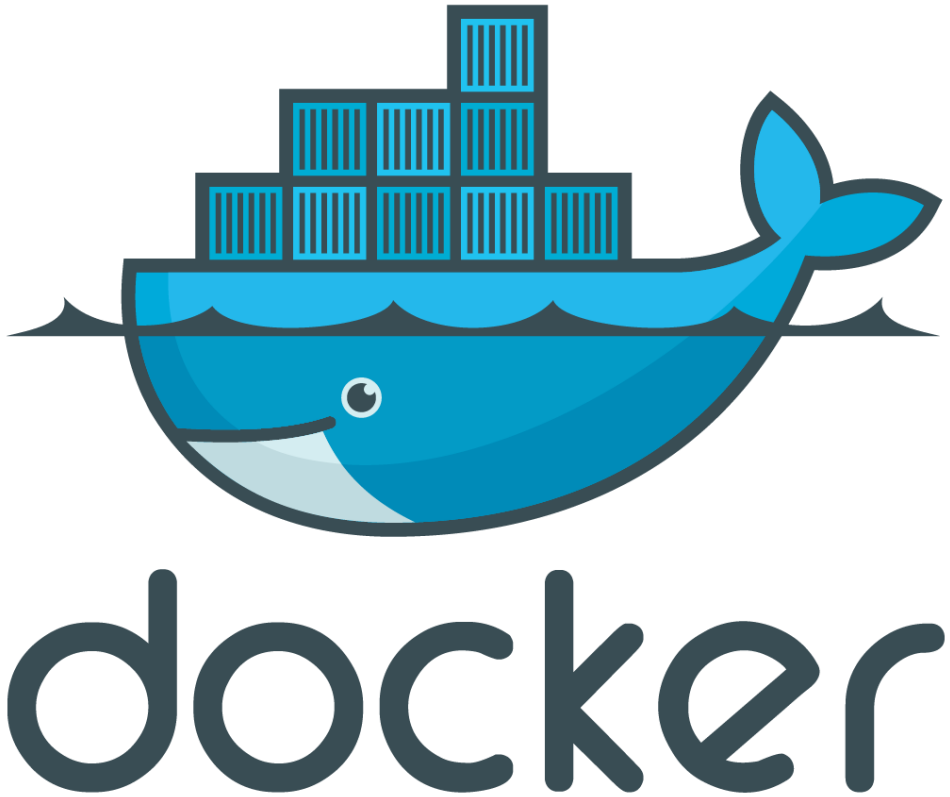


Introduction to Containers

SQL Server On Linux and Docker

Chris Taylor

Jarrin Consultancy
SQL Server Specialists

Worked with SQL Server since 2001

MCSE – Data Platform

Exceptional DBA Award finalist

Damn that Jeff Moden and his RBAR and Tally tables ☺

SQLNE PASS ~~Chapter~~ Group Leader

SQLRelay Organiser (Newcastle)

Formerly one of those “dirty devs”

Contact:

Twitter: @SQLGeordie

Email: chris.taylor@jarrinconsultancy.com

Blog: www.chrisjarrintaylor.co.uk

GitHub: github.com/SQLGeordie

Agenda

- Session Aim
- What are containers?
- Containers vs Virtual Machines
- Images
- Getting Setup
- Volumes
- Dockerfile
- Docker Hub
- Multi-Container Applications

Not on the Agenda

- Docker-Machine
- Orchestration
  - Docker-Swarm
  - Kubernetes
- Networking and Linking

Also….Not on the Agenda

- Containers / Orchestration in the Cloud
  - AWS Elastic Container Service (ECS)
  - Azure Container Service (AKS)

Session Aim

- High(ish) level insight into containers and what you can do with them
- Learn by example
  - Demo’s
  - My mistakes ☺
- Enough of a taste to get the container bug and start experimenting!

Well, it worked on my machine!

The Problem

Those pesky Dev's!!

https://cdn.geekwire.com/wp-content/uploads/2012/02/nerd-bigstock_Extreme_Computer_Nerd_1520708.jpg

The Real Problem

- Adapting to changing markets
- Environmental
  - Code, system tools, system libraries, settings

What are Containers

- Next evolution in virtualisation
- Lightweight, stand alone, executable package of a piece of software
  - Separation of applications or services on the same container host
  - Isolated, resource controlled, and portable operating environment
- Enables true independence between applications / infrastructure / developers / IT ops

"Basically, a container is an isolated place where an application can run without affecting the rest of the system, and without the system affecting the application."

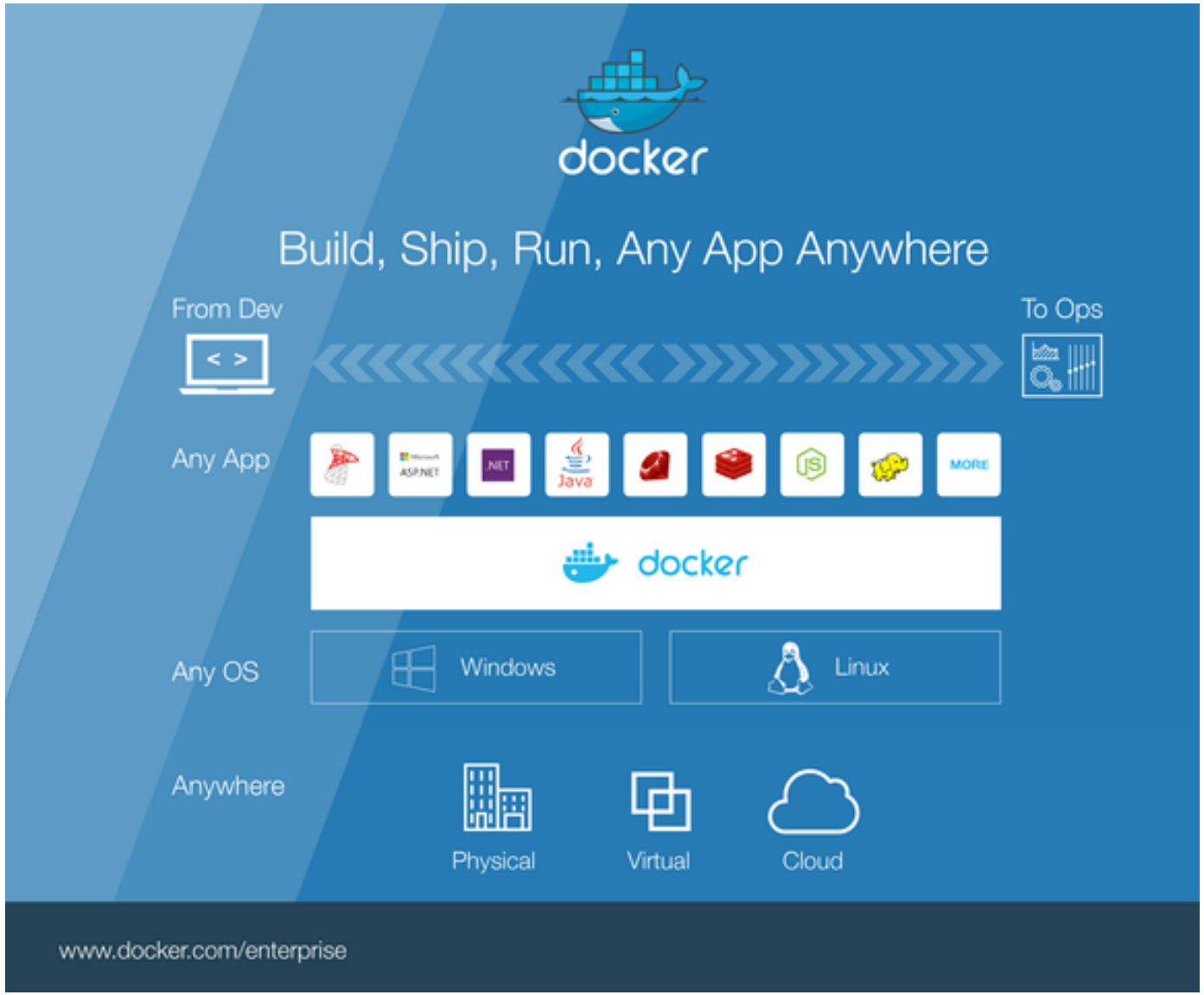
https://docs.microsoft.com/en-us/virtualization/windowscontainers/quick-start/

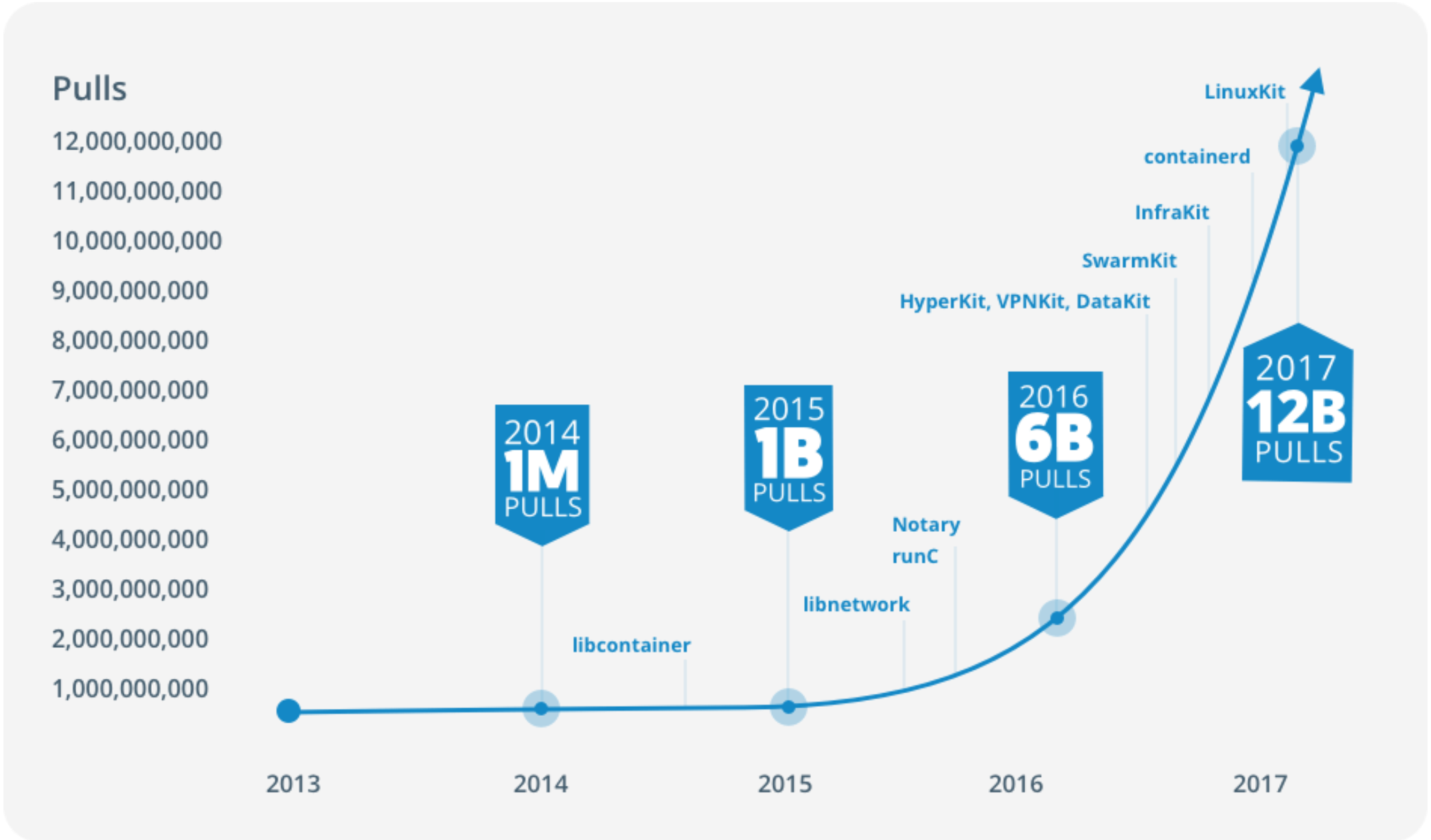
Container History

- 1979 – Unix v7 (chroot)
- 2000 – FreeBSD Jails
- 2001 – Linux VServer
- 2004 – Oracle Solaris Containers
- 2005 – Open Virtuzzo
- 2006 – Process Containers
- 2008 – Linux Containers (LXC)
- 2011 – Cloud Foundry Warden
- 2013 – Let Me Contain That For You (LMCTFY)
- 2013 – Docker and the Future
- 2015 – VMWare vSphere and Container Integration (Project Bonneville)
    - Hybrid virtualisation with vSphere and vCloud Director
- 2016 – Windows Server 2016 and Windows 10 (Pro/Anniversary) support

http://blog.aquasec.com/a-brief-history-of-containers-from-1970s-chroot-to-docker-2016

What is Docker?





https://www.docker.com/what-container

Kernel

- The core of the OS
- Application requests will go through this
- Controls everything from access to the HDD to memory management
- Runs in it’s own memory space

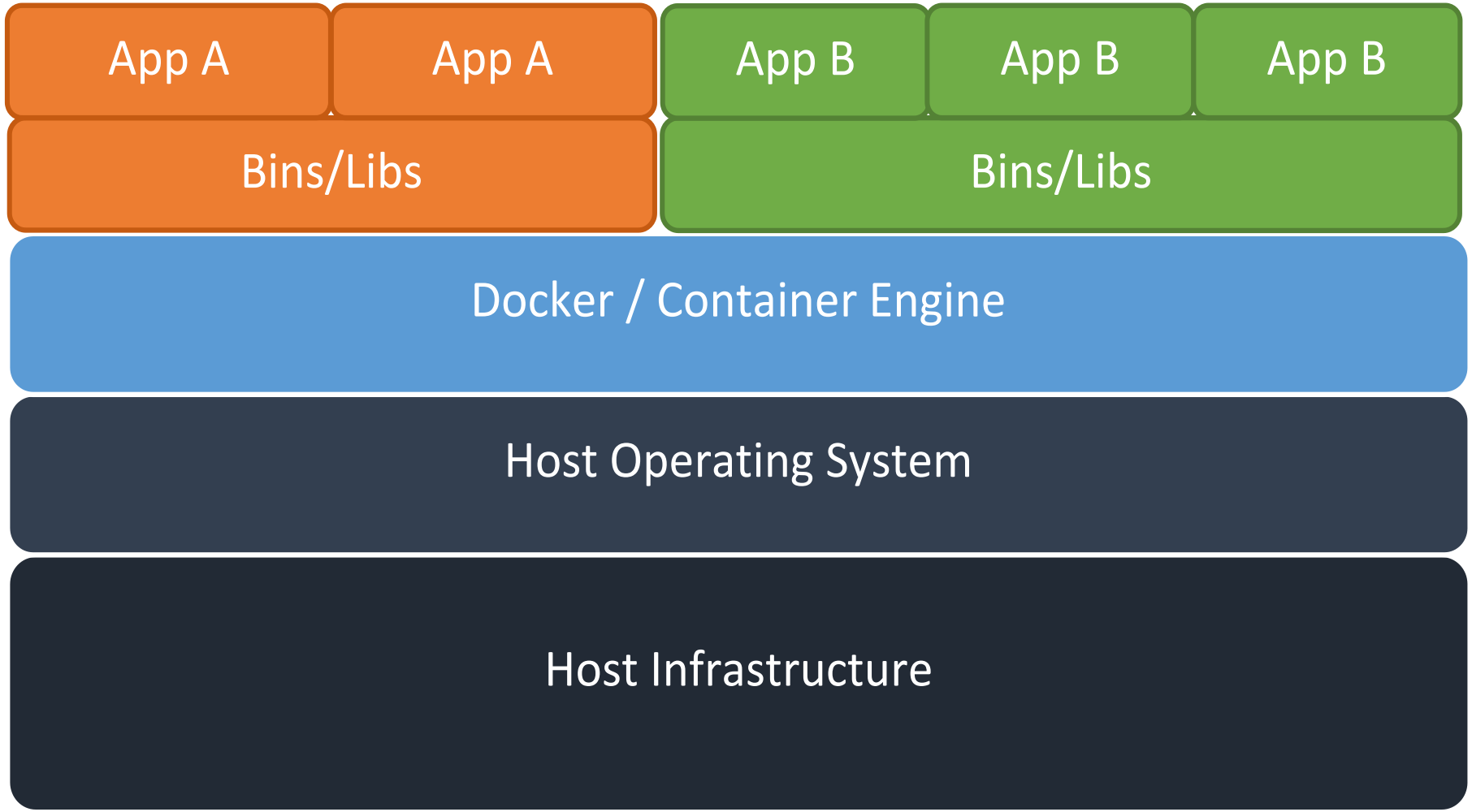
“It can be thought of as the program which controls all other programs on the computer”

https://simple.wikipedia.org/wiki/Kernel_(computer_science)

Container Terminology – The Basics

- **Container Host**
  - Physical or Virtual computer system configured with the Windows Container feature.
- **Container OS Image**
  - Containers are deployed from images. The container OS image is the first layer in potentially many image layers that make up a container. This image provides the operating system environment.
- **Container Image**
  - A container image contains the base operating system, application, and all application dependencies needed to quickly deploy a container.
- **Container Registry**
  - Container images are stored in a container registry, and can be downloaded on demand.
- **Dockerfile**
  - Dockerfiles are used to automate the creation of container images.

Container Overview



Pros

- Consolidation:
  - Average container size can be very small (**Not Windows/SQL Server - ~12GB**)
  - Less Resource Intensive
  - Server can host significantly more containers than virtual machines.
- Low Cost:
  - Potentially decrease your operating cost (less servers, less staff) and your development cost (develop for one consistent runtime environment).
- Speed:
  - Can spin up in seconds
  - Decrease the time needed for development, testing, and deployment of applications and services
- Consistency:
  - Simplify deployments, no difference between running your application locally, on a test server, or in production.
  - Great option for microservices, DevOps and continuous deployment.

Cons

- Security:
  - Sharing of the Kernel / OS Components means less isolation
    - Hyper-V Containers can help here
- OS Flexibility:
  - Becoming less of an issue with Windows Integration and the Docker CLi.
- Networking:
  - Can be tricky
  - Maintaining connections whilst maintaining isolation
- Management:
  - Seen as an *art*
  - Various tools becoming more popular (ie. Swarm/Kubernetes)

So how are Containers different to VMs?

Virtual Machine vs Containers

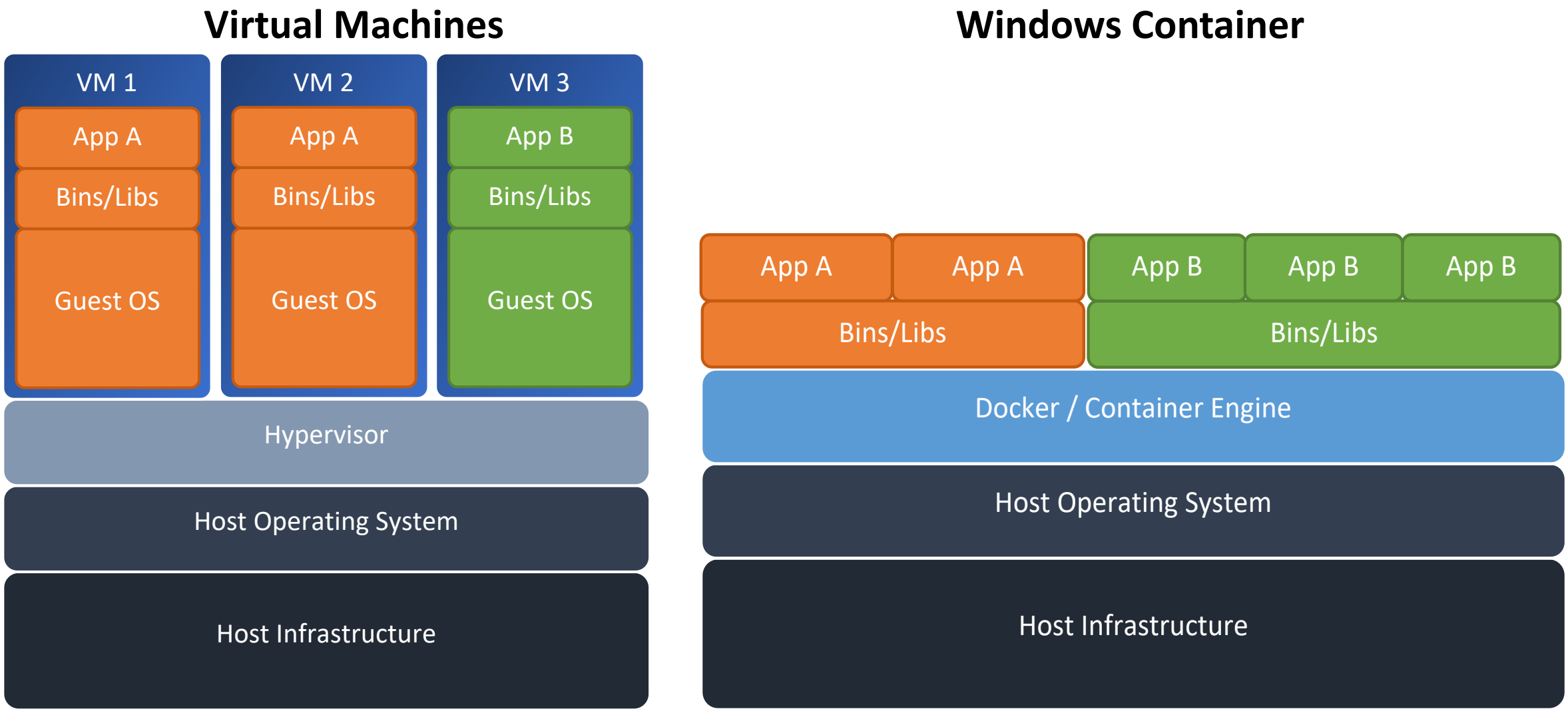
Virtual Machines

- Contain a complete operating system and applications
- Hypervisor-based virtualization can be resource intensive
- Can be large
- Hypervisors used to share and manage hardware
- Virtual machines residing on the same host can run different operating systems

Windows Containers

- Bound by the host operating system / daemon, containers on the same server use the same OS
- Smaller size
  - Windows Images still *large(ish*)
- Virtualizing the underlying operating system
- Share the kernel of the host OS to access the hardware
- Best Practice - 1 process per container
  - Portability

Virtual Machine vs Windows Container



Windows Containers vs Hyper-V Containers

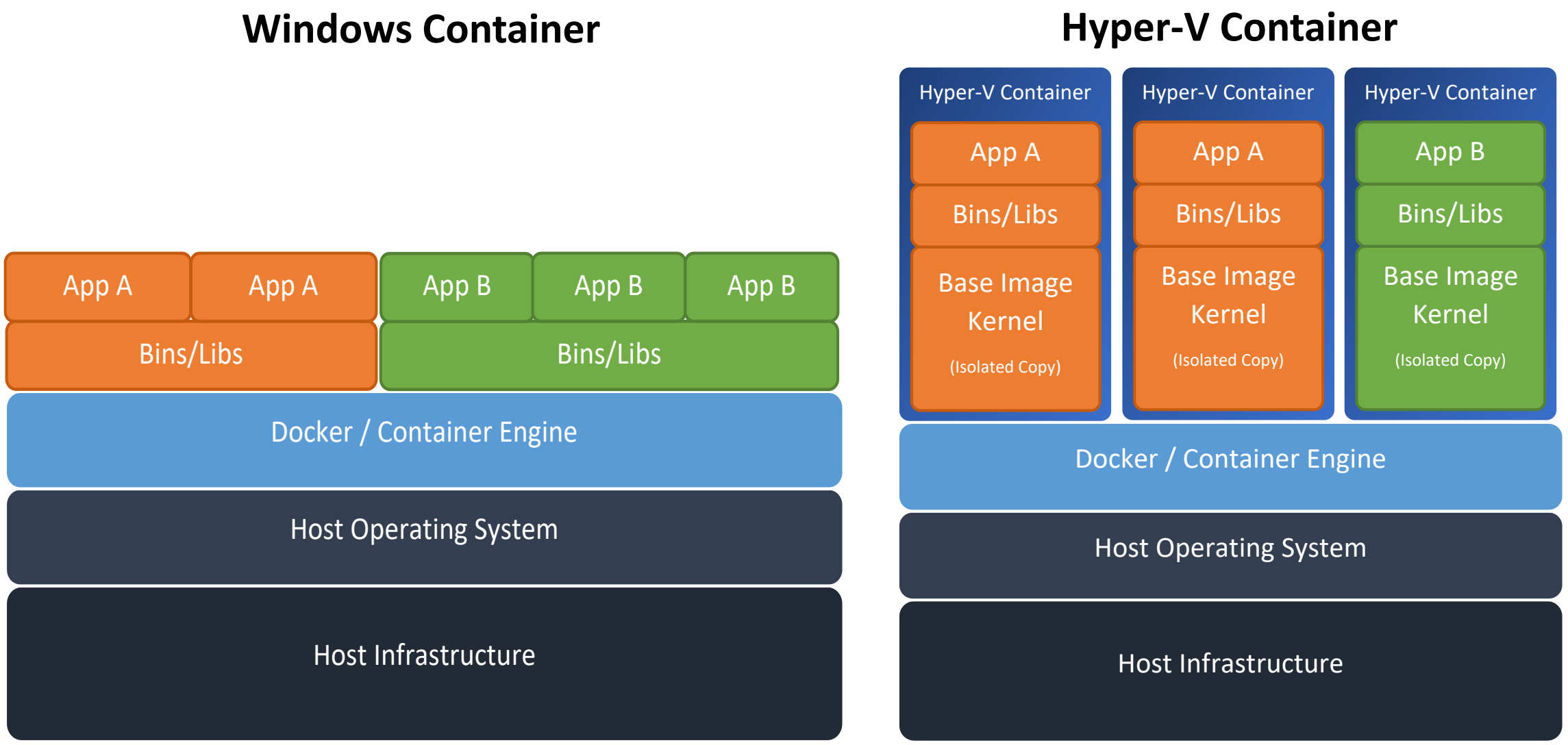
Windows Server containers

- Multiple container instances can run concurrently on a host
- Provide application isolation through process and namespace isolation technology.
- Shares a kernel with the host and all containers running on the host
  - Simplifies patching!

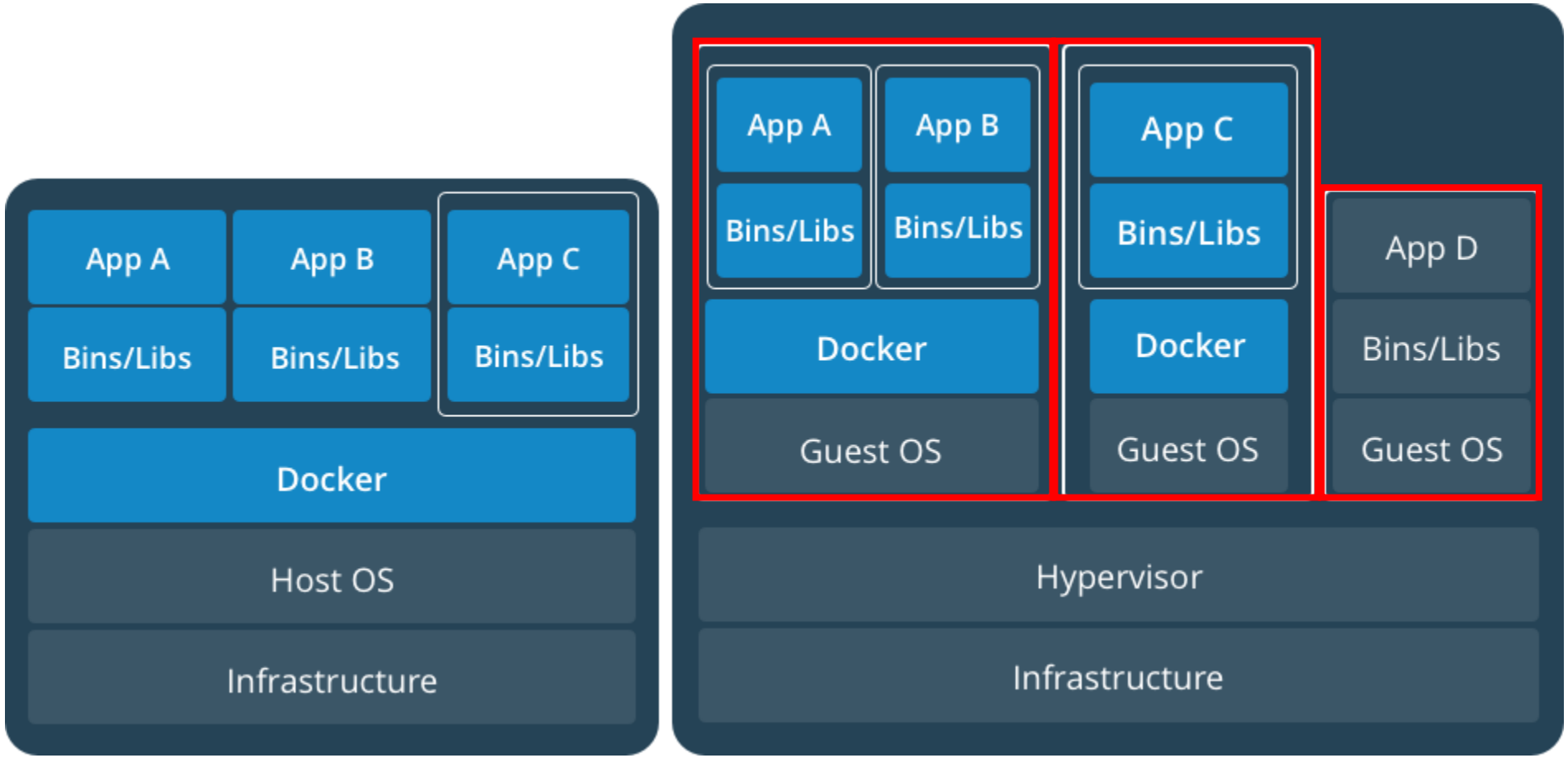
Hyper-V containers

- Multiple container instances can run concurrently on a host
- Each container runs inside of a special virtual machine.
  - Kernel level isolation
- Windows 10 always runs Hyper-V containers

Windows Containers vs Hyper-V Containers



Containers and VMs Together



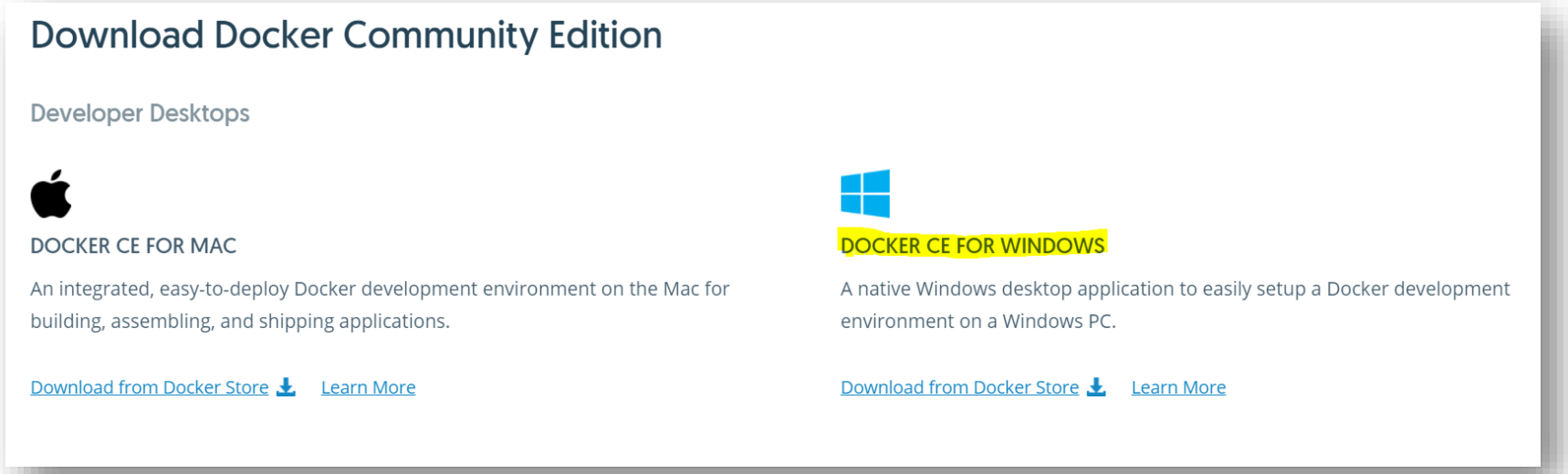
https://www.docker.com/what-container

What do I need to get setup?

- Downloads
- Host Machine Setup
  - Enable Features
  - Installing the Docker Engine
- Hyper-V setup
  - If you wish to use a VM as the Host

Downloads

- Can run Docker direct from host/dev machine
  - but I don't like installing anything locally I don't have to ☺
- Download:
  - Docker for Windows (Used for Windows 10)
  - SSMS 17.X (or other compatible version)
    - OR SQL Server Operations Studio…



https://www.docker.com/community-edition#/download

Host Machine Setup

- Enough RAM for VM running Docker (Minimum **3250MB** for Docker)
- OS – Windows 10 Pro, Enterprise and Education (with Anniversary Update)
- Host processors require nested virtualisation
- Enable Hyper-V on Host
- Hyper-V Settings
  - Create Virtual Switch with External Access
- Docker Toolbox if your machine does not meet the requirements

Installing the Docker engine (Windows 10)

```
Enable-WindowsOptionalFeature -Online -FeatureName:Microsoft-Hyper-V -All

# Download script and run:
.\Enable-NestedVm.ps1 "Win10_Docker“
```

Install Docker for Windows

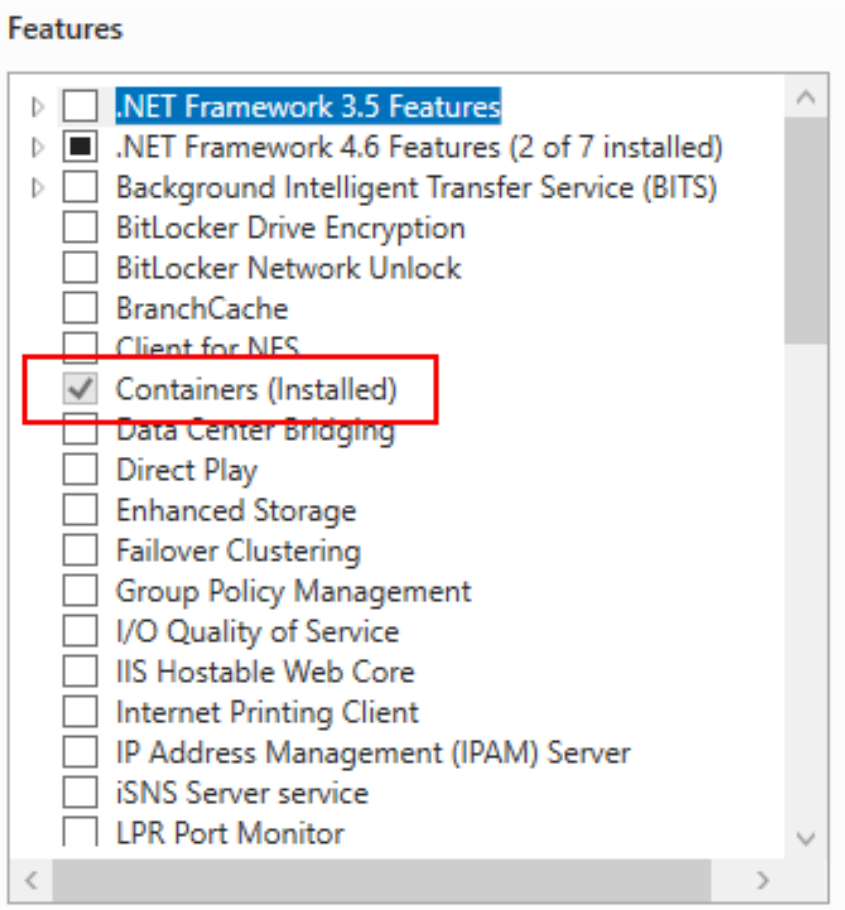
```
docker container run hello-world:nanoserver
```

Installing the Docker EE engine (Windows Server 2016)

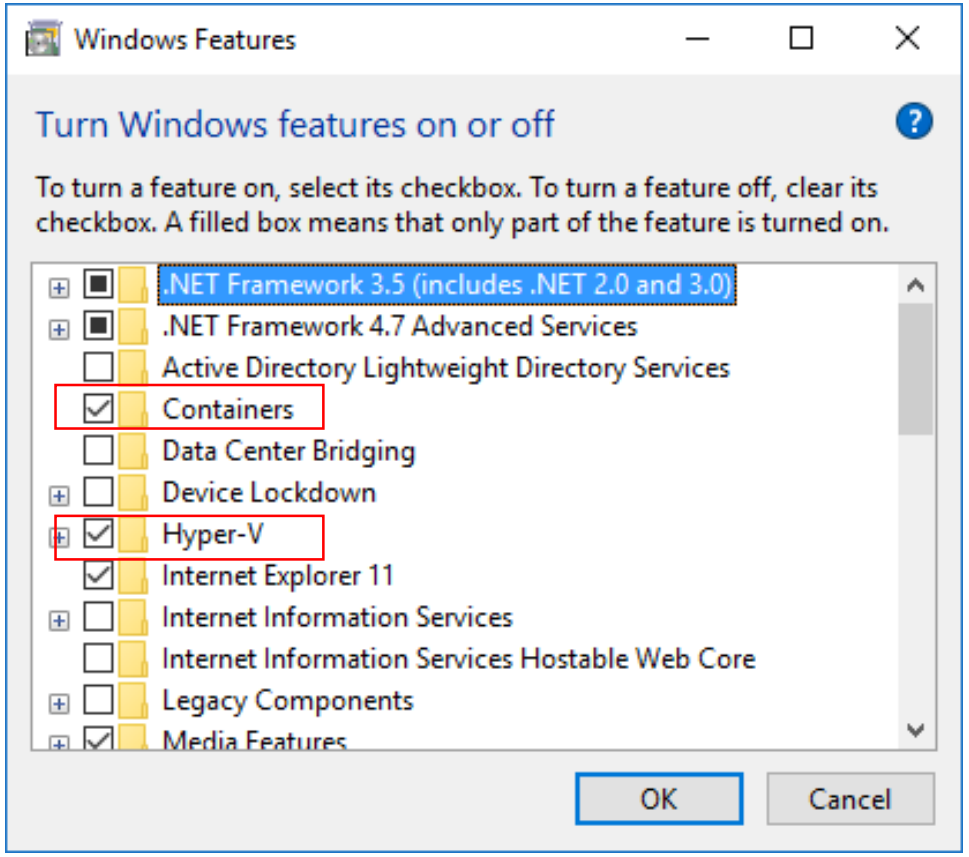
```
# PowerShell module from Docker Inc.
Install-Module -Name DockerProvider –Force (Or use DockerMSFTProvider)

# Install package docker from the provide DockerMsftProvider (does not work on Win10)
Install-Package -Name docker -ProviderName DockerProvider –Force (Or use DockerMSFTProvider)

Restart-Computer -Force

# Test running a container
docker run hello-world:nanoserver
```

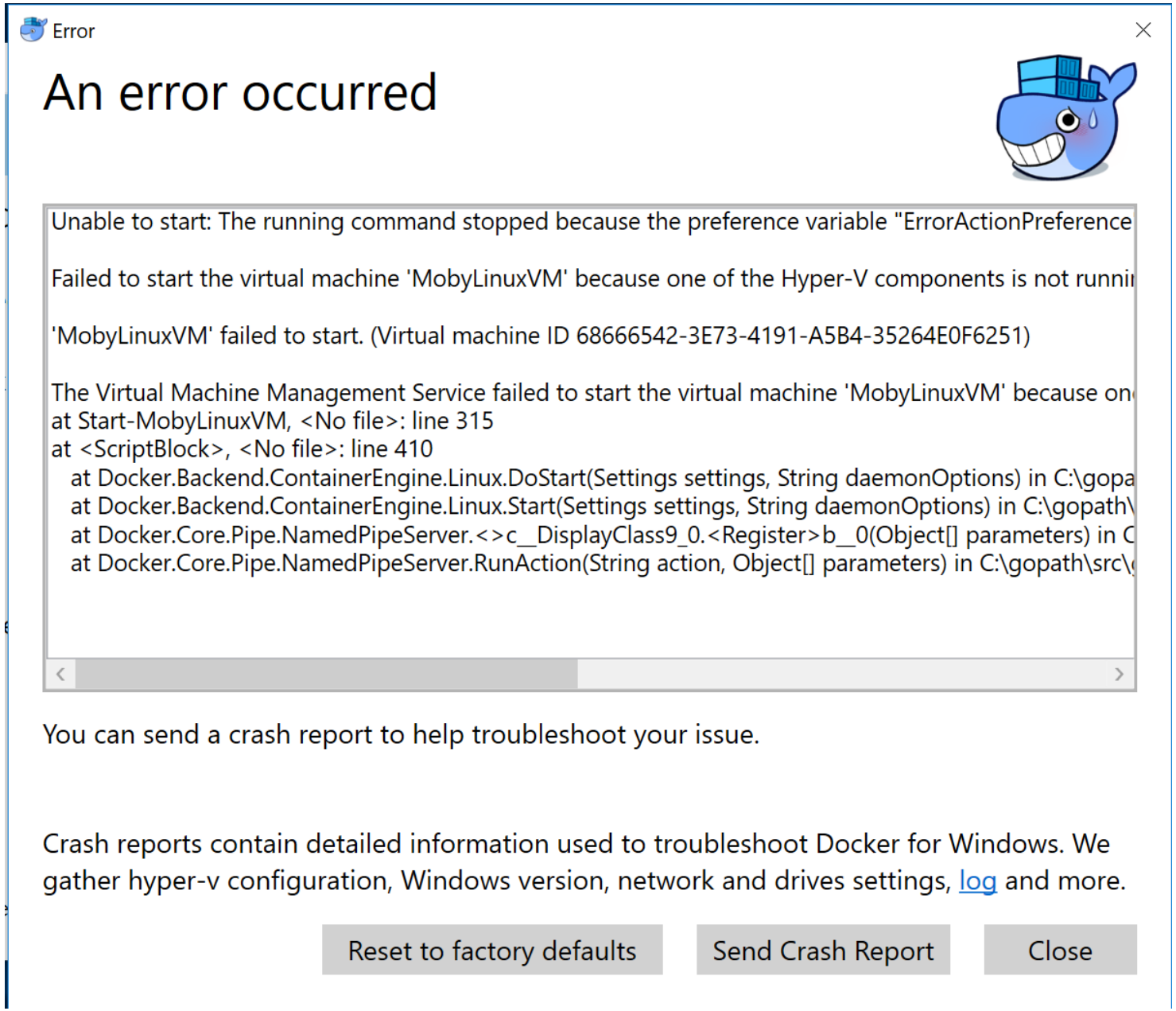
Enable Features

Windows Server 2016

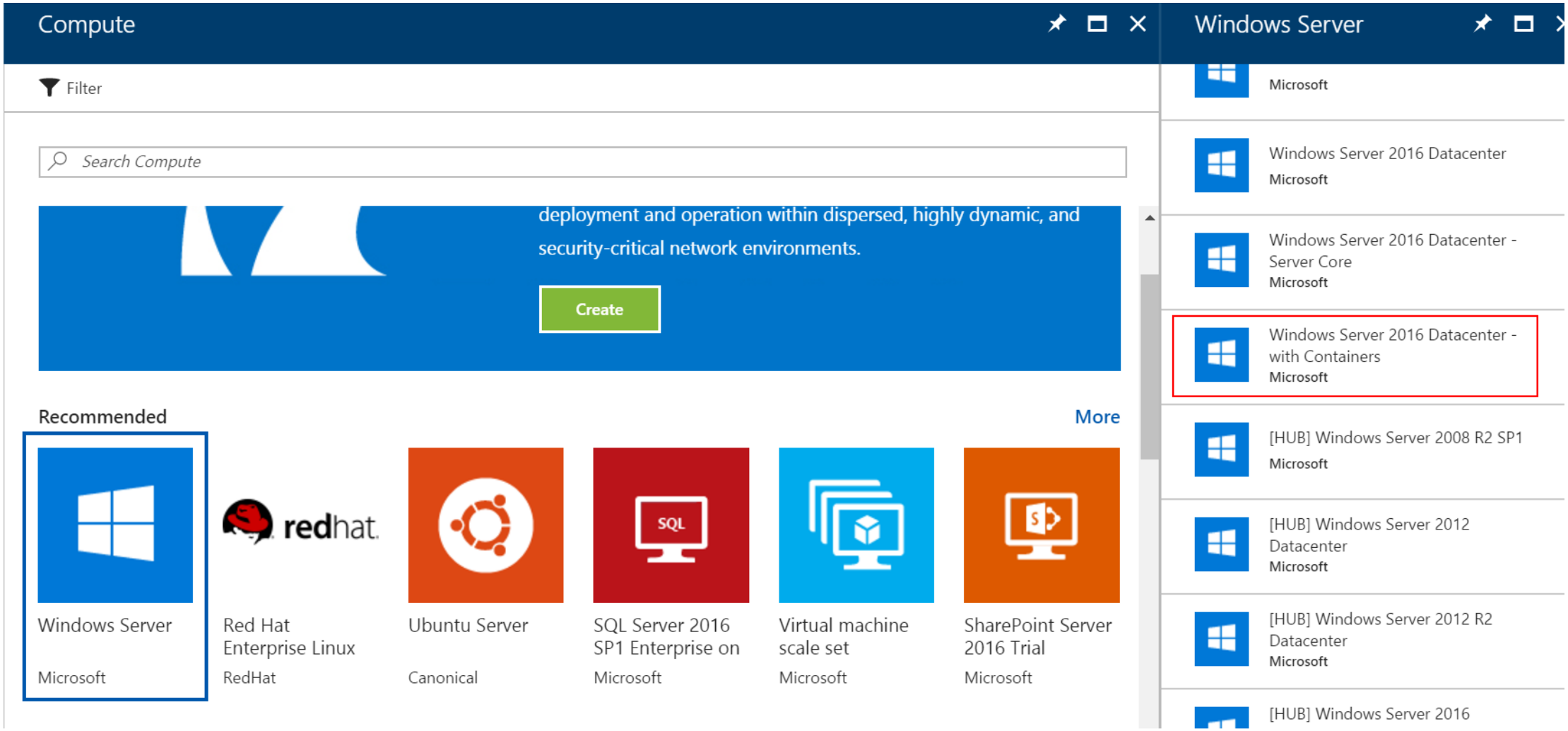


Windows 10



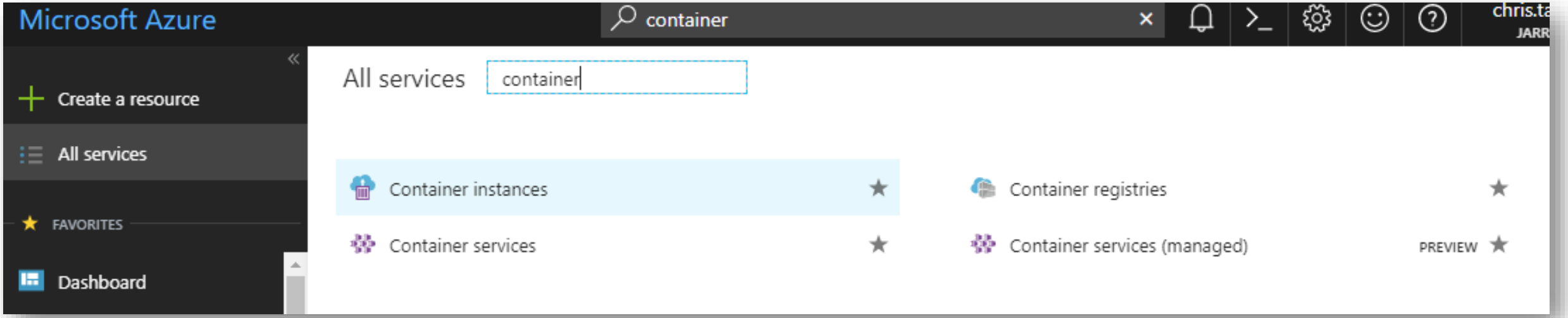

Error
An error occurred
Unable to start: The running command stopped because the preference variable "ErrorActionPreference
Failed to start the virtual machine 'MobyLinuxVM' because one of the Hyper-V components is not runni
'MobyLinuxVM' failed to start. (Virtual machine ID 68666542-3E73-4191-A5B4-35264E0F6251)
The Virtual Machine Management Service failed to start the virtual machine 'MobyLinuxVM' because on
at Start-MobyLinuxVM, <No file>: line 315
at <ScriptBlock>, <No file>: line 410
at Docker.Backend.ContainerEngine.Linux.DoStart(Settings settings, String daemonOptions) in C:\gopa
at Docker.Backend.ContainerEngine.Linux.Start(Settings settings, String daemonOptions) in C:\gopath\
at Docker.Core.Pipe.NamedPipeServer.<>c__DisplayClass9_0.<Register>b__0(Object[] parameters) in C
at Docker.Core.Pipe.NamedPipeServer.RunAction(String action, Object[] parameters) in C:\gopath\src\
You can send a crash report to help troubleshoot your issue.
Crash reports contain detailed information used to troubleshoot Docker for Windows. We gather hyper-v configuration, Windows version, network and drives settings, log and more.
Reset to factory defaults
Send Crash Report
Close

Containers on Azure



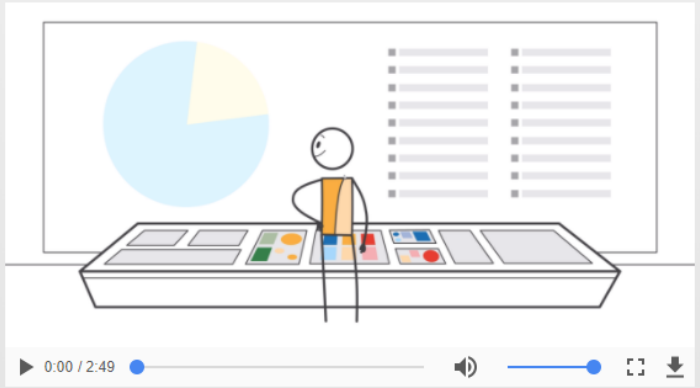
Containers on Azure

- Container Instances
- Containers as a Service (CaaS)



Containers on AWS (ECS)

Amazon Elastic Container Service (ECS)



Amazon ECS makes it easy to deploy, manage, and scale Docker containers running applications, services, and batch processes. Amazon ECS places containers across your cluster based on your resource needs and is integrated with familiar features like Elastic Load Balancing, EC2 security groups, EBS volumes and IAM roles.

Get started

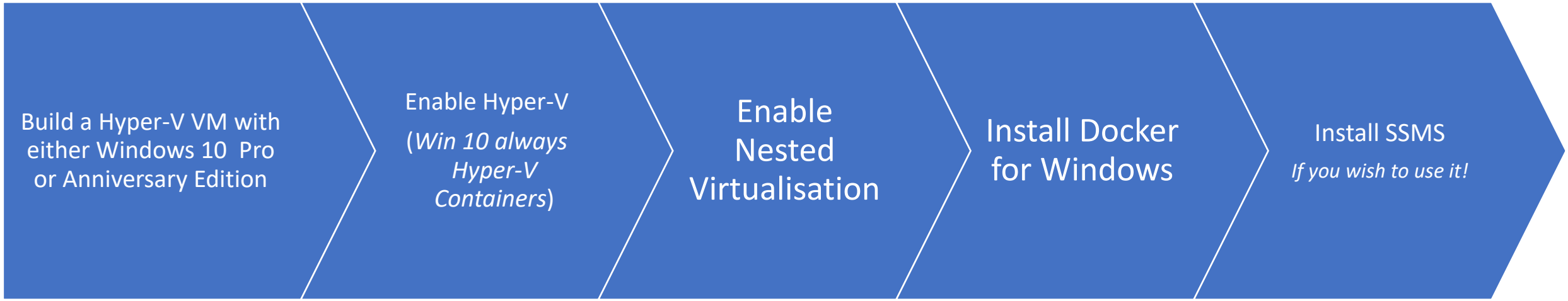
Learn more about Amazon ECS

Run containers at scale

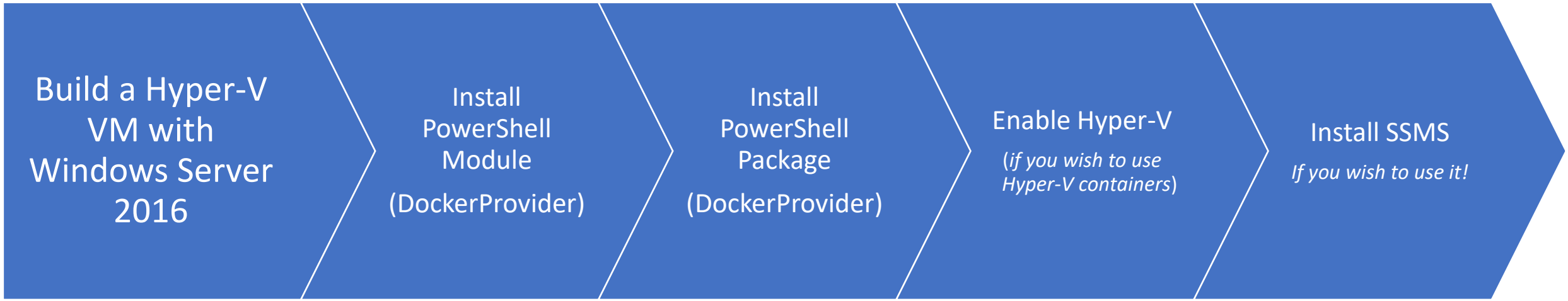
Flexible container placement

Integrated and extensible

Hyper-V Setup – Windows 10 Pro



Hyper-V Setup – Windows Server 2016



Windows Firewall Issue?

- Different menu's if you have the firewall enabled
- Cannot share drives from Host to Container
- Possible Fixes:
  - Port 445 blocked?
    - Allow connection to 10.0.75.1 port 445 (the Windows host) from 10.0.75.2 (the virtual machine)
  - Restriction on network profile?
    - vEthernet (DockerNAT) to Private?
  - Disable/Enable "File and Printer Sharing for Microsoft Networks"?
    - Essentially Opening port 445!

Docker Commands

- docker version
- docker search *<imagename>*
- docker pull *<imagename>:<tag>*
- docker images
- docker run *<parameters>*
- docker ps –a
- docker inspect *<containername>*
- docker logs *<containername>*
- docker stop *<containername>*
- docker start *<containername>*
- docker commit
- docker push *<imagename>*
- docker rm *<containername>*
- docker rmi *<imagename>*

Volumes vs Mounts

Volumes

- Does not increase size of the container
- Easier to back up or migrate than bind mounts.
- Work on both Linux and Windows containers.
- Can be safely shared among multiple containers.
- Volume drivers allow you to store volumes on remote hosts or cloud providers, to encrypt the contents of volumes, or to add other functionality.

Bind Mounts

- Host file/folder is mounted into a container
- Limited functionality compared to volumes
- Not portable between images
- Rely on the host machine’s filesystem having a specific directory structure available

SQL on Linux Container DEMO

That’s fantastic, but I have a gazillion databases to restore!!!

http://giftsforlearning.com/wp/tough-questions-with-no-good-answers-whats-a-parent-to-do/

Dockerfile

- Contains instructions (commands) to create an image
  - Each instruction creates a layer!
- Automate builds using *docker build*
- Dockerfile – no file extension

docker build -t newimagename .

Beware!

- Be careful with creating too many (unnecessary?) instructions
  - Remember the layering?
  - Wrap the instructions into minimal layers / commits:

Multiple Layer Image	Simplified Image
FROM microsoft/mssql-server-linux:latest	FROM microsoft/mssql-server-linux:latest
WORKDIR /usr/src	WORKDIR /usr/src
COPY ./shell /usr/src/sqlscript	COPY ./shell /usr/src
RUN chmod +x /usr/src/restoredb1.sh RUN chmod +x /usr/src/restoredb2.sh RUN chmod 755 /usr/src	RUN chmod +x /usr/src/restoredb1.sh && \ chmod +x /usr/src/restoredb2.sh && \ chmod 755 /usr/src
CMD /bin/bash ./entrypoint.sh	CMD /bin/bash ./entrypoint.sh

NOTE!!

- Repository must be lowercase
  - docker build *imagenamehere* .
- ENV attach_dbs doesn't work for Linux containers
  - Works on Windows containers
  - COPY and run .sql in shell (sh) scripts OR
  - sqlcmd CREATE DATABASE……FOR ATTACH
- sqlservr.sh
  - opt/mssql/bin/sqlservr.sh doesn't exist anymore
  - opt/mssql/bin/sqlservr instead
    - If you don't then SQL Server won't start and no scripts can execute
- Run something like /bin/bash script afterwards

Docker-Compose(Multi-Container Applications)

- docker-compose <build>
- yml (YAML) files

```
version: "3"
services:
  web:
    build: .
    ports:
      - "8000:80"
    depends_on:
      - db
  db:
    image: "microsoft/mssql-server-linux"
    environment:
      SA_PASSWORD: "your_password"
      ACCEPT_EULA: "Y"
```

Image Sharing and Reuse

- Export/Import (local)

  docker save --output= busybox.tar busybox

  docker load --input busybox.tar

- DockerHub (cloud)
  - Commit a Container

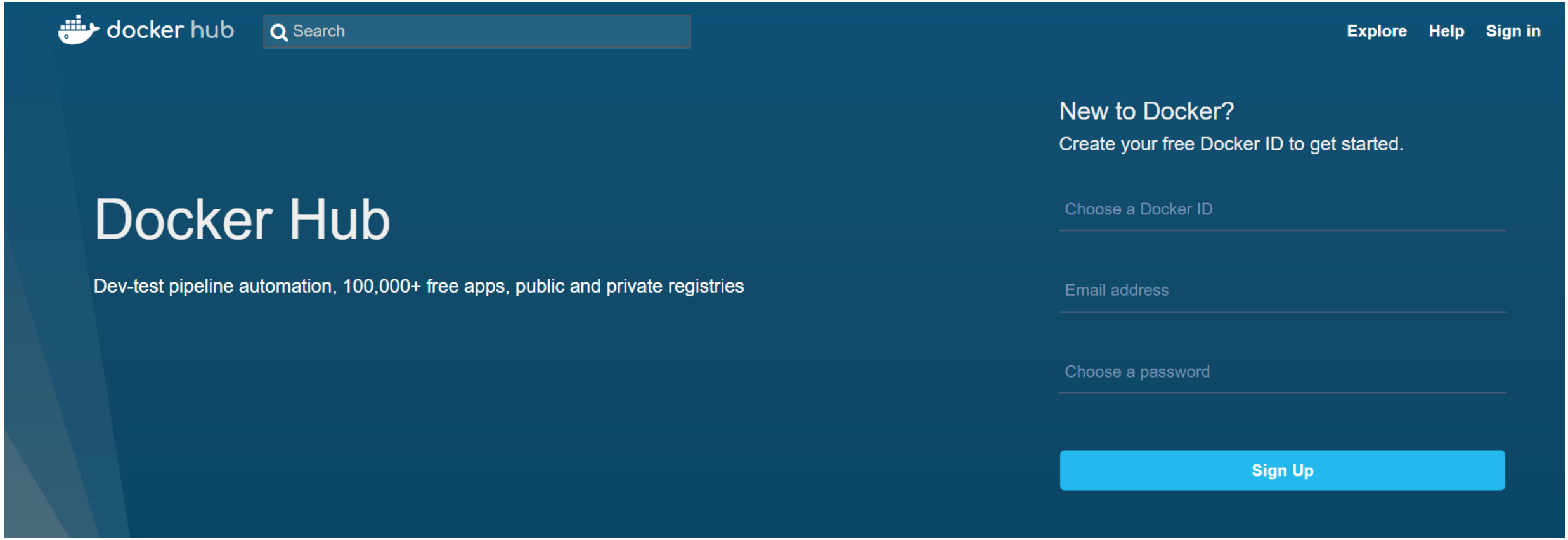
    docker commit sqllinuxrestore sqllinuxrestore:v1
  - Tag an Image

    docker tag sqllinuxrestore:v1 sqlgeordie/sqlrepository:sqllinuxrestore
  - Push to Docker Hub

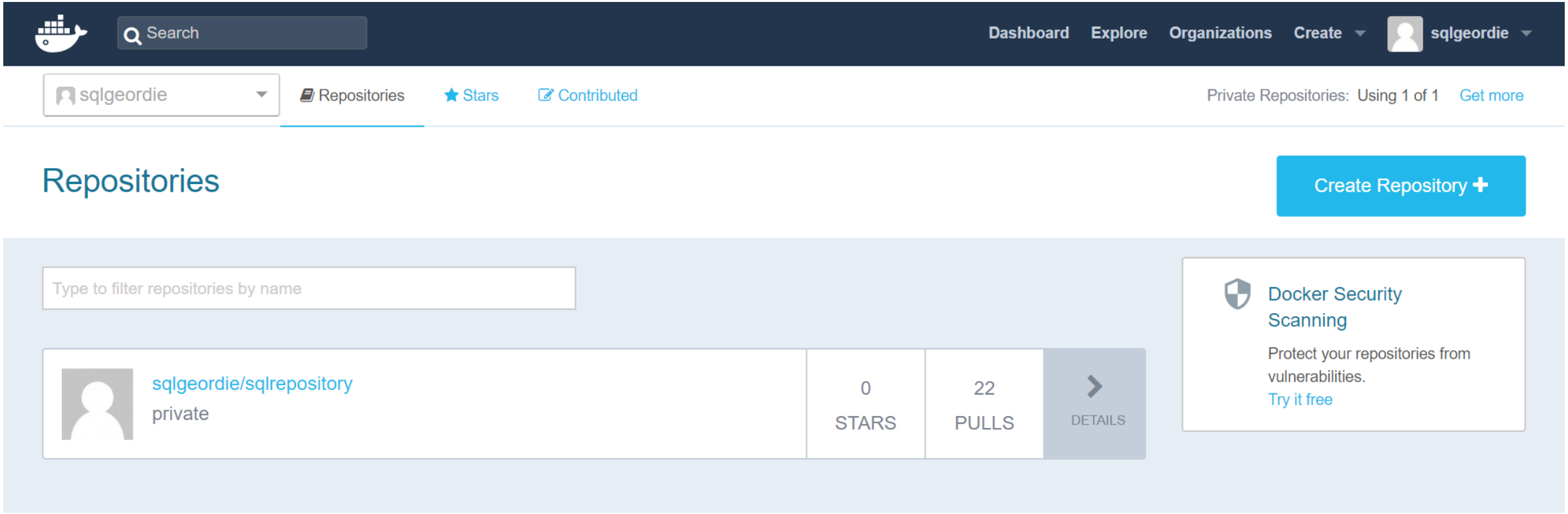
    docker push sqlgeordie/sqlrepository:sqllinuxrestore

SQL on Linux Container DEMO

Docker Hub - hub.docker.com



Repository


Search
Dashboard
Explore
Organizations
Create
sqlgeordie
sqlgeordie
Repositories
Stars
Contributed
Private Repositories: Using 1 of 1
Get more
Repositories
Create Repository +
Type to filter repositories by name
sqlgeordie/sqlrepository
private
0
STARS
22
PULLS
DETAILS
Docker Security Scanning
Protect your repositories from vulnerabilities.
Try it free

Images and Tags

Make sure you tag your images!

Repo Info | Tags | Collaborators | Webhooks | Settings

Tag Name	Compressed Size	Last Updated
tagtest	479 MB	4 days ago
linuxagentxps	452 MB	11 days ago
sqllinuxdockerfilerestore	464 MB	6 months ago
sqllinuxdockerfilerestoreaw	545 MB	6 months ago

Microsoft Images and Tags

mssql-server-linux	mssql-server-windows-developer	mssql-server-windows-express
2017-latest 2017-CU1 latest 2017-GA	2017-latest latest 2017-GA 2017-CU1 2017 2017-windowsservercore-10.0.14393.1715 2016-sp1 2016-sp1-windowsservercore-10.0.14393.1715 2016-sp1-windowsservercore-10.0.14393.1480 2016-sp1-windowsservercore-10.0.14393.1198 2016-sp1-windowsservercore-10.0.14393.693	2017-latest latest 2017-GA 2017-CU1 2017-windowsservercore-10.0.14393.1715 2017 2016-sp1 2016-sp1-windowsservercore-10.0.14393.1715 2016-sp1-windowsservercore-10.0.14393.1480 2016-sp1-windowsservercore-10.0.14393.1198 2016-sp1-windowsservercore-10.0.14393.693 2016-windowsservercore-10.0.14393.447 2016 2016-sp1-windowsservercore-10.0.14393.447

*Notice there is nothing pre-2016, MSFT do not support these but there are some publicly available – see Andrew Pruski - https://hub.docker.com/u/dbafromthecold/

Docker Hub
DEMO

Logs and Trouble Shooting

- Limited monitoring out the box
- Docker Knowledge Hub
- docker logs <container_name>
- docker system <df, events, info, prune>
- Docker Cli logs
- Could use TP tools
  - eg. SentryOne, cAdvisor (Google)

https://docs.docker.com/docker-for-windows/troubleshoot/

Docker-Compose(Multi-Container Applications)

- docker-compose <build>
- yml (YAML) files

```
version: "3"
services:
  web:
    build: .
    ports:
      - "8000:80"
    depends_on:
      - db
  db:
    image: "microsoft/mssql-server-linux"
    environment:
      SA_PASSWORD: "your_password"
      ACCEPT_EULA: "Y"
```

Licensing (Docker)

- Community Edition (CE)
  - **Free!**
- Enterprise Edition (EE)
  - 3 Levels (Basic / Standard / Advanced)
  - $1500 - $3500 / Node / yr
  - EE Basic **free** for Windows Server 2016 customers

https://www.docker.com/pricing

Licensing (Windows)

Production

- Licensing is at the host level,
  - each machine or VM which is running Docker.
  - run any number of Windows Docker containers on that host.
- Windows Server 2016
  - support from Microsoft and Docker, Inc.

Development

- Docker CE runs on Windows 10 and is free, open-source software.
- Like the server version, run any number of Windows Docker containers.

https://blog.docker.com/2017/01/docker-windows-server-image2docker/

Licensing (SQL Server)

“Regardless of where you run it - VM, Docker, physical, cloud, on prem - the licensing model is the same and it depends on which edition of SQL Server you are using.”

https://github.com/Microsoft/mssql-docker

Performance

- See link to Simon Sabin's blog:
  - https://sabin.io/blog/sql-server-container-performance/

- Summary:
  - *"The container seems a bit faster up to four users, but then trails off with the VM being faster later on."*
  - *Expected the container to outperform the VM by a factor of 10-20%.*
  - *Difficult to draw any real conclusions.*
  - *Not enough reasons from a performance standpoint to recommend containers for database hosting in an enterprise environment."*

Alternatives and TPVs

- WinDocks
  - Allows images of older versions of SQL Server to be created
- Portainer.io
  - GUI based tool
- Kubernetes
- Docker Swarm
- Amazon Elastic Container Service (ECS)
- Azure Container Service
- Marathon
- CoreOS Fleet
- Open Stack Magnum
- Diego
- Hashicorp Nomad

Conclusion

Good

- Docker provides a facility to quickly provision environments
- Consolidation and Resource savings can be exceptional
- Docker Hub has 10000's of publicly available repositories / images

Not so good

- Storage fiddly / not user friendly
- Lack of monitoring via Docker
  - TP tools available – cAdvisor
- Platform Independency still in its infancy
  - Windows Docker Service

Summary

- Session Aim
- What are containers?
- Containers vs Virtual Machines
- Images
- Getting Setup
- Volumes
- Dockerfile
- Docker Hub
- Docker Compose

Contact

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Blog

www.jarrinconsultancy.com\blog

www.chrisjarrintaylor.co.uk

Questions?

Links

- SQL Server on Linux:
- SQLPAL: https://blogs.technet.microsoft.com/dataplatforminsider/2016/12/16/sql-server-on-linux-how-introduction/
-
- Getting Started:
- Docker 101: https://www.slideshare.net/Docker/docker-101-nov-2016?next_slideshow=2Docker 101 - Nov 2016
- https://www.simple-talk.com/sysadmin/virtualization/working-windows-containers-docker-basics/
-
- Simple Hello World on nanoserver:
- https://docs.microsoft.com/en-us/virtualization/windowscontainers/quick-start/quick-start-windows-10
-

Links

- Introduction:
  - Docker introduction
- General:
  - https://blog.sixeyed.com/windows-containers-and-docker-5-things-you-need-to-know/
- Licensing:
  - https://blog.docker.com/2017/01/docker-windows-server-image2docker/
- Installing:
  - https://mathaywardhill.com/2017/04/12/installing-sql-server-vnext-on-linux-using-docker-on-windows-10/
- SQL On Linux:
  - https://docs.microsoft.com/en-us/sql/linux/sql-server-linux-setup-docker
  - https://roadtoalm.com/2017/01/06/running-a-linux-sql-server-in-a-docker-container/
- Connecting to SQL via sqlcmd:
  - http://searchsqlserver.techtarget.com/tip/Use-these-commands-to-deploy-SQL-Server-Docker-containers

Links

- Nested Virtualisation (for VMs):
  - https://www.youtube.com/watch?v=ycCK1EyJG6Y (nested virtualisation)
- Windocks:
  - https://www.windocks.com/blog-2/Windows-Containers-at-Work
- Performance:
  - https://sabin.io/blog/sql-server-container-performance/
  - https://facility9.com/2017/01/how-do-i-update-my-sql-server-docker-container/
- Error pushing image (add collaborators):
- http://stackoverflow.com/questions/41984399/denied-requested-access-to-the-resource-is-denied-docker/42403423
- Terminology:
  - http://itproguru.com/expert/2016/10/docker-create-container-change-container-save-as-new-image-and-connect-to-container/
- Volumes:
  - http://paper.li/e-1483951345?read=http%3A%2F%2Fthedatafarm.com%2Fdata-access%2Fmashup-sql-server-on-linux-in-docker-on-a-mac-with-visual-studio-code%2F
  - http://www.tricksofthetrades.net/2016/03/14/docker-data-volumes/
  - https://www.richard-banks.org/2017/03/connecting-to-sql-on-docker.html

Links

- Hyper-V containers:
  - https://www.simple-talk.com/sysadmin/virtualization/working-windows-containers-docker-stride/?utm_source=simpletalk&utm_medium=pubemail&utm_content=20170512-slota2&utm_term=simpletalkmain
  - https://hyper-v.nu/archives/hvredevoort/2015/05/nested-hypervisor-in-windows-server-vnext/
  - https://blogs.technet.microsoft.com/uktechnet/2016/01/11/windows-containers-what-they-are-and-how-they-work/
  - Windows Server and Docker - The Internals Behind Bringing Docker and Containers to Windows by Taylor Brown and John Starks

- Tutorials:
  - Docker Container Tutorial #1 Containers vs Images - Focuses on Ubuntu
  - Learn Docker in 12 Minutes 👍
  - Learn Docker in 20 Minutes