



OVERVIEW OF THE VDI MARKET

NORTHERN AMERICA



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EXECUTIVE SUMMARY

Starting in 2020, the COVID-19 pandemic caused an intense scramble within organizations to enable work-from-anywhere options. Companies were forced to find ways they could support remote access to applications and data from any device or location, without compromising performance or security.

As successive lockdowns and health measures made it impossible for employees to benefit from traditional office facilities, the Virtual Desktop Infrastructure (VDI) market and its cloud-based variants, also known as Desktop-as-a-Service (DaaS), saw a massive uptick in adoption.

This document offers a comparative study of the major Cloud Virtual Desktop Infrastructure players in North America.



WHAT IS A VIRTUAL DESKTOP STRUCTURE-AS-A-SERVICE

DEFINITION

While infrastructure is typically synonymous with servers and networking, desktops can represent a large fleet of computers with the same requirements in terms of lifecycle management. Here again Cloud Computing, by its very nature, shifts CAPEX expenditures to OPEX model.

VDI allows businesses to provide employees with the right measure of desktop performance along with easily manageable security and access control without investing in hardware. **DaaS is not only easier on IT personnel, it also provides convenient remote access to compute power.**

Various offerings in the market differ in terms of terminology and usage, so we will consider a VDI offering to be comprised of 3 main components:

- Compute infrastructure
- User directory
- Virtual desktop software

These 3 components enable several features, including:

- Creation of desktop instances
- Management of computer and users links
- Billing granularity

Despite the urgency caused by the pandemic, the concept of virtualized desktops consumed by a group of employees is not new. However, it has been enhanced by cloud computing and its inherent capabilities, such as greater performance and flexible consumption and billing.

A VDI instance is typically a Virtual Machine (VM) with a properly configured remote Graphical User Interface (GUI) and multimedia software access. Users are generally managed via an Active Directory (AD) or equivalent and access their virtual desktop via a custom client or a web browser.



IMPLEMENTATIONS

AMAZON WORKSPACES



WorkSpaces is the AWS implementation of DaaS. It offers a small variety of flavors and options for various computational and business scenarios.

VM options range up to 16 vCore, 122 GB bundles.

It provides Windows software and licenses as well as Linux under Amazon Linux.

EXPEDIENT



Expedient Enterprise Workspace is a complete VDI service architected for ease of use and high performance, providing full desktop OS support and powered by VMware Horizon DaaS.

Expedient Enterprise Workspace delivers a consistent desktop experience with full video, audio, and USB device compatibility, as well as support for Windows 10, Zoom, WebEx, Slack, and Microsoft Teams, along with other collaboration tools.

AZURE VIRTUAL DESKTOP



Azure Virtual Desktop is based on Microsoft's Virtual Machine catalog, providing from small utility VMs to gargantuan ones. This product is powered by traditional Microsoft software and protocols, and so provides Windows desktops.

GOOGLE CLOUD VIRTUAL DESKTOP



Google Cloud doesn't directly provide Desktop-as-a-Service. Like Microsoft, they use their classic Infrastructure-as-a-Service technology but combine it with Virtual Desktop software options available on their marketplace.

Providers include Citrix, Nutanix, or VMware. The advantage of this flexibility is balanced by an extra cost for software licensing.



INFRASTRUCTURE CATALOGS

Today, a common desktop configuration is pretty powerful, coming with 8-core machines and from 8 to 16GB of RAM.

While most office workstations require less, particularly with Linux-based operating systems, **some tasks need much more computing power or storage capacity.**

For instance, a team of data scientists can require a storage capacity exceeding 200GB and a high ability of calculation from several dozen processors.



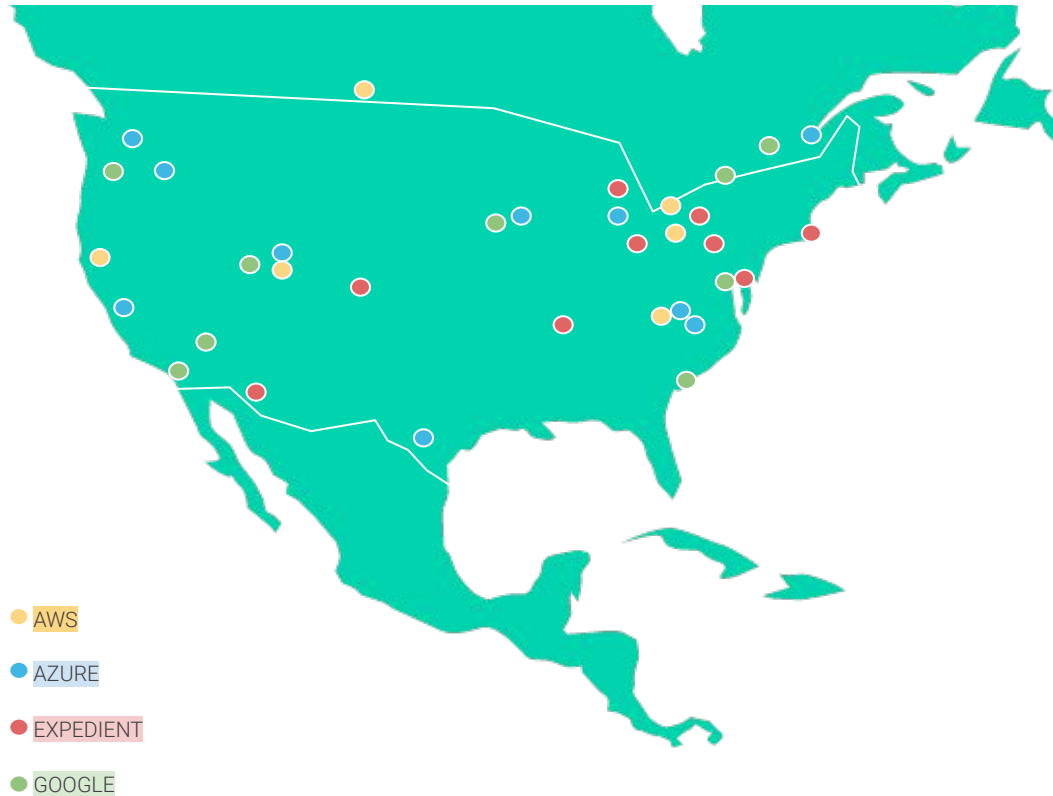
	CPU	RAM	STORAGE	LINUX	WINDOWS	GPU
AWS	1 to 16	2 to 122	90 to 275	✗	✗	✗
AZURE	1 to 416	1 to 11 TB	flexible	NO	✗	✗
EXPEDIENT	2 to 24	8 to 96 GB	flexible	NO	✗	✗
GOOGLE	1 to 96	1 to 1.4TB	flexible	✗	✗	✗

Note : A virtual machine with a high density of CPU and RAM will be more likely to host several users simultaneously.



LOCATION & facilities

The selected providers all have a wide network in North America with data centers all around the United States.



PERFORMANCE TESTING

ASSESSMENT CRITERIA

This study explores the different aspects of Virtual Desktop Infrastructure performance described above. Performance testing is conducted to compare performance of configurations deemed equivalent. Several types of VDI instances are selected with a configuration approaching the following specifications:

- 2CPUs 8GB of RAM
- 4CPUs 16GB of RAM

The test scenarios aim to evaluate the performance of the infrastructure. We used Geekbench for system performance and Flexible I/O Tester (FIO) for the storage speed measurements.

Cloud Mercato aims to perform relevant apples-to-apples comparisons across vendors. **For the purpose of this study, in order to consistently evaluate each solution's hardware, we tried to only select Linux-based OS for their light overhead.**



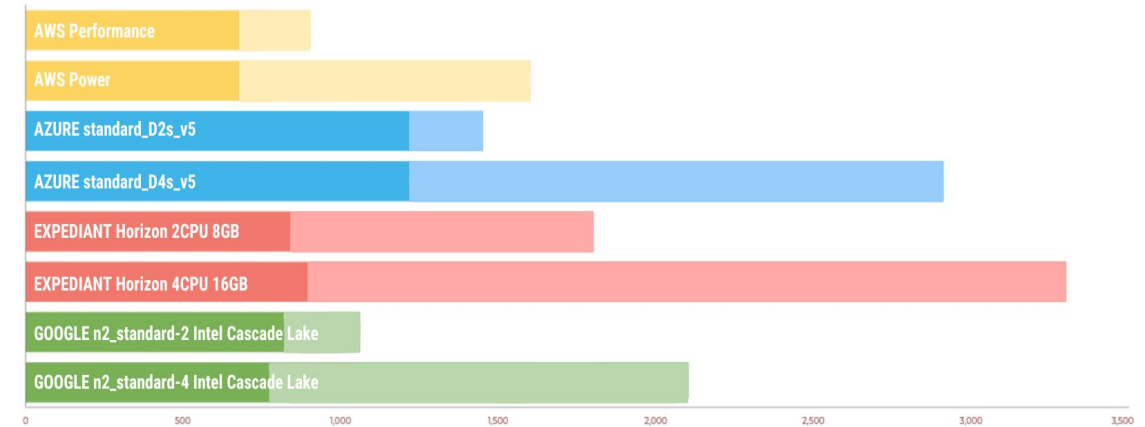
Geekbench 5

Geekbench is a performance test suite designed to evaluate the compute strength of a computer.

This software is recognized for its large panel of workload types containing Integer tests such as compression, as well as Floating Point and Cryptography with Machine Learning, or Physics Simulations.



Single and multi-score (transparent)
Higher is better



ASSERTION

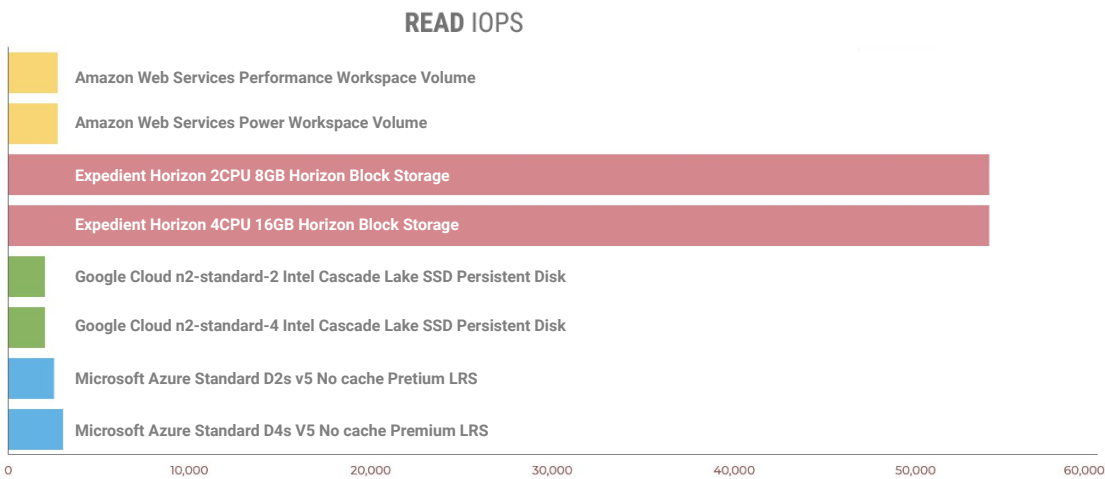
Expedient has the fastest virtual processors across products tested.

Despite the latest generation of CPU like Ice Lake at Azure, Expedient's Intel Cascade Lake-R CPUs are able to deliver better multi-core performance, making it the best choice for a pooled DaaS configuration.

FLEXIBLE I/O ENGINE

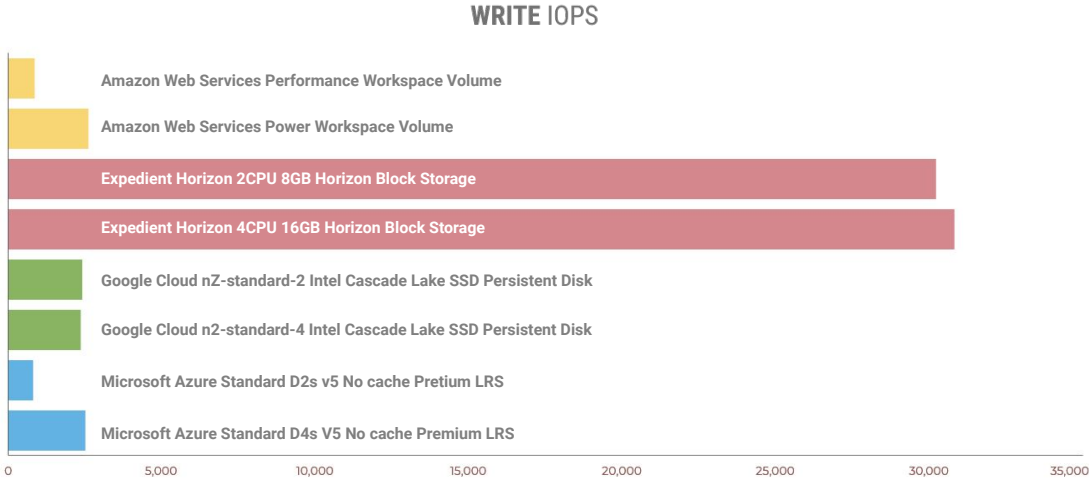
Unlike RAM, SSDs aren't almost instantaneous storage. Each operation – and especially write operations – suffers from latency inherent to the handling of data. In cloud environments, virtualization allows providers to set a fixed capacity and thus directly define the performance given to users.

With FIO, Cloud Mercato seeks for the maximum available throughput in terms of read and write IOPS (Input/Output per second). The scenario consists of an intensive read of 4KB blocks, then intensive write. The performance of Block Storage from Google and Azure is highly dependent on the volume size. The measurements done here are made with 100GB volumes.



ASSERTION

AWS, GCP, and Azure exhibit a low level of performance due to the throttling configured on the provider side. Expedient allows users to take advantage of unutilized IOPS when available, resulting in a better and more consistent desktop experience.

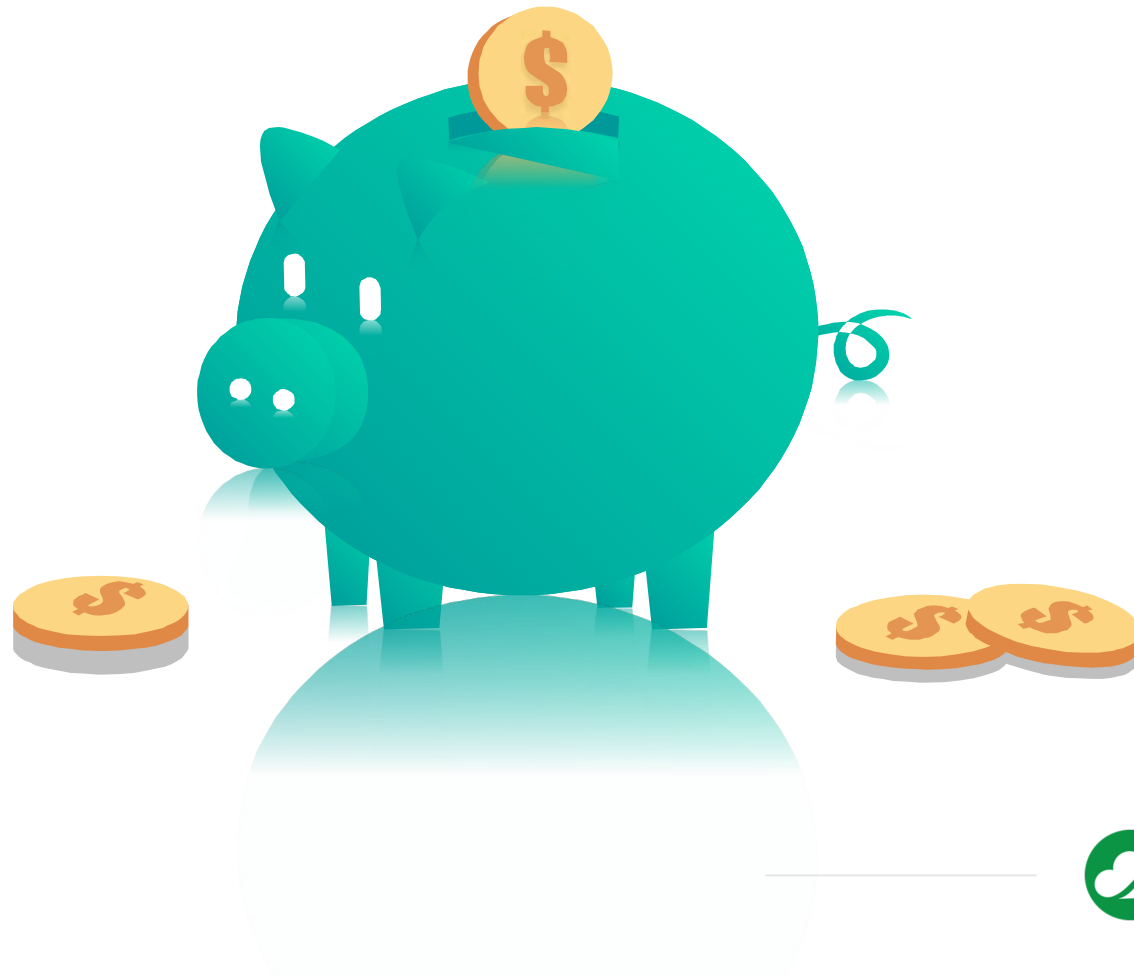


ASSERTION

Again, Expedient outperforms competitors with 30K IOPS in write operations. As much in reading as in writing, they have chosen and delivered a quality of service well above their peers.



PRICING



PRICE STRUCTURE

Across the various providers, pricing is calculated differently.
We define the following items:



Infrastructure Costs

Virtual Machine
Extra storage
Egress traffic



User Management

User directory
Per-users fees



Licence Fee

Operating systems
VDI Software

NOTE The items above represent common chargeable areas that factor into price. This list is not exhaustive.





AMAZON WORKSPACES

AWS VDI options come in bundles. The price for each bundle consists of a monthly component and an hourly component for time used, or a fixed monthly rate.

Infrastructure

The WorkSpaces catalog is pretty simple: 5 types of VM plugged into Block Storage. Like other AWS services such as Lightsail, these machines are re-branded EC2 instances. Here's an exhaustive list of the CPU-based instance types and their pricing.



The cost of traffic between WorkSpaces and users is free but egress traffic from WorkSpaces to the Internet is billed like the general EC2 costs as described on the right. The more you send, the less it costs per GB. Ingress traffic is free.



NAME	CPU	RAM	HOURLY	MONTHLY
VALUE	1	2	7.25 + 0.17/hr	21.00
STANDARD	2	4	7.25 + 0.26/hr	29.00
PERFORMANCE	2	7,5	7.25 + 0.43/hr	41.00
POWER	4	16	7.25 + 0.64/hr	66.00
POWERPRO	8	32	7.25 + 1.49/hr	123.00

Pricing in USD from us-east Northern Virginia

First GB	Free
After 1GB	0.090
After 10 GB	0.085
After 50 TB	0.070
After 150 TB	0.050





User directory

In addition to infrastructure, WorkSpaces needs a Microsoft Active Directory (AD) to maintain user registries.

A wide array of options are available for the user directory, both on-platform and external. **Here's an exhaustive list of the available options.**

	Managed AD Standard	Managed AD Enterprise	Simple AD Small	Simple AD Large	AD connector
DESCRIPTION	Microsoft AD integrated to AWS		In-house alternative		Proxy to an existing active directory
	1GB Max	17GB Max	500 users max	5000 users max	
START PRICE (per month)	87.60	292.00	36.50	109.50	109.50

Pricing in USD from us-east Northern Virginia

Licensing & extras

Microsoft Windows license charges translate to about a \$5/month increase in monthly charges.

Every WorkSpaces user also gets access to a 50 GB allowance of Amazon WorkDocs. Various discounts exist for certain categories of users (for example, educational users).

Amazon also provides WorkSpaces Application Manager (WAM), a portal available to administrators to manage deployment and access to services available via WorkSpaces. Basic functionality is available for free as WAM Lite and includes user and group access control and basic reporting. WAM Standard is available for \$5/month and adds more granular controls for administrators.





Price estimation

The total cost is calculated based on the hardware configuration as well as additional hardware components such as additional storage. AWS proposes a simple billing bundling users to VMs. With theoretically one user per VM the pricing is quite linear: there's a base fee for your AD, with the major portion is estimated by your requirements in terms of desktop.

Two main models are available in terms of charge assessments:

Hourly: A base fee is applied. Users have the opportunity to shut down their instance and suspend the billing.

Monthly: A static per month fee is applied. In comparison and on a pro rata basis of 1 month, a large discount of 60% is observable.

An invoice can be summarized with the following basic formula:

(Number of users * Instance) + Traffic + Active Directory





AZURE VIRTUAL DESKTOP

Azure clearly separates the users and hardware with their personal versus pooled types. Powered on top of the Virtual Machine offering, Desktop lets a maximum of 6 simultaneous working users per VM vCPU.

Infrastructure

As noted above, the Desktop service is based on Azure Virtual Machines with all the associated fees. Both services share:

- Virtual Machine
- Block storage
- Traffic egress and inter-region

First GB	free
After 1GB	0.080
After 10 GB	0.065
After 50 TB	0.060
After 150 TB	0.040

Egress traffic is billed at the price of the Free underlying infrastructure, Azure Virtual Machines. The traffic to Microsoft 365 is considered similar to Internet traffic.

Microsoft has one of the biggest virtual machine catalogs to cover a diverse variety of workloads and offer a high density of CPU/RAM per machine.

Most of the Virtual Machines are available under hourly, yearly, and 3-year payment options. With a long term engagement, they offer a discount of up to 60-70%.

Below you'll find a sample of the latest Azure Virtual Machine considered for a general purpose. The long term commitments are displayed at an hourly scale:

NAME	CPU	RAM	Hourly	1 year	3 year
D2 v5	2	8	0.100	0.057	0.036
D4 v5	4	16	0.190	0.113	0.073
D8 v5	8	32	0.380	0.226	0.146

Pricing in USD from us-east Northern Virginia





User directory

Azure provides a variety of authentication options, including in-house Azure Active Directory.
Free Included in Azure subscription 50K objects max

It has a free tier that includes basic AD functionality and 6.00 several premium tiers that come with application access and various other benefits.

Licensing and extras

Azure offers direct integration with major software providers, including Citrix and VMware Horizon via VMware Cloud.

TYPE	PRICE PER USER	COMMENT
Free AD	Free	Included in Azure subscription 50K objects max
Office 365	6.00	Includes 365 Business Basic
P1	6.00	Enhanced feature set
P2	9.00	High level security features

Price estimation

The overall cost of Desktop-as-a-Service on Azure is basically equivalent to the Virtual Machine Infrastructure plus the Active Directory.





EXPEDIENT

Infrastructure

Unlike competitors, Expedient made the choice of offering a tailor-made service. Instead of self-service requiring a comprehensive knowledge of technologies, the client works with Expedient engineering teams to design and deliver a solution based on sizing and performance requirements.

The aim in a cloud computing model is to provide easy access to on-demand services with pay-as-you-go billing options. The challenge is that DaaS infrastructures have a level of complexity that is more difficult to abstract. By providing guidance as the solution is built and then optimizing, Expedient delivers standardized desktop deployments at scale that include full audio, video, and USB capabilities, as well as optimized performance for Windows 10, Zoom, WebEx, Slack, and MS Teams, along with other collaboration tools.

The service is based on VMware Horizon and is fully managed by Expedient. Expedient Enterprise Workspace also supports Bring-Your-Own-Device (BYOD) strategies without incurring additional costs.

NAME	CPU	RAM	MONTHLY
Standard	2	8	50.00
Medium	4	16	70.00
Large	6	24	90.00
Extra large	8	32	110.00

Pricing in USD

User directory

Expedient offers its own managed AD service or allows the client to use their own. In some cases a hybrid model is offered.

Licensing & extras

Expedient includes a VMware Horizon license in its pricing. Windows OS licensing can be purchased through Expedient and a BYOL arrangement is available for MS Windows licenses for some scenarios.

Price estimation

The total cost of the VDI platform is defined at the design step with the Expedient team.





GOOGLE CLOUD VIRTUAL DESKTOP

Infrastructure

DaaS at Google Cloud is a combination of Google Compute Engine and one of their Virtual Desktop partners. For our estimation, we selected Citrix as a VDI vendor.

NAME	CPU	RAM	HOURLY	MONTHLY	1 year	3 year
n2-standard-2	2	8	0.110	0.089	0.071	0.051
n2-standard-4	4	16	0.220	0.173	0.131	0.094
n2-standard-8	8	32	0.440	0.349	0.262	0.187

Pricing in USD from us-east4 without Windows license

The same egress costs as Google Compute Engine apply. As Citrix isn't an in-house solution, the traffic between your Cloud infrastructure and its clients is billed at the same rate.

First GB	0.085
After 10 GB	0.065
After 150 TB	0.045





User directory

The system used for user management depends heavily on the chosen DaaS software. In the case of an Active Directory, Google Cloud offers the Managed AD service. This product has simple billing of \$0.40 per hour or \$292 for a 730-hours month.

Licensing and extras

Depending on the DaaS software chosen, at Google, the pricing of license vendors will always be an extra cost.

Price estimation

Infrastructure + partner license



COST ESTIMATIONS

Desktop-as-a-Service requires many components and among all the cloud providers, a wide variety of options and configurations exist. To allow a comparison between vendors we designed several use cases matching with different company sizes.



SMALL
COMPANY/STARTUP



CORPORATE
OFFICE







LARGE-SCALE
OFFICE

Following the Google partners strategy, we selected Citrix Workspaces as the Desktop-as-a-Service software.



Scenario 1 : Small company/startup

Let us consider a small office with 30 workers who each need full-time Windows desktops with a standard Microsoft 365 Business Basic or an equivalent product. The desktops are used approximately 220 hours per month which represents close to 48 hours per week.

	 AWS	 AZURE	 EXPEDIENT	 GOOGLE
COMPONENTS	Power Bundle x30 Simple AD Small x1 Microsoft 365 x30	D4s x30 256GB SSD x30 AD Free x1 Microsoft 365 x30	4CPU-16GB-200GB x30 Managed AD x1 Microsoft 365 x30	n2-standard-4 x30 100GB SSD x30 Managed AD x1 Workspace x30 Citrix Connector x1 Citrix User x30
COST CALCULATION	78.00 x 30 36.50 x 1 6.00 x 30	42.24 x 30 19.71 x 30 0.00 x 1 6.00 x 30	70.00 x 30 99.00 x 1 6.00 x 30	39.08 x 30 19.00 x 30 6.00 x 30 292.00 x1 39.08 x1 3.05 x 30
TOTAL COST	2,556.50	2,038.25	2,329.00	2,344.98

AWS : Each VM is a Power Bundle with 4 vCPU, 16 GB RAM, 175 GB root volume and 100 GB user volume rented with the monthly billing.

Azure: Each user gets a D4s with 4 cores and 16 GB RAM. VM with a 256 GB SSD of persistent storage.

Expedient: Each user gets a VM with 4 vCPU, 16 GB RAM and 200 GB of storage that is billed monthly.

Google : We use an n2-standard-4 equipped with 4 vCPU, 16GB of RAM and 100GB of additional storage. Citrix is implemented with a Hybrid Design Pattern. It requires:

- A Google Managed AD on a full-time basis
- A Citrix Cloud Connector configured in a n2-standard-4





For the office software, we chose Google Workspace (formerly G-Suite), which, despite its name, must not be confused with any DaaS as it is a collaborative work suite.

The Citrix Users License pricing is an approximation as Citrix does not display a public pricing for less than 500 users.



Scenario 2 : Corporate office





We have a base of 500 employees using MS office or equivalent on a 220 hour per month basis.

	 AWS	 AZURE	 EXPEDIENT	 GOOGLE
COMPONENTS	Power Bundle x500 Simple AD Large x1 Office 365 x500	D4s x500 256GB SSD x500 AD Office 365 x500	4CPU-16GB-200GB x500 Managed AD x1 Microsoft 365 x500	n2-standard-4 x500 100GB SSD x500 Managed AD x1 Workspace x500 Citrix Connector x1 Citrix User x500
COST CALCULATION	78.00 x 500 109.50 x 1 6.00 x 500	42.24 x 500 19.71 x 500 6.00 x 500	70.00 x 500 99.00 x 1 6.00 x 500	39.08 x 500 19.00 x 500 292.00 x 1 6.00 x 500 39.08 x 1 3.05 x 500
TOTAL COST	42,036.50	33,975.00	38,099.00	33,896.08



Scenario 3 : Large-scale office

We have a base of 1500 employees and would opt for an engagement of 1 year to benefit from discounts. The company uses a lightweight application and the requirement in terms of compute power is low, so multi-user session hosts are more appropriate. Desktops must be permanently turned on and available, so a long term option has to be prioritized.

	 AWS	 AZURE	 EXPEDIENT	 GOOGLE
COMPONENTS	Value Bundle x1500 Simple AD Large x1	D8s x100 128GB SSD x100 AD Free x1	8 vCPU-32GB- 100GB x 100 Managed AD x1 Managed Remote Desktop Services (RDS) x 1	n2-standard-8 x100 100GB SSD x100 Managed AD x1 Citrix Connector x1 Citrix User x1500
COST CALCULATION	25.00 x 1500 109.50 x 1	164.98 x 100 9.85 x 100 0.00 x 1	243.60 x 100 99.00 x 1 122.00 x 1	191.26 x 100 19.00 x 100 292.00 x1 39.08 x1 2.68 x 1500
TOTAL COST	37,609.50	17,503.00	24,588.00*	25,377.08*

AWS : The longest contract offered by AWS is a monthly one with a VM per user. We chose a Value Bundle powered by 1 CPU and 2 GB of RAM.

Azure: We use the pooling architecture with a total of 800 vCPU as 0.5 vCPU per user with a rest of 50 vCPU. The pool is composed of 100 D8s of 8 vCPU, 32GB of RAM and 128 GB of Storage. We opt for a 1-year contract.

Expedient: We use Expedient's Managed Remote Desktop Services (RDS) platform at 800 vCPU at 0.5 vCPU per user. The VMs are billed on a monthly rate with a 1 year contract.

Google : Similar to Azure, 100 n2-standard-8 are pooled for a total of 800 vCPU at 0.5 per user. The VMs are billed a Committed use discount of 1 year.

***RDS Licensing** : With Azure and Google, customers are expected to bring their own RDS licenses under License Mobility and Software Assurance. With Expedient, clients can bring their own RDS licenses under License Mobility and Software Assurance or purchase them from Expedient. AWS includes the RDS license per desktop.



CONCLUSION

To ease the comparison of the different DaaS, we'll focus on the main points observed earlier in the report:

- Infrastructure performance
- Cost
- Design, implementation, and maintenance

Following these 3 criteria, **Expedient leads this panel of providers because of their added-value propositions.**

Most public clouds opted for a self-service design where consumers, knowing their requirements, choose what they believe to be the best fit for their workload. Unfortunately, VDI is a high level service, especially when it comes to dealing with the various options and features. In this topic, Expedient notably differentiates itself from market leaders by its high-level of support, providing a team of engineers helping from design to daily maintenance.

While Expedient fits in the market average in terms of pricing, the performance level of Expedient's infrastructure is far superior than competitors, making them the best price/performance value. On top of this, support is included in their pricing, where it's an optional fee with the other vendors.



ABOUT CLOUD MERCATO

Cloud Mercato is a consulting and research firm dedicated to the study of the cloud market. **Our ambition is to bring transparency to the cloud industry by the data.**

To achieve our goal, we have created the Cloud Transparency Platform, a knowledge base gathering precise information on vendors and products.

Our philosophy is also to share the largest part of our data, analysis and projects for free, just to enlighten the minds of consumers and vendors.

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[Amazon WorkDocs](#)

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[Committed use discounts](#)

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[What is Azure Virtual Desktop?](#)

[Azure Virtual Desktop pricing](#)

[Azure AD service limits and restrictions](#)

EXPEDIENT

[Enterprise Workspace Overview](#)

CITRIX

[Workspace pricing](#)

