time effort**.

## Organizations must embrace new technology



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Today, countless industries around the world are disrupted by digitalization: from healthcare to entertainment, from retail to manufacturing.

It's critical that organizations embrace new technology as an opportunity to evolve, serve their customers better, and gain a competitive advantage.

This is where cloud computing plays a significant role.

## Discussion

What is your “why” for embracing transformation?

- What are you trying to achieve with digital transformation?
- What is your organization’s mission statement?
  - Does it align more with why or how?
- What is the risk of not embracing transformation and new technology for your organization?



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Let's pause for a quick discussion. I'm curious to hear about **why** you and/or your organization have chosen to embrace transformation.

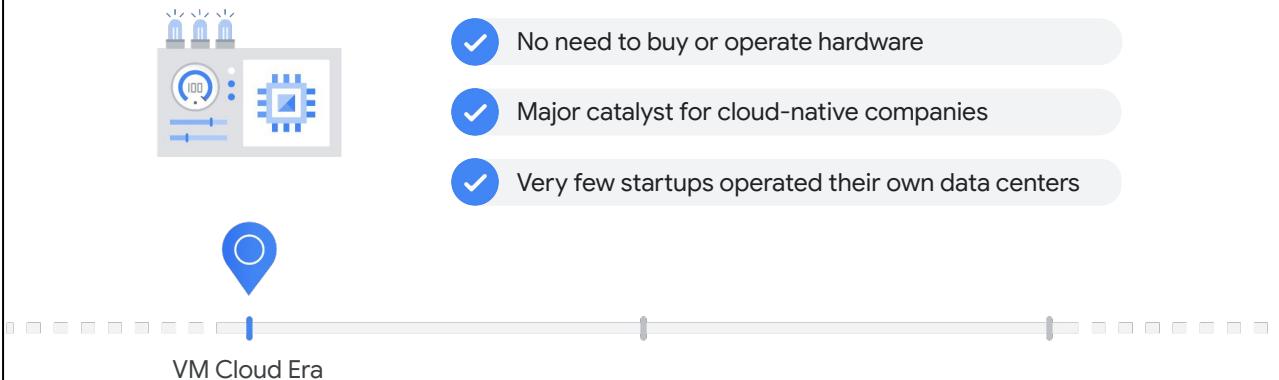


## Cloud eras

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To understand the cloud computing landscape today and what true digital transformation looks like, we should first understand how we got here.

## VM cloud era

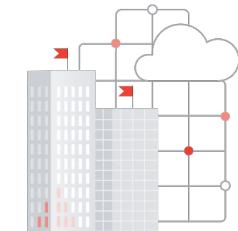


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It started with the **VM cloud era**. VM stands for virtual machine. New organizations, mostly startups, realized that they could forgo ever buying or operating hardware and just start in the cloud. This was a major catalyst for many of the great cloud-native companies that we all rely on today, such as Twitter, Spotify, and PayPal.

By the end of this first VM cloud era, very few startups operated their own data centers.

## Infrastructure cloud era



- Saved costs
- Faster development
- Better security
- Reduction of management load
- Focus on building new capabilities

Infrastructure  
Cloud Era

Google Cloud

Next was the **infrastructure cloud era**, which is when organizations migrated their IT infrastructure to the cloud.

This migration saved costs because infrastructure could scale up and down more quickly and easily. Faster development was possible because companies didn't need long-term infrastructure planning and security was better.

Also, reducing the management load on IT staff lets organizations direct more people and resources to focus on building new capabilities.

In this last decade of the infrastructure cloud, companies that ignored this migration were left trailing behind.

Digital transformation is more than simply migrating and shifting systems to the cloud

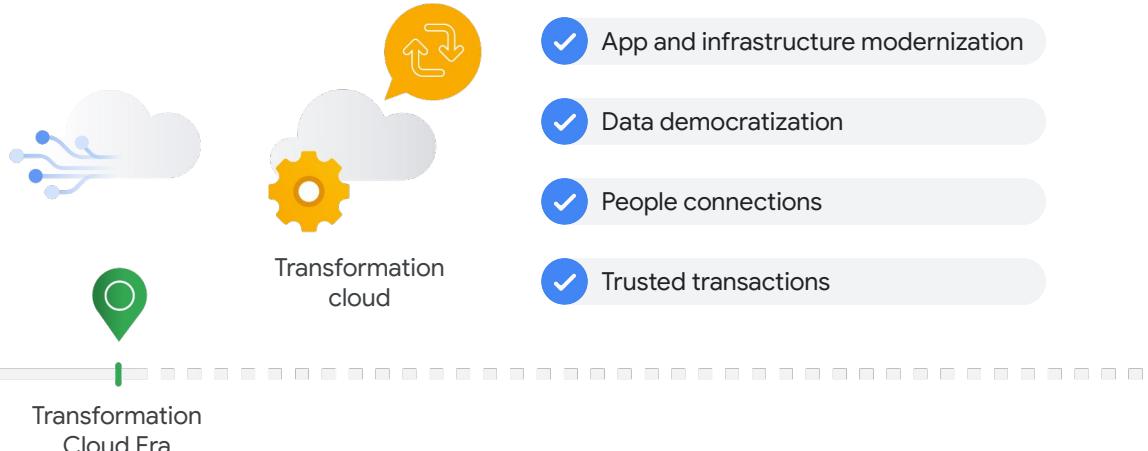


Although the return on investment of these early cloud migrations was important, it didn't provide compelling **transformative** or **disruptive results** or fundamentally change how people worked outside of IT.

This is because digital transformation is more than simply migrating and shifting systems to the cloud for cost saving and convenience.

As we look ahead, reinventing the future means changing not only where business is done, but *how* it is done. It requires maximizing the benefits of the cloud and building an environment that enables every person, process, and technology to bring the highest level of innovation to the business.

## A transformation cloud provides an environment for...



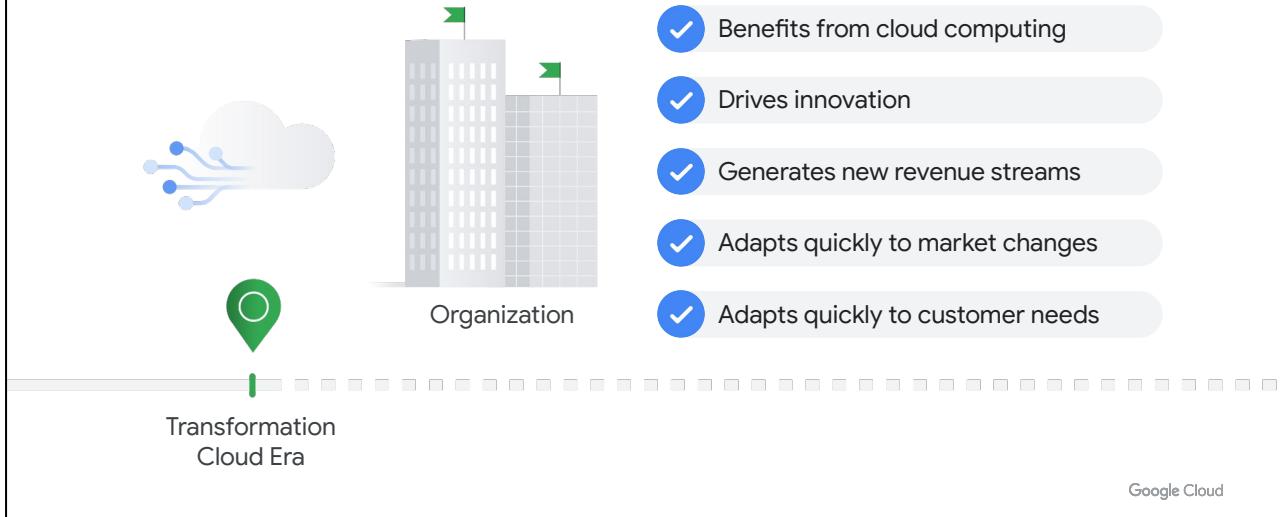
This is what brings us to the transformation cloud era, where organizations are not just making infrastructure decisions, but are truly focusing on transforming. Digitalization is now fundamental, and this era is about spreading transformation among all teams in an organization.

To facilitate this degree of constant innovation and progress, today's most ambitious organizations are building **transformation clouds**.

A transformation cloud is a new approach to digital transformation. It provides an environment for app and infrastructure modernization, data democratization, people connections, and trusted transactions.

It's built on an easy-to-use platform with customized industry solutions that gives organizations the confidence that they are saving money and creating a more sustainable future for everyone.

## A transformation cloud era organization...



The result is an organization that benefits from cloud computing to drive innovation, generate new revenue streams, and adapt quickly to market changes and customer needs.

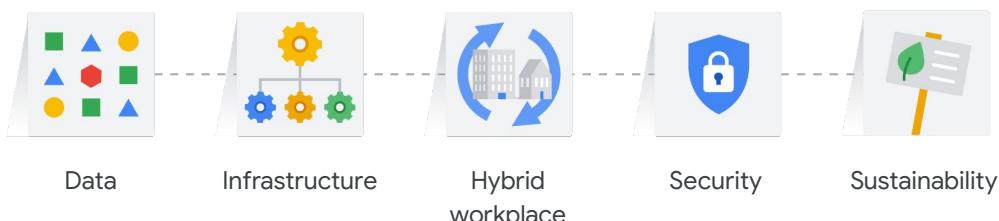
A major indicator for organizations that are accelerating their innovation is how they think about transformation.

Instead of asking infrastructure questions about where their apps and services should run, they ask transformation questions about how to build an environment that helps every person, process, and technology to adapt to changing business needs.

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Instead of asking infrastructure questions about where their apps and services should run, they ask transformation questions about how to build an environment that helps every person, process, and technology to adapt to changing business needs.

# Biggest challenges and needs to accelerate digital transformation



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So, what are the types of problems and questions that make organizations undergo a digital transformation?

At Google, when we talk to our customers about their biggest business challenges and what they need to accelerate digital transformation, we consistently hear five themes.

1. **First**, they want to be the best at understanding and using data. Today, organizations must unify data across streams, lakes, warehouses, and databases so that they can quickly and easily break down data silos, generate real-time insights, and make better business decisions; thus reducing cost and inefficiencies.
2. **Second**, they want the best technology **infrastructure**. Organizations are looking for a cloud platform that will serve as their foundation for growth and has the flexibility to innovate securely and adapt quickly based on market needs.
3. **Third**, they want to create the best hybrid workplace. The fundamental shift in how and where we work requires new, stronger connections and collaboration, and many interactions that took place in person have been digitized. This change requires more intentional connections and collaboration.
4. **Fourth**, it's critical for organizations to know that their data, systems, and users are **secure**. The digital world is seeing more severe security issues, so now companies are rethinking their security posture. They must find ways to identify and protect everything from people and customers to data and

1. transactions in a fast-changing environment.
2. **Finally**, organizations are prioritizing sustainability as a critical, board-level topic. They want to create a more sustainable future through products and services that minimize environmental impact.

These are the top drivers for digital transformation that we see, and the challenges that many organizations face as they navigate their journey.

06



## Google's transformation cloud

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## Capabilities that form the basis of the transformation cloud



Data



Open infrastructure



Collaboration



Trust



Sustainable technology

Google Cloud

There are five primary capabilities that form the basis of the transformation cloud.

They are:

- Data
- Open infrastructure
- Collaboration
- Trust
- And sustainable technology and solutions.

Let's explore each, starting with the **data**.

## Data is critical for innovation and differentiation



Only 26.5% of companies have succeeded in creating a data-driven organization, to realize tangible and measurable value from their data

NewVantage Partners  
Data and AI Executive Survey 2022

Google Cloud

Data is the key to unlocking value from AI, making it critical for innovation and differentiation.

But becoming a data-driven company can be difficult if datasets are siloed across operational and analytical data stores.

According to the [NewVantage Partners' Data and AI Executive Survey 2022](#), only 26.5% of companies have succeeded in creating a data-driven organization, to realize tangible and measurable value from their data.

## Data cloud



- A data cloud is a unified solution to manage data across the entire data lifecycle.
- Data clouds let organizations identify and process data with great scale, speed, security, and reliability.
- Leading companies use a data cloud to encourage data-driven transformation, all with AI built in.

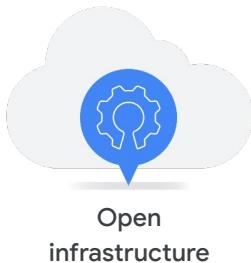
Google Cloud

A **data cloud** is a unified solution to manage data across the entire data lifecycle, regardless of whether it sits in Google Cloud or in other clouds.

It lets organizations identify and process data with great scale, speed, security, and reliability.

Leading companies like Ford, Spotify, Wayfair, and UPS use a data cloud to encourage data-driven transformation quickly, securely, and at scale, all with AI built in.

# Open infrastructure cloud



- Freedom to securely innovate and scale from on-premises, to edge, to cloud.
- Brings services to different physical locations, while leaving the operation, governance, and evolution of the services to Google Cloud.
- Run applications in the place that makes the most sense, using hybrid and multicloud approaches based on open-source software.
- Facilitates faster innovation and reduces lock-in to a single cloud provider.

Google Cloud

Next up is the **open infrastructure**.

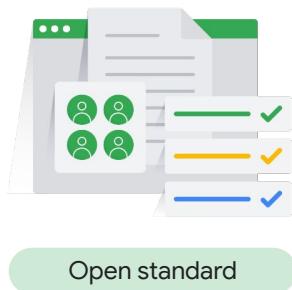
Organizations choose to modernize their IT systems on Google's open infrastructure cloud because it gives them freedom to securely innovate and scale from on-premises, to edge, to cloud on an easy, transformative, and open platform.

Open infrastructure cloud brings Google Cloud services to different physical locations, while leaving the operation, governance, and evolution of the services to Google Cloud.

Instead of relying on a single service provider or closed technology stack, today most organizations want the freedom to run applications in the place that makes the most sense, using hybrid and multicloud approaches based on open source software.

An open infrastructure cloud facilitates faster innovation and reduces lock-in to a single cloud provider by giving organizations the choice and flexibility to build, migrate, and manage their applications across on-premises and multiple clouds.

## Open standard vs open source



- Software with particular specifications
- Accessible and usable by anyone
- Guidelines for software functionality

Google Cloud

Let's take a moment to define two terms that are often confused: **open standard** and **open source**.

**Open standard** refers to software that follows particular specifications that are openly accessible and usable by anyone. They have guidelines for software functionality, which help avoid vendor lock-in and ensure that the products that use these standards perform in an interoperable way. Examples of open standards are HTTP for requesting content on the web or XML for storing structured data.

## Open standard vs open source



Open source

- Source code is publicly available
- Free for anyone to use, modify, and share
- Created through public collaboration

Google Cloud

**Open source** refers to software whose source code is publicly accessible and free for anyone to use, modify, and share. A decentralized community generally develops open source software as a public collaboration, based on a philosophy of transparency and the open exchange of ideas.

Open source plays a critical role in an open cloud to deliver customers the portability they expect.

## Collaboration cloud



- Helps transform how people connect, create, and collaborate.
- People and culture are as important as technology.
- Organizations have increased both location and time flexibility in work arrangements.
- Information and frontline workers across regions and industries need to collaborate securely from anywhere, and on any device.

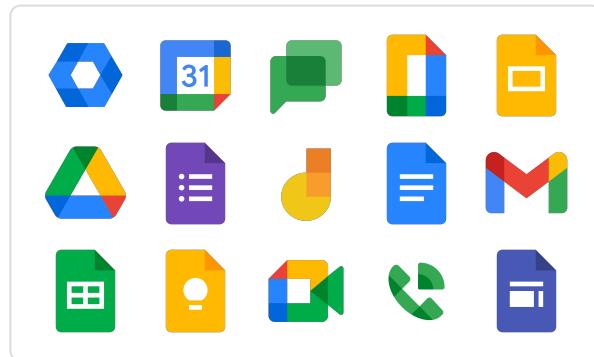
Google Cloud

**Collaboration** helps transform how people connect, create, and collaborate.

A transformation cloud isn't just about technology. **People and culture** are just as important. Organizations have increased both location and time flexibility in work arrangements since the COVID-19 pandemic began, and hybrid work is here to stay.

With the definition of the workplace forever changed, it's essential that information and frontline workers across regions and industries connect, create, and collaborate securely from anywhere, and on any device. This new hybrid work environment needs to support a mix of in-person and remote interactions, including immersive digital and mobile experiences.

## Collaboration cloud



Google Workspace

Google Cloud

At Google, for example, we offer a collaboration cloud through Google Workspace. Workspace brings together communication and collaboration apps including Gmail, Chat, Calendar, Drive, Docs, Sheets, and Meet into a people-first experience powered by Google AI.

## Trusted cloud



Trust

- A trusted cloud helps organizations protect what's important with advanced security tools.
- The annual cost of cyber crime is expected to reach **\$10.5 trillion** annually by 2025.
- Organizations are finding ways to identify and protect everything, from people and customers to data and transactions.
- Organizations want to find, analyze, resist, and remediate threats at global scale while maintaining control of their digital assets.

Google Cloud

A **trusted cloud** helps organizations protect what's important with advanced security tools.

According to Cybersecurity Ventures, the annual cost of cyber crime is expected to reach \$10.5 trillion annually by 2025.

Due to the rise of cybersecurity threats, every company is rethinking its security posture. This means finding ways to identify and protect everything, from people and customers to data and transactions—in a fast-changing environment.

Organizations see the cloud as more secure than on-premises, and they want to make it simple so that employees, customers, and contractors can safely access their services. They want to create better visibility to find, analyze, resist, and remediate threats at global scale, and benefit from cloud innovations while maintaining control of their digital assets.

## Sustainable technology



Sustainable  
technology

- Using technology and solutions that help organizations build and work more sustainably.
- Cloud computing is estimated to save **1 billion metric tons** of CO<sub>2</sub> emissions by 2024.
- The largest corporations have the opportunity to lead the way in helping the world reduce its emissions and operate on carbon-free energy.
- Google Cloud partners with customers to decarbonize their digital apps and infrastructure with our sustainable technology and solutions.

Google Cloud

Finally, a transformation cloud is built on a **sustainable foundation**, using technology and solutions that help organizations build and work more sustainably. Today, organizations are now encouraged to help create a cleaner, more sustainable world and they need new technologies that help them progress consistently.

According to IDC, cloud computing is estimated to save **1 billion metric tons of CO<sub>2</sub> emissions by 2024**.

The largest corporations have the opportunity to lead the way in helping the world reduce its emissions and operate on carbon-free energy always. For that reason, companies are moving to the cloud, and they want a sustainable infrastructure to power their business.

At Google Cloud, for example, we partner with customers to decarbonize their digital apps and infrastructure with our sustainable technology and solutions.

## Sustainable technology



Google Cloud data centers are **2 times as energy-efficient** as a typical enterprise data center.

Moving to Google Cloud can dramatically **decrease** a customer's IT-related **carbon footprint**.

Google Cloud

We proudly operate the cleanest cloud in the industry, with the smartest data centers that are 2 times as energy-efficient as a typical enterprise data center.

Moving to Google Cloud can dramatically decrease a customer's IT-related carbon footprint.

## Discussion

**Do the transformation themes align with your organization's goals?**

Consider the capabilities of a transformative cloud:

- Data
- Open infrastructure
- Collaboration
- Trust
- Sustainable technology and solutions

Which are most important to your organization?

What challenges do you foresee on the journey?

Where in the cloud journey are you today?



Google Cloud

**Do the transformation cloud themes align with your organization's goals?**

Consider the capabilities of a transformative cloud:

- Data
  - Open infrastructure
  - Collaboration
  - Trust
  - Sustainable technology and solutions
- 
- Which are most important to your organization?
  - What challenges do you foresee on the journey?
  - Where in the cloud journey are you today?

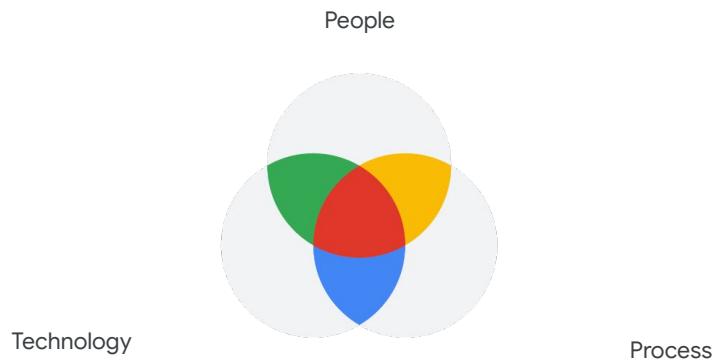


## The Google Cloud Adoption Framework

Google Cloud

So, how can organizations approach their cloud journey?

## How can organizations approach their cloud journey?



Google Cloud

Moving to the cloud offers enormous benefits for transforming businesses. Yet there are also risks.

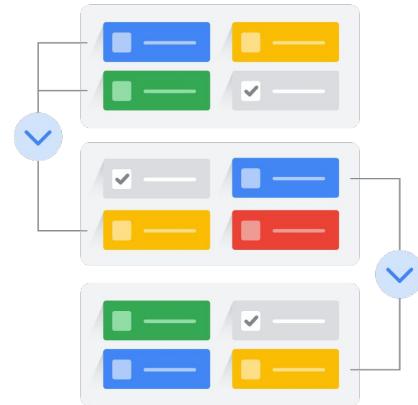
The challenge is multidimensional, with far-reaching implications for the solutions that will run in the cloud, and also for the technologies that support them, the people who must implement them, and the processes that govern them.

The rubric of people, process, and technology is a familiar one. It forms the basis of the Google Cloud Adoption Framework, which was created to support customers on their cloud journey.

# The Google Cloud Adoption Framework serves as a map

The framework structures and aligns

- Short-term tactical objectives
- Mid-term strategic objectives
- Long-term transformational objectives



Google Cloud

The value of the Google Cloud Adoption Framework is that it serves as a map to help organizations adopt the cloud quickly and effectively by creating a comprehensive action plan for accelerating cloud adoption.

It does this by structuring and aligning short-term tactical, mid-term strategic, and long-term transformational business objectives.

It provides a solid assessment of where an organization is in its cloud journey and actionable programs that get it to where it wants to be.

## Cloud maturity assessment

Establishes where an organization is currently



Reveals areas where an organization might be weaker or underinvested

Google Cloud

A cloud maturity assessment helps to establish where an organization is currently regarding the cloud adoption themes recognized by Google Cloud.

It can quickly reveal any areas where an organization might be weaker or underinvested. This is especially powerful if an organization was previously unaware of this lack of maturity.

The Google Cloud Adoption Framework is more than just a model; it's also a map to real, tangible tasks that organizations need to adopt the cloud.

After cloud maturity has been assessed and actions have been recommended, it's easy to scope and structure a cloud adoption program using the framework.

# Module 1

## Digital Transformation with Google Cloud

### Lessons

- 01 Why cloud technology is transforming business
- 02 Fundamental cloud concepts
- 03 Cloud computing models and shared responsibility

Google Cloud

Welcome to the second lesson of the Digital Transformation with Google Cloud module. To understand the impact that the cloud can have on a business, it's important to first recognize some of the fundamental cloud concepts.

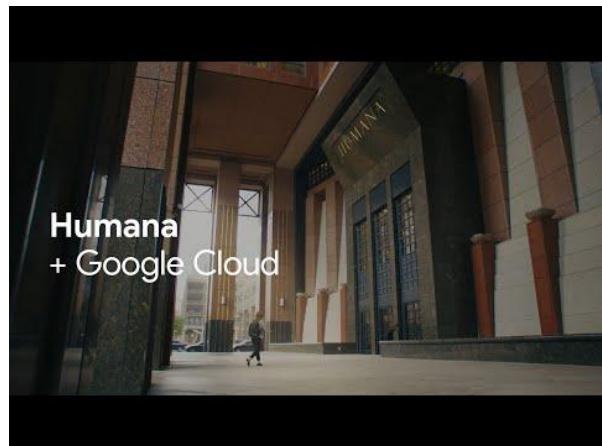


## Cloud adoption success stories

Google Cloud

Cloud adoption has made a positive impact on some of the world's leading companies across various industries.

## Customer Story - Humana



Google Cloud

Let's see how Humana uses Google Cloud to reimagine the future of healthcare.

Google Cloud helps Humana analyze hundreds of calls a day from customers, patients and members. Google Cloud's speech-to-text API turns calls into transcripts instantly and then all this data is used to find patterns and trends. That means Humana can review hundreds of calls in minutes rather than days. Together, Humana and Google Cloud are making healthcare better one day at a time.

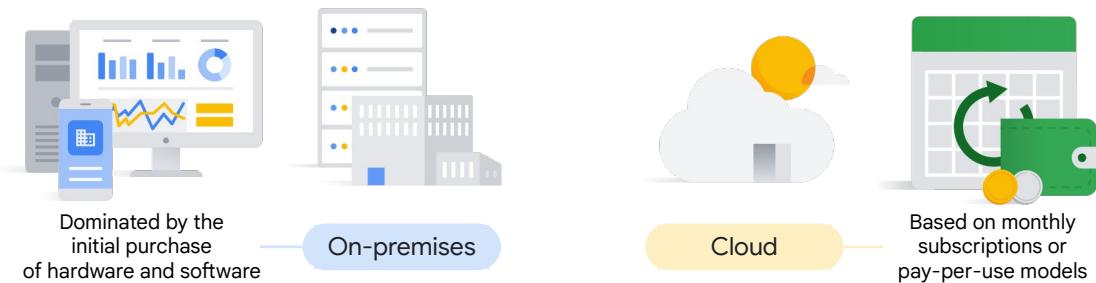
02

## Total cost of ownership

Google Cloud

Organizations often perform a cloud total cost of ownership (or TCO) analysis when they are considering moving to the cloud.

## Total cost of ownership (TCO)



Google Cloud

This analysis aims to weigh the cost of cloud adoption against the cost of running their current on-premises systems.

For **on-premises**, TCO is associated with assessing the cost of static resources throughout their lifetime. However due to the dynamic nature of the **cloud**, predicting future costs can be challenging. A common mistake that organizations make when attempting to calculate cloud TCO is to directly compare the running costs of the cloud against their on-premises system. These costs are not equivalent.

The cost of on-premises infrastructure is dominated by the initial purchase of hardware and software, but cloud computing costs are based on monthly subscriptions or pay-per-use models.

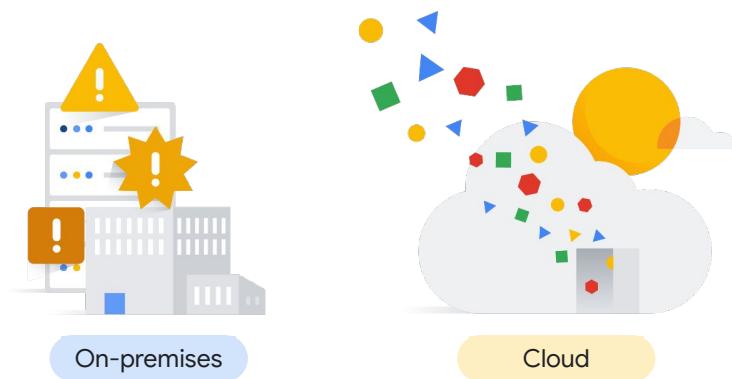
## On-premises considerations



Google Cloud

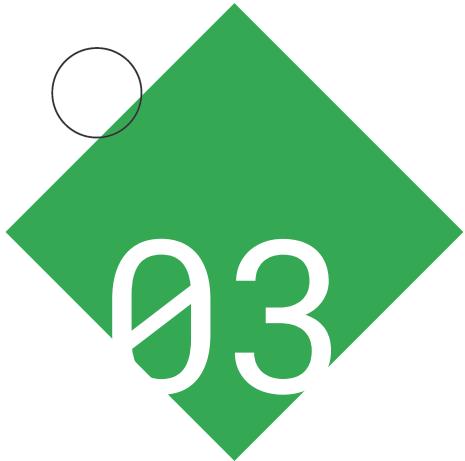
It's also important to consider all the operational costs of running your own data center, such as power, cooling, maintenance, and other support services. A data center is a building or facility that houses a large amount of IT infrastructure, computing, and storage resources in one place.

## The opportunity cost of not migrating to the cloud



Google Cloud

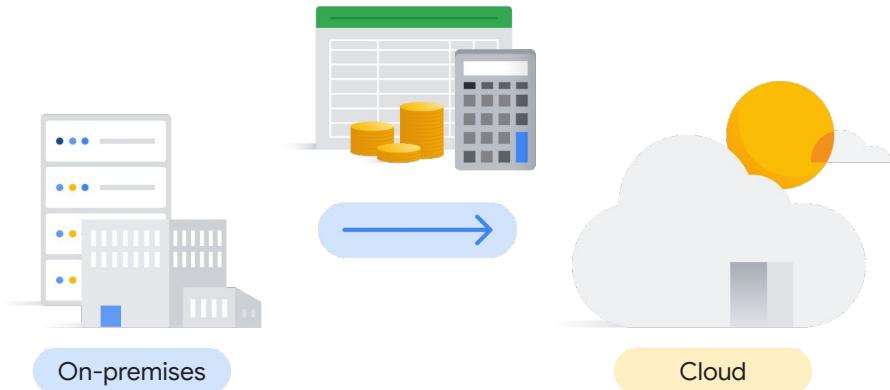
Finally, intangible costs, such as the opportunity cost of not migrating to cloud and the missed benefits, should be considered.



## Capital expenditures versus operating expenses

Google Cloud

## Managing costs change when you move to the cloud



Google Cloud

One area where cloud differs from traditional IT is in how managing costs changes when you move to the cloud.

## From capital expenditure to operating expenses



Google Cloud

With organizations moving from on-premises infrastructure to on-demand cloud services, there's a major shift in spending *from* capital expenditures *to* operating expenses.

But what's the difference between these two?

## Capital expenditures (CapEx)



Capital  
expenditures  
(CapEx)

Upfront business expenses  
put toward fixed assets

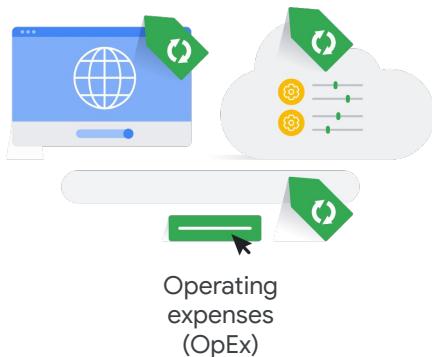
Google Cloud

**Capital expenditures, or CapEx**, are upfront business expenses put toward fixed assets. Organizations buy these items once, and they benefit their business for many years.

For example, in IT, these expenditures might mean buying hardware like servers, printers, or cooling systems. Maintaining these assets is also considered CapEx because it extends their lifetime and usefulness.

Small businesses can find CapEx spending challenging because large one-time purchases are often high cost. The more money you put toward CapEx means less free cash flow for the rest of the business.

## Operating expenses (OpEx)



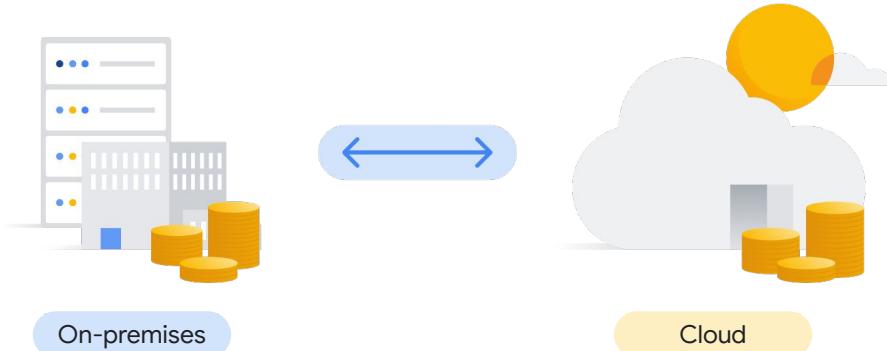
Recurring costs for a more immediate benefit

Google Cloud

And then there are **operating expenses, or OpEx**, which are recurring costs for a more immediate benefit. This represents the day-to-day expenses to run a business.

In IT, these expenses might be yearly services like website hosting or domain registrations, or the subscription fee for cloud services. OpEx covers the spendings on pay-as-you-go items, but are not considered major long-term investments like CapEx items.

## Recognizing cost differences



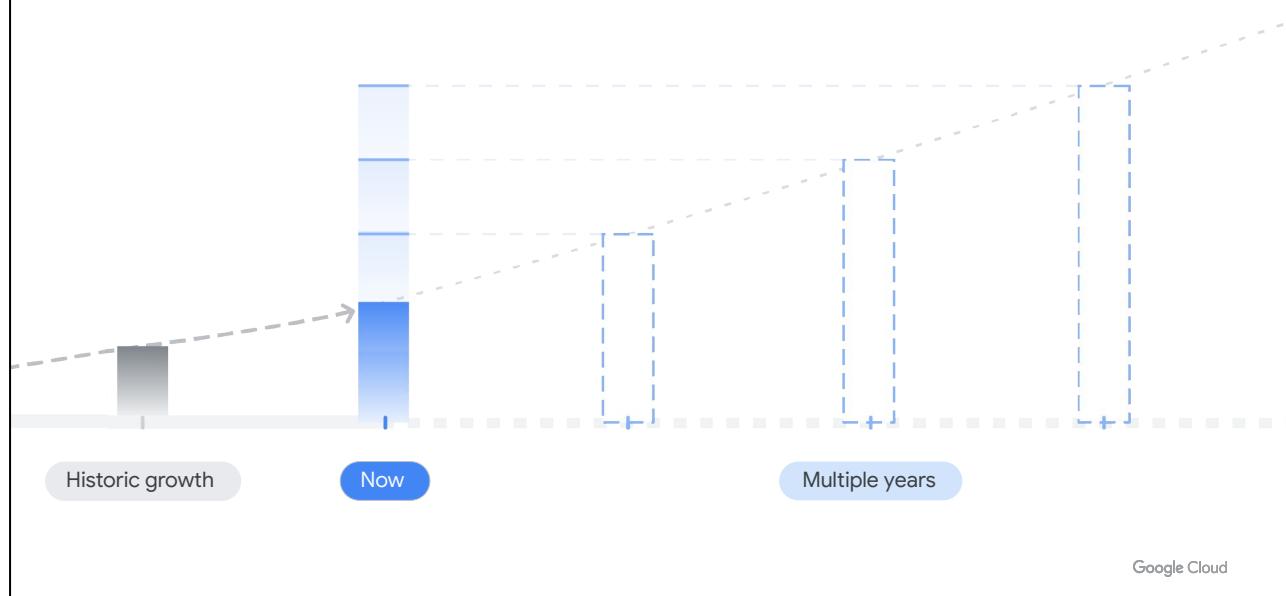
Google Cloud

Understanding the difference between CapEx and OpEx is helpful in recognizing how costs differ between on-premises and the public cloud.

In the on-premises CapEx model, cost management and budgeting are a one-time operational process completed annually.

Data centers require a huge CapEx investment up front as organizations purchase space, equipment, and software and hire a workforce to run and maintain everything.

## Capital expenditures (CapEx)

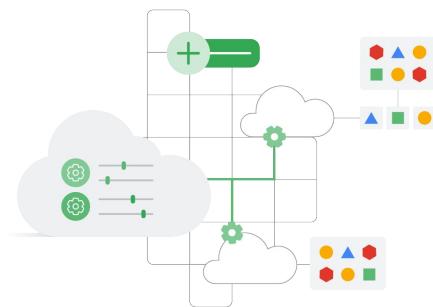


Forecasting is based on a metric such as historic growth to determine the needs for the next month, quarter, year, or even multiple years.

Moving to cloud's on-demand OpEx model enables organizations to pay only for *what* they use and only *when* they use it. Budgeting is no longer a one-time operational process completed annually. Instead, spending must be monitored and controlled on an ongoing basis due to the dynamic nature of cloud use within organizations.

## Infrastructure procurement changes in the cloud

Any employee can create resources in seconds on infrastructure owned and managed by a cloud provider.



Google Cloud

How infrastructure is procured has radically changed, too. In a more decentralized cloud world, any employee can create resources in seconds on infrastructure owned and managed by a cloud provider.

Organizations save on power, cooling, and floor space; they save on management because they don't have to install, operate, upgrade, and troubleshoot it themselves. And they're not depreciating the equipment—the cloud provider is.

Cloud gives organizations the ability to start small and grow organically instead of having to guess at what is needed next week, next month, and next year.

Costs match actual usage and are now operational expenses.

# Quiz

## Question

An organization has shifted from a CapEx to OpEx based spending model. Which of these statements is true?

- A. They will only pay for what they forecast.
- B. Budgeting will only happen on an annual basis.
- C. They will only pay for what they use.
- D. Hardware procurement is done by a centralized team.

Google Cloud

An organization has shifted from a CapEx to OpEx based spending model. Which of these statements is true?

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# Quiz

## Answer

An organization has shifted from a CapEx to OpEx based spending model. Which of these statements is true?

- A. They will only pay for what they forecast.
- B. Budgeting will only happen on an annual basis.
- C. They will only pay for what they use.
- D. Hardware procurement is done by a centralized team.



Google Cloud

The correct answer is C.

- A. They will only pay for what they forecast.
  - o Why this is the **incorrect** answer: While organizations using OpEx models will undoubtedly factor in forecasts for expected usage to predict expenses, paying for what they forecast isn't the core function of shifting to OpEx. Paying for actual usage is.
- B. Budgeting will only happen on an annual basis.
  - o Why this is the **incorrect** answer: Budget cycles can vary with both CapEx and OpEx spending. OpEx spending, due to its potential for variability, might even make quarterly or monthly budgeting more important for an organization.
- C. They will only pay for what they use.
  - o Why this is the **correct** answer: This is the core distinction between CapEx (Capital Expenditure) and OpEx (Operating Expenditure). In a CapEx model, a company invests in owning an asset upfront. With OpEx, the company pays for a service on an ongoing basis, only paying for the amount of service actually used. This is similar to paying a monthly internet bill versus buying a router outright.
- D. Hardware procurement is done by a centralized team.
  - o Why this is the **incorrect** answer: This statement about hardware procurement could sometimes be true, but it's not directly related to the shift from CapEx to OpEx. Both models could implement centralized or decentralized hardware procurement practices.

## Discussion

What impact would an OpEx model have on your organization?

Considerations:

- Procurement
- Forecasting
- Billing
- Cost management
- Impact on people and teams

What value might an OpEx model bring to your business?



Google Cloud

What impact would an opex model have on your organization?

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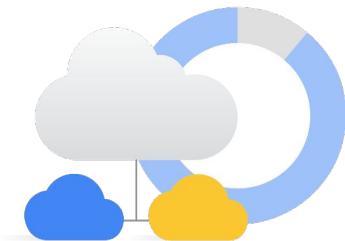
04



**Private cloud,  
hybrid cloud, and  
multicloud strategies**

Google Cloud

## Recall, most organizations embrace a multicloud strategy



89% of respondents  
have a multicloud strategy



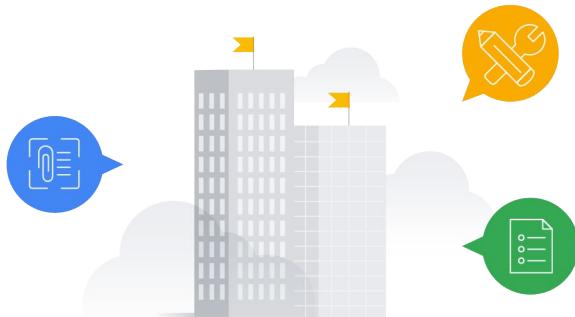
80% of respondents  
have a hybrid strategy

Flexera 2022 State of the Cloud Report

Google Cloud

Today, most organizations embrace a multicloud strategy. According to the “Flexera 2022 State of the Cloud Report”, 89% of respondents reported having a multicloud strategy, and 80% of them take a hybrid approach by combining public and private cloud.

## What is a hybrid or multicloud strategy used for?



Let's explore different requirements, drivers, and uses cases

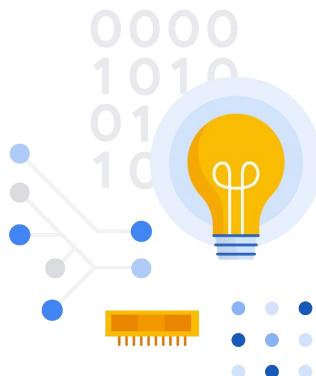
Google Cloud

So, what is a hybrid or multicloud strategy used for? Let's explore some different business requirements, drivers, and use cases that lead an organization to choose this kind of approach.

## 01 | Access to the latest technologies



- Best-in-class approach to cloud features
- Scale, security, and agility to innovate fast
- Advanced capabilities



Google Cloud

### Access to the latest technologies

Running workloads in multiple clouds empowers organizations to leverage the latest innovations and capabilities from each cloud provider, thus taking a best-in-class approach to cloud features and obtaining the scale, security, and agility to innovate fast. Cloud can help organizations build out capabilities, such as advanced analytics services, that might be difficult, or impossible, to implement in existing environments.

## 02 | Running apps on-premises



Freedom to innovate while still meeting legacy technology needs



Google Cloud

### Running apps on-premises

Organizations may have regulated applications that must remain on-premises or mainframe systems that are difficult to move to the cloud. A hybrid approach provides the freedom to innovate while still meeting legacy technology needs.

## 03 | Modernize at the right pace



- Migrate at a pace that makes sense
- Transform technical infrastructure over time



Google Cloud

### Modernize at the right pace

With a hybrid cloud, organizations can migrate applications to the cloud at the pace that makes sense for their business and transform their technical infrastructure over time.

## 04 | Improved return on investment

- ✓ Expand cloud computing capacity without increasing data center expenses
- ✓ Reduce CapEx or general IT spending
- ✓ Improve transparency



Google Cloud

### Improved return on investment

By adding a public cloud provider to their existing on-premises infrastructure, organizations can expand their cloud computing capacity without increasing their data center expenses. This can help reduce CapEx or general IT spending, and improve transparency regarding costs and resource consumption.

## 05 | Flexibility through choice of tools



- Wider choice of tools and developer talent
- Better response to changing market demands
- Avoid vendor lock-in concerns



Google Cloud

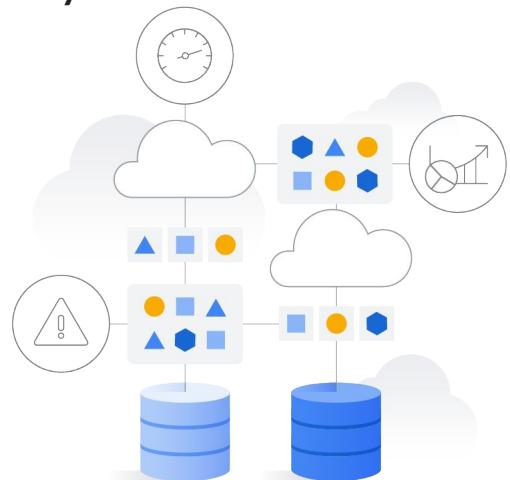
### Flexibility through choice of tools

Hybrid and multi-cloud strategies have advantages for organizations as a whole, but specifically benefit development teams that are working on different projects and tackling unique challenges across different lines of business.

A wider choice of tools and developer talent can be applied to a particular business problem, which means responding better to changing market demands. It also avoids vendor lock-in concerns.

## 06 | Improve reliability and resiliency

- ✓ Distribute core workloads across multiple cloud and on-premise infrastructures
- ✓ Reduce downtime
- ✓ Reduce concerns about over-dependence on a single source of failure
- ✓ Improve quality and availability of a service



Google Cloud

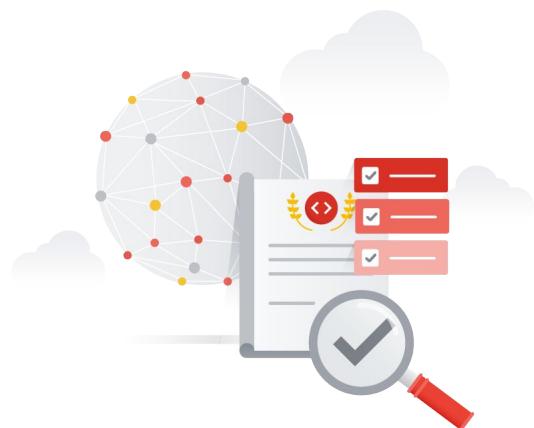
### Improve reliability and resiliency

Organizations can distribute core workloads across multiple cloud and on-premises infrastructures to reduce downtime and concerns about over-dependence on a single source of failure. This approach can improve the quality and availability of a service.

## 07 | Maintain regulatory compliance



Ensure compliance with regional data governance, residency, or digital sovereignty requirements



Google Cloud

### Maintain regulatory compliance

Many industries have rules from governmental or regulatory bodies regarding where their app can operate. Adopting a hybrid solution is an effective way for an organization to ensure compliance with regional data governance, residency, or digital sovereignty requirements.

## 08 | Running apps at remote edge locations

- ✓ Meet performance and latency requirements
- ✓ Run select apps at the network edge



Google Cloud

### And finally, **running apps at remote edge locations**

Organizations in industries that run distributed apps at remote locations, such as kiosks in retail or networks in telecom, can benefit from hybrid cloud. These apps often require improved performance and low latency, and a hybrid approach lets them run select apps at the network edge.

# Quiz

## Question

An organization has made significant investments in their own infrastructure and has regulatory requirements for their data to be hosted on-premises. Which cloud implementation would best suit their needs?

- A. Public Cloud
- B. Private Cloud
- C. Platform as a service
- D. Software as a service

Google Cloud

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- A. Public Cloud
- B. Private Cloud
- C. Platform as a service
- D. Software as a service



Google Cloud

The correct answer is B.

- A. Public Cloud
  - Why this is the **incorrect** answer: Public clouds (like AWS, Google Cloud, or Azure) offer high scalability and flexibility, but data is housed in the cloud provider's data centers. For an organization with regulatory requirements to house data on-premises, this wouldn't be suitable.
- B. Private Cloud
  - Why this is the **correct** answer: A private cloud provides the security and control offered by on-premises infrastructure but leverages cloud computing features for scalability and resource management. This is an ideal model when strict data regulations dictate that an organization must maintain complete control over their data and environment.
- C. Platform as a service.
  - Why this is the **incorrect** answer: PaaS provides a development and deployment environment but not the underlying infrastructure itself. The organization's regulatory requirements necessitate control over the underlying infrastructure, making PaaS less suitable.
- D. Software as a service
  - Why this is the **incorrect** answer: SaaS solutions (like Salesforce or Gmail) are pre-built applications. Since the organization needs custom control over their data hosting, a pre-built application wouldn't meet their needs.

# Quiz

## Question

An organization wants to innovate using the latest technologies, but also has compliance needs that specify data must be stored in specific locations. Which cloud approach would best suit their needs?

- A. Public Cloud
- B. Multicloud
- C. On-premises infrastructure
- D. Hybrid Cloud

Google Cloud

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- C. On-premises infrastructure
- D. Hybrid Cloud



Google Cloud

The correct answer is D.

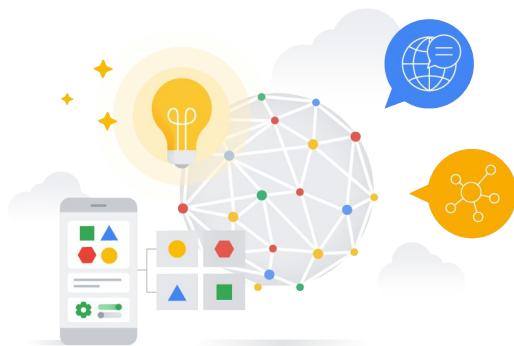
- A. Public Cloud
  - Why this is the **incorrect** answer: The shared infrastructure of public clouds doesn't always address specific data location requirements for compliance.
- B. Multicloud
  - Why this is the **incorrect** answer: While a multicloud approach can increase flexibility, it doesn't inherently solve the issue of compliance related to data location.
- C. On-premises infrastructure
  - Why this is the **incorrect** answer: While full on-premises offers maximum control over data location, it might create limitations on access to the latest technologies or scaling resources quickly to take advantage of new opportunities.
- D. Hybrid Cloud
  - Why this is the **correct** answer: A hybrid cloud approach combines on-premises infrastructure with public cloud services. This gives the organization the flexibility to take advantage of innovative public cloud technologies while keeping sensitive data in a controlled, compliant, on-premises environment.



## How a network supports digital transformation

Google Cloud

## The importance of a reliable network



The ability to connect customers, employees, cloud applications, and devices enables modern organizations to succeed.

With every innovation, the underlying apps and services rely on the network to communicate and connect.

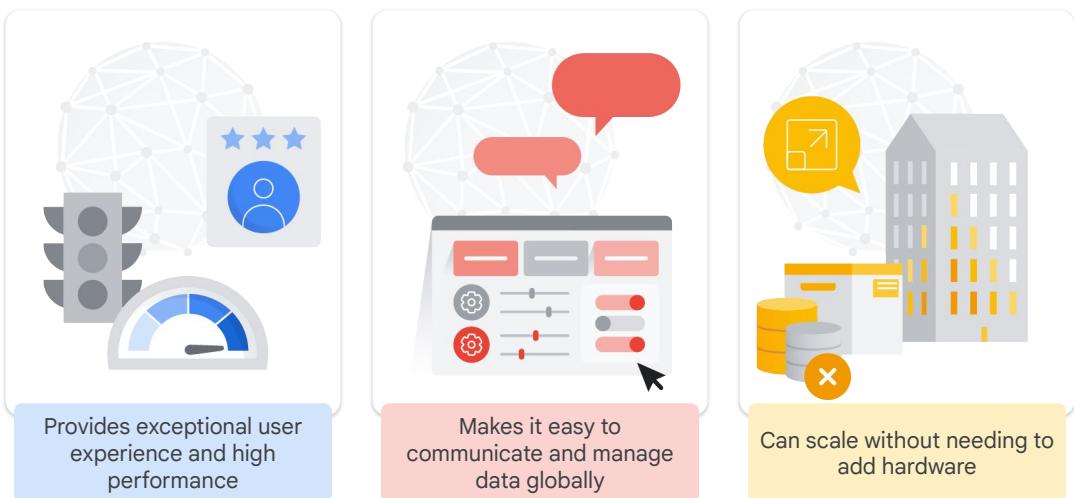
Google Cloud

Digital transformation has increased the importance of the network. The ability to connect customers, employees, cloud applications, and devices enables modern organizations to succeed.

With every innovation, the underlying apps and services rely on the network to communicate and connect.

But how does a reliable networking architecture support a digital transformation strategy?

## A reliable network supports digital transformation

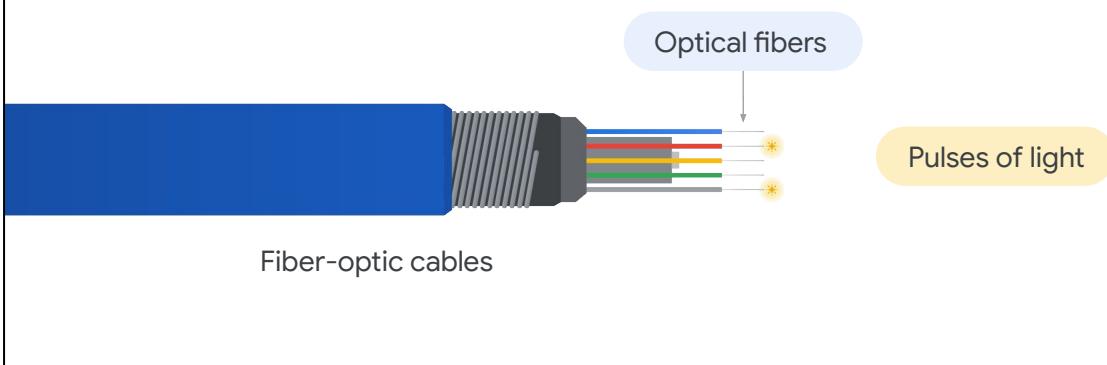


Google Cloud

A fast, reliable, and low-latency global network ensures exceptional user experience and high performance. It also makes it easier to communicate and manage data globally. With ever more distributed workforces and online businesses, having virtual network services that can easily scale without adding hardware ensures that organizations can adapt.

## How does a network operate?

### Fiber-optic networks



Google Cloud

So, how does a network operate?

Let's start with the foundation of the modern internet: fiber-optic networks.

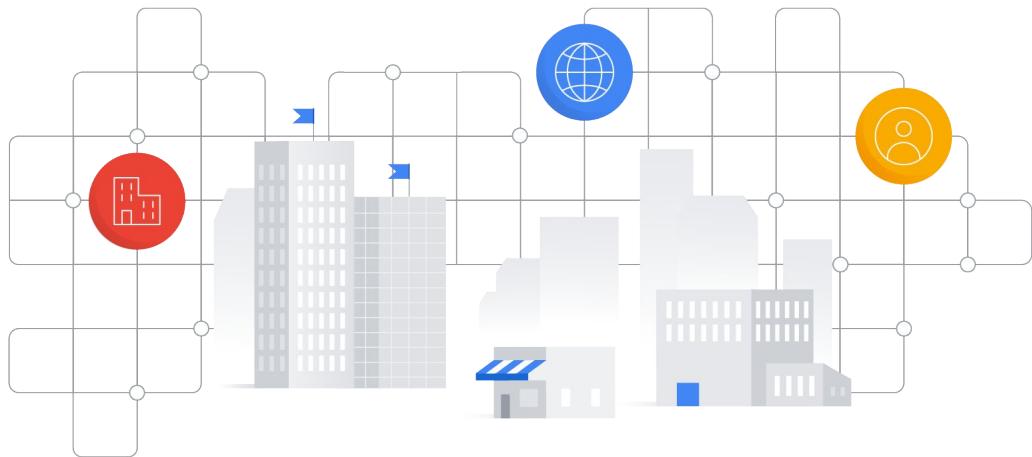
Fiber-optic cables contain one or more optical fibers, which are thin strands made of glass or plastic. These fibers are used to transmit data as pulses of light over long distances.

Subsea fiber-optic cables carry 99% of international network traffic, yet we barely notice they exist.

The first subsea cable was deployed in 1858 for telegraph messages between Europe and North America. A message took over 17 hours to deliver, at 2 minutes and 5 seconds per letter by Morse code.

Today, a single cable can deliver a whopping 340 Terabits per second. That's more than 25 million times faster than the average home internet connection!

## How is this content available within milliseconds?

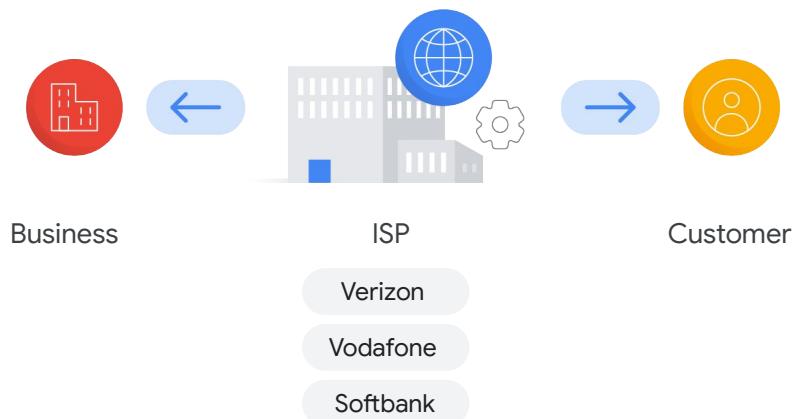


Google Cloud

Every shared video, sent email, and downloaded app depends on data traffic that moves through international network infrastructure. But how is this content available to people within milliseconds?

A rich ecosystem of companies and local providers build a global infrastructure that provides businesses and people around the world with the best possible internet experience.

## Internet service providers (ISPs)



Google Cloud

These include companies like internet service providers (or ISPs). ISPs provide access to the internet to both personal and business customers, handling the traffic between the customer and the internet as a whole.

Some examples of ISPs include Verizon, Vodafone, and Softbank.

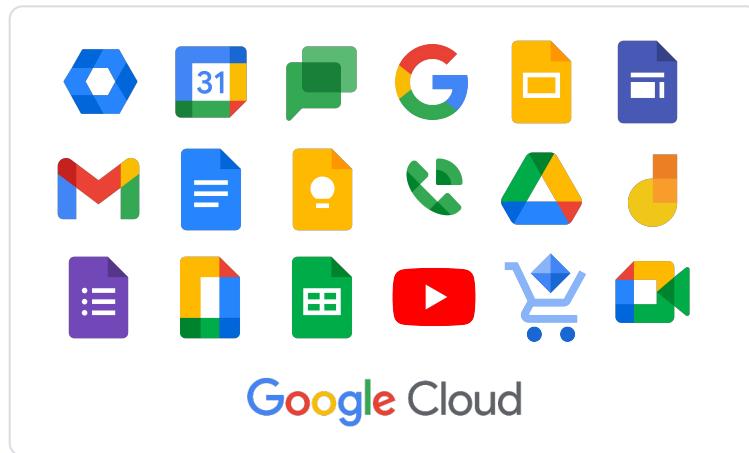
## The Google network of fiber-optic cables



Google Cloud

The infrastructure that makes Google's global reach possible is our network of fiber-optic cables that run on both land and sea. This network connects our data centers and points of presence like highways connect major cities.

**Google owns and operates data centers**



Google Cloud

Google owns and operates data centers all over the world. In these Google data centers, products like Search, Gmail, YouTube, and Google Cloud are run for people and organizations around the world, 24 hours a day, seven days a week.

# Internet protocols



IP address

Internet Protocol



Domain name



DNS

Domain Name System

Google Cloud

Within this vast global network, how do all the different parts recognize and communicate with each other? There are protocols that make it work.

## IP address



IP stands for Internet Protocol



A series of numbers that can identify a network or the location of a particular device on a network

Google Cloud

Let's start with an **IP address**. The IP stands for Internet Protocol, and this address is a series of numbers that can identify a network or the location of a particular device on a network.

## Domain name



An easy-to-remember name that maps directly to an IP address or set of IP addresses on the internet



The unique name that appears after the @ sign in email addresses and after www. in web addresses



The domain name example.com might translate to the IP address 198.102.434.8

Google Cloud

A **domain name** is an easy-to-remember name that maps directly to an IP address or set of IP addresses on the internet. It's the unique name that appears after the @ sign in email addresses and after www. in web addresses. For instance, the domain name example.com might translate to the IP address 198.102.434.8. Other examples of domain names are google.com and youtube.com.

## Domain Name System



- ✓ A DNS server is a database of domain names mapped to IP addresses used by computers to communicate with each other.
- ✓ It's like the phone book of the web. Every time you visit a website, your computer performs a DNS lookup.
- ✓ In the same way a phone book translates a name like "Acme Pizza" into the correct phone number, DNS translates a web address like [www.google.com](http://www.google.com) into the IP address of the computer hosting that site.

Google Cloud

And then there's a **Domain Name System**, or DNS. A DNS server stores a database of domain names mapped to IP addresses that can be queried and used by computers to communicate with each other.

This system is like the phone book of the web. Every time you visit a website, your computer performs a DNS lookup. A phone book translates a name like "Acme Pizza" into the correct phone number to call; similarly, the DNS translates a web address like "[www.google.com](http://www.google.com)" into the IP address of the computer hosting that site. In this case, it's the Google homepage.

## Discussion

What impact could poor network performance have on digital transformation?

Considerations:

- User experience
- Business operations
- Communication
- Data management
- Innovation and transformation



Google Cloud

What impact could poor network performance have on digital transformation?

Considerations:

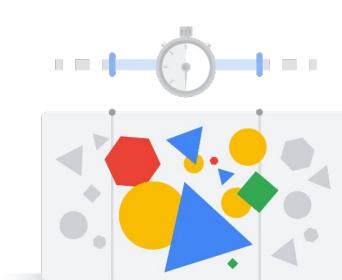
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06

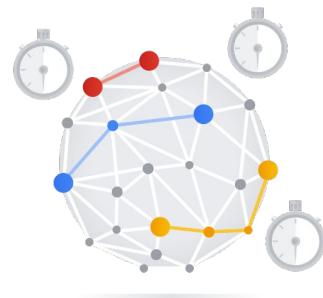


## **Network performance: Bandwidth and latency**

# Network performance and measurement



Bandwidth



Latency

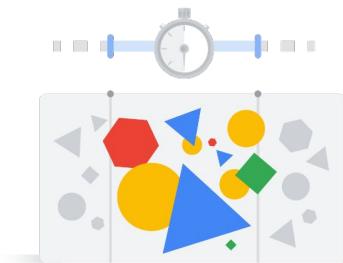
Google Cloud

Now that you've been introduced to some of the fundamentals of networking, let's explore how networks perform and are measured.

Two important terms in networking are **bandwidth** and **latency**. Let's define them both.

# Bandwidth

- ✓ A measure of how much data a network can transfer in a given amount of time
- ✓ Measured in megabits per second (Mbps) or gigabits per second (Gbps)
- ✓ Higher bandwidth allows a computer to download information more quickly



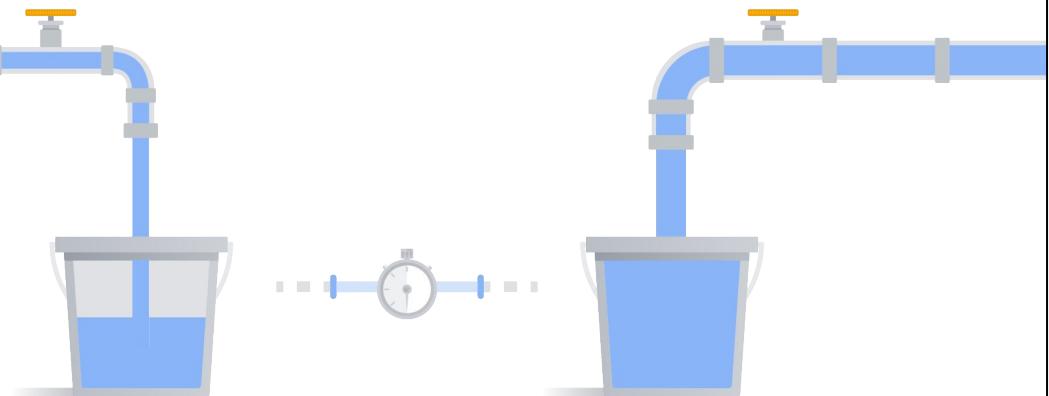
Bandwidth

Google Cloud

**Bandwidth** is a measure of how much data a network can transfer in a given amount of time.

This rate of data transfer is typically measured in terms of “Megabits per second” (or Mbps) or “Gigabits per second” (or Gbps). Generally speaking, a higher bandwidth allows a computer to download information from the internet more quickly.

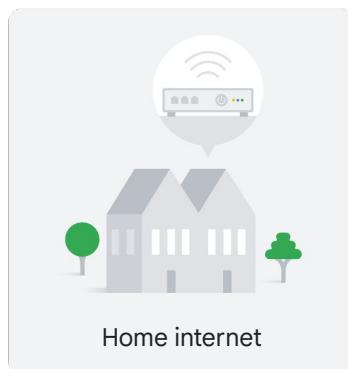
## Bandwidth



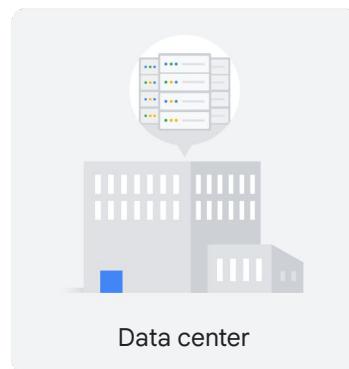
Google Cloud

One way to think of bandwidth is to picture water flowing through a pipe. The bandwidth would be the volume of water a pipe can handle flowing through per second. A wider pipe can handle more water.

## Bandwidth



Home internet



Data center

Bandwidth:  
**100 Mbps to 1+ Gbps**

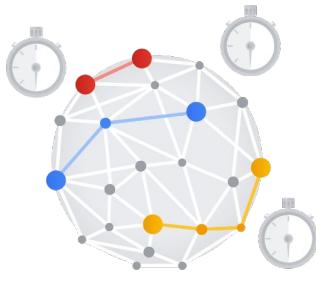
Bandwidth:  
**10 to 100 Gbps**

Google Cloud

An internet service provider may provide a home internet connection with 100 MegaBits per second to over 1 GigaBit per second; a data center may have lines with bandwidth from 10 to 100 GigaBits per second!

Having a high bandwidth is useful when sending a large amount of data per second, such as streaming high-definition video, but it's not the only important measure of network performance. For example, for users playing real-time multiplayer games online, latency will matter much more.

# Latency



The amount of time it takes for data to travel from one point to another



Measured in milliseconds



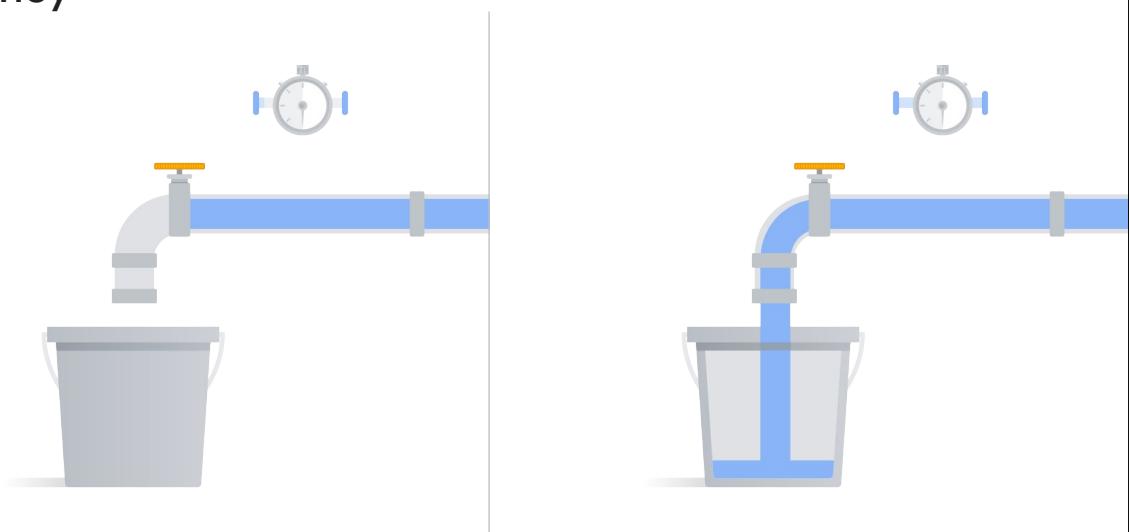
Describes delays in communication over a network

Latency

Google Cloud

Network **latency** is the amount of time it takes for data to travel from one point to another. Often measured in milliseconds, latency, sometimes called lag, describes delays in communication over a network.

## Latency



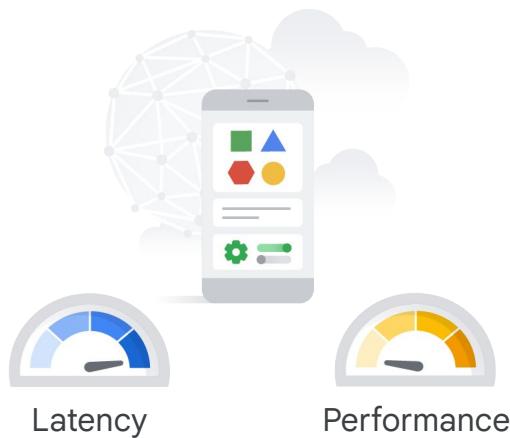
Google Cloud

Going back to our flowing water analogy, latency is the delay from the moment the water pipe is opened until water starts flowing through.

Ideally, latency should be as close to zero as possible. However, because it's a result of the physical distance that data must travel – through wires, fiber optics, routers, and more – to reach its destination, each “hop” along the way adds a small amount of latency to the communication.

No matter how much data you can send and receive at once, it can only travel as fast as network latency allows.

## Latency can affect an app's performance



The farther a user is from a server, or the more fragmented the network is, the bigger the latency.

Google Cloud

Imagine an image file took just 10 milliseconds to download with a high-bandwidth connection, but a user had to wait 100 milliseconds before receiving the first byte of data.

In this case, the latency, or how much time it took for data packets to travel from one point to another in the network, accounted for most of the time.

Cloud computing and mobile technologies have made it easier for developers to reach global audiences, but high latency can drag down an application's performance.

Websites run slower for some users depending on their physical location, even if both the user and the server have excellent bandwidth.

So the farther a user is from a server, or the more fragmented the network is, the bigger the latency. Reducing latency is essential to reaching users faster.

# Quiz

## Question

Which network performance metric describes the amount of data a network can transfer in a given amount of time?

- A. Latency
- B. Bandwidth
- C. Domain Name System (DNS)
- D. Fiber optics

Google Cloud

Which network performance metric describes the amount of data a network can transfer in a given amount of time?

- A. Latency
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# Quiz

## Answer

Which network performance metric describes the amount of data a network can transfer in a given amount of time?

- A. Latency
- B. Bandwidth
- C. Domain Name System (DNS)
- D. Fiber optics



Google Cloud

The correct answer is B.

- A. Latency
  - Why this is the **incorrect** answer: Latency refers to the time it takes for a data packet to travel from the source to the destination and back, not a direct measure of the amount of data transferred.
- B. Bandwidth
  - Why this is the **correct** answer: Bandwidth is the definitive metric for the amount of data a network can transfer in a given time. It's typically measured in bits per second (bps), kilobits per second (Kbps), megabits per second (Mbps), and so on. Think of it as the width of a highway – the wider it is, the more cars (data) can travel through at once.
- C. Domain Name System (DNS)
  - Why this is the **incorrect** answer: DNS plays the role of a "phonebook" for the internet. It translates human-readable domain names (like www.google.com) to machine-readable IP addresses. DNS is vital for finding resources on the network but doesn't directly relate to data transfer capacity.
- D. Fiber optics
  - Why this is the **incorrect** answer: Fiber optics are a type of transmission medium. They use light to carry data over long distances and offer extremely high bandwidths. However, fiber optics in themselves are just a physical element; they don't directly tell you the

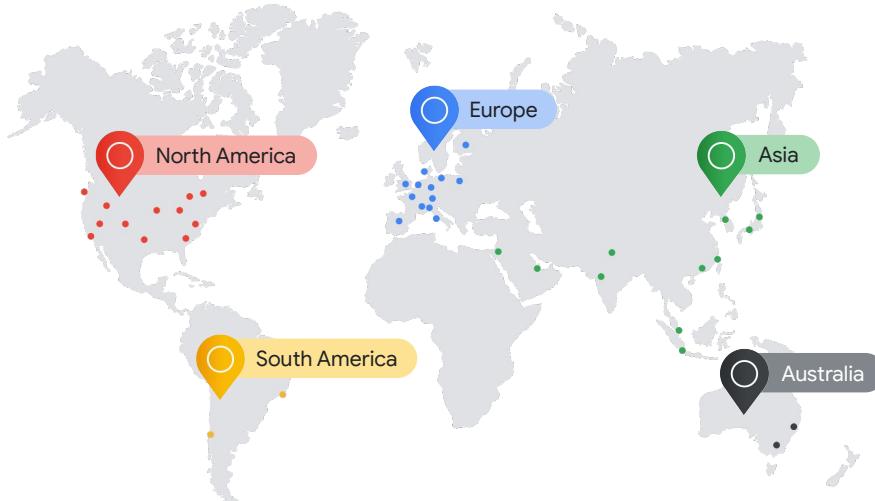
- actual data transfer rate.



## Google Cloud regions and zones

Google Cloud

## Google's network is one of the largest of its kind



Google Cloud

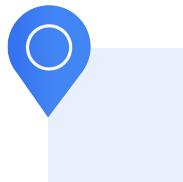
Google has invested billions of dollars over the years to build its network, which is one of the largest networks of its kind on Earth. It's designed to give customers the highest possible throughput and lowest possible latencies for their applications.

Google Cloud's infrastructure is based in five major geographic locations: North America, South America, Europe, Asia, and Australia.

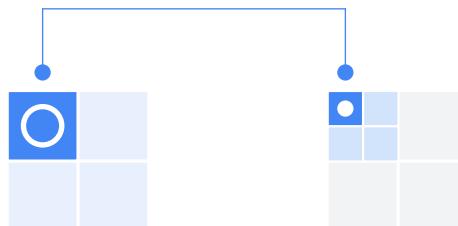
Having multiple service locations is important because choosing where to locate applications affects qualities like availability, durability, and latency, the latter of which measures the time a packet of information takes to travel from its source to its destination.

## Regions and zones

Regions represent independent geographic areas and are composed of zones.



Location



Regions

Zones

Google Cloud

Each of these locations is divided into several different **regions** and **zones**. Regions represent independent geographic areas and are composed of zones.

# Regions



Region



europe-west2

Zones

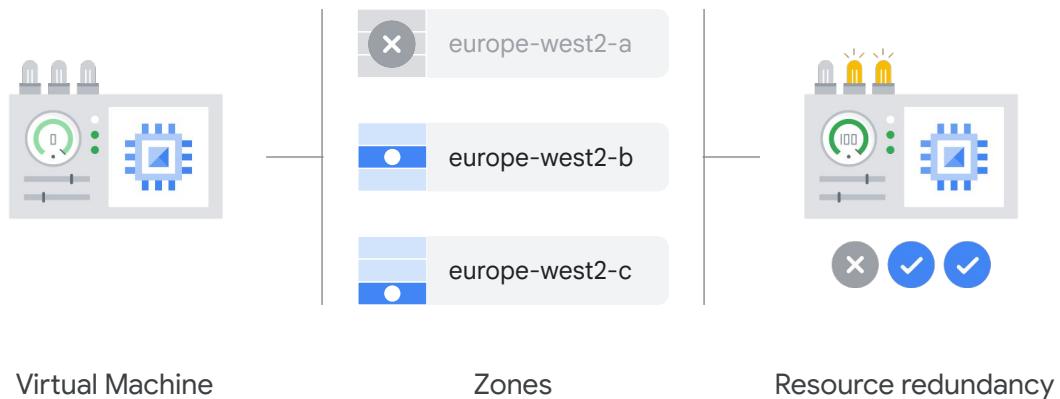


Google Cloud

For example, London, or europe-west2, is a region that currently comprises three different zones.

A zone is an area where Google Cloud resources are deployed.

## Zones can ensure resource redundancy



Google Cloud

For example, if you launch a virtual machine using Compute Engine, it will run in the zone that you specify to ensure resource redundancy.

## You can also run resources in different regions

Natural disaster



Region 01



Region 02



Region 03

Regions



Application

Google Cloud

You can also run resources in different regions. This is useful for bringing applications closer to users around the world and also for protection in case there are issues with an entire region, such as a natural disaster.

Some of Google Cloud's services support placing resources in what we call a **multi-region**.

For example, Cloud Storage lets you place data within the Europe multi-region. This means it's stored redundantly in at least two geographic locations, separated by at least 160 kilometers within Europe, like London and Belgium.

You can find the most up-to-date numbers for Google Cloud regions and zones at [cloud.google.com/about/locations](http://cloud.google.com/about/locations).

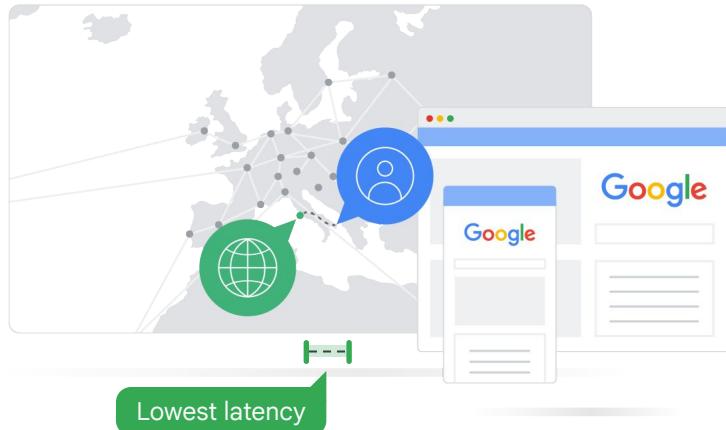


## Google's edge network

Google Cloud

# Keeping traffic on Google's private network

A recommended best practice for organizations is to keep their traffic on Google's private network for most of its journey.



When a user opens a Google app or web page, Google responds to that request from an edge network location.

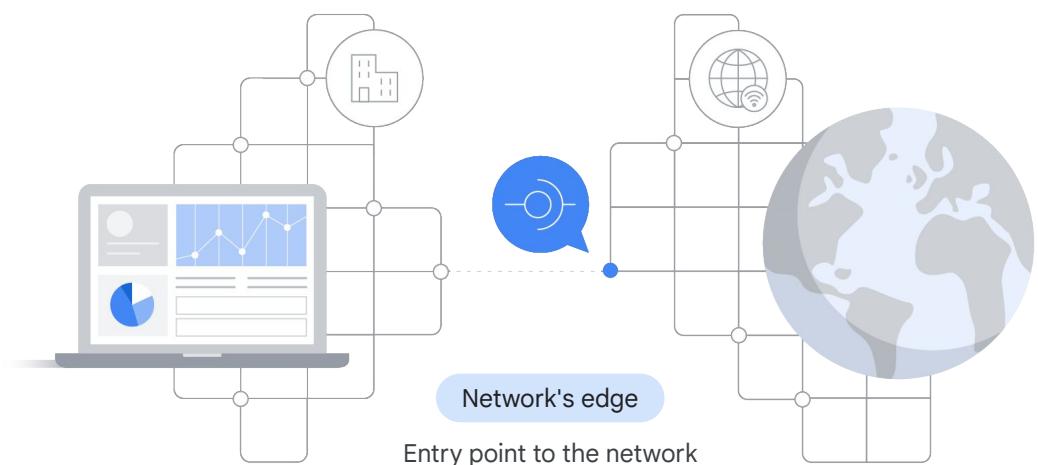
Google Cloud

A **recommended best practice** for organizations is to keep their traffic on Google's private network for most of its journey. Using the same network that powers products like Gmail, Google Search, and YouTube allows organizations to take advantage of the performance that global infrastructure provides.

When a user opens a Google app or web page, Google responds to that request from an edge network location that will provide the **lowest latency**.

Understanding Google's edge network and how it maintains caches that store popular content near its users helps organizations choose when to hand off traffic to Google.

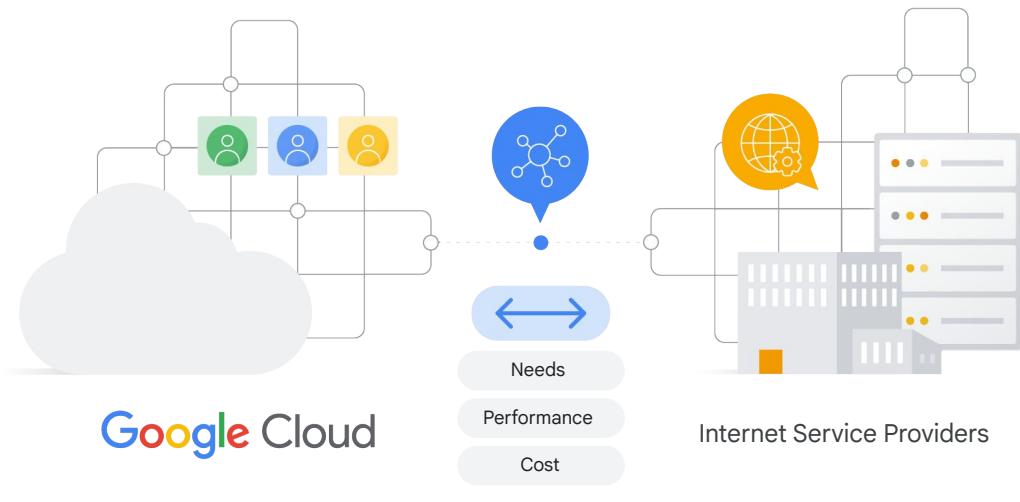
## Network's edge



Google Cloud

A **network's edge** is defined as the place where a device, or an organization's network, connects to the internet. It's called the “edge” because this is the **entry point to the network**.

## Google's edge network is how we connect with ISPs



Google Cloud

Google's edge network is **how we connect with ISPs** to get traffic to and from users. It's made up of network infrastructure that organizations can hand off traffic to based on user **needs, performance, and cost**.

## Network infrastructure supports transformation



Google aims to deliver services with:

- High performance
- High reliability
- Low latency

Google Cloud

Google aims to deliver its services with high performance, high reliability, and low latency for users. We have invested in network infrastructure that's aligned with this goal and that also allows us to exchange traffic efficiently and cost-effectively with network operators.

# Quiz

## Question

An organization wants to ensure they have redundancy of their resources so their application remains available in the event of a disaster. How can they ensure this happens?

- A. By putting resources in the Domain Name System (DNS)
- B. By assigning a different IP address to each resource
- C. Using the edge network to cache the whole application image in a backup
- D. By putting resources in different zones

Google Cloud

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- C. Using the edge network to cache the whole application image in a backup
- D. By putting resources in different zones



Google Cloud

The correct answer is D.

- A. By putting resources in the Domain Name System (DNS)
  - Why this is the **incorrect** answer: DNS helps users find resources on the internet by translating domain names to IP addresses. While DNS is critical for application accessibility, simply putting resources in DNS doesn't create redundancy or guarantee disaster recovery.
- B. By assigning a different IP address to each resource
  - Why this is the **incorrect** answer: While unique IP addresses are necessary for network communication, they don't inherently provide redundancy. If a server with a specific IP address fails, the application relying on it will likely become unavailable.
- C. Using the edge network to cache the whole application image in a backup
  - Why this is the **incorrect** answer: Edge networks help improve application performance by bringing content closer to users, and caching can reduce load on back-end systems. However, caching in itself doesn't guarantee full redundancy in case of a major disaster affecting core application resources.
- D. By putting resources in different zones
  - Why this is the **correct** answer: Zones are geographically distinct locations with independent power, cooling, and networking infrastructure. Spreading resources across multiple zones significantly reduces the risk of a single site disaster taking down an entire application.

# Module 1

## Digital Transformation with Google Cloud

### Lessons

- 01 Why cloud technology is transforming business
- 02 Fundamental cloud concepts
- 03 Cloud computing models and shared responsibility

Google Cloud

Let's start the third lesson of Digital Transformation with Google Cloud.

When moving to the cloud, there are decisions to make around the type of cloud computing service model to use. This decision impacts the levels of responsibility between an organization and their cloud service provider.



## Cloud computing service models

Google Cloud

Cloud adoption has made a positive impact on some of the world's leading companies across various industries.

# The cloud's impact on resource management



Traditional IT



Cloud computing

Organizations are responsible for all of their IT infrastructure when it's completely on-premises.

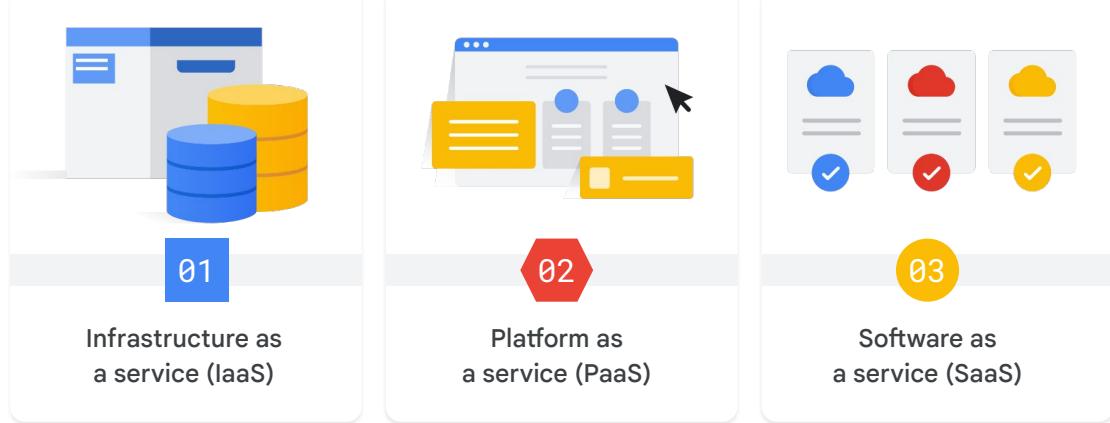
Allows for a third party to be responsible for some part of the infrastructure.

Google Cloud

The world of cloud computing has a diverse set of computing service models to choose from, depending on customer requirements. You might have heard of terms like IaaS, PaaS, and SaaS. These terms represent the different cloud computing models provided "as a service" by cloud providers. As a service" refers to the way IT resources are consumed in these models, and is a key difference between cloud computing and traditional IT.

- In **traditional IT**, an organization consumes resources, such as hardware, software, and development tools, by purchasing, installing, managing, and maintaining them in its own on-premises or self-managed data center. Organizations are responsible for all of their IT infrastructure when it's completely on-premises.
- In **cloud computing**, the cloud service provider owns, manages, and maintains the resources. The customer consumes those resources, which are provided on a subscription or pay-as-you-go basis. All you need is an internet connection. Cloud computing allows for a third party to be responsible for some part of the infrastructure. This means that organizations then have more time to focus on their core business.

## Cloud computing service models



Google Cloud

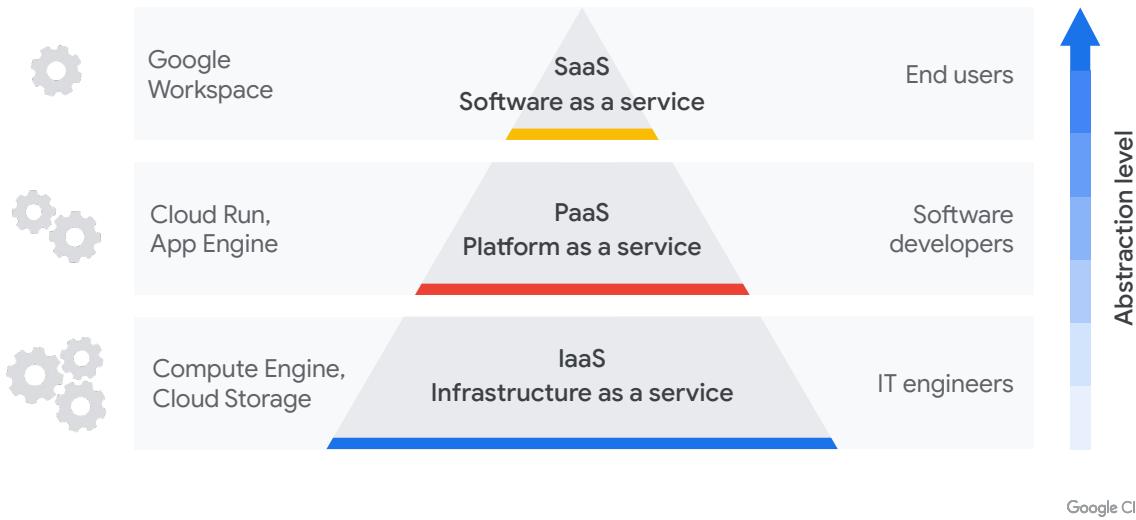
Coming up, we're going to explore three different cloud computing service models:

- **Infrastructure as a service**, or IaaS, which offers infrastructure resources such as compute and storage.
- **Platform as a service**, or PaaS, which offers a develop-and-deploy environment to build cloud apps.
- And **software as a service**, or SaaS, which delivers complete applications as services.

Each model offers distinct features and functionalities, and knowing the differences between them helps organizations choose one to best fit their business' needs.

It's important to remember that most organizations that use cloud often use a combination of cloud computing models to solve for different needs.

## Abstraction hides underlying infrastructure



You can visualize these cloud computing models in layers. As you move up the layers from one model to another, each model requires less knowledge and management of the underlying infrastructure. This concept is called **abstraction**.

In cloud architecture, as the level of abstraction increases, less is known about the underlying implementation. The goal of "abstracting away" infrastructure is to reduce complexity by removing unnecessary information and simplifying operations.

To give some examples of products you may be familiar with:

- **Compute Engine** and **Cloud Storage** are examples of Google Cloud IaaS products. You can create and run virtual machines with Compute Engine, and you can store any type of data with Cloud Storage.
- **Cloud Run** and **BigQuery** are examples of Google Cloud PaaS products.
  - Cloud Run is a fully managed, serverless platform for developing and hosting applications at scale, which takes care of provisioning servers and scaling app instances based on demand.
  - BigQuery is a fully managed enterprise data warehouse that manages and analyzes data, and can be queried to answer big data questions with zero infrastructure management.
- Finally, the suite of products that make up **Google Workspace** is an example of a Google Cloud SaaS product.



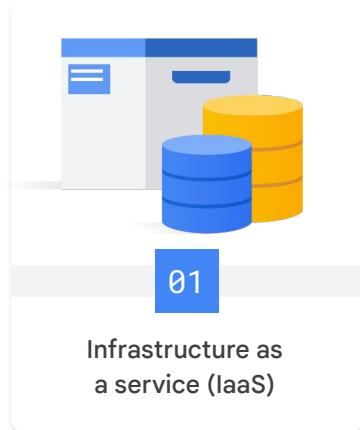
## IaaS: Infrastructure as a service

Google Cloud

Now let's look at each of these computing models in more detail.

We'll start with infrastructure as a service, or IaaS.

## Features of IaaS



- On-demand availability of almost infinitely scalable infrastructure resources over the internet.
- Lease resources instead of having to buy hardware outright, paying only for what's used.
- Same technologies and capabilities as a traditional data center without having to physically maintain or manage it.

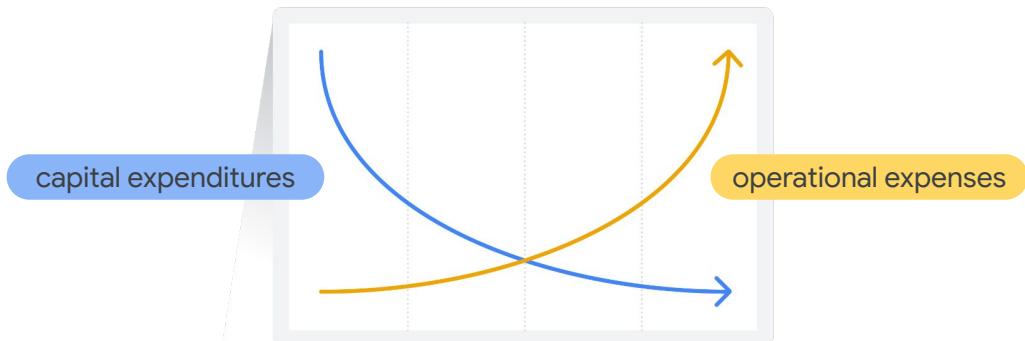
Google Cloud

IaaS is a computing model that offers the on-demand availability of almost infinitely scalable infrastructure resources, such as compute, networking, storage, and databases as services over the internet.

IaaS allows organizations to lease the resources they need instead of having to buy hardware outright, and they only pay for what they use.

It provides the **same technologies** and capabilities as a traditional data center without having to **physically maintain** or manage all of it.

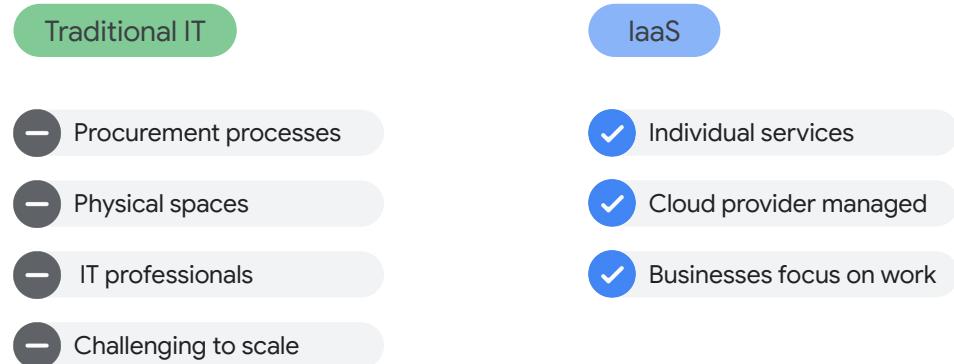
## IaaS transforms CapEx into OpEx



Google Cloud

One of the main reasons businesses choose IaaS is to reduce their capital expenditures and transform them into operational expenses. As we previously discussed earlier today

## Comparing traditional IT to the IaaS model



Google Cloud

IaaS is appealing because acquiring computing resources to run applications or store data the traditional way requires **time and capital**.

Organizations must purchase equipment through **procurement** processes that can take months. They must also invest in **physical spaces**, which are typically specialized rooms with power and cooling. And after deploying the systems, they need **IT professionals** to manage them.

This traditional way is **challenging to scale** when demand spikes or business grows. Organizations risk running out of capacity, or overbuilding and ending up with underutilized infrastructure.

In contrast, IaaS resources are offered as individual services, so organizations can choose what they need. The cloud provider **manages the infrastructure**, and businesses can concentrate on installing, configuring, and managing **software** and keeping their **data** secure.

## The benefits of IaaS



Economical



Efficient



Boosts productivity



Reliable



Scalable

Google Cloud

So, what are the benefits of IaaS?

It's **economical**. Because IaaS resources are used on demand and you only pay for what you use, IaaS costs are fairly predictable and easy to budget for.

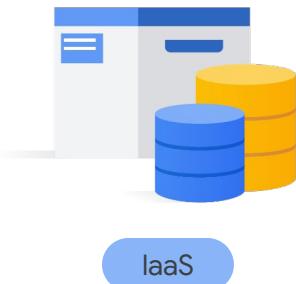
It's **efficient**. IaaS resources are regularly available when you need them. As a result, there are fewer delays when infrastructure is expanded and resources aren't wasted by overbuilding capacity. This efficiency leads to faster development lifecycles and ultimately a faster time to market.

It **boosts productivity**. Because the cloud provider is responsible for setting up and maintaining the physical infrastructure, IT departments save time and money. They can then redirect resources to more strategic activities.

It's **reliable**. IaaS has no single point of failure. Even if one component of the hardware resources fails, the service usually remains available.

And it's **scalable**. One of the biggest advantages of IaaS in cloud computing is the capability to scale the resources up and down rapidly according to business needs.

## IaaS use cases



- Unpredictable workload volumes or need to move quickly in response to business fluctuations
- Require more infrastructure scalability and agility than traditional data centers can provide
- High business growth that outpaces infrastructure capabilities.
- Unpredictable spikes in demand for infrastructure services
- Low utilization of existing infrastructure resources

Google Cloud

So, what scenarios would IaaS be good for?

The flexibility and scalability of IaaS is useful for organizations that:

- Have unpredictable workload volumes or need to move quickly in response to business fluctuations.
- Require more infrastructure scalability and agility than traditional data centers can provide.
- Have high business growth that outpaces infrastructure capabilities.
- Experience unpredictable spikes in demand for infrastructure services.
- And see low utilization of existing infrastructure resources.

03



## PaaS: Platform as a service

Google Cloud

Platform as a Service, or PaaS, is a computing model that offers a cloud-based platform for **developing, running, and managing applications**. PaaS provides a framework for developers that they can build upon and use to create customized applications.

## Features of PaaS

02

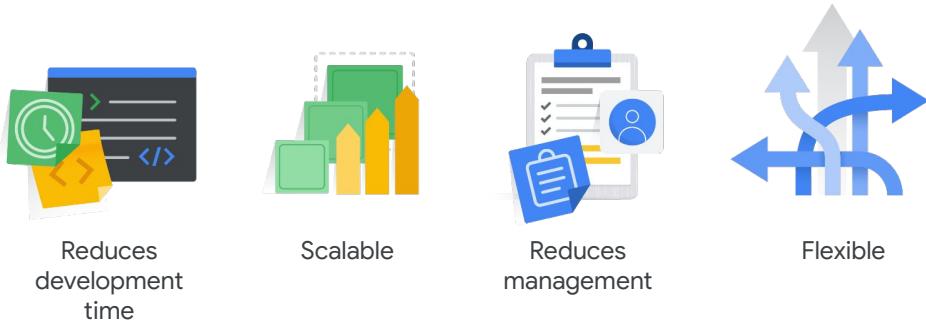
Platform as  
a service (PaaS)

- Provides a platform for developers to develop, run, and manage their own apps
- No need to build and maintain the associated infrastructure
- Can use built-in software components to build applications
- Reduces the amount of code written

Google Cloud

PaaS is appealing because it provides a platform for developers to develop, run, and manage their own apps without having to build and maintain the associated infrastructure. They can also use built-in software components to build their applications, which reduces the amount of code they have to write.

## The benefits of PaaS



Google Cloud

So, what are the benefits of PaaS?

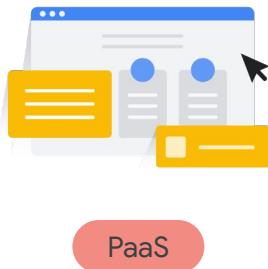
It **reduces development time**. Developers can go straight to coding instead of spending time setting up and maintaining a development environment, which leads to faster time to market.

It's **scalable**. With PaaS, organizations can purchase additional capacity for building, testing, staging, and running applications whenever they need it. It also allows for applications to be designed to take advantage of the inherent scalability of cloud infrastructure.

It **reduces management**. By abstracting the management of underlying resources even further than IaaS, PaaS offloads infrastructure management, patches, updates, and other administrative tasks to the cloud service provider. This provides a cost-effective way to focus on new functionality.

And it's **flexible**. With support for different programming languages and easy collaboration for distributed teams, PaaS provides developers with the flexibility to deliver various projects—from prototypes to enterprise solutions—on the same platform.

## PaaS use cases



- Create unique and custom applications without owning and managing infrastructure
- Rapidly test and deploy applications
- Have legacy applications and want to reduce the cost of operations
- Have a new app project to be deployed quickly by growing and updating the app as fast as possible
- Want to only pay for resources while they're being used
- Want to offload time-consuming tasks

Google Cloud

So, what scenarios would PaaS be good for?

PaaS is suitable for organizations that:

- Want to create unique and custom applications without investing a lot in owning and managing infrastructure.
- Want to rapidly test and deploy applications.
- Have many legacy applications and want to reduce the cost of operations.
- Have a new app project that they want to deploy quickly by growing and updating the app as fast as possible.
- Want to only pay for resources while they're being used.
- And want to offload time-consuming tasks such as setting up and maintaining application servers and development and testing environments.



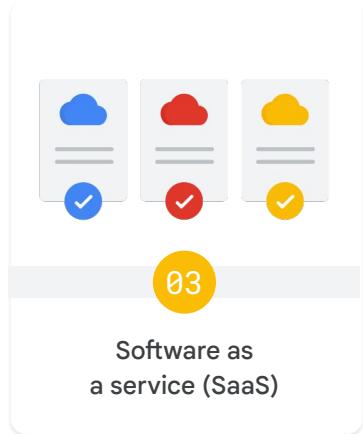
## SaaS: Software as a Service

Google Cloud

Software as a service, or SaaS, is a computing model that offers **an entire application**, managed by a cloud provider, through a web browser.

The cloud provider hosts the application software in the cloud and delivers it through a browser. With this model, you don't need to download or install any of it.

## Features of SaaS



- Abtracts technology completely from the consumer
- The end user doesn't need to care about the underlying infrastructure
- Organizations pay a subscription fee for access to a ready-to-use software product
- Google Workspace is a Google Cloud SaaS product

Google Cloud

SaaS is appealing because it abstracts technology completely from the consumer; the end user doesn't need to care about the underlying infrastructure, which is the cloud provider's responsibility. Organizations simply pay a subscription fee for access to a ready-to-use software product.

**Google Workspace**, which includes tools such as Gmail, Google Drive, Google Docs, and Google Meet, is a Google Cloud SaaS product.

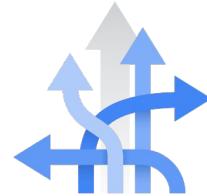
## The benefits of SaaS



Low maintenance



Cost-effective



Flexible

Google Cloud

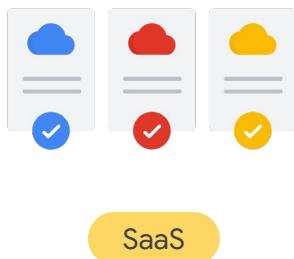
So, what are the benefits of SaaS?

It's **low maintenance**. SaaS eliminates the need to have IT staff download and install applications on each individual computer. With SaaS, vendors manage all potential technical issues, such as data, servers, storage, and updates in the cloud. This helps to streamline maintenance and support for an organization.

It's **cost-effective**. SaaS is based on a subscription model with a fixed, inclusive, monthly or annual account fee. Predictable costs and per-user budgeting allows for clear financial governance.

It's **flexible**. Everything is available over the internet when a user signs in to their personalized account online. They can access the software from anywhere, any device, anytime.

## SaaS use cases



- Want to use standard software solutions that require minimal customization
- Don't want to invest time or internal expertise in maintaining applications or infrastructure
- Need more time for IT teams to focus on strategic projects
- Need to access apps from various devices and locations

Google Cloud

And what scenarios would SaaS be good for?

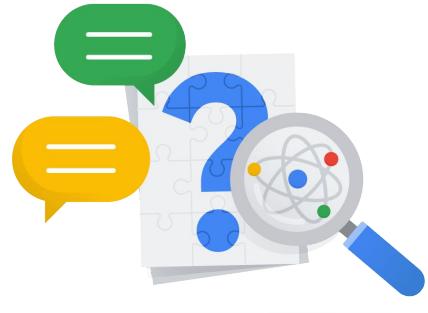
Well, SaaS is suitable for organizations that:

- Want to use standard software solutions that require minimal customization.
- Don't want to invest time or internal expertise in maintaining applications or infrastructure.
- Need more time for IT teams to focus on strategic projects.
- And need to access apps from various devices and locations.

## Discussion

Think of an application in your business today.  
What business drivers would lead you to choose one service model over the other for a particular use case?

- Considerations that may influence your choice:
  - Business needs
  - Required functionality
  - Available expertise
- What benefits would using a particular service model bring your organization?



Google Cloud

Think of an application (or particular process or workload) in your business today.

What business drivers would lead you to choose one service model over the other for a particular use case? (eg IaaS, PaaS or SaaS)

Considerations that may influence your choice:

- Business needs
- Required functionality
- Available expertise

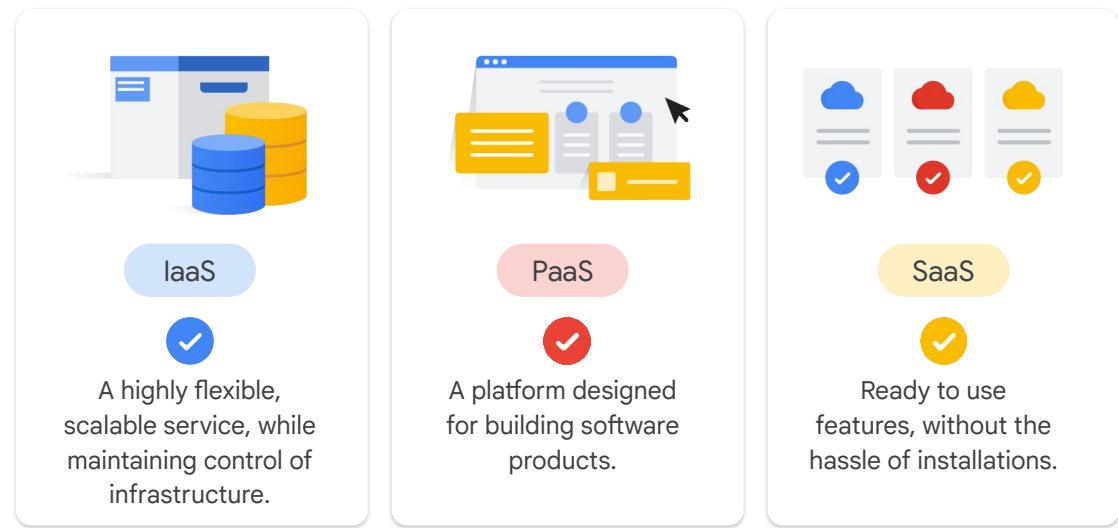
What benefits would using a particular service model bring your organization?



## Choosing a cloud computing model

Google Cloud

## Choosing the best cloud computing option



Google Cloud

So, how does an organization decide which cloud computing model is the best option for them? The answer depends on their business needs, required functionality, and available expertise.

If they are looking for a highly flexible, scalable service—while maintaining control of their infrastructure—then **IaaS** is the right choice. This model offers the most control and customization, but also requires the most management responsibilities and technical expertise.

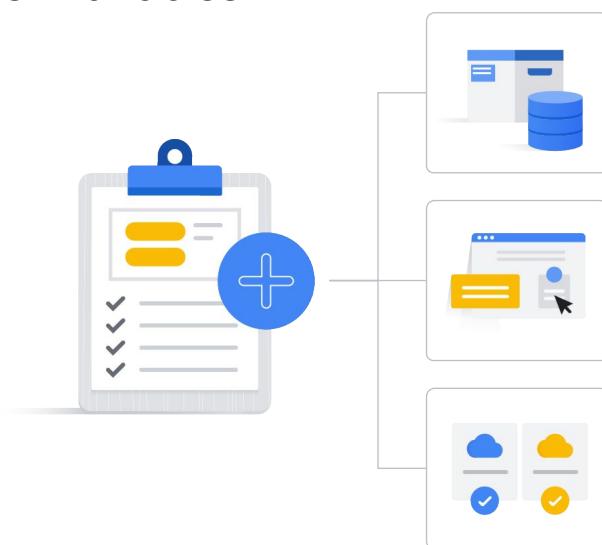
If they need a platform designed for building software products, then **PaaS** would help their business immediately. This provides a cost-effective way to build applications, but still requires some technical expertise and less management.

If they want features that are ready to use, without the hassle of installations, then **SaaS** might be the best option. This represents the least management responsibilities and technical expertise, but also offers the least control and customization.

These computing models are not mutually exclusive, though. Depending on the use case, most organizations will use combinations of all three to solve for different business needs.

## Compare options based on variables

- Management level
- Control
- Responsibility
- Flexibility
- Expertise needed



Google Cloud

They'll need to compare their options based on variables such as management level, control, responsibility, flexibility, and expertise needed.

## Scenario: IaaS



Imagine a large organization needs to implement a new inventory management system.

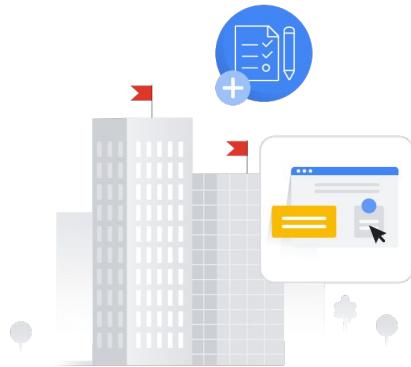
- Use in-house expertise to develop the system and manage the infrastructure
- IT team has complete control over server configurations
- IT team has to manage and maintain servers

Google Cloud

For example, imagine a large organization needs to implement a new inventory management system.

If they had the in-house expertise to develop it and the willingness to manage the infrastructure, they could build this with IaaS resources. The organization's IT team would have complete control over server configurations, but also bear the burden of managing and maintaining them.

## Scenario: PaaS



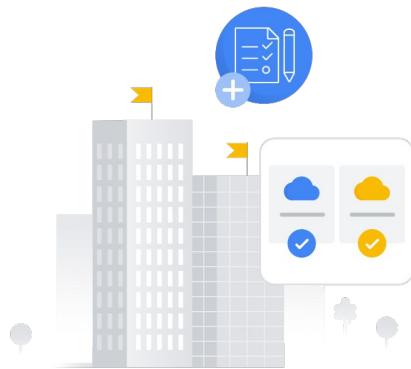
Imagine a large organization needs to implement a new inventory management system.

- Build a custom CRM application while offloading management of infrastructure
- Retain complete control over application features
- Reduce management load

Google Cloud

They could choose a PaaS solution and build a custom CRM application while offloading management of infrastructure to the cloud service provider; retaining complete control over application features, but reducing the management load.

## Scenario: SaaS



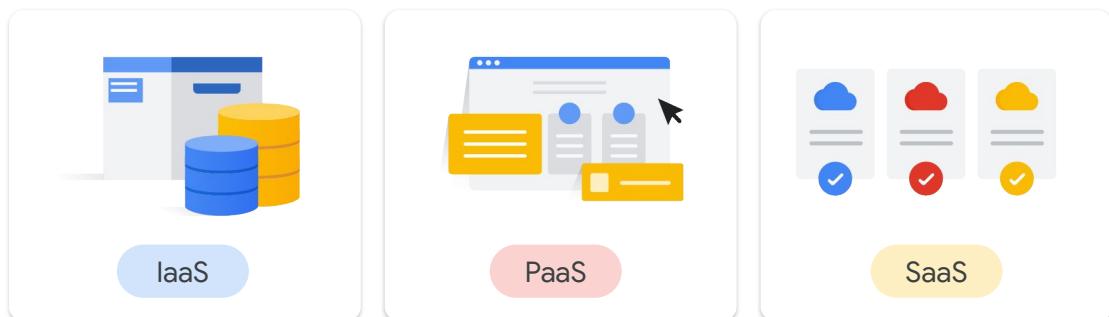
Imagine a large organization needs to implement a new inventory management system.

- Buy a ready-made solution
- No daily management of infrastructure
- Give up all control over software features and functionality

Google Cloud

Finally they could choose to buy a ready-made SaaS solution; having no daily management of infrastructure, but also giving up all control over features and functionality in the software.

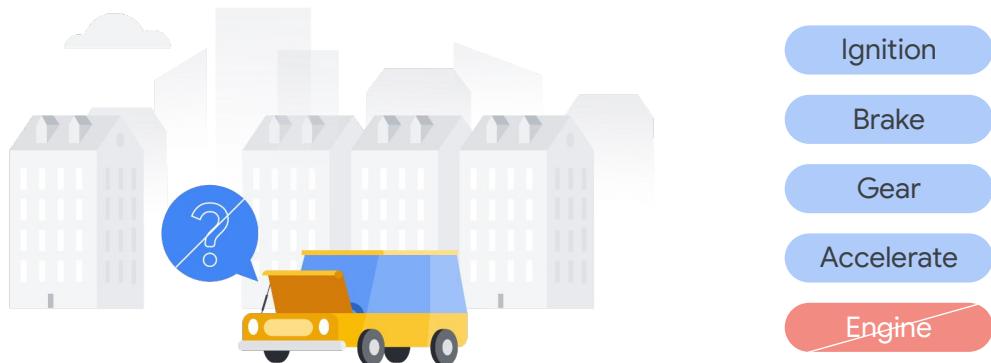
## Compare the benefits and tradeoffs for each use case



Google Cloud

Each of these options is a viable solution, so organizations must compare the benefits and tradeoffs for each use case. These cloud computing service models give organizations choices, flexibility, and options that on-premises hosting simply can't provide.

When driving, you don't think about how the engine is operating under the hood

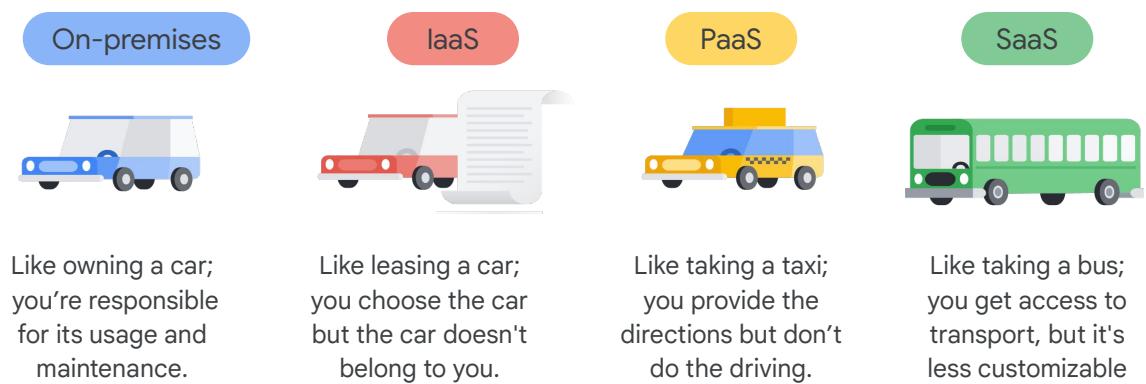


Google Cloud

Think about **abstraction** in the way that you operate a car. When you turn on the ignition, press the brake, put the car into gear, and accelerate, you're not thinking about how the engine is physically operating under the hood, right?

That complexity is abstracted away from you, so you can focus on driving safely to your destination. Abstraction is one of the core features of cloud computing.

## Organizations must decide the level of control and management they require



Google Cloud

When choosing between cloud computing service models, organizations must decide the level of control and management they'll require, or how much they want to hide technical details and focus on business needs.

Let's use a transportation analogy to see how on-premises, IaaS, PaaS, and SaaS compare with each other.

- **On-premises** IT infrastructure is like owning a car. When you buy a car, you're responsible for its usage and maintenance. Upgrading means buying a new car, which takes time and can be costly.
- **IaaS** is like leasing a car. When you lease a car, you choose a car and drive it wherever you want, but the car isn't yours. Upgrading is easier though, as you can just lease a new car.
- **PaaS** is like taking a taxi. You provide specific directions, like the code, but the driver does the actual driving.
- And **SaaS** is like going by bus. You still get access to transport, but it's less customizable. Buses have designated routes, and you share the space with other passengers.

# Quiz

## Question

Which cloud computing service model offers a develop-and-deploy environment to build cloud applications?

- A. Infrastructure as a Service (IaaS)
- B. Platform as a Service (PaaS)
- C. Software as a Service (SaaS)
- D. Function as a Service (FaaS)

Google Cloud

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# Quiz

## Answer

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- A. Infrastructure as a Service (IaaS)
- B. Platform as a Service (PaaS)
- C. Software as a Service (SaaS)
- D. Function as a Service (FaaS)



Google Cloud

The correct answer is B.

- A. Infrastructure as a Service (IaaS)
  - Why this is the **incorrect** answer: IaaS provides the foundation of cloud computing – virtualized compute, storage, and network resources. However, it doesn't include the pre-configured development tools and application frameworks typically offered by PaaS.
- B. Platform as a Service (PaaS)
  - Why this is the **correct** answer: PaaS is designed specifically to deliver a comprehensive environment for developing, testing, deploying, and managing cloud-based applications. It provides essential infrastructure (servers, storage, networking) along with middleware, development tools, databases, and other components developers need without them having to manage the underlying layers.
- C. Software as a Service (SaaS)
  - Why this is the **incorrect** answer: SaaS provides access to ready-to-use, often web-based, applications managed by the vendor (think Gmail or Salesforce). Users consume these applications but don't develop their own within a SaaS environment.
- D. Function as a Service (FaaS)
  - Why this is the **incorrect** answer: FaaS is best suited for executing discrete, event-driven code snippets (functions). It doesn't provide the full suite of tools and frameworks typically needed for building complete cloud applications.

# Quiz

## Question

Which option best describes a benefit of Infrastructure as a Service (IaaS)?

- A. It's efficient, as IaaS resources are available when needed and resources aren't wasted by overbuilding capacity.
- B. It reduces development time, as developers can go straight to coding instead of spending time setting up and maintaining a development environment.
- C. It's cost-effective, as all infrastructure costs are handled under a single monthly or annual subscription fee.
- D. It has low management overhead, as all administration and management tasks for data, servers, storage, and updates are handled by the cloud vendor.

Google Cloud

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## Answer

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Google Cloud

The correct answer is A.

- A. It's efficient, as IaaS resources are available when needed and resources aren't wasted by overbuilding capacity.
  - Why this is the **correct** answer: This directly relates to the core benefit of IaaS: scalability and elasticity. With IaaS, organizations can quickly add or remove compute, storage, and network resources as needed. This prevents costs associated with buying and maintaining hardware they might not fully utilize.
- B. It reduces development time, as developers can go straight to coding instead of spending time setting up and maintaining a development environment.
  - Why this is the **incorrect** answer: This describes a benefit more typical of Platform as a Service (PaaS). PaaS includes pre-configured development tools, reducing setup time for developers.
- C. It's cost-effective, as all infrastructure costs are handled under a single monthly or annual subscription fee.
  - Why this is the **incorrect** answer: IaaS generally uses a pay-as-you-go model rather than a flat subscription fee. Costs vary based on usage, making it cost-effective in preventing overprovisioning, but not through a single, flat fee.
- D. It has low management overhead, as all administration and management tasks for data, servers, storage, and updates are handled by the cloud vendor.
  - Why this is the **incorrect** answer: While IaaS does reduce a degree of infrastructure management, certain tasks still fall under the

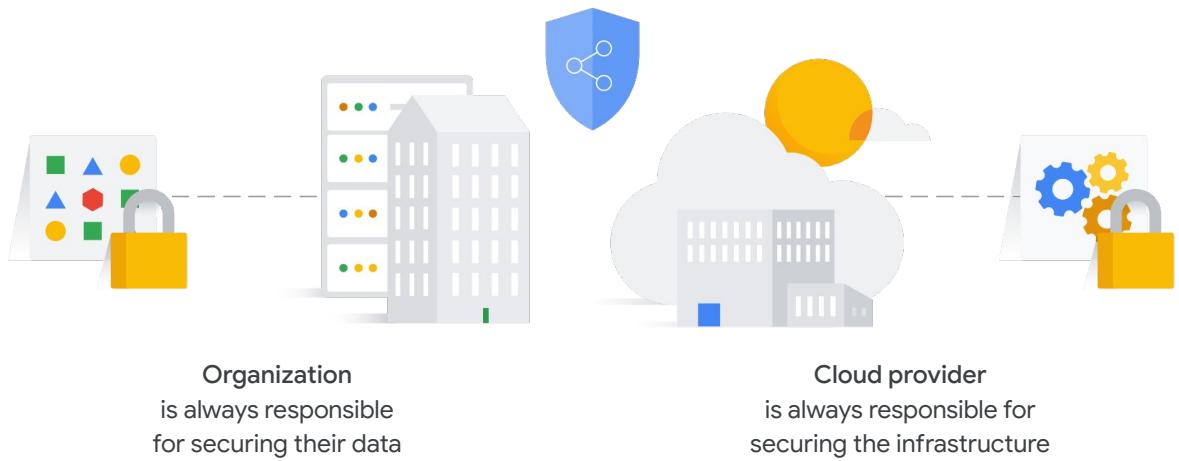
- organization's responsibility, such as virtual network configuration, managing user accounts, and installing necessary applications and middleware to name a few. The vendor mainly handles the physical hardware and virtualization layer.



## The shared responsibility model

Google Cloud

## The shared responsibility model



Google Cloud

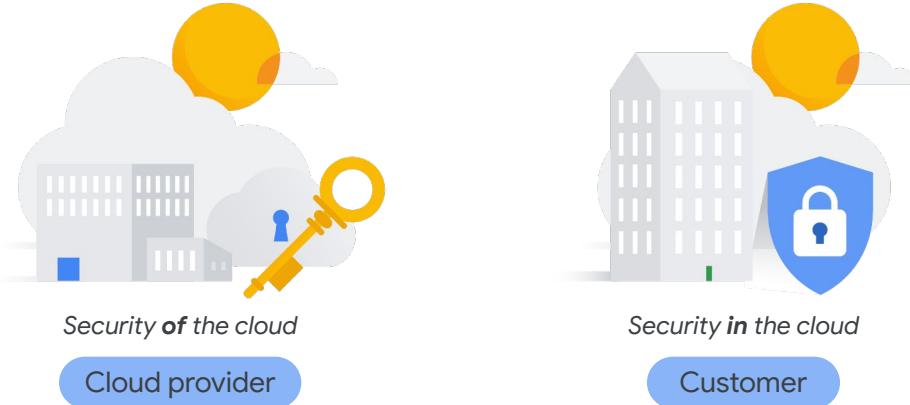
One area of responsibility where each of the cloud computing models differ is security.

When an organization manages its data in its own data centers, that organization is responsible for all aspects of its security. However, as infrastructure is moved to the cloud, some aspects of the responsibility shift to the cloud provider.

This concept is called the **shared responsibility model**.

Security in the cloud is a shared responsibility between the cloud provider and the customer. Although direct responsibilities change based on the cloud computing service model, organizations are always in control of securing their data, and the cloud provider is always responsible for securing the infrastructure.

## Security **of** the cloud vs. security **in** the cloud



Google Cloud

At Google Cloud, we defend organizations' data against threats and fraudulent activity with the same infrastructure and security services we use for our own operations.

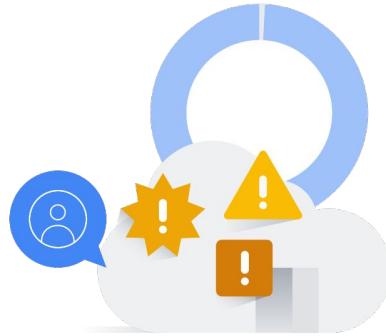
However, security *of* the cloud and security *in* the cloud are two different things.

Simply put, the cloud provider is responsible for the security **of** the cloud, while the customer is responsible for security **in** the cloud.

“

99% of all cloud security failures will result from user error

*Is the Cloud Secure?*  
Gartner, 2019



Google Cloud

It's important for organizations to understand how the specific customer responsibilities vary according to the type of cloud computing model used.

This is especially important because, according to a Gartner [report](#), **99% of all cloud security failures will result from user error** through the year 2025.

Organizations must understand their roles and responsibilities in cloud security to guarantee it.

## Who is responsible for securing what?



Cloud provider



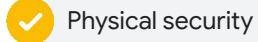
Customer



Hardware



Networks



Physical security



Configurations



Access policies



User data

Google Cloud

If you look at the various cloud computing models together, you can see where the cloud provider's responsibility ends and where the customer's responsibility begins.

A general guideline for shared responsibility is that "if you configure or store it, you're responsible for securing it."

This generally means that a cloud provider is responsible for securing the parts of the cloud that it directly controls, such as hardware, networks, and physical security.

At the same time, the customer is responsible for securing anything that they create within the cloud, such as the configurations, access policies, and user data.

# Ratios of responsibility

	On-prem	IaaS	PaaS	SaaS
Content	■	■	■	■
Access Policies	■	■	■	■
Usage	■	■	■	■
Deployment	■	■	■	■
Web App security	■	■	■	■
Identify	■	■	■	■
Operations	■	■	■	■
Access and authentication	■	■	■	■
Network security	■	■	■	■
Guest OS, data & content	■	■	■	■
Audit logging	■	■	■	■
Network	■	■	■	■
Storage + encryption	■	■	■	■
Hardened Kernel + IPC	■	■	■	■
Boot	■	■	■	■
Hardware	■	■	■	■
Physical security	■	■	■	■

■ Customer responsibility  
■ Google responsibility

Google Cloud

No matter which cloud provider you use, there is shared responsibility. Let's examine the ratios of responsibility between Google Cloud as a service provider and our customers.

The blue squares represent the parts of the infrastructure security that the customer is responsible for, while the yellow squares represent the elements that Google Cloud is responsible for. As You'll notice that the blue squares represent the customer responsibility, which decreases as you move from on-premises to SaaS.

Let's begin with **on-premises**. When an organization runs its own on-premises data centers, security for the infrastructure is solely the responsibility of the organization's internal teams. They are responsible for securing servers and the data stored on them.

Next is **infrastructure as a service**. When an organization transitions to an IaaS computing model, it assigns some IT security responsibilities to Google Cloud. This includes being responsible for the physical resources and sharing responsibility with the customer for the security of the infrastructure and network.

The rest, such as the security of the operating system, software stack required to run their applications, and their data, is the responsibility of the customer. This allows customers the most freedom and control, but also places most of the responsibility in their hands.

When an organization uses the **platform as a service** model, more of the responsibility is passed over to Google Cloud. This includes full responsibility for the physical infrastructure, the access and authentication, network security, and guest operating systems. The customer is still responsible for the security of any content, such as code or data, produced on the platform.

Lastly, with the **software as a service** model, Google Cloud is responsible for almost every aspect of security—from the underlying infrastructure to the actual application. Customers still have some security responsibilities, such as application usage, access policies like authentication settings to prevent phishing attacks, and the user content.

## Customers are always responsible for the security of their data



Google Cloud

Google Cloud

One important aspect of the shared responsibility model is that customers are always responsible for the security of their data, whether they have on-premises data centers or only pay a monthly subscription for a single user license. The customer controls who or what has access to their data.

Google Cloud is committed to keeping customers' data secure, but security is a shared responsibility, and requires collaboration.

## Discussion

A retail company with on-premises servers is struggling to meet seasonal peaks in their business and the impact on their supply chain. One of the appeals of cloud is offloading repetitive IT management, yet they are concerned about giving up control, and the expertise needed to be responsible for the cloud security.

They considered building a custom supply chain app, but are unsure they have the expertise and resources to manage the app infrastructure, as it's not their core business focus.



### What service model would you recommend and why?

Google Cloud

A retail company with on-premises servers is struggling to meet seasonal peaks in their business and the impact on their supply chain. One of the appeals of cloud is offloading repetitive IT management, yet they are concerned about giving up control, and the expertise needed to be responsible for the cloud security.

They considered building a custom supply chain app, but are unsure they have the expertise and resources to manage the app infrastructure, as it's not their core business focus.

### What service model would you recommend and why?

#### Considerations

- Management level
- Expertise of people
- Level of control and customization
- Responsibility

# Quiz

## Question

What is seen as a limitation of on-premises infrastructure, when compared to cloud infrastructure?

- A. The on-premises networking is more complicated.
- B. Scaling processing is too difficult due to power consumption.
- C. Maintenance workers do not have physical access to the servers.
- D. The on-premises hardware procurement process can take a long time.

Google Cloud

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Google Cloud

The correct answer is D.

- A. The on-premises networking is more complicated.
  - Why this is the **incorrect** answer: This isn't inherently a greater limitation than the complexity of managing networking in a cloud environment. Both require specialized knowledge.
- B. Scaling processing is too difficult due to power consumption.
  - Why this is the **incorrect** answer: Power consumption can be a factor in limiting on-premises scaling, but the more pressing issue is usually just having available physical space in data centers, rather than solely an issue of power capacity.
- C. Maintenance workers do not have physical access to the servers.
  - Why this is the **incorrect** answer: This isn't always the case. Organizations often have physical on-premises data centers or server rooms where their on-site teams can work directly on equipment. Furthermore, remote management tools increasingly reduce the need for hands-on access for many maintenance tasks.
- D. The on-premises hardware procurement process can take a long time.
  - Why this is the **correct** answer: This is a significant limitation. Buying new hardware involves research, vendor selection, price negotiation, shipping, and then physical installation and configuration. This process can take weeks or even months, potentially creating delays for businesses needing to grow or respond to new opportunities.

# Quiz

## Question

In the cloud computing shared responsibility model, what types of content are customers always responsible for, regardless of the computing model chosen?

- A. The customer is responsible for all infrastructure decisions, server configurations and database monitoring.
- B. The customer is responsible for securing anything that they create within the cloud, such as the configurations, access policies, and user data.
- C. The customer is responsible for security of the operating system, software stack required to run their applications and any hardware, networks, and physical security.
- D. The customer is not responsible for any of the data in the cloud, as data management is the responsibility of the cloud provider who is hosting the data.

Google Cloud

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Google Cloud

The correct answer is B.

- A. The customer is responsible for all infrastructure decisions, server configurations and database monitoring.
  - Why this is the **incorrect** answer: The extent of customer responsibility for infrastructure and configuration varies greatly depending on the cloud computing model. With IaaS, there's more customer involvement, whereas in PaaS and SaaS much of this is handled by the provider.
- B. The customer is responsible for securing anything that they create within the cloud, such as the configurations, access policies, and user data.
  - Why this is the **correct** answer: Regardless of whether it's IaaS, PaaS, or SaaS, the customer always retains responsibility for the data they put into the cloud and how they configure its security.
- C. The customer is responsible for security of the operating system, software stack required to run their applications and any hardware, networks, and physical security.
  - Why this is the **incorrect** answer: These responsibilities generally fall on the cloud provider, especially for aspects like hardware and physical security. However, with IaaS, some operating system or network configuration duties might still rest with the customer.
- D. The customer is not responsible for any of the data in the cloud, as data management is the responsibility of the cloud provider who is hosting the data.
  - Why this is the **incorrect** answer: Ultimate responsibility for the data

- and its associated risks belongs to the customer.