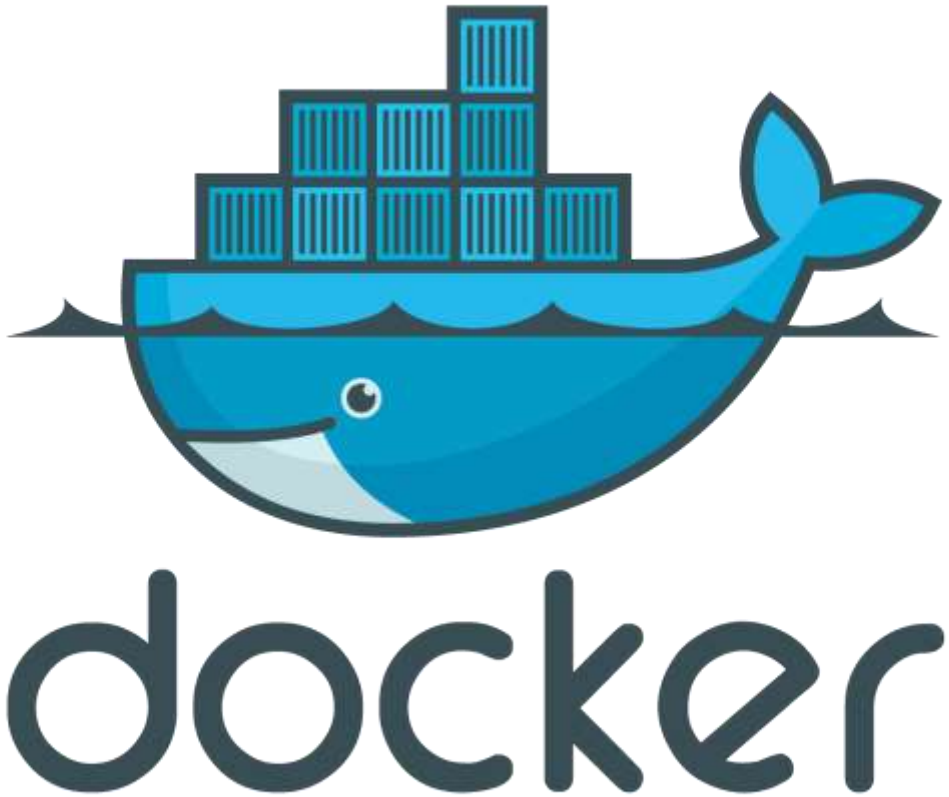


Introduction to Containers

SQL Server and Docker

Chris Taylor

Jarrin Consultancy (SQL Server Specialists)

Worked with SQL Server since 2002

MCSE – Data Platform

Exceptional DBA Award finalist

Damn that Jeff Moden and his RBAR and Tally tables ☺

SQLNE PASS ~~Chapter~~ Group Leader

SQLRelay Organiser

Partnerships:

- SentryOne Partner / PAC
- Redgate Partner / FORG
- Pragmatic Works Partner
- Nitrosphere Partner

Formerly one of those “dirty devs”

http://www.tonyvalderama.com/images/viz/sidsexist.gif

https://i.pinimg.com/originals/54/55/ac/5455accb7ce75570b750bbe6ecdab906.jpg

@SQLGeordie

Agenda

- Session Aim
- What are containers?
- Containers vs Virtual Machines
- Images
- Getting Setup
- Volumes
- Dockerfile
- Docker Hub
- Briefly:
  - Logs and troubleshooting
  - Multi-Container Applications
  - Licensing
  - Performance
- Q&A

Not on the Agenda

- Docker-Machine
- Docker-Swarm
- Networking and Linking

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

- Variances:
  - Environmental
  - Hardware
  - Security

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."

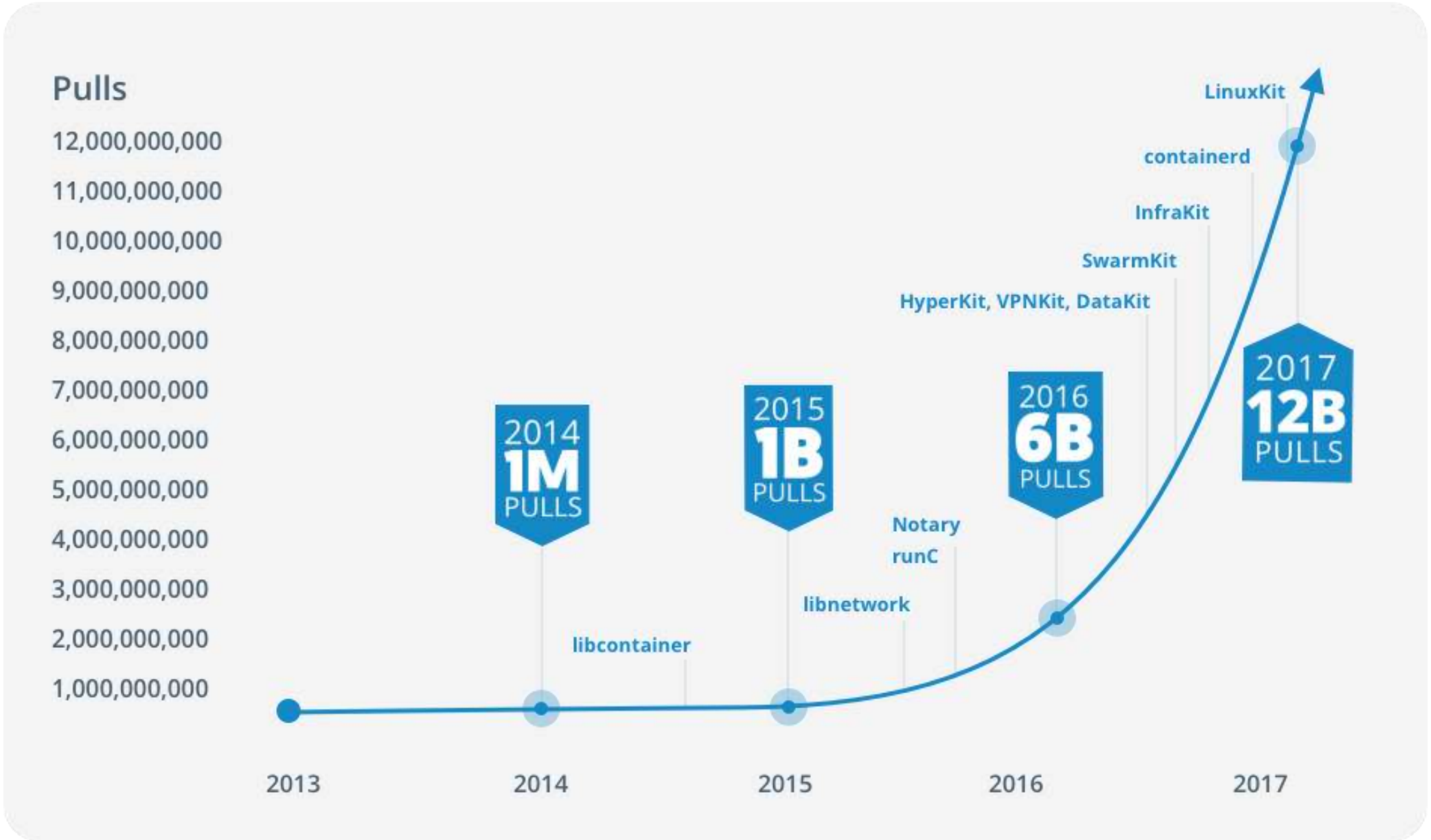
https://docs.microsoft.com/en-us/virtualization/windowscontainers/quick-start/

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

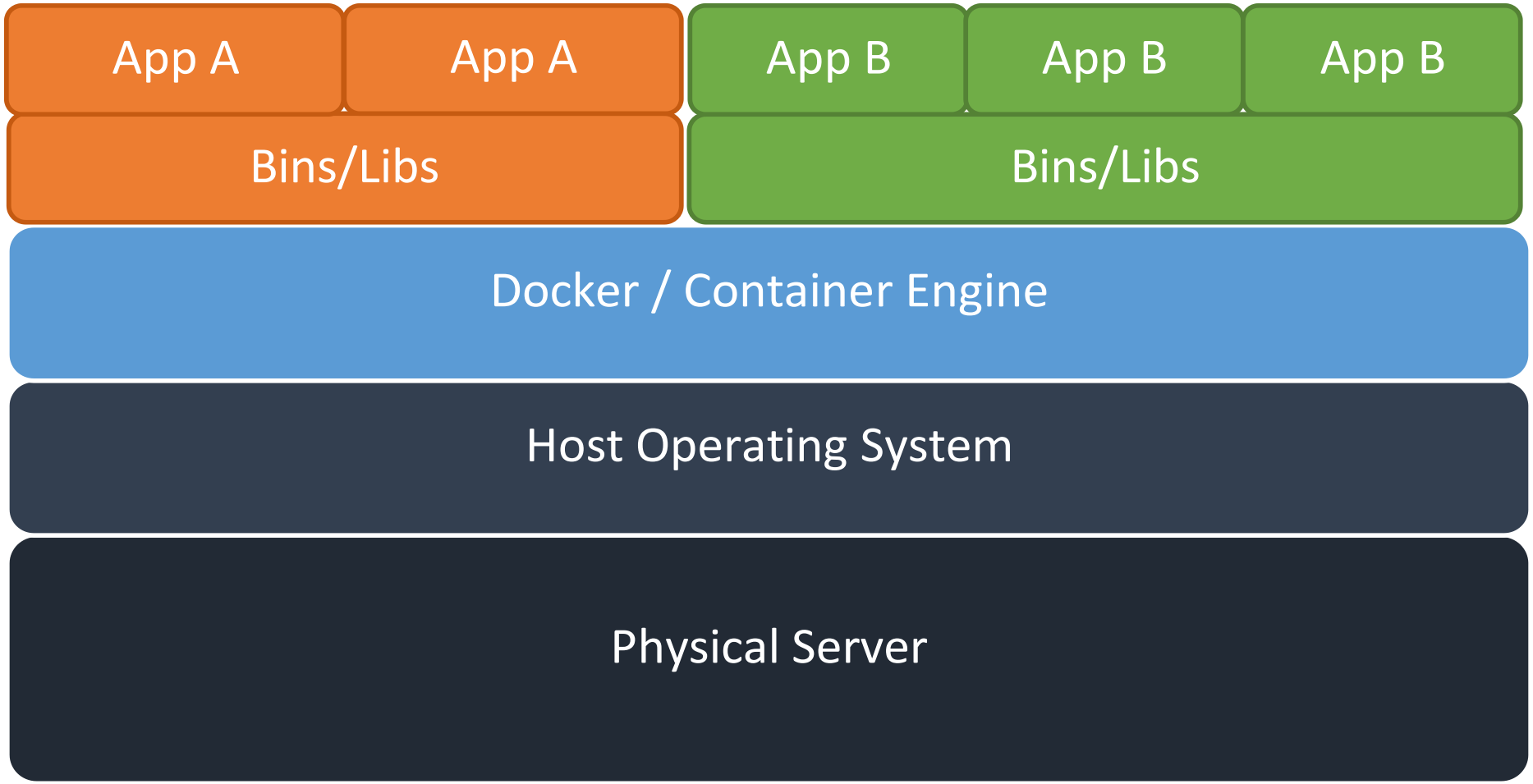
Kernel

- 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 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?
- 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

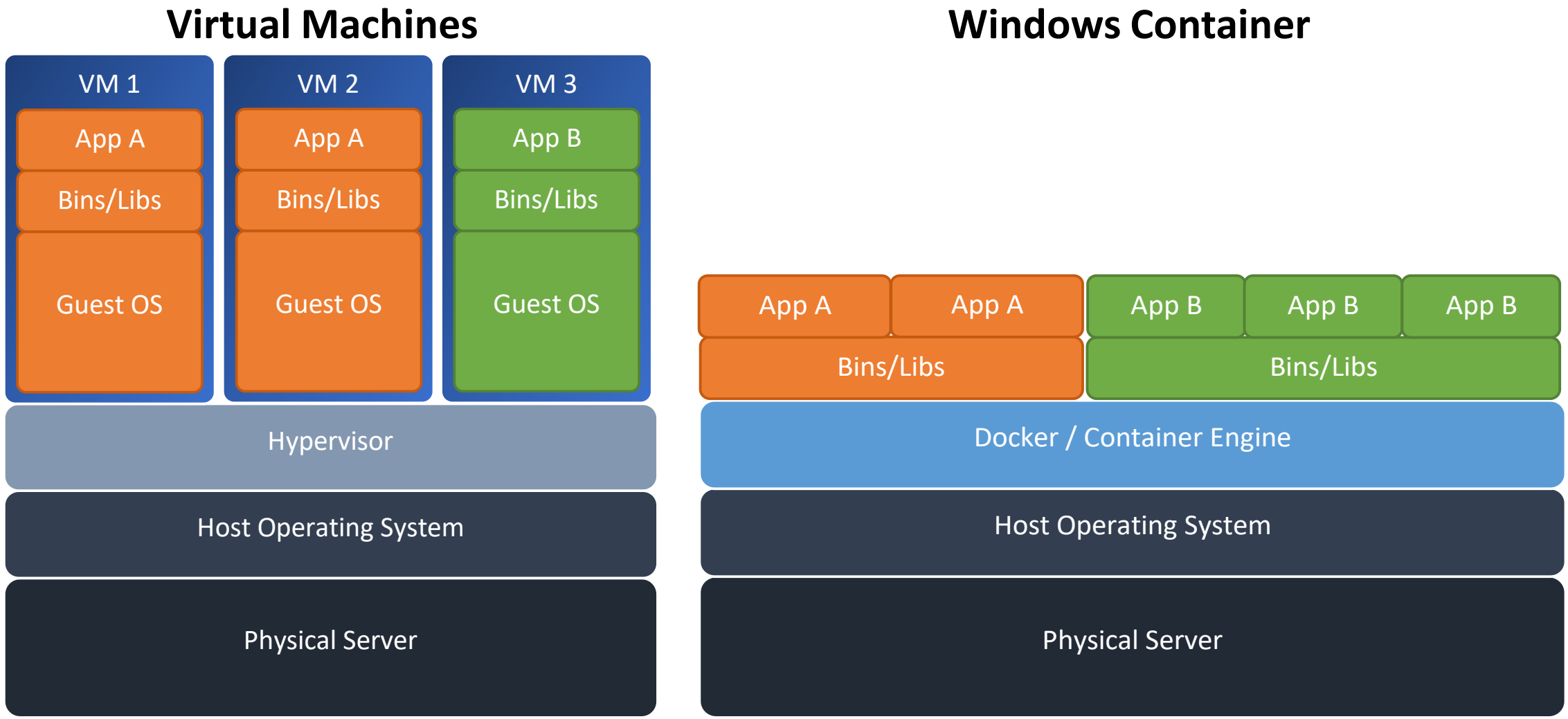
Virtual Machines

- 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

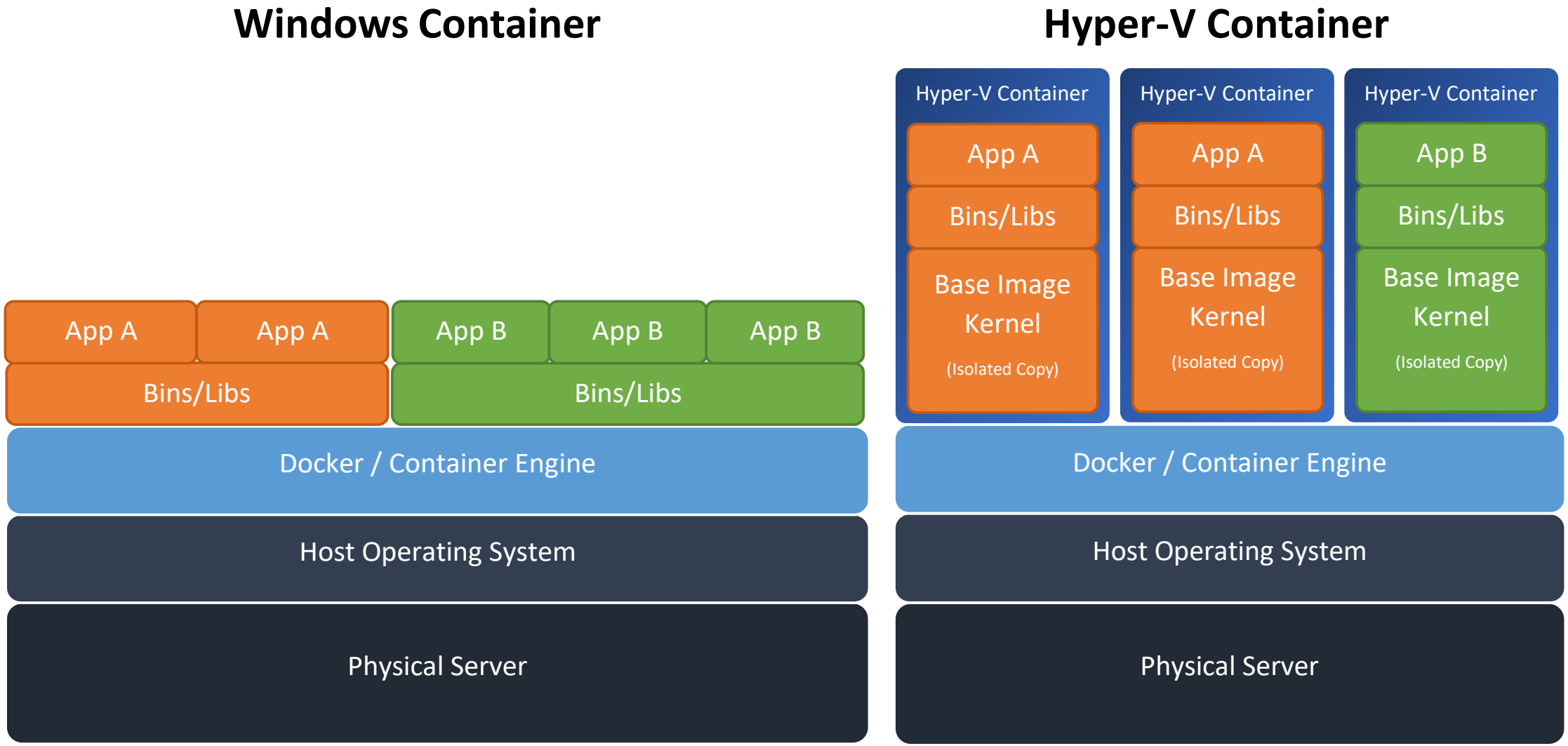
Windows Server containers

- 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!

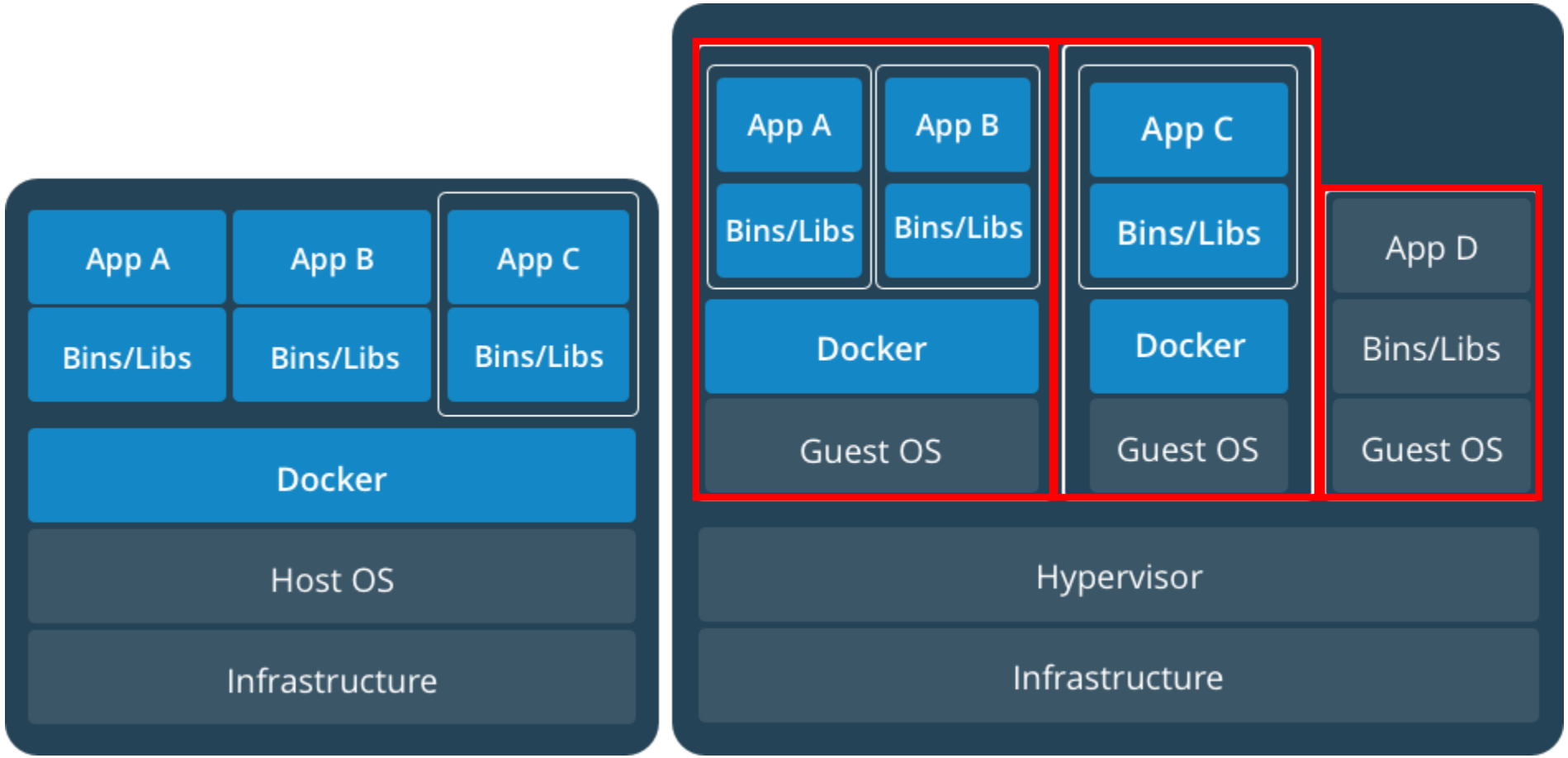
Hyper-V containers

- 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

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.

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 or Anniversary Edition
- Host processors require nested virtualisation
- Enable Hyper-V on Host
- Hyper-V Settings
  - Create Virtual Switch with External Access

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

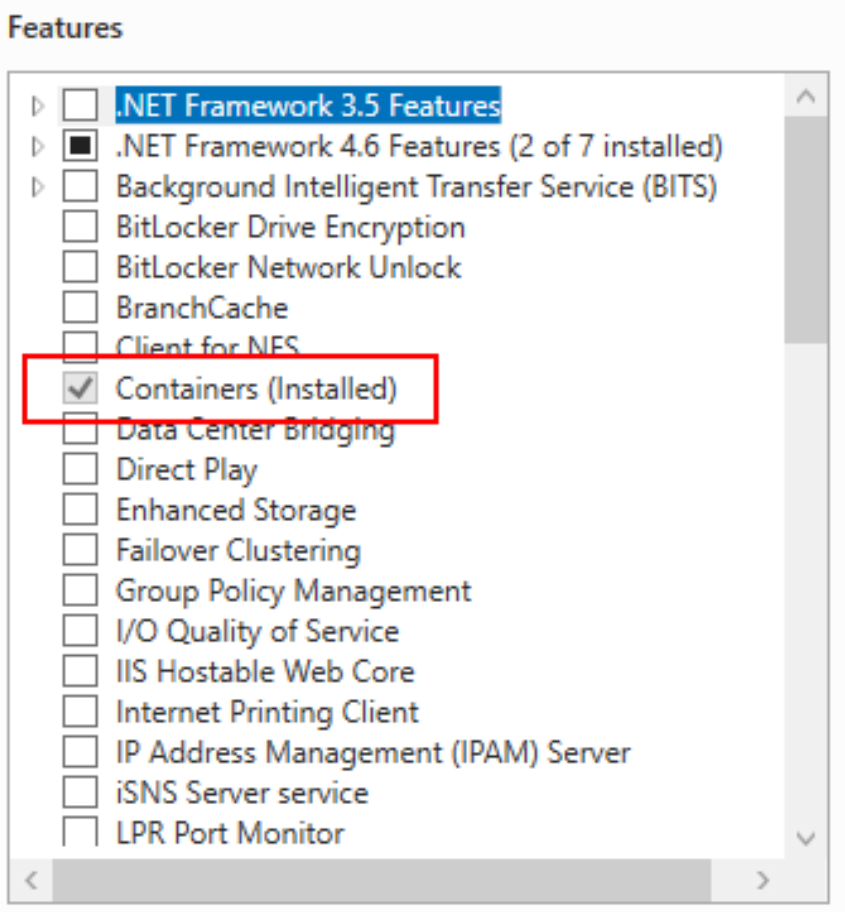
```
docker container run hello-world:nanoserver
```

Installing the Docker EE engine (Windows Server 2016)

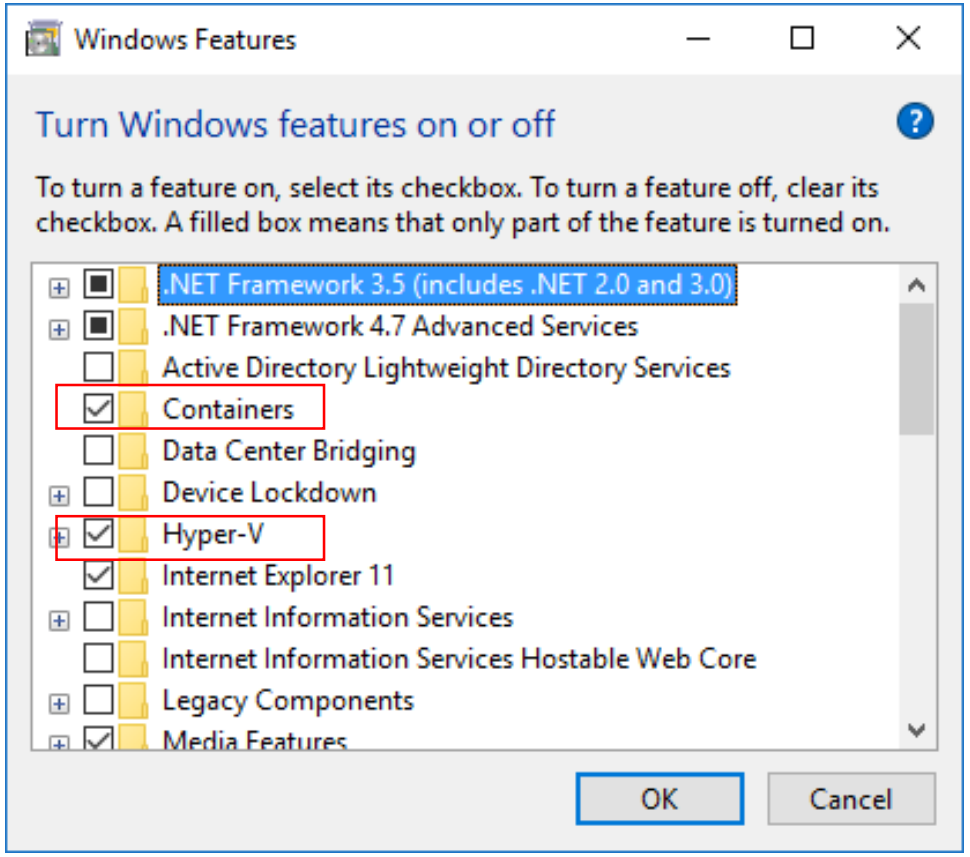
```
# PowerShell module from Docker Inc.
Install-Module -Name DockerProvider –Force (Or use DockerMSFTProvider)

# 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

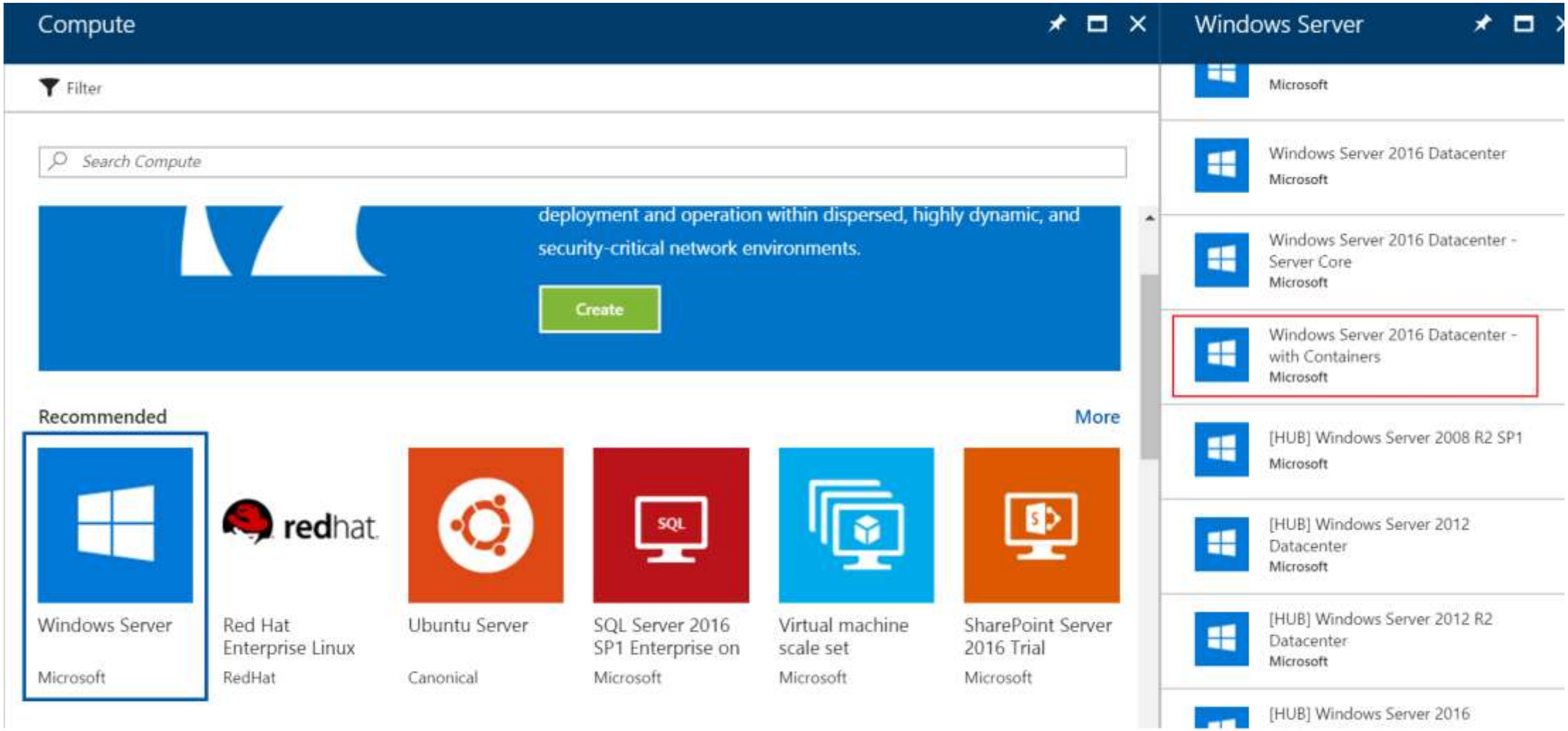
Windows Server 2016



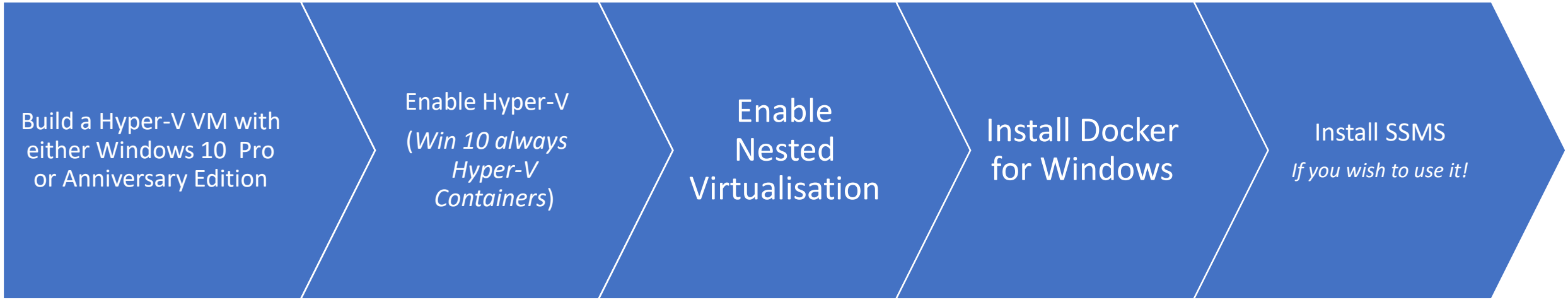
Windows 10



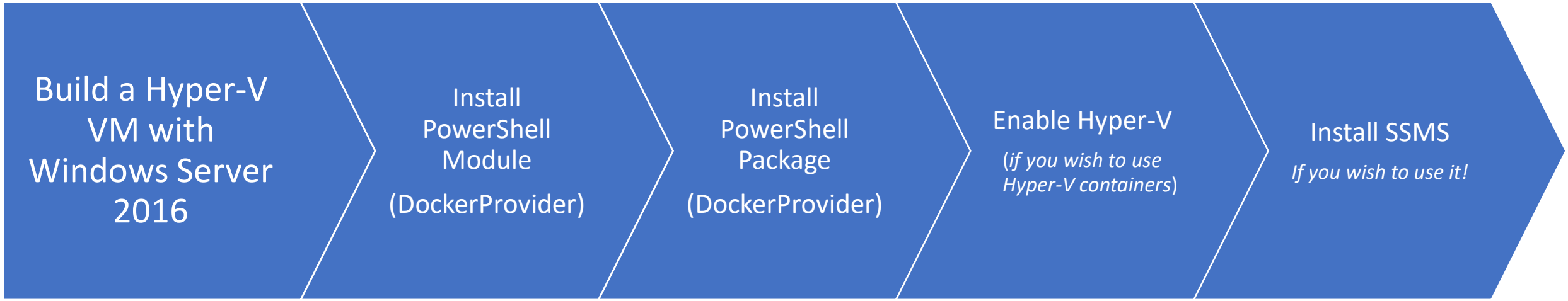
Containers on Azure



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"?
    - Did nothing for me!

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

Dockerfile
DEMO

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
    ```

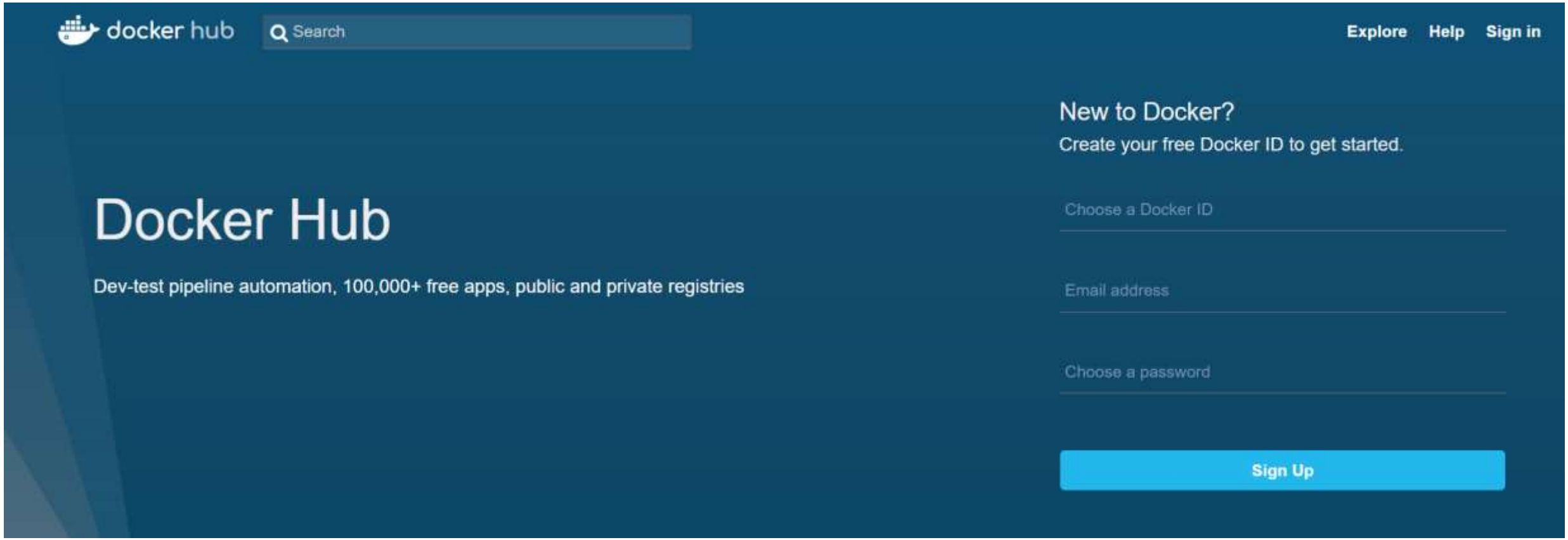
  - Tag an Image

    ```
    docker tag sqllinuxrestore:v1 sqlgeordie/sqlrepository:sqllinuxrestore
    ```

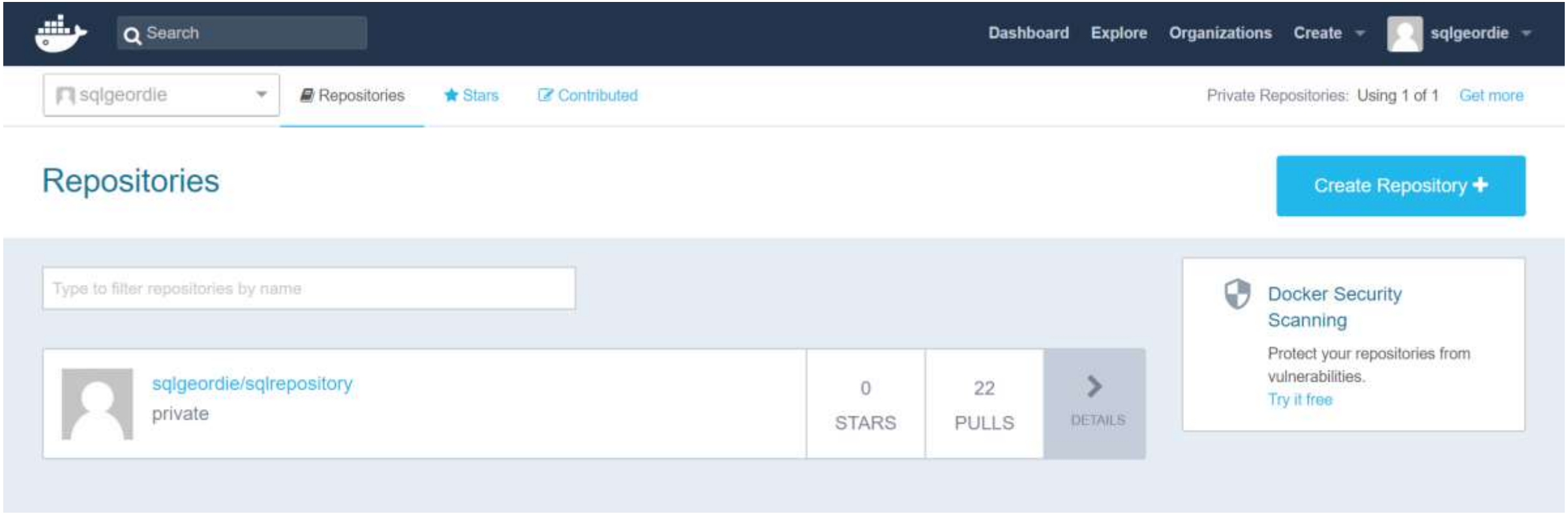
  - Push to Docker Hub

    ```
    docker push sqlgeordie/sqlrepository:sqllinuxrestore
    ```

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 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 for Windows runs on Windows 10 and is free, open-source software.
- Docker for Windows can also run a Linux VM on your machine
- Like the server version, run any number of Windows Docker containers.

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

Licensing (SQL Server)

- Licensing has not been finalised
- Express and Developer Editions are free
- Standard and Enterprise will have a cost
  - Think VM Licensing

“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
https://www.microsoft.com/en-us/sql-server/sql-server-2017-editions

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 space savings can be exceptional
- Docker Hub has 1000'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

- Briefly:
  - Logs and troubleshooting
  - Multi-Container Applications
  - Licensing
  - Performance

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