SynchroNet

The Market is Growing

AWS End User Compute Offerings vs. Azure Virtual Desktop

With the massive shift to a work and learn from home world, many organizations and schools need to find ways to enable their employees and students to access the applications they need from anywhere, on any device. The market of providers who offer services and tools to deliver this capability is growing. This whitepaper will dive into, and compare, the technical and business features of AWS End User Compute services such as WorkSpaces and AppStream 2.0 with Microsoft's Azure Virtual Desktop offering.

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Executive Summary

The ability for employees and students to work from anywhere on any device has shifted from being a privilege to a requirement – which is in addition to the already prevalent need to provide secure, remote access to third-parties for many organizations. With this shift comes a need to be able to provide access to desktops and applications at minutes' notice in a cost-effective manner. As the demand grows, more players are coming into the market. This paper focuses on the comparison of Microsoft's Azure Virtual Desktop (AVD) and Amazon Web Services' WorkSpaces and AppStream 2.0. It is intended to provide technical teams, and IT leadership a view in to the technical and business features of each offering to aid in making an educated and strategic decision for their company's end user computing environment.

Amazon Web Services (AWS) offers two distinct services for desktop and application delivery. **Amazon WorkSpaces** is a managed and secure Desktop-as-a-Service (DaaS) solution. It can be used to quickly provision persistent Windows or Linux desktops in a scalable and cost-effective fashion. **Amazon AppStream 2.0** is a non-persistent alternative to WorkSpaces. It is a fully managed application and desktop streaming service that allows you to centrally manage your desktop applications and deliver them to any user on any computer or mobile device.

Microsoft's Azure Virtual Desktop is a desktop and application virtualization service that supports persistent and non-persistent sessions in a full desktop or RemoteApp experience. It runs on Microsoft's Azure cloud platform and can quickly deploy and scale and too can run on any endpoint device.

Microsoft and Amazon are both known for their robust service offerings and are leaders in the cloud. When it comes to the end user computing (EUC) space, they have both created services and tools that allow for secure remote work and educational delivery services. While both providers offer similar services, there are distinct differences in costs, architecture, and operations that must be explored to make an informed decision on which is better for your organization. In this whitepaper, we will explore the key business and technical features, differences, pros, and cons of each of the services.

Architecture

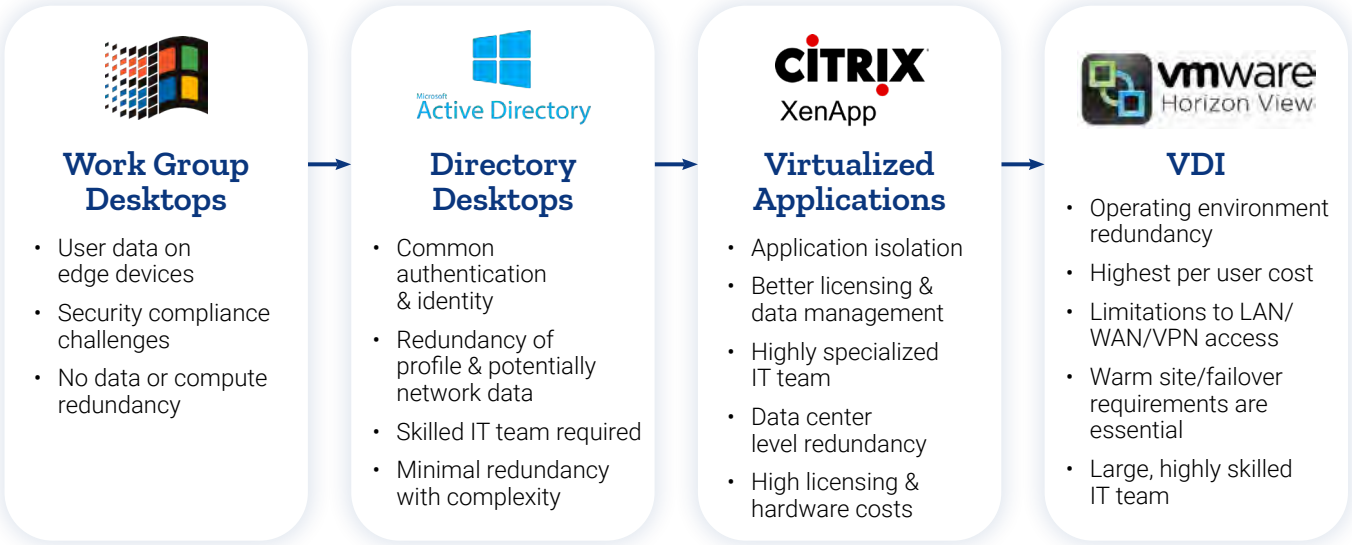
Background

One of the fundamental pillars of a cloud end user computing solution is the architecture. How a service is delivered, the design of the supporting infrastructure, the governance and responsibility model, and how systems are secured and accessed are all major factors that must be understood when deciding on what solution is best for your organization. Before we focus on the present and the future, it is beneficial to look back at where we came from. Figure 1 below will show you the advancement of EUC environments over time. As the PC became more extensible with access to the LAN and WAN, the availability of management tools and need for standardization and increased security grew. Combining these capabilities allowed organizations to create a managed, environment that could operate globally within organization's "four walls."

As the need for more global and secure access to PC technology grew, Virtual Desktop Infrastructure (VDI) became the next logical step in the EUC evolution. VDI promised more cost efficiency, standardization, increased security, and reduced complexity relative to managing a fleet of PCs on everyone's desks. However, many of the aspirational goals that VDI worked towards never came to fruition. VDI was (and is) often riddled with complexity, uptime challenges, cost overruns to truly scale, lack of cost-effective DR/business-continuity, configuration sprawl, and vendor lock-in. All of this essentially renders the traditional on-premises VDI model hard to sustain financially, let alone flexible enough to evolve to your business needs at pace.

Today, we are at another pivotal point in the evolution of EUC technology. Organizations are looking to evacuate existing legacy VDI environments and transition to a Desktop-as-Service model. The most basic, but sometimes defining, element in exploring the feasibility of Amazon WorkSpaces, AppStream 2.0 and Microsoft AVD is the cloud platform those services operate within. To run WorkSpaces or AppStream, you must have an AWS account plus supporting infrastructure, and to operate a Azure Virtual Desktop

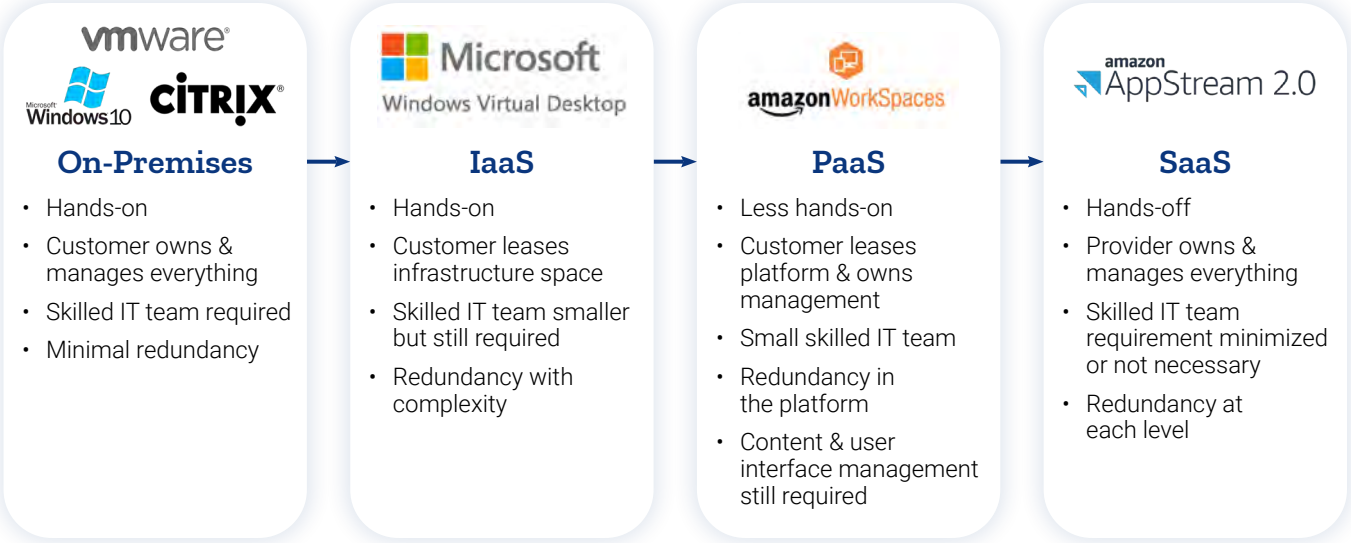
Figure 1: Legacy Environments and Evolutions



environment, you must have an Azure subscription plus supporting infrastructure. For organizations that already have a strong presence or commitment to a specific cloud provider, the corresponding EUC service may be the right path, but it is still recommended to step back and understand all of the decision points.

The three main cloud service models are IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and Software as a Service (SaaS). While this whitepaper will not dive deep into those models, it is important to understand what they are and why one model may be preferred over another in a deployment and operations scenario. Figure 2 below provides a high-level view of the progression from on-premises to SaaS and where the vendors' EUC solutions fit. The evolution in the cloud space and move from a traditional LAN/WAN structure advanced the users' interactions to anywhere, anytime work patterns. This created a large-scale migration to an improved turnkey service for the end user that allowed for the abstraction of operations and application layering. The long-sought goal of a service for familiar tools and ready access to data without concern for the backend components is being realized as the final phase of the distributed compute and access model takes shape globally in the form of "Desktop as a Service."

Figure 2: Cloud Evolution for End User Compute



Services' Architecture

AMAZON WEB SERVICES

Amazon's AWS solution offerings focus on the PaaS and SaaS models, eliminating the customer need for advanced knowledge and large IT staff to provide a desktop and application experience. All the backend components such as hypervisors, hosted operating systems, and patches are handled by AWS, creating a turnkey solution for their customers. This does not mean the customer loses control of the management within their environment. Change controls are still in place from the management level, but the mechanics behind the scenes are run and maintained by AWS. This allows for flexibility and expansion to happen smoothly and within a measurable and predictable cost model. Additionally, the end user experience remains seamless, even when significant changes occur on the back end, as AWS can handle the economy of scale for those changes. Overall, the PaaS and SaaS based architectures of both AppStream 2.0 and WorkSpaces deliver a production-ready solution that is attractive for cost savings and ease of deployment and operation as customers move to a more consumption-based model for IT resources.

The underlying AWS architecture requirements for AppStream 2.0 and WorkSpaces are similar in construct and simplicity. The prerequisites are network focused and are standard for any cloud deployment and are not specific to EUC. This standardization provides the benefit that the underlying infrastructure is likely to already have be templatized and is something that can easily be deployed by an existing Cloud Team. The EUC components can then be managed separately by your Desktop/EUC Team who will not need deep cloud expertise to operate, grow, or change the end user experience as your business needs change.

Once you have the core networking components in place, you can begin to design and architect the EUC solution itself. There will be some design decisions that will vary based on offering (e.g. WorkSpaces or AppStream), and other basic architectural concepts that remain standard across both. For both offerings, there is a one-to-one relationship between users and instances at a given time, meaning that you will not be contending with other users for resources on the underlying EC2 instance. The base imaging and maintenance of the operating system is handled by AWS (though for WorkSpaces, customers do have a "Bring Your Own Image" model that allows a customer to leverage their own operating system image). They also fully manage all hypervisor instances with easy-to-use consoles for managing and deploying the individual WorkSpaces and/or AppStream instances. A focused and simple application delivery mechanism and a single interface that accommodates broad distribution are features in the application space that sets both AWS solutions apart. A customer can leverage Active Directory Group Policies and third-party tools, like SCCM, for the administration and automation of OS and application configuration. AWS also allows for seamless management of data shares and access controls, streamlining the experience and minimizing customer interactions for maintenance.

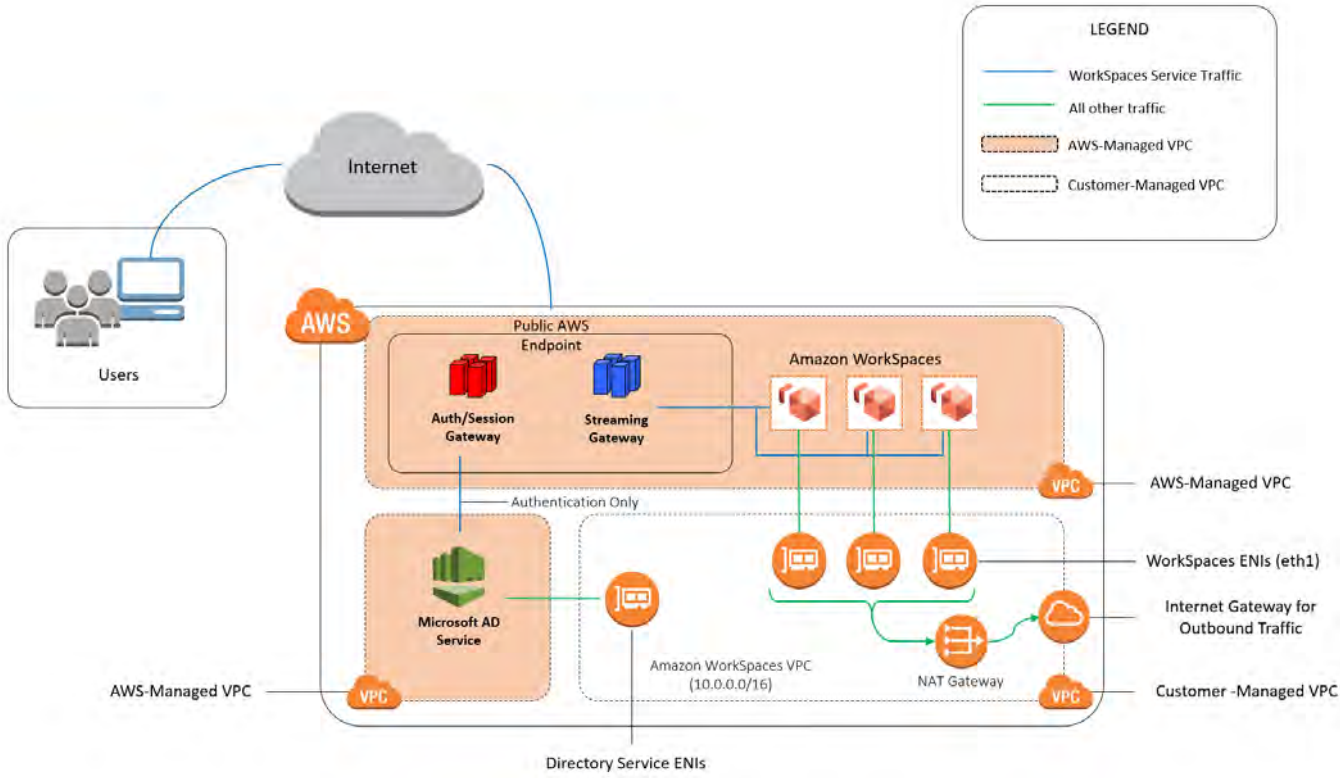
The common theme with AWS offerings is the maturity and simplicity of the architecture and design of each solution. Amazon WorkSpaces were launched in 2014 and AppStream 2.0 was available in late 2016. AWS was the front-runner in releasing EUC service offerings, and they have remained dedicated to enhancing their solutions to become the turnkey, cost-effective, low maintenance products they are today.

WorkSpaces

Amazon WorkSpaces are persistent virtual desktops that are available as bundles of operating system, compute resources, storage space and software applications. The WorkSpaces will provide your end users with either an Amazon Linux cloud desktop or a Windows 10 experience provided by Windows Server 2016. From a Windows perspective, you can purchase licenses through AWS or you can bring your own Windows 10 desktop licenses to WorkSpaces if they meet Microsoft's licensing requirements. The desktops can be accessed via the Amazon WorkSpaces client application or Chrome or Firefox web browsers, mobile devices, and are available in 13 AWS regions.

The basic architectural design for WorkSpaces is illustrated in Figure 3 below. The two main customer components that WorkSpaces are associated with are a VPC and directory. In the case of WorkSpaces, your VPC will house the WorkSpaces primary network interface, NAT Gateway, Internet Gateway, and Directory Services ENIs. All other components, like the authentication and streaming gateways, the WorkSpaces instances and management/streaming network interfaces, and Microsoft AD Service live in AWS managed VPCs. Th directory must be configured in AWS Directory Service or Managed Microsoft AD and is used by WorkSpaces to authenticate users. A user would access their WorkSpace via the client or browser and enter their login information which is then passed to the authentication gateway. The gateway forwards the traffic to the directory and after the user is authenticated, the streaming traffic is initiated through the streaming gateway. Each provisioned WorkSpace will have two elastic network interfaces. The first (eth 0) is part of the AWS managed VPC and is used for management and streaming.

Figure 3: Amazon WorkSpaces Architectural Diagram



Source: ***https://docs.aws.amazon.com/workspaces/latest/adminguide/amazon-workspaces.html***

The other interface (eth 1) has an IP address from your VPC and is the primary network interface application access. There are two protocols supported by Amazon WorkSpaces: PCoIP and WorkSpaces Streaming Protcol (WSP) [Currently in public beta.] The decision on which to use will depend on several factors like the type of devices used by your end users, operating system, network conditions, and video support needs. PCoIP supports Teradici zero client devices and Windows 7, 10 and Linux WorkSpaces. WSP is still in beta but allows better productivity across the globe and under uncertain network conditions, supports bidirectional video and webcams, but supports only Windows 10 WorkSpaces. Other features, like MFA, encryption, and source IP control for accessing WorkSpaces, are available and may also be a part of your architecture.

As visualized in Figure 3, there is very little for the customer to design, implement, and support outside of the fundamental network and directory structure. This requires little effort from your Cloud Team and allows for your Desktop and EUC Team to focus on the actual EUC components. A custom image will contain the OS, software, and settings for the WorkSpace. The custom bundle combines that image with the hardware from which a WorkSpace can be launched. You will be able to pick the bundle that provides the appropriate resources, storage, and pricing for your use case. These bundles provide a simple "menu item" approach for deployment that, combined with the simple overall architecture, allows your resources to focus their efforts on end user experience and optimizations.

AppStream 2.0

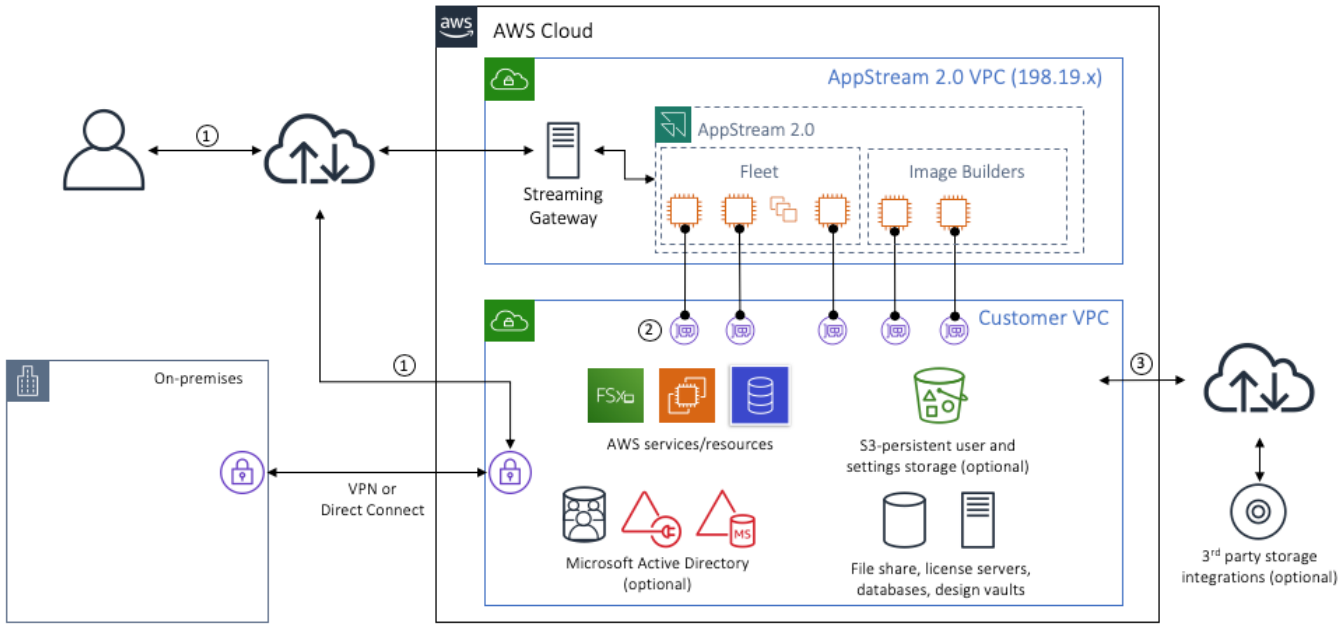
Amazon AppStream 2.0 is a non-persistent application and desktop streaming service. It allows for central management of your applications and the ability to secure those applications and deliver them to any computer. Applications run on virtual machines using the NICE DCV protocol, which provides for a highly responsive end user experience. AppStream can be hosted in multiple AWS regions globally and can be delivered as individual applications or as a full desktop experience. Applications can be accessed via the AppStream 2.0 Windows Client or via an HTML5 compatible browser from a computer or mobile device. You can connect and configure your own storage and identity management systems or use the built-in user management and add persistent storage.

The basic architectural design for AppStream 2.0 is illustrated in Figure 4 below. Like Amazon WorkSpaces, the key component to get started is a customer VPC, which can easily be deployed by your Cloud Team. Your VPC will house the S3 buckets for persistent user and settings storage, Microsoft AD components, supporting infrastructure such as file shares and license servers, and other AWS services like FSx. This VPC will also be the point of connectivity back to on-premises via a VPN or DirectConnect and to third party storage if desirable. There will be an AWS-managed AppStream 2.0 VPC that contains your Streaming Gateway, image builders and fleets. Just like with WorkSpaces, each AppStream 2.0 streaming instance has two network interfaces. The customer network interface lives in your VPC and provides connectivity to your network resources, the internet, and is used to join your instance to your directory if applicable. The other interface is for management and is connected to a secure AppStream 2.0 management network used for interactive streaming to a user's device and to allow AppStream 2.0 to manage the instance. The management network IP address is always from the 198.19.0.0/16 range so it is important to not use this range for your customer VPC CIDR block as this may create conflict and cause your streaming instances to be unreachable.

AppStream 2.0 is like WorkSpaces in that it has a very simple design and there is little for the customer's Cloud Team to design and manage. On top of the infrastructure, the main three AppStream components

are Image Builders, Fleets, and Stacks. These items can be managed by your Desktop or EUC Team with minimal training as they do not require any AWS specific knowledge. AppStream 2.0 uses EC2 instances to stream applications and the instances are launched from base images called Image Builders. A custom image is created by connecting to an Image Builder instance, installing, and configuring your applications, then creating a snapshot. Once you have an image, you will create a fleet which consists of streaming instances that run the specified image. The fleet parameters will determine when your instances run, how they are paid for, and the instance type. The Fleet Type options are Always-On or On-Demand. The Always-On instance will be immediately available for a higher cost and the On-Demand instances will have a 1-2-minute delay for end-users but come at less expensive cost. The instance type for your fleet will dictate the resources, such as vCPU, memory, and GPU, that your streaming instance will have. Like WorkSpaces bundles, there is a finite "menu" of options to choose from for your use case. The final layer is the stack which consists of streaming resources and the policies for controlling access to these resources. Your Desktop or EUC Team will be able to use Fleet and Stack settings to fine-tune the user experience and costs. There are enough configuration options, from disconnect timeouts and scaling policies to storage integrations and application settings persistence, for you to fine-tune a user experience, but not too many that there must be rigid and thorough training for a Cloud or Desktop team to understand all of the levers and impact.

Figure 4: Amazon AppStream 2.0 Architectural Diagram



Source: ***https://aws.amazon.com/blogs/architecture/bbva-helping-global-remote-working-with-amazon-appstream-2-0/***

AZURE VIRTUAL DESKTOP

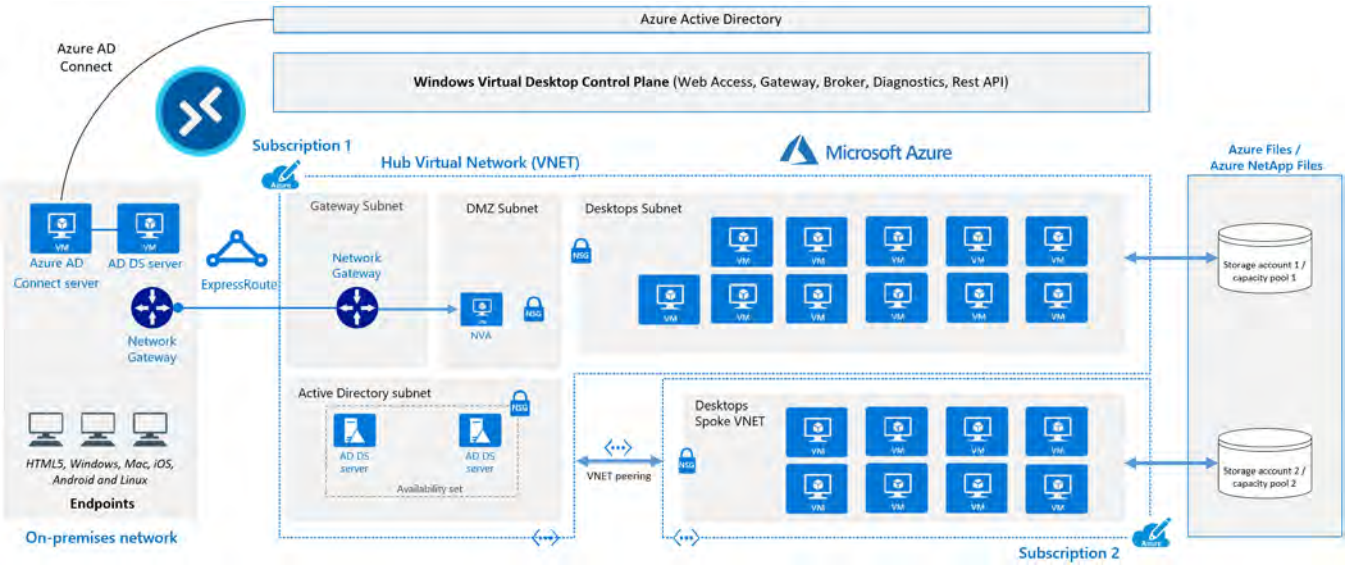
Microsoft's Azure Virtual Desktop offers a mainly IaaS solution, with small pieces of PaaS, that is focused on granularity within the virtual structure. This approach offers detailed interaction with the support and maintenance components of the solution which can attract a particularly tech-savvy customer but deter a customer with limited resources or Azure knowledge. Although the base hypervisor and virtualization stacks are fairly uniform, the implementation and management of the environment falls mostly on the customer, including monitoring and break-fix.

The underlying Azure infrastructure required to run Azure Virtual Desktop is similar to what's needed for the AWS solutions. It is primarily network focused, requiring an Azure Virtual Network (VNet) with subnets and Network Security Groups (NSGs). It will also be required for you to have an Azure AD setup for identity and access management. All Azure Virtual Desktops must be domain joined, so Active Directory Domain Services are another requirement. Active Directory Group Policies and tools like SCCM can be used by the customer for application settings and delivery. Access to AVD can be locked down using Azure Conditional Access policies and native MFA.

Figure 5 below illustrates the standard Azure Virtual Desktop architecture. In a AVD environment, the Microsoft-managed Azure Virtual Desktop Control Plane consists of the Web Access service, Remote Connection Gateway service, Connection Broker, Remote Desktop Diagnostics, and extensibility components. The customer is then responsible for managing the remaining parts. As opposed to the AWS solutions' architectures where the underlying streaming instances for AppStream 2.0 and the actual EC2 instances for WorkSpaces reside in an AWS-managed VPC with just a network interface in the customer's VPC, Microsoft's solution has the desktop virtual machines in the customer's VNet. This means that the customer will have the added responsibility of managing a more complex sizing, costing, and maintenance effort regarding these VMs.

Azure Virtual Desktop offers two types of desktops: personal and pooled. Desktops are accessible through the AVD Remote Client App of through a web browser. Personal desktops are Microsoft's persistent desktop solution and is more comparable to Amazon WorkSpaces. Pooled desktops are Microsoft's non-persistent solution and are more comparable to Amazon AppStream 2.0. One of the key differentiators of AVD is the Windows 10 Enterprise Multi-session host which allows for multiple concurrent interactive sessions. This capability can have cost-savings benefits, but it can also introduce additional risk and need for Azure expertise. With multiple users leveraging the same underlying virtual machine, there is the potential contention of resources and the ability for one user to impact another. Microsoft publishes multi-session sizing recommendations **here**, but subject matter experts have observed that reaching max user capacity will typically impact performance and they instead guide you to plan for fewer users than Microsoft recommends. AVD is similar to Citrix hosted in a multi-user, shared environment, one user running a CPU, disk, or RAM-intensive application can affect large quantities of users on the same stack.

Figure 5: Microsoft AVD Architectural Diagram



Source: ***https://docs.microsoft.com/en-us/azure/architecture/example-scenario/AVD/windows-virtual-desktop***

Overall, the architecture of Microsoft Azure Virtual Desktop puts more design, implementation, and run responsibility on the customer than that of its AWS counterparts. The offering was unveiled in September of 2018, being made available in public preview in March of 2019. The newness of the solution can be seen in some of the design complexities, but if you are a company with strong Azure expertise and a desire to control, maintain, monitor, and operate the significant number of granular technical components the solution requires and your organization has a willingness to commit time from your Cloud Team resources to design and deliver your End User Compute environment, Microsoft's Azure Virtual Desktop solution may be a consideration. Keep in mind that each component much function "just right" to maintain a positive user experience, uptime, and to avoid degradation. In the spring of 2020, Microsoft released a spring update of their AVD solution, announcing that it is now an Azure Resource Manager service. This was a major shift from Microsoft that brought several benefits, but also fundamentally changed the game for customers. There is no simple way to migrate from the original architecture to the new without the need for advanced scripting or a third-party tool. AVD being a newer solution means that major, user-impacting updates like this are to be expected and must be accounted for when making a commitment to the solution.

Capabilities

As you explore the different cloud EUC solutions, it is critical to understand the capabilities of each solution and which of these capabilities come out of the box versus needing a third-party tool to accomplish. When a solution requires a third-party tool for capabilities that another tool may provide out of the box, that tool will also require additional money, time, and resources to purchase, deploy, and maintain. The below table provides a view into the capabilities of AppStream 2.0, WorkSpaces, and AVD. Following along with the IaaS, PaaS, and SaaS maturity model presented in the Architecture section, Microsoft's AVD solution requires a third-party tool or other cloud services to reach capability parity with the AWS solutions. We will dive more into the features, costs, and benefits of the available third-party solutions later in this whitepaper.

	Amazon WorkSpaces	AVD Personal Desktop
Image Management	OOB	Third Party
Fixed Predictable Pricing	OOB	N/A
Automated Backups	OOB	Cloud Service
Image Portability	OOB	Third Party/Cloud Service
Linux Support	OOB	N/A
Business Continuity	OOB	Cloud Service
Cost Analysis	Cloud Service	Third Party/Cloud Service
Automated User Based Provisioning	Third Party	Third Party
User Self-Service	Third Party	N/A
	Amazon AppStream 2.0	**AVD Pooled Desktops**
App or Desktop View	OOB	OOB
Utilization-Based Autoscaling	OOB	Third Party/Cloud Service
Image Management	OOB	Third Party
Image Portability	OOB	Third Party/Cloud Service
Cost Analysis	Cloud Service	Third Party/Cloud Service

OOB = Capability is available as a native part of the service

Third Party = Third party tool available to accomplish this capability

Cloud Service = Capability not available as a part of the service, but can be accomplished using another in-house cloud service

N/A = No available way to accomplish this capability

Pricing

Background

Costs have always been a key piece of the cloud journey and the same is true when it comes to the EUC and DaaS conversation. Both AWS and Microsoft market a cost-effective and scalable desktop and application delivery solutions, but it is important to understand all the components, offerings and pricing models that comprise each of the services. When exploring costs of solutions, you must include the hard and soft costs. The hard costs will be those that are for the infrastructure, licenses, and other tangible components. The soft costs, that are sometimes harder to quantify but must still be considered, are those like the number, skillset, and time commitment of resources required to implement and support the environment. A solution may have compelling hard costs but come with complexities that raise the soft costs, or vice versa. An organization should also consider uptime or degradation risk a solution introduces into the environment, as it may have a direct business cost impact, or internal (or possibly external) organizational reputational risk if instability or performance are outside customer expectations.

It will be important for your organization to define and understand the Total Cost of Ownership for each solution offering. As you will see in the coming sections that dive into the pricing of each solution, the IT resource demands will greatly impact TCO. In both AWS solutions, the demands on your IT team and the need for a large, highly skilled AWS Team will be low. An AWS Engineer will be necessary for the setup and maintenance of the network, but your existing Desktop or EUC Team will be able to take on the WorkSpaces and AppStream provisioning and maintenance with little AWS knowledge. On the other side, a AVD environment will require an Azure Architect, Engineer, Operations, and Support resource(s). Given the granularity of the solution, your IT needs will be similar to those of an on-premises VDI environment, with little TCO benefit of moving to a cloud solution, other than getting out of the data center hardware investment cycle.

Services' Pricing

AMAZON WEB SERVICES

Each of the AWS solutions offer a couple of different billing options and the choice comes down to your use case and needs. In both cases, you are only charged for what you use, there is no upfront investment, and no long-term commitment. While it is a prerequisite to have an AWS account and supporting infrastructure backend, the setup is simple with minimal costs. Additionally, given the SaaS model of the AWS solution offerings, with all the backend components being handled by AWS, customers can maintain a measurable and predictable cost model. This turnkey nature of WorkSpaces and AppStream also limits your soft costs as there is less need for advanced knowledge and a large IT staff to support backend infrastructure. In most cases, your existing Desktop or VDI Team can manage the AppStream and WorkSpaces environment with just light training.

Below are high level cost details for Amazon WorkSpaces and AppStream 2.0. You can find pricing tables in **Appendix A**. The costs that are presented in these tables are the true, publicly available, market price of each service or feature with no assumptions of committed spend or reservations. The Microsoft licensing fees applicable to WorkSpaces and AppStream are straightforward, with WorkSpaces offering both a license included and BYOL option, eliminating confusion when calculating total cost of ownership.

WorkSpaces

Amazon WorkSpaces offers two different pricing models, monthly or hourly. The monthly option allows you to pay a fixed monthly fee for unlimited usage during the month. With hourly billing, you pay a small fixed monthly fee per WorkSpace to cover infrastructure and storage costs, then a low hourly rate for each hour the WorkSpace is used. A general rule of thumb is that 80 hours of usage per month will be the break-even point between monthly and hourly billing.

Amazon WorkSpaces Pricing

AppStream 2.0

Amazon AppStream 2.0 instances are charged based on capacity. There are always-on fleets that provide instant-on access to applications where instances are charged hourly and are charged the applicable rate even when users are not connected. The other option is on-demand fleets where users will experience a small delay in accessing their first application (typically 1-2 minutes), but instances are charged hourly when they are being used for streaming sessions with just a small hourly stopped instance fee when they are not being used for streaming sessions. In addition to these two options, there are image builder instance fees and user fees. Image builder instances are charged hourly when running regardless of whether an administrator is connected. User fees are charged monthly for each end user who launches a streaming session. This $4.19 charge is a Microsoft RDS SAL flat fee that is charged per user for the month in which the streaming session occurred and is the same regardless of when users first launch their sessions in the month. This fee does not apply to image builders. There is an option to bring your own RDS CAL licenses using Microsoft License Mobility under specific requirements, in which case you will not be charged monthly Microsoft license user fees by AWS.

Amazon AppStream 2.0 Pricing

AZURE VIRTUAL DESKTOP

Microsoft's AVD offering is like its AWS counterparts in that it also offers a consumption-based model and there are Azure infrastructure related needs. AVD allows for more granularity within the virtual structure, which can be advantageous to a particularly tech-savvy customer but can also create variability and confusion in getting to the true costs of a solution. When compared to the straightforward pricing tables offered by AWS for their solutions, the Azure AVD pricing calculator has many more levers that can impact costs. In many cases, in an attempt to try and simplify the costing model, companies will develop their own cost calculators or rely on third parties to assist, sometimes making it more difficult to easily determine cost impacts to your organization. On top of the lack of clarity on cost impacts, the people and monetary resources required to develop and maintain a custom cost calculator or a third-party solution will need to be understood and tracked towards Total Cost of Ownership. Microsoft offers a AVD Solution Configurator to estimate Azure compute, storage, and networking costs. The link to this tool is available below along with a screenshot in Figure 6 that shows just a sampling of the many details that must be gathered to estimate costs of AVD. With the added complexities in calculating true costs also comes increased soft costs as detailed interaction with the support and maintenance components of the solution requires a skilled IT staff. In this case, your Desktop or VDI Team is usually not equipped with the Azure skillset that is needed to implement and support the AVD environment. The Azure Cloud Team will need to play a larger role in AVD, or your desktop team will require more thorough training to become deep Azure SMEs.

Given the intricacies of the different costing models, array of implicating factors, and the complex calculations, straightforward cost tables like those from AWS are not readily available for AVD. If you would like to dive deeper in to the Azure AVD costs, you can find their pricing information and calculator through the links below. Links will provide both reserved and on-demand pricing, but it is important to note that Microsoft's advertised prices may assume a 3-year Reserved Instance and Azure Hybrid Benefit. With these assumptions, you must make sure that when performing a cost analysis of EUC tools, you are comparing apples to apples. Licensing can be a moot point when it comes to AVD costs if you have Software Assurance, but it will be imperative to understand your Microsoft licensing and the potential administration implications. You will also find that AVD prices will be broken out between Personal Desktops or Multi-session Desktops. Many customers will take advantage of the features and cost-effectiveness of the multi-session desktops. This can be an effective solution for some clients, but it will add to the soft costs of administering the environment and having the resources to make the required sizing and deployment decisions, along with the monitoring required to ensure there is no service degradation due to runaway or over-use of shared resources.

Azure Virtual Desktop Pricing

Azure Pricing Calculator

AVD Solution Configurator

Example Pricing Scenarios

The below two tables will provide simple example pricing scenarios that compare Amazon AppStream 2.0 to AVD Pooled Desktops and Amazon WorkSpaces to AVD Personal Desktops. These examples focus solely on the EUC services costs and do not incorporate the soft costs of resources and time or third-party tools that may be required to reach desired functionality for a solution. In both scenarios, you will see that the calculations for AVD require more components and ultimately end up being more expensive than the Amazon offerings.

Pricing Comparison

Microsoft AVD – Pooled Desktops

Services Cost Calculations

- 250 concurrent users
- VM Size: Standard F8s_v2 8 vCPU(s) 16GB RAM, 64GB Temporary Storage
- # of VM for 2vCPU, 4GB RAM/user: 63
- Region: West US
- Usage - Working Hours: M-F for 10 hours/day = 220 hours/month
- Licensing: M365 F3 (Includes Office web and mobile apps)

VM + Storage Costs

- VM: $0.424/hour * 220 hours * 63 VMs = $5,876.64
- Storage: $19.71/disk/month * 63 VMs = $630.72
- Total = $6,174.72/month

Licensing

M365 F3: $10/user/month

$10 * 250 users = $2,500/month

Azure ADDS (Required)

$109.50/month

Services Total

Monthly Total: **$9,116.86/month**

Monthly Per User Cost: **$36.47/user/month**

Amazon AppStream 2.0

Services Cost Calculations

- 250 concurrent users
- AppStream Instance Size: stream.standard.medium (2vCPU, 4GiB RAM)
- Always-On Instances: 1 hour/day (22 days) added to the time for provisioning each morning
- Region: US West (Oregon)
- Usage - Working Hours: M-F for 10 hours/day = 220 hours/month
- Assumption that client is licensed for standard cloud services app such as Teams, Exchange, OneDrive, and SharePoint

AppStream Pricing

- $0.10/hour * 242 hours * 250 users = $6,050/month

Microsoft RDS SAL Fee

$4.19 * 250 users = $1,047.50

Services Total

Monthly Total: **$7,097.50/month**

Monthly Per User Cost: **$28.39/user/month**

Summary: Amazon AppStream 2.0 offers a dedicated instance per user for $2,019 less/month than AVD that requires users to leverage shared resources and potentially contend for CPU and RAM. This is a savings of $8.08/user/month.
Note: These costs do not include any third-party tools that may be required for desired functionality. You can see the prices of these services in the Third-Party Tools section of this whitepaper.

Pricing Comparison

Microsoft AVD – Personal Desktops

Services Cost Calculations

- 250 users
- VM Size: Standard F1s (1vCPU, 2GB vRAM), StandardHDD OS disk (128GB)
- Region: West US
- Usage - Working Hours: M-F for 10 hours/day = 220 hours/month
- Licensing: M365 Business Plan
- Azure Backup to obtain feature parity for backups

VM + Storage Costs

- VM: $0.062/hour * 220 hours = $13.64/month
- Storage: $5.89/disk/month

(250 users * $13.64) + (250 users * $5.89) = $4,882.50/month

Licensing

M365BP: $20.00/user/month

$20 * 250 users = $5,000/month

Azure ADDS (Required)

$109.50/month

Azure Backup

$10/VM/month + cost of storage (not included in example)

250VMs * $10 = $2,500/month

Services Total

Monthly Total: **$12,492/month**

Monthly Per User Cost: **$49.97/user/month**

Amazon WorkSpaces

Services Cost Calculations

- 250 users
- Workspace size: Value (1vCPU, 2GB RAM), 80GB Root Volume, 50GB User Volume
- Region: US West (Oregon)
- Usage: Unlimited
- License Included Option + Plus Applications Bundle
- User Volume Backups every 12 hours included in costs

WorkSpaces Pricing

- $28.00/user/month

250 users * $28.00 = $7,000

Plus Applications Bundle

(Microsoft Office Professional, Trend Micro, IE 11, Firefox): $15.00/user/month

250 users * $15.00 = $3,750

Services Total

Monthly Total: **$10,750/month**

Monthly Per User Cost: **$43.00/user/month**

Summary: Amazon WorkSpaces offers the same resources with unlimited usage (compared to users being restricted to 220 hours/month from AVD unless you purchase reserved instances which are more expensive) for $1,742 less/month. This is a savings of $6.97/user/month.
Note: These costs do not include any third-party tools that may be required for desired functionality. You can see the prices of these services in the Third-Party Tools section of this whitepaper.

Note: If you want unlimited usage with Microsoft AVD, you will want to purchase a 1- or 3-year reserved instance, which will lock you in for that duration. In this example, costs are below:

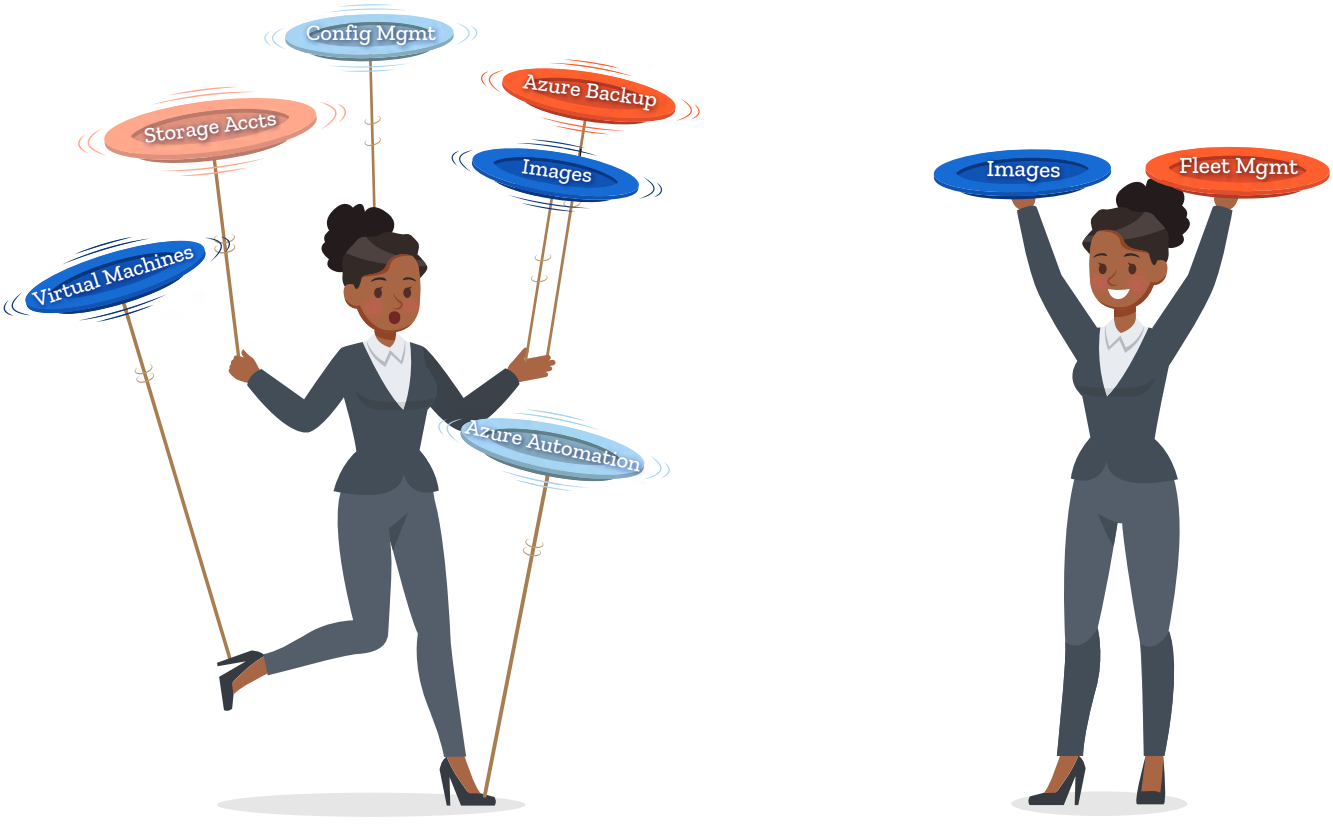
- 1 Year Reserved VM Costs: $6,978.80 | Monthly Total: $16.060.80 ($64.24/user)
- 1 Year Reserved VM Costs: $4,743.17 | Monthly Total: $13,825.17 ($55.30/user)

Operations

Background

The next cloud EUC pillar for comparison is operations. This category dives into the day to day effort and resources that are required for steady state support, maintenance, and administration of the environment. One of the most basic requirements of Operations is a Service Level Agreement (SLA). Amazon, for both **WorkSpaces** and **AppStream**, advertises 99.9% availability and backs their SLAs with service credit percentages. When looking at Microsoft AVD, they "**strive to attain 99.9%**" availability for the desktop, and do not back this with any service credit options. This distinction will be critical for organizations that guarantee SLAs to their own customers. On top of SLAs, overall, you will find that the operations of Microsoft's AVD solution requires resources with deeper Azure expertise than Amazon solutions require AWS knowledge. As illustrated in Figure 7 on the following page, in an AWS environment, you will need Builders who will need to know some AWS terminology and functions, then your Operators who focus solely on the AppStream or WorkSpaces product and will require only very basic AWS skills. On the AVD side, since you are deploying and maintaining Azure services such as VMs, Backups, and Automation, your Operators and Builders will need to have a fair amount of Azure knowledge and there will be a requirement for an Azure SME that can be consulted for the other functions. Additionally, as referenced throughout this whitepaper, the general consensus of the Microsoft AVD solution is that it requires an added piece ("the glue"), such as a third-party tool like Nerdio or Advanced PowerShell scripts, to bring it all together and truly make it an enterprise-ready product.

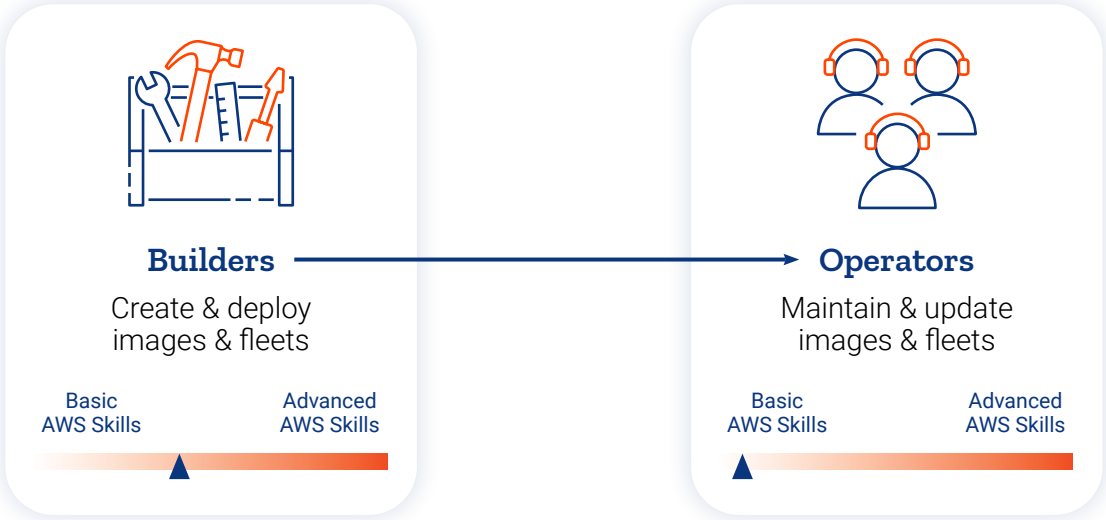
The Plate Spinning of Operations



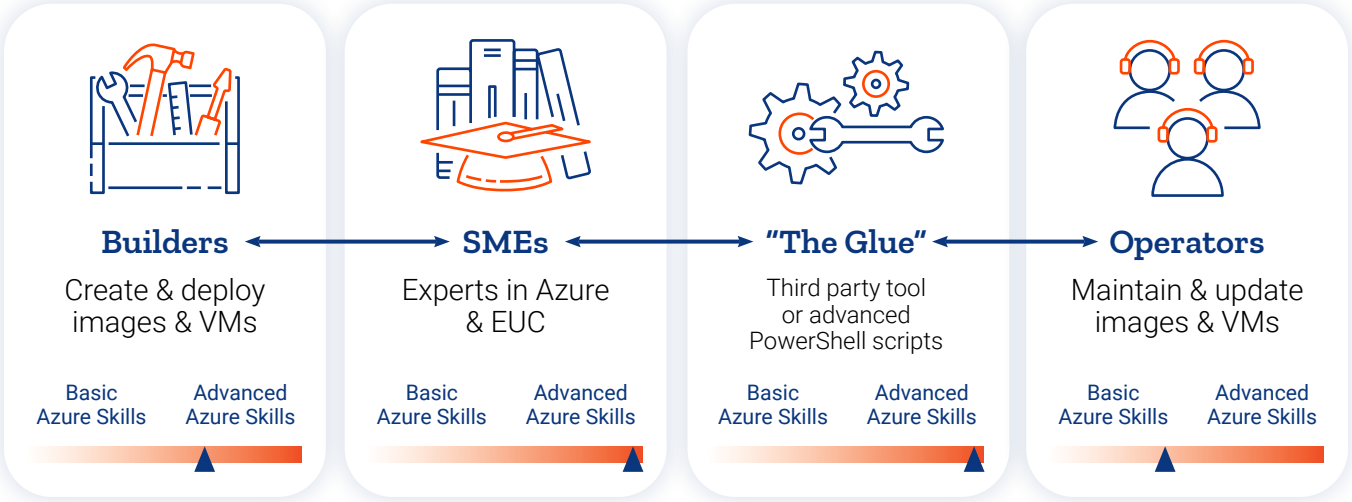
Microsoft AVD AWS Solutions

Figure 7: AWS and Microsoft Key Roles and Functions

AWS Solutions



Microsoft AVD



Following the complexity theme, you must also consider the number of pieces of technology that each role must manage, monitor, and support. The time commitment of your resources and the time to restore service in the event of an outage are directly proportional to the number of "plates" that your resources must spin when administering your environment. In an AWS environment, your builders and operators are only responsible for image and fleet management. All the "behind-the-scenes" pieces like the EC2 instances, backups, and autoscaling scripts are managed for you by AWS, sight-unseen. On the contrary, in a AVD environment, your resources are spinning many plates as they must directly manage infrastructure and functions such as Azure VMs, backups, Azure Automation scripts, images, and storage accounts. With the virtual machines being maintained by your Operations Team, you must also consider configuration drift. In a pooled desktop situation, users have the ability to make configuration changes to virtual machines and if there is not a process or tool in place to ensure these changes are made to all VMs, one machine could be different than another. This can directly impact the end user experience if they are accessing sessions on different hosts with inconsistent configurations when logging in at various times.

Services' Operations

AMAZON WEB SERVICES

Continuing with the theme of simplicity and a turnkey product, the operations of both AWS EUC solutions are straightforward and focus more on delivering a positive user experience than managing underlying infrastructure. The Cloud Team will need to have little involvement after the initial networking configuration and the Desktop or EUC Team will require minimal AWS skills to manage and maintain the WorkSpaces and/or AppStream 2.0 environment, thus freeing them up to focus on improving the user experience and responding to business needs.

WorkSpaces

When it comes to Amazon WorkSpaces, many of the day to day operations that are required in an on-premises VDI or AVD environment are managed for you by AWS. By default, Amazon WorkSpaces enables maintenance windows. These maintenance windows are configurable on an AlwaysOn WorkSpace, but not configurable for AutoStop WorkSpaces. It is possible, though not recommended, to opt out of the service default maintenance windows for Windows WorkSpaces. Your Amazon WorkSpaces are configured to install software updates automatically at 2AM each Sunday by default. You will also have full control over the Windows Update configuration and can use Active Directory Group Policy to configure this to meet your company's requirements. Tags can be used as they are with any other AWS resource to group Amazon WorkSpaces for operational or pricing needs.

The main task of your Desktop or EUC Team for WorkSpaces will be to provision them. You can decide on an image creation methodology that will reduce image sprawl as much as possible. Some examples may be to create images that contain required applications for specific business units or grouped by resource demands, especially for graphics intensive applications. The Operations team will be able to create

images and bundles that fit each use case and the provisioning of WorkSpaces can be done via the console, CLI or automated by leveraging the **SynchroNet CLICK solution** detailed in the Third-Party Tools section of this whitepaper. AWS also provides you with the ability to customize how your users log in to their WorkSpace. You can restrict web access if desired and can also leverage uniform resource identifies to provide a simplified login experience that integrates with other workflows in your organization. For example, you can automatically generate URIs that register your users by using their WorkSpaces registration code which will bypass the manual registration process. Additionally, Amazon offers a service called Amazon WorkSpaces Application Manager (WAM), which is a fast, flexible and secure way of deploying and managing your WorkSpaces applications. This service accelerates software deployment, upgrades, patching and retirement by packaging Microsoft Windows desktop applications into virtualized containers. The applications still run on the end user's WorkSpace as though they are natively installed.

Beyond provisioning, the other main operational tasks will be to restart, rebuild, restore, and delete WorkSpaces, and to change resource allocation. This can all be done via the AWS console or via self-service. Once self-service management is enabled, a user is empowered to perform these day-to-day tasks on their own without the intervention of an IT admin or helpdesk agent. A restart of a WorkSpace is the same as a regular OS reboot whereas a rebuild will retain the user volume but then return the WorkSpace to its original state. A restore of a WorkSpace will retain the root and user volumes then return the WorkSpace to the last healthy state detected by the service. WorkSpaces get automatically backed up every 12 hours, eliminating the need for a complex backup solution to be created and managed. There are also monitoring metrics available through CloudWatch and CloudTrail.

Overall, Amazon WorkSpaces require little effort when it comes to the steady state operation. Most commons issues can be resolved via a self-service reboot or rebuild. The Amazon Workspaces client applications for Windows and macOS support USB and Bluetooth keyboards, mice, USB audio headsets, and USB printers by default with no additional administration needed. The underlying EC2 instances are owned and maintained by AWS and your Desktop, EUC, and Cloud Teams are left to focus on optimizing and automating the end user experience and other tasks like application installs and image creation.

AppStream 2.0

With Amazon AppStream 2.0, the main operational tasks will be image creation and updates with image builders and fine-tuning your fleet auto scaling and timeout settings. Images are created by launching an image builder and installing and configuring your applications. This can be done via the GUI or CLI. You can customize the maximum session duration time, disconnection timeout, idle disconnect timeout, and scaling policies. The scaling policies let you dictate minimum and maximum capacity and scale out or in based on capacity utilization. With this scaling be automated, there is little maintenance required ongoing other than monitoring and tweaking your policies as needs arise. All these customizations allow you to control costs and user experience. It will be your responsibility to keep your images up to date, including Windows updates, but this can be scripted using the Image Assistant CLI operations. USB devices can be used with AppStream by leveraging the AppStream client for access, connecting and configuring the USB device with the Image Builder, creating an image, and a user sharing the device with their session. The only other item that will need to be managed will be your user pools or directory configuration to control access to applications.

Due to the non-persistent nature of AppStream 2.0 and the instances themselves being owned and managed by AWS, the day to day tasks in an AppStream environment are very limited. This allows you to have your Desktop or EUC Team focus on optimizing the user experience and require little AWS knowledge. There is not a need to have a large operations team as the solution is delivered as a SaaS model with much of the steady state support being managed for you or able to be automated in some fashion.

AZURE VIRTUAL DESKTOP

The themes of complexity and high demand of your IT teams continue into the operations of Microsoft's Azure Virtual Desktop solution. There are more technical components to master which can be a benefit to a company that has that Azure expertise and wants that level of control, but can be a blocker to adoption for organizations that do not have the appropriate resources or desire a cloud solution that demands less focus on the underlying infrastructure than your stand on-premises environment. The operations of a AVD environment will require your Cloud Team's technical Azure skills to maintain the underlying infrastructure and your Desktop or EUC Team skills to manage the application delivery and user experience. It is a significant resource investment to keep the lights on due to the complex nature of the solution's pieces, parts, and the skills required to do so.

In a AVD environment, the virtual machines that host the desktops exist in the customer's VNet and must then be managed just like any other virtual machine in an Azure environment. You will create host pools which are a collection of one or more identical VMs within your environment. It will be your responsibility to configure the VM, define domain and network properties, then set host pool properties. The VM configuration will require you to select a resource group, choose a VM location and size, provide the number of VMs and a name prefix, then choose an image. Next, you will have to choose what kind of OS disks you want, select the virtual network and subnet, apply networking configurations, then define the domain join parameters. The host pool setup process creates a desktop application group by default and for the host pool to work as intended, you must also publish this app group to users or user groups and register the app group to a workspace. Once all this work is complete, a download link for an

Azure Resource Management template is created based on your configuration. You will need to run this Azure Resource Manager template to provision a new host pool. With all these steps and the detailed configuration parameters for each, resources with strong Azure skills will be required for provisioning.

When provisioning desktops, you will need to take in to account many factors, such as peak and off-peak concurrency, work hours, pooled versus personal, and sizing. You will also need to configure RDP properties to control any device redirection and use USB devices. Azure Virtual Desktop controls which session host a user will connect to via one of two load balancing methods. The choice of which one will be your decision. Breadth-first load balancing will allow you to evenly distribute user sessions across all hosts in the pool. Depth-first load balancing allows you to saturate one session host at a time. This method can be preferred for cost conscious companies but will require an Azure expert to leverage Azure Automation to create dynamic scaling. This feature is not available in a streamlined out-of-the-box manner like it is for Amazon AppStream 2.0.

Once you have a host pool, there will be additional day to day tasks required of you to keep the environment healthy. It is your responsibility to performance administrative tasks such as maintaining and patching the OS and performing backups. When leveraging the Personal Desktop for a persistent experience, you will need to leverage the Azure Backup and Site Recovery service via the Azure Portal or PowerShell to create a backup schedule. There is no out-of-the-box automated backup solution in place. It is also recommended to use FSLogix for user profiles, which will require expertise with that technology.

In summary, Microsoft's Azure Virtual Desktop provides granular control of the virtual machine environment that creates your host pools. This can be advantageous to Azure savvy operations teams who want to have fine grained control of their environment. However, if you do not have the technical expertise or do not want to dedicate resources to basic day to day administrative tasks like you do in an on-premises environment, you may find yourself in a "biting off more than you can chew" predicament quickly into your AVD journey.

Third-Party Tools

There is an array of third-party tools and services that advertise ways to enhance your EUC experience. This section will review the major third-party players for each solution. When deciding on an EUC platform, you will want to understand the benefits a third-party tool provide, the costs of said benefits, and if these benefits and costs are worthwhile for a full cloud solution in comparison to your on-premises EUC environment.

SynchroNet CLICK

SynchroNet CLICK is a User Automation Platform for that leverages the power of serverless technology to automate user, workspace, and application life cycles. CLICK currently supports Amazon WorkSpaces with AppStream 2.0 being on the roadmap. It integrates with Microsoft Active Directory to use existing user administration workflows to ensure that WorkSpaces are provisioned and deprovisioned accurately and uniformly as users join, transfer, and leave your organization. This provides for a more "set it and forget it" administration which reduces the amount of time and resources required, and provides a security benefit of users only having access to the WorkSpace that is meant for their role and that their WorkSpace gets terminated when they are removed from the AD group. CLICK also provides a self-service portal for end users to be able to view status, start, stop, reboot, and resend registration emails. This self-service feature greatly reduces the number of basic support tickets that get submitted by end users. Service desk staff can also leverage CLICK to perform these actions if an organization sees this as a better fit. This strategy empowers the service desk and reduces the number of support tickets that must be escalated to your Cloud and/or Desktop Teams. Lastly, CLICK provides a Cost Optimization Dashboard that displays information to help you understand the spend based on market price and utilization of your WorkSpaces fleet, and to act on cost optimization recommendations. Overall, CLICK offers many valuable capabilities on top of the standard Amazon WorkSpaces service. It is an easy to deploy SaaS solution, is available directly through the AWS Marketplace, greatly enhances the value proposition of the WorkSpaces solution, and comes at a low, fixed price with no minimum. You can view the prices in the image below. These are the true costs of the solution, and given the maturity of the SaaS solution, there are no hidden infrastructure costs.

Figure 9: SynchroNet CLICK Pricing

SynchroNet CLICK

Below are the total costs for these different subscription durations. Additional taxes or fees may apply.

Units	Description	1 Month	12 Months
10 User Plan	$3.00/user/month	$30	$360
500 User Plan	$2.50/user/month	$1,250	$15,000
5,000 User Plan	$1.50/user/month	$7,500	$90,000
10,000 User Plan	$1.00/user/month	$10,000	$120,000

Additional usage fees

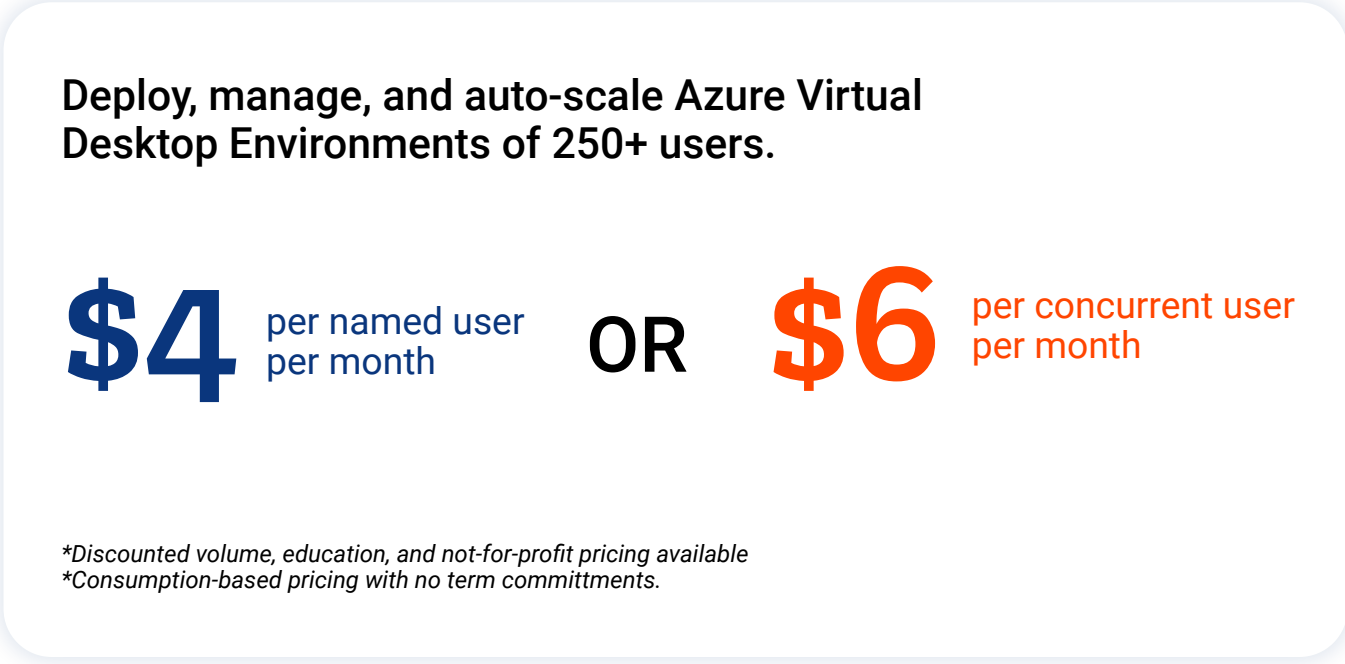
Description	Fees
$3.00/user/month (Overage for 10 User Plan)	$3/unit
$2.50/user/month (Overage for 500 User Plan)	$2.5/unit
$1.50/user/month (Overage for 5,000 User Plan)	$1.5/unit
$1.00/user/month (Overage for 10,000 User Plan)	$1/unit

You will be billed monthly for additional usage costs if your usage exceeds your contract. Your additional usage costs will be determined by the number of units you use above your contract.

Nerdio

Nerdio Manager for AVD is a third-party tool that addresses many of the technical and security requirements of an Enterprise customer and is used to automate and manage large AVD environments. The focus on the large enterprise is important to note with Nerdio and is also reflected in their pricing model. If you are an enterprise of 250 or more users, the capabilities that Nerdio adds to AVD may be worth the spend, but if you are a smaller shop, you likely do not have a good use case for their solution, and thus taxing further what is assumed to be a smaller IT team. Nerdio Manager for AVD is an all-PaaS Azure application, which means that you will have Azure infrastructure, such as a SQL Database and App Service Plan, that you must deploy, maintain, and pay for. Once deployed, Nerdio can help with unified image creation and management, autoscaling, monitoring, cost calculations, and other administration tasks that typically require Azure portal interaction. Nerdio provides Dynamic Host Pools which allows for scaling your pooled desktops in and out based on utilization. Without Nerdio, you must use Azure Automation and have PowerShell knowledge to accomplish this capability in Azure. When it comes to cost management, Nerdio will provide a cost calculator to predict costs based on usage but will not pull in actual costs like CLICK to be able to provide cost optimization opportunities. A common theme among users, which can be echoed on Nerdio's blog post: **Full Disclosure: Nerdio Manager for AVD Costs and Licensing**, is that Nerdio is required to make AVD enterprise ready. This blog post also represents the true costs running Nerdio in your environment. You will see that you can pay per-named user or per-concurrent user, but there is a monthly minimum of $1,000/month, which equates to around 250 users. Overall, Nerdio provides a user-friendly console that can automate some of the more difficult AVD actions, but it also has its own limitations, comes at a high cost, and is geared to the enterprise customer.

Figure 10: Nerdio Manager for AVD Pricing



Citrix/VMware

Azure Virtual Desktop allows for partner integrations like Citrix and VMware Horizon Cloud on Microsoft Azure. **Citrix** extends the value of AVD by providing enterprise tools that can improve user density and performance, automate provisioning, and simplify management activities. **VMware Horizon Cloud on Microsoft Azure** is a cloud service that enables your organization to deploy AVD desktops and applications while still leveraging all the features of VMware Horizon. If you are an existing Citrix or VMware customer, this may be an appealing point, but it also means that you are adding these solutions on top of your AVD environment, so you're still maintaining the infrastructure and complexity, but you are out of the on-premises hardware business. You will still be responsible for owning and managing your legacy Citrix and/or VMware solutions and relationships, so unless you are under severe hardware investment pressure, at a refresh point, or have the need to reduce data center space, going this route adds complexity on top of complexity.

Conclusion

Throughout this whitepaper we have explored the architectural, cost, and operational factors that contribute to a cloud EUC solution decision. We have dove into the components and features of Amazon's WorkSpaces and AppStream 2.0 and Microsoft's Azure Virtual Desktop. While each of these solutions offer benefits and fit in to unique use cases, ***it is the expert opinion of SynchroNet that AWS is able to offer a more robust and turnkey solution that can provide the key benefits that organizations have come to know and love of cloud solutions.*** Amazon WorkSpaces are an excellent choice for a company that wants to provide a persistent desktop experience to their users and AppStream 2.0 offers just as complete of a solution in a non-persistent fashion. Both services require little Cloud Team involvement or AWS expertise beyond the initial networking configuration. Your Desktop or EUC Team will be able to implement and maintain these solutions with little training and will see a return on investment in actual cost savings and resource availability for focus on business-driven needs as compared to an on-premises environment. Azure Virtual Desktop may be the solution of choice for the tech savvy company with a niche use case and/or the expendable resources to design, price, implement, and support the environment like they do in an on-premises environment. Amazon's solutions were first into the market and have matured into production-ready solutions. Microsoft is new to the market and releasing new features often, but still has a way to go before maturing into a full-fledged product that can be on par with its AWS competitor.

Authors

SynchroNet

SynchroNet is recognized as the global leader of End User Computing on AWS.

Kristen Hagedorn is a seasoned enterprise infrastructure and cloud technologist. With five years of experience in the virtualization, infrastructure, and cloud space at Aon, Kristen then spent the next two years as the lead cloud engineer on HUB International's transformational journey to AWS. This experience led her to be the Manager of Infrastructure and Cloud Engineering at HUB International before transitioning to SynchroNet where she is currently a Technology Strategist. Kristen is an enterprise-level thought leader in cloud and end user technologies with a keen ability to strategize at the 30,000-foot view as well as contribute technically at the 5-foot view.

Ron Thomas is an experienced professional integrations consultant and technologist with over 30 years' focus on virtualization technologies and user experience solutions. Working across the Energy, Financial Services, Manufacturing and Technology industries, Ron has consolidated application and data management with redundancy, consistency, and recovery models to improve the daily user experience. He has repeatedly delivered improved ROI in the EUC space and contributed to improving business results across mid-size businesses, large enterprises, and government organizations. Currently, Ron is a Technology Strategist with SynchroNet and is an industry leader in end user compute technologies.

Note: This whitepaper was written with significant consultation from a Microsoft and Azure expert who has experience with multiple enterprise level AVD deployments.

Revision History

Version Number	Date	Comments
Version 1.0	November 5, 2020	Original publication

Appendix A - Cost Data

A-1: Amazon WorkSpaces Pricing Table

*Costs based on US East (N. Virginia) region and Windows Options. Other regions and Linux prices can be viewed **here.***

Type	Root Volume	User Volume	License Included Monthly Pricing	License Included Hourly Pricing	BYOL Monthly Pricing	BYOL Hourly Pricing
Value 1 vCPU, 2GB Mem	80 GB	10 GB	$25.00	$7.25/month + $0.22/hour	$21.00	$7.25/month + $0.17/hour
Value 1 vCPU, 2GB Mem	80 GB	50 GB	$28.00	$9.75/month + $0.22/hour	$24.00	$9.75/month + $0.17/hour
Value 1 vCPU, 2GB Mem	80 GB	100 GB	$31.00	$13.00/month + $0.22/hour	$27.00	$13.00/month + $0.17/hour
Value 1 vCPU, 2GB Mem	175 GB	100 GB	$36.00	$19.00/month + $0.22/hour	$32.00	$19.00/month + $0.17/hour
Standard 2 vCPU, 4GB Mem	80 GB	10 GB	$33.00	$7.25/month + $0.30/hour	$29.00	$7.25/month + $0.26/hour
Standard 2 vCPU, 4GB Mem	80 GB	50 GB	$35.00	$9.75/month + $0.30/hour	$31.00	$9.75/month + $0.26/hour
Standard 2 vCPU, 4GB Mem	80 GB	100 GB	$38.00	$13.00/month + $0.30/hour	$34.00	$13.00/month + $0.26/hour
Standard 2 vCPU, 4GB Mem	175 GB	100 GB	$44.00	$19.00/month + $0.30/hour	$40.00	$19.00/month + $0.26/hour
Performance 2 vCPU, 8GB Mem	80 GB	10 GB	$45.00	$7.25/month + $0.47/hour	$41.00	$7.25/month + $0.43/hour
Performance 2 vCPU, 8GB Mem	80 GB	50 GB	$47.00	$9.75/month + $0.47/hour	$43.00	$9.75/month + $0.43/hour
Performance 2 vCPU, 8GB Mem	80 GB	100 GB	$50.00	$13.00/month + $0.47/hour	$46.00	$13.00/month + $0.43/hour
Performance 2 vCPU, 8GB Mem	175 GB	100 GB	$56.00	$19.00/month + $0.47/hour	$52.00	$19.00/month + $0.43/hour
Power 4 vCPU, 16GB Mem	80 GB	10 GB	$70.00	$7.25/month + $0.68/hour	$66.00	$7.25/month + $0.64/hour
Power 4 vCPU, 16GB Mem	80 GB	50 GB	$72.00	$9.75/month + $0.68/hour	$68.00	$9.75/month + $0.64/hour
Power 4 vCPU, 16GB Mem	80 GB	100 GB	$74.00	$13.00month + $0.68/hour	$70.00	$13.00/month + $0.64/hour
Power 4 vCPU, 16GB Mem	175 GB	100 GB	$78.00	$19.00month + $0.68/hour	$74.00	$19.00/month + $0.64/hour
PowerPro 8 vCPU, 32GB Mem	80 GB	10 GB	$127.00	$7.25month + $1.53/hour	$123.00	$7.25/month + $1.49/hour
PowerPro 8 vCPU, 32GB Mem	80 GB	50 GB	$130.00	$9.75month + $1.53/hour	$126.00	$9.75/month + $1.49/hour

PowerPro 8 vCPU, 32GB Mem	80 GB	100 GB	$134.00	$13.00/month + $1.53/hour	$130.00	$13.00/month + $1.49/hour
PowerPro 8 vCPU, 32GB Mem	175 GB	100 GB	$140.00	$19.00/month + $1.53/hour	$136.00	$19.00/month + $1.49/hour
Graphics 8 vCPU, 15GiB Mem, 1GPU, 4GiB Video Mem	100 GB	100 GB	$735.00	$22.00/month + $1.75/hour	$731.00	N/A
GraphicsPro 16 vCPU, 122GiB Mem, 1GPU, 8GiB Video Mem	100 GB	100 GB	$999.00	$66.00/month + $11.62/hour	$995.00	$66.00/month + $11.57/hour

Default Application Bundle
- Apps: Utilities (Internet Explorer 11, Firefox)
- No additional Charge

Plus Applications Bundle – License Included WorkSpaces Only
- Apps: Microsoft Office Professional, Trend Micro Worry-Free Business Security Services, Utilities (Internet Explorer 11, Firefox)
- Additional $15.00/month

Microsoft Office for BYOL WorkSpaces Bundle – BYOL WorkSpaces Only
- Apps: Microsoft Office Professional
- Additional $14.75/month

A-2: Amazon AppStream 2.0 Pricing Table

*Costs based on US East (N. Virginia) region and Windows Options. Other regions and Linux prices can be viewed **here.***

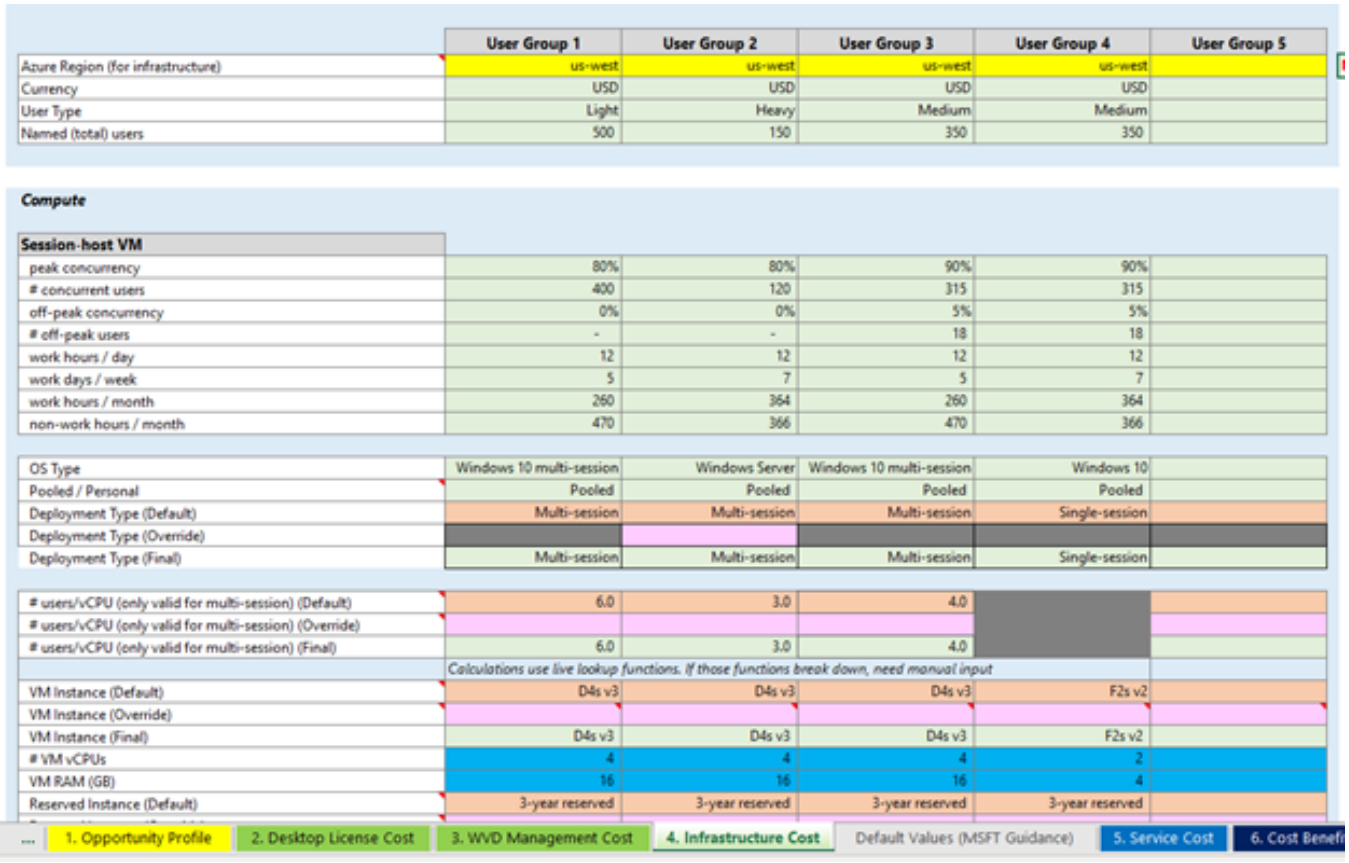
Type	vCPU	Memory (GiB)	GPU Memory (GiB)	Hourly Pricing
General Purpose stream.standard.medium	2	4	N/A	$0.10
General Purpose stream.standard.large	2	8	N/A	$0.20
Compute Optimized stream.compute.large	2	3.75	N/A	$0.25
Compute Optimized stream.compute.xlarge	4	7.5	N/A	$0.50
Compute Optimized stream.compute.2xlarge	8	15	N/A	$1.00
Compute Optimized stream.compute.4xlarge	16	30	N/A	$2.00
Compute Optimized stream.compute.8xlarge	32	60	N/A	$4.00
Memory Optimized stream.memory.large	2	15.3	N/A	$0.25
Memory Optimized stream.memory.xlarge	4	30.5	N/A	$0.50
Memory Optimized stream.memory.2xlarge	8	61	N/A	$1.00
Memory Optimized stream.memory.4xlarge	16	122	N/A	$2.00
Memory Optimized stream.memory.8xlarge	32	244	N/A	$4.00
Memory Optimized stream.memory.z1d.large	2	16	N/A	$0.45
Memory Optimized stream.memory.z1d.xlarge	4	32	N/A	$0.90
Memory Optimized stream.memory.z1d.2xlarge	8	64	N/A	$1.80
Memory Optimized stream.memory.z1d.3xlarge	12	96	N/A	$2.70
Memory Optimized stream.memory.z1d.6xlarge	24	192	N/A	$5.40
Memory Optimized stream.memory.z1d.12xlarge	48	384	N/A	$10.80
Graphics G4 stream.graphics.g4dn.xlarge	4	16	16	$1.00
Graphics G4 stream.graphics.g4dn.2xlarge	8	32	16	$1.58
Graphics G4 stream.graphics.g4dn.4xlarge	16	64	16	$2.73

Graphics G4 stream.graphics.g4dn.8xlarge	32	128	16	$5.14
Graphics G4 stream.graphics.g4dn.12xlarge	48	192	16	$8.62
Graphics G4 stream.graphics.g4dn.16xlarge	64	256	16	$10.28
Graphics Design stream.graphics-design.large	2	7.5	1	$0.25
Graphics Design stream.graphics-design.xlarge	4	15.3	2	$0.50
Graphics Design stream.graphics-design.2xlarge	8	30.5	4	$1.00
Graphics Design stream.graphics-design.4xlarge	16	61	8	$2.00
Graphics Pro stream.graphics-pro.4xlarge	16	122	8	$2.05
Graphics Pro stream.graphics-pro.8xlarge	32	244	16	$4.10
Graphics Pro stream.graphics-pro.16xlarge	64	488	32	$8.20

On-Demand Stopped Instance Fee

- All Instance Types: $0.025/hour

Figure 6: AVD Solution Configurator



	User Group 1	User Group 2	User Group 3	User Group 4	User Group 5
Azure Region (for infrastructure)	us-west	us-west	us-west	us-west	
Currency	USD	USD	USD	USD	
User Type	Light	Heavy	Medium	Medium	
Named (total) users	500	150	350	350	

Compute

Session-host VM					
peak concurrency	80%	80%	90%	90%	
# concurrent users	400	120	315	315	
off-peak concurrency	0%	0%	5%	5%	
# off-peak users	-	-	18	18	
work hours / day	12	12	12	12	
work days / week	5	7	5	7	
work hours / month	260	364	260	364	
non-work hours / month	470	366	470	366	

OS Type	Windows 10 multi-session	Windows Server	Windows 10 multi-session	Windows 10	
Pooled / Personal	Pooled	Pooled	Pooled	Pooled	
Deployment Type (Default)	Multi-session	Multi-session	Multi-session	Single-session	
Deployment Type (Override)					
Deployment Type (Final)	Multi-session	Multi-session	Multi-session	Single-session	
# users/vCPU (only valid for multi-session) (Default)	6.0	3.0	4.0		
# users/vCPU (only valid for multi-session) (Override)					
# users/vCPU (only valid for multi-session) (Final)	6.0	3.0	4.0		
	Calculations use live lookup functions. If those functions break down, need manual input				
VM Instance (Default)	D4s v3	D4s v3	D4s v3	F2s v2	
VM Instance (Override)					
VM Instance (Final)	D4s v3	D4s v3	D4s v3	F2s v2	
# VM vCPUs	4	4	4	2	
VM RAM (GB)	16	16	16	4	
Reserved Instance (Default)	3-year reserved	3-year reserved	3-year reserved	3-year reserved	

... 1. Opportunity Profile | 2. Desktop License Cost | 3. WVD Management Cost | 4. Infrastructure Cost | Default Values (MSFT Guidance) | 5. Service Cost | 6. Cost Benefi

Source: https://www.microsoft.com/en-us/us-partner-blog/2020/04/07/is-your-customer-right-for-AVD-take-these-4-steps-to-price-an-offer-and-decide/