Team “Hello World” 10/09/2020
Team Lead: Matthew Caponi

Matthew Caponi - 011161928
Shaan Shariff - 015741750
Wonsuk Seo - 018660874
Ian Macabulos - 016401240
Nkechidindu Okorie - 015340349
Jakub Koziol - 016523856

Request for Approval

Video Streaming Server

Business Need

One of the core features of VCQC Connect is live video streaming coming from VCQC On the Go. We need a way to find a way to broadcast the video from VCQC On the Go to VCQC Connect. The way that this will need to be done is through a local server on the host machine of VCQC On the Go that broadcasts the video to a remote web server that is then accessed by VCQC Connect. Therefore, we must assess which web server is best suited to live-streaming video so that we can request 3rd party approval for that technology, if it differs from the technology already available in our 1st party stack.

The Options

Almost all web servers have video streaming capabilities. The most popular web servers are Microsoft IIS, NGINX, and Apache HTTP Server.

Microsoft IIS[1]
Microsoft IIS is a web server created by Microsoft that is available on Windows computers and integrated with the .NET and .NET Core frameworks.

NGINX[2]
NGINX is an open source web server that excels at high-volume traffic and is commonly used as a load balancer and reverse proxy, as well as a standard web server.

Apache HTTP Server[3]
Apache HTTP Server is an open source web server that is commonly packaged with Linux distributions.

---

[1] https://www.iis.net/
[2] https://www.nginx.com/
[3] https://httpd.apache.org/

License

Microsoft IIS requires a Microsoft license for the Windows server or operating system that IIS is deployed on.

NGINX is open source and licensed under the FreeBSD License, which, among other things, permits NGINX to be used in closed-source, commercial products, free of charge.[4] [5]

Apache HTTP Server is licensed under the Apache License 2.0, which among other things, gives permission for Apache HTTP Server to be used in commercial products, free of charge.[6]

Comparisons

Operating System			
	Windows	**macOS**	**Linux**
IIS[7]	X		
NGINX[8]	X	X	X
Apache[9]	X	X	X

Verdict
NGINX and Apache both have cross-platform support.

Native Video Streaming Module or Extension	
IIS[10]	IIS Live Smooth

[4] Nginx/nginx. (2019, January 28). Retrieved September 20, 2020, from https://github.com/nginx/nginx/blob/master/docs/text/LICENSE

[5] The 2-Clause BSD License. (n.d.). Retrieved September 20, 2020, from https://opensource.org/licenses/BSD-2-Clause

[6] https://groups.google.com/g/alt.apache.configuration/c/042hhGcLWUs/m/rDJdt5b927cJ?pli=1
[7] https://www.dnsstuff.com/windows-iis-server-tools
[8] https://nginx.org/en/#tested_os_and_platforms
[9] https://httpd.apache.org/docs/2.4/install.html

	Streaming
NGINX[11]	ngx_http_hls_ module
Apache	No native support, plugin needed

Verdict
Both IIS and NGINX have live-streaming extensions/modules, while Apache requires a third party plug in.

Supported Video Format		
	MP4	**FLV**
IIS[12]	X	
NGINX[13]	X	X
Apache	n/a	n/a

Verdict
NGINX has greater video format support.

Media Streaming Protocol			
	HTTP	**HLS**	**RTMP**
IIS[14]	X	X	
NGINX[15]	X	X	X
Apache[16]	Through plugin	Through plugin	N/A

Verdict

---

[10] https://docs.microsoft.com/en-us/iis/media/live-smooth-streaming/getting-started-with-iis-live-smooth-streaming
[11] http://nginx.org/en/docs/http/ngx_http_hls_module.html
[12] https://docs.microsoft.com/en-us/iis/media/iis-media-services/iis-media-services-readme
[13] https://www.nginx.com/products/nginx/streaming-media/#:~:text=The%20HLS%2FVOD%20module%20in,m4v%2C%20and%20.
[14] https://docs.microsoft.com/en-us/iis/media/live-smooth-streaming/getting-started-with-iis-live-smooth-streaming
[15] https://www.nginx.com/products/nginx/modules/rtmp-media-streaming/
[16] https://docs.unified-streaming.com/introduction/index.html

NGINX has greater media streaming protocol support.

Integration with ASP.NET Core	Native Integration	Compatible
IIS[17]	X	X
NGINX[18]		X
Apache[19]		X

Verdict
IIS is the only web server to have native integration with ASP.NET Core, however, configuration on the other web servers is relatively simple.

Pros and Cons

Microsoft IIS

Pros

- Integration with ASP.Net Core

Cons

- Can only run on Windows.
- Lacks RTMP.
- Only supports .mp4
- Smooth-streaming client recommended for use by Microsoft IIS Smooth Streaming, Microsoft Silverlight, loses support in October 2021.[20]

NGINX

Pros

- Cross-platform
- MP4 and FLV
- RTMP support

Cons

- No native integration with ASP.NET Core

Apache HTTP Server

Pros

- Cross-platform

Cons

---

[17] https://docs.microsoft.com/en-us/aspnet/core/tutorials/publish-to-iis?view=aspnetcore-3.1&tabs=visual-studio

[18] https://docs.microsoft.com/en-us/aspnet/core/host-and-deploy/linux-nginx?view=aspnetcore-3.1

[19] https://docs.microsoft.com/en-us/aspnet/core/host-and-deploy/linux-apache?view=aspnetcore-3.1

[20] https://support.microsoft.com/en-us/windows/silverlight-end-of-support-0a3be3c7-bead-e203-2dfd-74f0a64f1788

- No native integration with ASP.NET Core
- No native live-streaming modules or extensions.

Discussion

Both Microsoft IIS and NGINX have native live-video streaming modules/extensions. Live-video streaming is possible with Apache through plug-ins, however, lack of native support reduces the attractiveness of Apache for this need. Microsoft IIS has native integration with ASP.NET Core, however, setting up NGINX and Apache with ASP.NET Core is very simple. NGINX is also the only server which supports RTMP, however, HLS will be preferable anyways since it works with HTML5 video players. Between IIS and NGINX, only NGINX is cross platform. IIS also has a major issue, which is that the smooth-streaming client it requires will be losing support in October 2021.

Verdict

NGINX
NGINX is the best of all worlds. It is cross platform, has a variety of options to choose from when it comes to streaming protocols, and will continue to have support. The only con of NGINX is that it does not have native integration with ASP.NET Core. This won't make much of a difference though because the configuration for ASP.NET Core is very easy with NGINX. The clear choice for our live-streaming server is NGINX.

Embedded Video Player

Business Need

One of the primary features of VCQC Connect is the live-video streaming, which enables Connect to monitor the activities of the quadcopter. To enable this feature, we will need to have an embedded video player, from which the video will be played from. There are dozens of options, however, we will be assessing three options in particular that are free, open source, and high quality.

The Options

JPlayer[21]
JPlayer is a jQuery plug-in that enables HTML5 and Flash web video.

Video.js[22]

[21] https://jplayer.org/
[22] http://www2.videojs.com/

Video.js is a javascript library that enables HTML5 web video.

Plyr[23]
Plyr is an HTML5 video player that utilizes javascript and css.

License

JPlayer[24]
JPlayer is licensed under the MIT license, which allows, among other things, for web apps using JPlayer to be used for commercial purposes.

Video.js
Video.js is licensed under the Apache License 2.0, which, among other things, gives permission for Video.js to be used in commercial products, free of charge.[25] [26]

Plyr[27]
Plyr is licensed under the MIT license, which allows, among other things, for web apps using Plyr to be used for commercial purposes.

Comparisons

Pricing	
JPlayer	Free
Video.js	Free
Plyr	Free

Verdict
All players are free.

Supported Browser					

[23] https://github.com/sampotts/plyr
[24] https://www.jplayer.org/about/#:~:text=Developed%20by%20Happyworm%2C%20jPlayer%20is,made%20real%20by%20Mark%20Panaghiston.
[25] Videojs/video.js. (2015, March 28). Retrieved September 20, 2020, from https://github.com/videojs/video.js/blob/master/LICENSE

[26] APACHE LICENSE, VERSION 2.0. (2004, January). Retrieved September 20, 2020, from http://www.apache.org/licenses/LICENSE-2.0

[27] https://github.com/sampotts/plyr/blob/master/LICENSE.md

	Chrome	Firefox	Internet Explorer	Safari	Opera
JPlayer	X	X	X	X	X
Video.js	X	X	X	X	X
Plyr	X	X	X	X	X

Verdict
All players work on all modern browsers.

Streaming Formats Supported		
	HLS	**RTMP**
JPlayer[28] [29]	X	X
Video.js[30]	X	Requires flash package
Plyr	X	

Verdict
Only JPlayer has native support for HLS and RTMP.

HTML5 vs Flash		
	HTML5	**Flash**
JPlayer[31]	X	X
Video.js	X	Package
Plyr	X	Plugin

Verdict
Only JPlayer has native support for HTML5 and Flash.

Media Formats								
	mp4	mp3	flv	flac	oga	acc	ogg	Wav
JPlayer	X	X	X	X	X	X		X

[28] https://jplayer.org/latest/developer-guide/
[29] https://www.streamingmedia.com/Articles/ReadArticle.aspx?ArticleID=94188&pageNum=2
[30] https://docs.videojs.com/tutorial-faq.html
[31]

Video.js[32]	X	X				X		
Plyr	X	X					X	

Verdict
Jplayer supports the most media format options.

Supported languages				
	HTML	**CSS**	**Javascript**	**Jquery**
JPlayer	X	X	X	X
Video.js	X	X	X	
Plyr	X	X	X	

Verdict
JPlayer has integrated use of JQuery.

Customization
All three allow customization of skins through html and css. Video.js in particular has more extensive customizability options.[33]

All three also allow customization of video player itself, although Video.js has more options in this regard.

Video.js has an extensive library of customization plugins.[34]

Verdict
Video.js has better customization options for the skins and the player.

Documentation
All three have sufficient documentation, but the documentation under Video.JS is more comprehensive.[35]

Verdict
Video.js has more extensive documentation.

[32] https://docs.videojs.com/tutorial-troubleshooting.html
[33] https://docs.videojs.com/#customizing
[34] https://videojs.com/plugins
[35] https://docs.videojs.com/

Pros and Cons

JPlayer

Pros

- Supports JQuery
- Native Flash support
- Native RTMP support

Cons

- Browsers without html5 compatibility cannot view the player in full screen.

Video.js

Pros

- Much more customizable skins
- Extensive library of plugins
- The most extensive documentation

Cons

- Required package for Flash and RTMP support.

Plyr

Pros

- Simple

Cons

- No RTMP support
- Requires plugin for flash support
- Less customization options
- Least documentation of the three

Discussion

All three players are very similar. JPlayer's native support of Flash and RTMP is a plus. It's also a plus that it is integrated with JQuery. Video.js on the other hand has much better customization options and documentation. Plyr seems to be the worst of both worlds, requiring plugins for flash, not as extensive customization, and lesser documentation.

Verdict

Video.js

Video.js seems to be a good middle ground and versatile option between the three. Great customization, compatibility with Flash and RTMP through a plugin, and extensive documentation, make it the best option for our team.

Cloud Computing Service

Business Need

Multiple members of our team will be working on the web application, VCQC Connect. There are many different components to the web application such as servers, databases, and various APIs, as well as our various microservices. This can easily get messy when it comes to collaborating on it with other team members. Having a Cloud Computing service will help make this process easier and more efficient by having a central location that our team can access. We plan on doing some of the development locally on our respective computers, and then push different components of the application to the cloud to a single master location. Having the application in a singular location will also make it much easier to conduct maintenance and updates. Finally, we will eventually need to host our website remotely, and Azure has great services to enable this.

The Options

Azure

- Microsoft's cloud computing service.

AWS

- Amazon's cloud computing service.

Google Cloud

- Google's cloud computing service.

License

Free Account

All three services offer free trial accounts for a duration of 12 months. These free accounts offer selected services for free, for a specified duration. The selected services all have specific limitations.

Free Account				
	Selected Free Services	**Duration**	**Credits?**	**Duration**
Azure[36]	Yes	12 months	$200	3 months

[36] https://azure.microsoft.com/en-us/free/

AWS[37]	Yes	12 months	No	N/A
Google Cloud[38]	Yes	Forever	$300	3 months

As seen in the table, Azure and AWS allow access for 12 months, while Google Cloud has no duration but more limiting restrictions. Azure and Google Cloud both offer credits to use on services that are not covered under the selected free services or that exceed the limits. For both Azure and Google Cloud, the credits expire after 3 months.

Student Account
All three also offer a student account, however, only Azure offers selected free services in conjunction with the student account as well as credits. The other two only offer credits and access to selected services through learning modules.

Student Account				
	Selected Free services?	**Duration**	**Credits?**	**Duration**
Azure[39]	Yes	12 months	$100	12 months
AWS[40]	Only learning modules	N/A	$100 for learning modules	N/A
Google Cloud[41]	Only learning modules	N/A	50 for learning modules	12 months

Verdict
While $300 worth of credits is enticing, three months is not a long enough duration to use them. The only subscription type that allows for both access to free services and credits for the whole 12 months is the Azure Student Account, therefore, Azure is the favorite for the subscription category.

Comparisons

Supported Data								

[37] https://aws.amazon.com/free/?all-free-tier.sort-by=item.additionalFields.SortRank&all-free-tier.sort-order=asc
[38] https://cloud.google.com/free
[39] https://azure.microsoft.com/en-us/free/students/
[40] https://aws.amazon.com/education/awseducate/students/
[41] https://edu.google.com/programs/?modal_active=none

Stores								
	File	**Disk**	**Object Storage**	**Data Lake Storage**	**Archive**	**Cache**	**Block Storage**	**Backup**
Azure[42]	X	X	X	X	X	X	X	X
AWS[43]	X	X	X	X	X	X	X	X
Google Cloud[44]	X	X	X	X	X	X	X	X

Verdict
Azure, AWS, and Google Cloud all have roughly the same data store options.

Supported Databases							
	SQL Server	**MySQL**	**MariaDB**	**CosmosDB**	**Postgre SQL**	**Oracle Database**	**MongoDB**
Azure[45]	X	X	X	X	X		X
AWS[46]	X	X	X		X	X	X
Google Cloud[47]	X	X	X	X	X	X	X

Verdict
Azure, AWS, and Google Cloud have roughly the same database options, although Azure doesn't have Oracle Database.

Integration with .NET Core	

[42] https://azure.microsoft.com/en-us/services/storage/
[43] https://aws.amazon.com/products/storage/
[44] https://cloud.google.com/storage
[45] https://azure.microsoft.com/en-us/product-categories/databases/
[46] https://aws.amazon.com/products/databases/
[47] https://cloud.google.com/products/databases

Azure[48] [49] [50]	Yes
AWS	No
Google Cloud	No

Verdict
Only Azure has native integration with .NET Core. This makes Azure a much more attractive option given that our backend will be developed with ASP.NET Core.

Managed Web App Hosting Supported Languages														
	Name	**C#**	**F#**	**Javascript**	**Python**	**Java**	**C++**	**Go**	**PHP**	**Powershell**	**Ruby**	**Node.js**	**ASP.NET**	**ASP.NET Core**
Azure[51]	App Service	X			X	X			X	X	X	X	X	X
AWS[52]	AWS Amplify				X	X			X		X		X	
Google Cloud[53]	App Engine				X	X		X	X			X		

Verdict

---

[48] https://docs.microsoft.com/en-us/aspnet/core/host-and-deploy/azure-apps/?view=aspnetcore-3.1&tabs=visual-studio
[49] https://docs.microsoft.com/en-us/azure/devops/pipelines/ecosystems/dotnet-core?view=azure-devops
[50] https://docs.microsoft.com/en-us/azure-stack/user/azure-stack-dev-start-howto-vm-dotnet?view=azs-2005
[51] https://docs.microsoft.com/en-us/azure/app-service/overview
[52] https://aws.amazon.com/developer/
[53] https://cloud.google.com/appengine/kb#:~:text=What%20languages%20are%20supported%20by,js.

Azure supports by far the most languages for its managed web hosting service, including ASP.NET Core. Azure is the preferable option in these regards.

Firewall Options	Name	Rule Baised	Zones	Filtering	Insight Panel	Rule Logging	Hierarchical Policies	Certificate	DNAT	SNAT	NAT	Scalability
Azure[54] [55]		X	X	X		X	X	X	X	X		X
AWS[56] [57]		X	X	X	X	X	X				X	X
Google Cloud[58]		X	X	X	X	X	X				X	X

Verdict
Azure has more extensive firewall options.

Pricing

The primary type of payment options for each cloud service is Pay-As-You Go. All three offer discounts based on 1 or 3 year commitments, however, these only are worth it if we have our resources running 24x7, which we won't.

Below is a comparison of the pay-as-you-go pricing for the different features we plan on using. It includes information on the differences between the free plan and student plan, as well as the overage price (going over the set limits). For most services, we will not need to go over the set limits, except for the Linux VM.

Linux VM						
	Name	**Model**	**Memory**	**Free Limitation**	**Student Limitation**	**Overage Price**
Azure[59]	Linux Virtual	D96as v4	8 GB	$200 credit within 3	$100 credit within 12	$.096/hour

[54] https://docs.microsoft.com/en-us/azure/firewall/features
[55] https://docs.microsoft.com/en-us/azure/firewall-manager/rule-hierarchy
[56] https://aws.amazon.com/waf/
[57] https://aws.amazon.com/firewall-manager/
[58] https://cloud.google.com/firewalls

	Machines			months	months	
AWS[60]	Amazon EC2	t3.large	8 GB	N/A	N/A	$.0998/hour
Google Cloud[61]	Computer Engine	e2-standard -2	8GB	$300 within 3 months	N/A	$.080486
Cheapest Overage	Google Cloud					
Most Expensive Overage	AWS					
Best Free benefits	Google Cloud					
Best Student Benefits	Azure					
Best Value	Azure					

While the free plans do offer a Linux VM for free for 750 hours of use, the VM offered does not have good enough specs.

Verdict
When comparing between the three on a vm of acceptable specs, Google Cloud does offer the lowest price. However, Azure's $100 credit to be used over 12 months makes Azure a better value overall.

Managed Web Hosting							
	Name	**Disk Space**	**Free Limitation**	**Student Limitation**	**Shared (Dev and testing)**	**Basic (no auto scale)**	**Standard (production workloads)**
Azure[62]	App Service	1 GB/1/10/50	10 web, mobile, or API apps free forever	10 web, mobile, or API apps free forever	$.013/hour	$.075/hour	$.10/hour

[59] https://azure.microsoft.com/en-us/pricing/details/virtual-machines/linux/
[60] https://aws.amazon.com/ec2/pricing/on-demand/
[61] https://cloud.google.com/compute/vm-instance-pricing
[62] https://azure.microsoft.com/en-us/pricing/details/app-service/windows/

AWS[63]	AWS Amplify	5 GB / Month / 12 months	1000 Build minutes per month/5GB stored per month/15 gb served per month	N/A	N/A	N/A	.01/ build minute//$.023 per gb stored per month/$.15 per GB served per month
Google Cloud[64]	App Engine	30 GB / month	28 hours per day F Instances	N/A	N/A	N/A	$.2/hour

Verdict
AWS offers the lowest overage prices, however, the free limitation only allows 1000 build minutes per month. Azure offers second lowest prices and the free as well as student account allows 10 web apps to be built with no time limitation that should be sufficient for our uses. Therefore, Azure will be the best option here.

VM Extra Storage						
	Name	**Disk Type**	**Disk Size**	**Free Limitation**	**Student Limitation**	**Over limit-price**
Azure[65]	Managed Disks	SSD	64 GB	64 GB x 2	64 GB x 2	$9.29/month
AWS[66]	Elastic Block Storage	SSD + Magnetic	30 GB	30 GB / 12 months free	N/A	.10/gb/month
Google Cloud[67]	Cloud Storage		5GB	5GB /month / 12 months	N/A	.023/gb/month
Cheapsest Overage	Google Cloud					
Most Expensive Overage	Azure					
Best Free benefits	Azure					

[63] https://aws.amazon.com/amplify/pricing/
[64] https://cloud.google.com/appengine/pricing
[65] https://azure.microsoft.com/en-us/pricing/details/managed-disks/
[66] https://aws.amazon.com/ebs/pricing/
[67] https://cloud.google.com/storage/pricing

Best Student Benefits	Azure					
Best Value	Azure					

Verdict
Google cloud offers the cheapest per/gb/month options. However, Azure's free account gives free access to two 64 GB SSDs, making it a far better value.

Database						
	Name	**Model**	Storage	**Free Limitation**	**Student Limitation**	**Price**
Azure[68]	SQL Database	s0	250 gb	250 GB/12 months	250 GB/12 months	$.0202/hour
AWS[69]	Amazon Relational Database Service	db.t2.micro	20 GB	750 hours/month and 20GB general purpose/20 GB backup	Credits	$.017/hour
Google Cloud[70]	SQL Server Database	SQL Server	$.204/GB/month SSD storage capacity	Not available	Not Available	$.204/GB/Month storage, .01134/hour license
Cheapest Overage	Google Cloud					
Most Expensive Overage	Azure					
Best Free benefits	Azure					
Best Student Benefits	Azure					
Best Value	Azure					

[68] https://azure.microsoft.com/en-us/pricing/details/sql-database/single/
[69] https://aws.amazon.com/rds/previous-generation/
[70] https://cloud.google.com/sql/pricing

Verdict
Google Cloud offers the cheapest overage, however, Azure allows for 250 Gb storage with its free and student plan, while Google Cloud has no free or student plan. AWS has cheapest overage, but it's free plan only allows for 20 GB. Therefore, the best value is going to be the Azure SQL Database.

Version Management				
	Name	**Free Limitation**	**Student Limitation**	**Price**
Azure[71]	Azure DevOps	5 Users, unlimited Github repos / 12 months	5 Users, unlimited Github repos / 12 months	Free for 5 users, then $6 per user per month
AWS[72]	AWS CodeCommit	5 users per month	5 users	Free for 5 users, then $1 per user
Google Cloud[73]	Cloud Source Repositories	5 users	5 users	Free for 5 users, then $1 per user
Cheapsest Overage	AWS & Google Cloud			
Most Expensive Overage	Azure			
Best Free benefits	Same			
Best Student Benefits	Same			
Best Value	Same			

Verdict
All three companies offer the exact same benefits regardless of plan, 5 users. However, Azure is the most expensive for overages. While that makes Azure less desirable, we don't plan on having any overages, so this shouldn't be an issue.

---

[71] https://azure.microsoft.com/en-us/pricing/details/devops/azure-devops-services/
[72] https://aws.amazon.com/codecommit/faqs/#:~:text=AWS%20CodeCommit%20costs%20%241%20per,Git%20requests%20for%20that%20month.
[73] https://cloud.google.com/source-repositories/pricing

Final Pricing Verdict
Azure has the cheapest prices for Linux VMs. When it comes to other services, while other companies have better prices in some services, Azure consistently has the best free and student account benefits. Therefore, overall, Azure is the best value.

Pros and Cons

Azure

Pros

- Both free account and student account options.
- Student account has the same access to free services as the free account and includes a $100 credit that lasts the entire 12 months. Does not only have to be used for learning modules.
- Native integration with .NET Core.
- Native integration with Visual Studio Code and Visual Studio.
- DevOps for version management and deployment, which is natively integrated with Visual Studio and VIsual Studio Code.
- App service natively supports ASP.NET Core.
- Has better free and/or student benefits in most services.
- Most services are a better value for the money, taking into account the free and/or student plans.
- Is the primary cloud service used by the US Military.

Cons

- Pay-as-you go rates on average are the most expensive.

AWS

Pros

- Web hosting management free version has autoscale.

Cons

- Free tier includes no credits.
- Student tier is only for learning modules.
- No native integration with .NET Core/
- Free selected services do not cover as much and are not as generous.

Google Cloud

Pros

- Free tier has the most generous credits.
- Cheapest pay-as-you go rates on average.
- Free tier of the App Eengine has autoscaling.

Cons

- Student tier is only for learning modules.
- No native integration with .NET Core.

Discussion

Azure, AWS, and Google cloud have similar offerings. All three have a free tier that allows for use of selected services. All three also have a student tier, however, only Azure's student tier gives access to the same free selected services as its free tier, and a generous $100 credit for 12 months of use, something that is actually even more ideal than the $200 of credits for only 3 months. Azure also had much better free/student tier benefits when it came to the restrictions and limitations on their selected services. AWS did not have any free credits for the free plan, and while Google Cloud had the most generous credit offering of $300 for 3 months, the Azure student plan that gives access to $100 for 12 months seems to be a better value, considering that we will be using pay-as-you go rates over a period longer than 3 months, not upfront reservations.

Azure was also the only cloud service with native integration with Visual Studio and Visual Studio Code, as well as .NET Core. A significant downside to Azure was that their App Service free tier does not have autoscaling, something that both AWS and Google Cloud did have for their web hosting management free tier service.

Verdict

Azure
While Azure has the most expensive pay-as-you-go rates in most cases, their free/student tier financial benefits and service benefits makes it the best value and cheapest option for our given use. Also, given its integration with .NET Core, which is the backend framework we will be using for the web app, and the recent adoption of Azure by the US military, Azure is the best choice for VCQC Connect.

Container Runtime

Business Need

We plan on using the microservices architecture for the design of VCQC Connect. Using the microservices architecture will:

- Speed up development by allowing team members to work on individual components separately, without having to worry as much about how they are affecting or being affected by dependencies.
- Make maintenance and updates far easier because a team member can work on a component without worrying about how they are affecting the system as a whole.
- Give us flexibility and room to respond to changing circumstances, especially considering that we are new to working on complex systems and will likely have to make major changes to the system in some manner.

- Make scaling the application to include future features much easier, as all we have to do is add a new module and connect it to the application with an API, rather than trying to have to incorporate it into existing code and revamp all the dependencies that come along with it.
    - Ex. of future feature: User Membership development environment.
- Minimize disruption to the web app when working on updates, something that is absolutely critical for military clients.
- Make the application far more portable, something that will be necessary given the uncertain future of the application after the class is over.
- Make the application more lightweight, as it only has to load components when they are needed.

In order to implement microservices, we have two main options; virtual machines or containers. Virtual machines are not a good option for us because they require far more memory allocation and have far less performance. Since containers share resources with the host machine (in this case the Linux VM), rather than partitioning off resources, this makes their memory usage and performance close to that of the host. Given that the memory capacity of the host machine is limited (since our budget only allows for certain Linux VM's), it is essential that we use the most efficient and performative option, which is containers.

The Options

Docker
Docker is a platform as a service technology that offers containers that can be used to package software.
LXC
LXC is a technology that allows the user to work with native linux containers.
Open VZ
OpenVZ is a technology that can run containers-like environments that only run on Linux and that like most container runtimes, share the OS kernel, but unlike containers, does partition some resources.

License

Docker
Docker has some components licensed under Apache License 2.0 and some licensed under the GNU General Public License.[74] [75] [76] Components licensed under Apache 2.0 have permission to

[74] Components & Licenses. (n.d.). Retrieved September 23, 2020, from https://www.docker.com/legal/components-licenses

[75] Open source components and licensing. (n.d.). Retrieved September 23, 2020, from https://docs.docker.com/desktop/opensource/

[76] https://www.gnu.org/licenses/gpl-3.0.en.html

be used in commercial products, while components licensed under GNU have permission to be used in closed-source, commercial products, free of charge.

LXC
LXC is licensed under the GNU LGPLv2.1+ license, which among other things, allows commercial use of products using LXC containers. The only stipulation that differs from the normal GNU license is that if a component covered by the license is modified, the product is required to be released under the same license. This would not be applicable in our case. [77]

OpenVZ
OpenVZ is licensed the GNU standard license which allows, among other things, for the software using OpenVZ containers to be for commercial use. [78]

Comparisons

Operating System			
	Windows	**Linux**	**Mac**
Docker[79]	X	X	X
LXC[80]		X	
OpenVZ[81]		X	

Verdict
Docker is the only one with cross-platform support.

Portability		
Docker[82]	Stateless container meant for one app	Designed to contain all needed resources and to be moved around and run on any machine

[77] https://linuxcontainers.org/lxc/introduction/#:~:text=Licensing,project%20is%20the%20GNU%20LGPLv2.
[78] https://wiki.openvz.org/User_Guide/OpenVZ_Philosophy#Licensing
[79] https://docs.docker.com/engine/faq/#does-docker-run-on-linux-macos-and-windows
[80] https://linuxcontainers.org/lxc/getting-started/
[81] https://help.ubuntu.com/community/OpenVZ
[82] https://archives.flockport.com/lxc-vs-docker/#:~:text=LXC%20is%20a%20container%20technology,cannot%20be%20treated%20as%20such.

LXC[83]	Virtual Environment	Closer to a VM
OpenVZ[84] [85]	Virtual environments	Meant to be used more as VPS than single application

Verdict
Docker is the only one that is designed to work with only a single application for portable use.

Pricing			
	Free Version	**Paid**	
Docker[86]	Less Team support	$7.99/month or $9/ user /month	
LXC	Completely Free		
OpenVZ[87]	Server Costs	Server Costs	

Verdict
LXC is the only one that is completely free.

Pros and Cons

Docker
Pros
- Industry standard container runtime environment.
- Cross-platform
- Meant for packaging single applications rather than acting as a virtual environment.
- Allows for better implementation of microservice architecture.

Cons
- Will have to pay $7.99 a month to get desired team benefits.

LXC
Pros
- Free
- Lightweight

[83] https://www.ionos.com/digitalguide/server/know-how/what-is-lxc-linux-containers/
[84] https://pasztor.at/blog/lxc-vs-docker/
[85] https://docs.openvz.org/openvz_users_guide.webhelp/_openvz_overview.html
[86] https://www.docker.com/pricing
[87] https://www.empire-hosting.net/virtuozzo-vps-hosting.html

- Can ssh into it.

Cons

- Containers act more as virtual machines.
- Not portable like Docker.
- Only works on Linux.

OpenVZ

Pros

- Can ssh into it.

Cons

- Acts more like a VPS than a container.
- Doesn't have the same portability as Docker.
- Works only on Linux.
- Server costs.

Discussion

While all three offer container runtimes, LXC and OpenVZ are more geared toward acting as virtual environments rather than containers for singular applications. Docker on the other hand is meant to isolate only the resources that are needed by the application being run in a given container, and to be able to be portable and run on any environment. Docker is also the only one that is cross-platform. Docker does have a free version, but for better team features like role-based access controls, a paid version is required.

Verdict

Docker

While we will likely end up using the mid-tier paid version, Docker is still far worth it. To implement our microservices architecture, we need portable containers that are meant to package a single application. Docker is the only one that we assessed that does this the way it is intended.