Docker on Windows Workshop

Slides ConDaysEU.bee42.com
WiFi: workshop or workshop-5g, Password: workshop2017

Intros

- Hello! I'm Dieter.

Dieter Reuter @Quintus23M, email: dieter.reuter@bee42.com

DockerConEU in Copenhagen

- Code "CaptainDieter" (-10%)

Agenda

- 10:00-11:15 part 1
- 11:15-11:30 coffee break
- 11:30-12:45 part 2
- 12:45-13:00 Q&A

Feel free to interrupt for questions at any time

Agenda

- Docker Fundamentals
- Setup Docker Engine on Windows Server 2016
- Learn about the base OS images
- Secure remote Docker access via TLS
- Networking
- Dockerfile best practices
- Persisting data using volumes

- Dockerizing a Windows application into containers

Pre-requirements

- Computer with network connection and RDP client
  - on Windows, you are probably all set
  - on macOS, get Microsoft Remote Desktop for Mac
  - on Linux, get rdesktop
- Some Docker knowledge

  (but that's OK if you're not a Docker expert!)

Nice-to-haves

- Docker Client if you want to remote control your Docker engine
  (available with Docker 4 Windows/Mac)
- GitHub account
  (if you want to fork the repo)
- Gitter account
  (to join the conversation during the workshop)
- Docker Hub account
  (it's one way to distribute images on your Docker host)

Hands-on sections

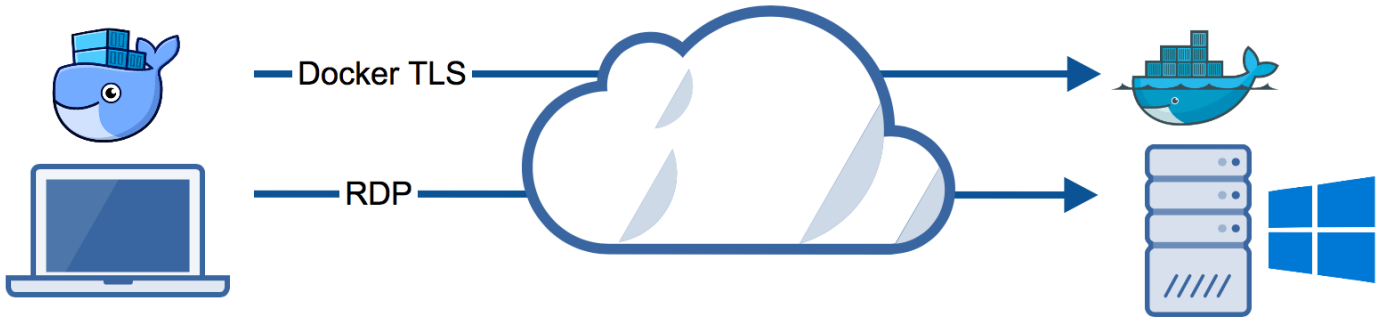
- The whole workshop is hands-on
- We will see Docker EE 17.03.0 in action
- You are invited to reproduce all the demos
- All hands-on sections are clearly identified, like the gray rectangle below

Exercise

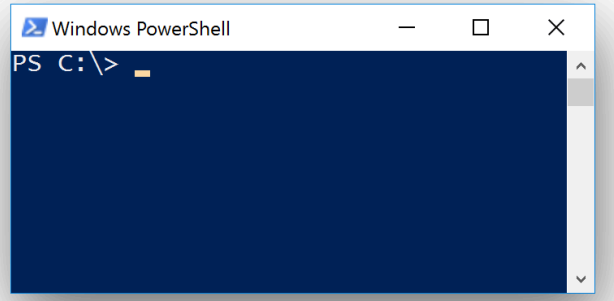
- This is the stuff you're supposed to do!
- Go to ConDaysEU.bee42.com to view these slides
- Join the chat room on gitter.im/windows-docker-workshop-containerdays2017/Lobby

We will (mostly) interact with RDP only

- We can work through the RDP session
- When we have the TLS certs, we can do it from local machine through the Docker API



Terminals



Once in a while, the instructions will say:
"Open a new terminal."

There are multiple ways to do this:

- open start menu, type `powershell` and click on the PowerShell icon
- press `[Windows] + R`, then enter `powershell` and press `[RETURN]`

You are welcome to use the method that you feel the most comfortable with.

Brand new versions!

- Docker Enterprise Edition 17.03.0
- Docker Compose 1.13.0

Exercise

- Log into your Docker host through RDP (user and password is on your card)

  `bee42-win-XX.westeurope.cloudapp.azure.com`

- Open a terminal
- Check all installed versions:

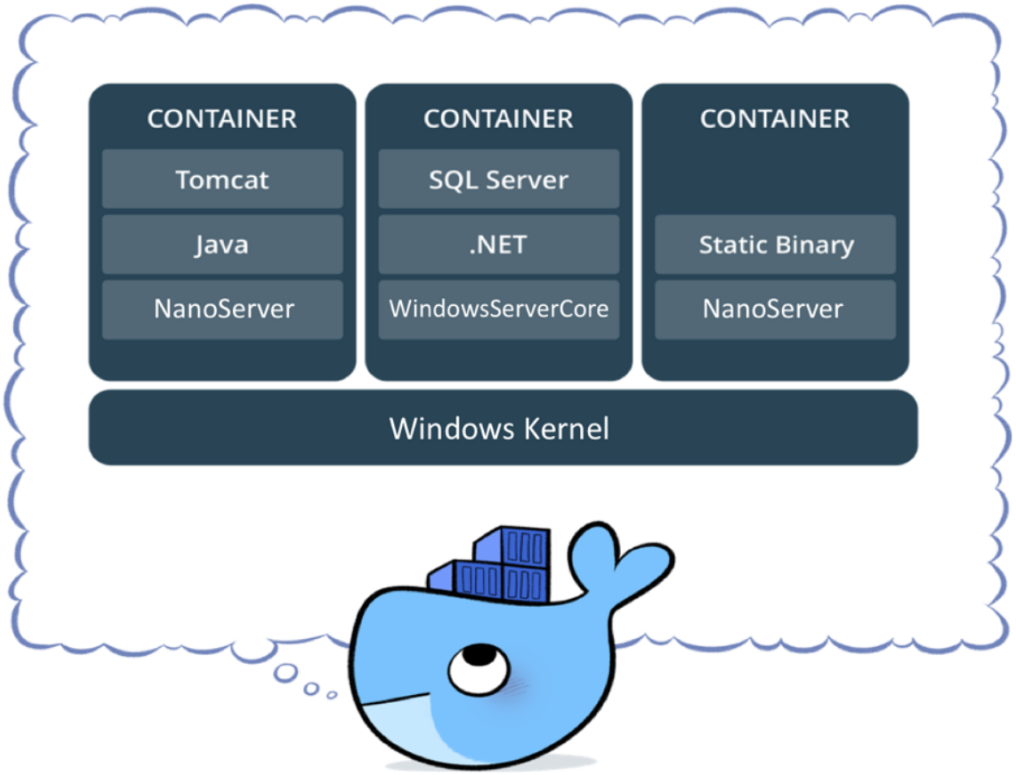
```
docker version
```

Docker Fundamentals

- Docker Host
- Docker Engine
- Docker Image
- Docker Container
- Docker Registry
- Dockerfile

What is a container?

- Standarized packaging for software and dependencies
- Isolate apps from each other
- Share the same OS kernel
- Works for all major Linux distributions
- Containers native to Windows Server 2016



Setting up Docker Host

Install Docker

- Install the Containers feature
- Install and start the Docker service

Exercise

- Install Docker and feature with Microsoft's package:

```
Install-Module -Name DockerMsftProvider -Repository PSGallery -Force
Install-Package -Name docker -ProviderName DockerMsftProvider
Restart-Computer -Force
```

https://store.docker.com/editions/enterprise/docker-ee-server-windows
https://docs.microsoft.com/en-us/virtualization/windowscontainers/quick-start/

Update your Host

- Install Windows updates for best container experience

⌨ Exercise

- Run Server Configuration:

```
sconfig
```

- Choose option >> `6` << to Download and Install Updates
- Choose option >> `A` << to download all updates

Check what you have done

- Check Docker Installation

⌨ Exercise

- Get version and basic information:

```
docker version
docker info
```

- Troubleshooting:

```
iwr https://aka.ms/Debug-ContainerHost.ps1 -UseBasicParsing | iex
```

https://github.com/Microsoft/Virtualization-Documentation

Update Docker Engine

- If there is a new version of Docker Engine available

⌨ Exercise

- Update to latest Docker Engine CS version:

```
Install-Package -Name docker -ProviderName DockerMsftProvider -Update -Force
Start-Service docker
docker version
```

Add tab completion to PowerShell

- There is a PowerShell module `posh-docker` to add tab completion for docker commands.

⌨ Exercise

- Install the `posh-docker` module and edit your `$PROFILE`

```
Install-Module -Scope CurrentUser posh-docker
notepad $PROFILE
```

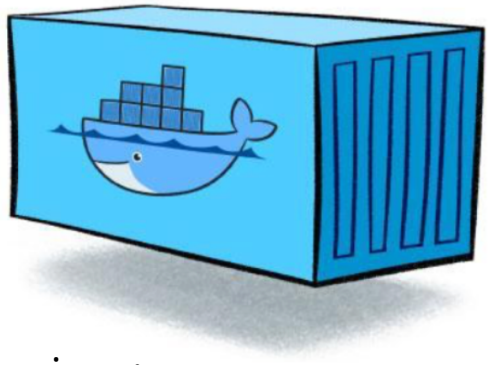
- Add the module to the `$PROFILE` and save the file

```
Import-Module posh-docker
```

- Open a new PowerShell terminal

Docker Images

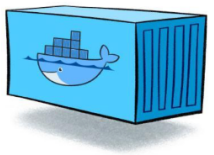
Windows base OS images



FROM microsoft/windowsservercore

- nearly full Win32 compatible
- about 9 GByte
- Download once, Base layer shared with all Windows images

FROM microsoft/nanoserver



- fast to boot
- about 900 MByte
- software may need porting
- No 32bit, no MSI

FROM [illegible]

~~FROM scratch~~

Base OS images

- Provided by Microsoft through the Docker Hub
- All Windows Docker images are based on one of these two OS images

Exercise

- Pull or update to latest Windows base OS images:

```
docker image ls
docker image pull microsoft/nanoserver
docker image pull microsoft/windowsservercore
```

Working with images

⌨ Exercise

- Inspect an image:

```
docker image inspect microsoft/windowsservercore
```

- Tag an image:

```
docker image tag microsoft/windowsservercore myimage
docker image tag microsoft/windowsservercore myimage:1.0
docker image ls
```

Containers

Docker Image vs. Container

Image

- Static snapshot of the filesystem and registry

Container

- Runtime environment for processes based on an image

Exercise

```
docker image --help
docker container --help
```

Run your first container

- Each container has its own environment
  - Host name
  - IP address
  - Environment variables
  - Current directory

Exercise

```
docker container run microsoft/nanoserver hostname
docker container run microsoft/nanoserver ipconfig
docker container run microsoft/nanoserver cmd /c set
docker container run microsoft/nanoserver cmd /c cd
```

How many containers have you run?

How many containers have you run?

- Answer: 4 (at least)

Listing containers

- Each container has a container ID
- You can give them a name
- You can see if a container is running
- You can see the exit code of a container

Exercise

- List running containers

```
docker container ls
```

- List also exited containers

```
docker container ls -a
```

View the logs of containers

- You can see the logs, even after container has exited

⌨ Exercise

- Get container ID of last container

```
docker container ls -lq
```

- Show output of last container

```
docker container logs $(docker container ls -lq)
```

Modifying files in containers

- You can see what has changed in the filesystem

⌨ Exercise

- Run a container that creates a file `test1.txt`

```
docker container run microsoft/nanoserver powershell -command Out-File test1.txt
```

- Show the differences between the container and the image

```
docker container diff $(docker container ls -lq)
```

Analyzing the diff

- What are all the other file differences?

Analyzing the diff

- What are all the other file differences?
  - Windows processes write into files and registry
  - Other Windows services are running
- Have you created the file `test1.txt` on your Docker Host?

Analyzing the diff

- What are all the other file differences?
  - Windows processes write into files and registry
  - Other Windows services are running
- Have you created the file `test1.txt` on your Docker Host?
  - No, only inside that single container

⌨ Exercise

- List current dir and `C:\` on your Docker Host

```
dir
dir C:\
```

Longer running processes

⌨ Exercise

- Run a container with a longer running process

```
docker container run microsoft/nanoserver ping -n 30 google.de
```

- Try to abort the container with `[CTRL] + C` and list containers

```
docker container ls
```

- You only aborted the Docker client, not the container

Interacting with containers

- Use `-it` to interact with the process in the container

⌨ Exercise

- Run a container with a longer running process

```
docker container run -it microsoft/nanoserver ping -n 30 google.de
```

- Try to abort the container with `[CTRL] + C` and list containers

```
docker container ls
```

Run an interactive container

- You also can work interactively inside a container

⌨ Exercise

- Run a shell inside a container

```
docker container run -it microsoft/nanoserver powershell
ls
cd Users
exit
```

Run containers in the background

- Use `-d` to run longer running services in the background

Exercise

- Run a detached "ping service" container

```
docker container run -d microsoft/nanoserver powershell ping -n 300 google.de
```

- Now list, log or kill the container

```
docker container ls
docker container logs $(docker container ls -lq)
docker container kill $(docker container ls -lq)
```

Cleaning up your containers

⌨ Exercise

- You can automatically remove containers after exit

```
docker container run --rm microsoft/nanoserver ping google.de
```

- You can remove containers manually by their names or IDs

```
docker container rm $(docker container ls -lq)
```

- You can remove all stopped containers

```
docker container prune
```

Docker Registry

Re-use the work of others

- The Docker Hub is a public registry for Docker images

⌨ Exercise

- Search of images with the Docker client

```
docker search microsoft
docker image pull microsoft/iis:nanoserver
```

- Go to https://hub.docker.com and search for images

Run images from Docker Hub

- Docker Hub is a place for Linux, Intel, ARM, Windows, ...

⌨ Exercise

- Try to run this PowerShell

```
docker container run -it microsoft/powershell
```

Run images from Docker Hub

- Docker Hub is a place for Linux, Intel, ARM, Windows, ...

⌨ Exercise

- Try to run this PowerShell

```
docker container run -it microsoft/powershell
```

- Only Windows images can be run on Windows Docker Hosts
- Only Linux images can be run on Linux Docker Hosts

Run IIS web server

- Microsoft has some Windows application images

⌨ Exercise

- Try to run this PowerShell

```
docker container run -d --name iis -p 80:80 microsoft/iis:nanoserver
```

- Now **on your local computer**, open a browser
  - http://bee42-win-XX.westeurope.cloudapp.azure.com

Windows Containers don't do loopback

- At the moment you can't reach the published port 80 from the Docker Host

Exercise

- Try to open the web site **from the Docker Host**

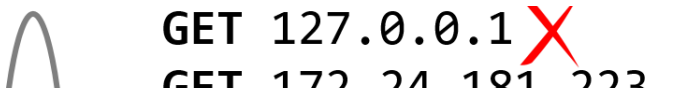
```
start http://localhost
```

- Or use the container IP address from the Docker Host

```
docker container inspect -f '{{.NetworkSettings.Networks.nat.IPAddress}}' iis
start http://$(docker inspect -f '{{.NetworkSettings.Networks.nat.IPAddress}}' iis
```

Windows Containers don't do loopback

- https://blog.sixeyed.com/published-ports-on-windows-containers-dont-do-loopback/



A closer look into IIS container

- The IIS is serving a standard welcome page.
- Let's enter the container and look behind the scenes.

Exercise

- Execute an interactive shell inside the still running IIS container

```
docker container exec -it iis powershell
```

- Go to the default folder with the web content of IIS

```
cd C:\inetpub\wwwroot
dir
```

- Modify the `index.html` file, but there is no editor :-(So `exit` the terminal again.

Serving own content with IIS

- The welcome page is nice, but we want to serve own content with IIS.

Exercise

- Open an editor on your Docker Host and create a local file `iisstart.htm`

```
<html><body>Hello from Windows container</body></html>
```

- Copy that file `iisstart.htm` into the running container

```
docker container cp iisstart.htm iis:C:\inetpub\wwwroot
```

- Reload your browser

Create a first own Docker image

- We have changed a container. Can we build a static image out of it?

⌨ Exercise

- Commit the changes of the container into a new image

```
docker container commit iis mywebsite
```

- Stop the running IIS container as we cannot commit while running

```
docker container stop iis
docker container commit iis mywebsite
```

- List the Docker images

Run your first own container

- You have created your first image `mywebsite`.
- Now run a new container with it.

⌨ Exercise

- Run your own website in a container

```
docker container run -d -p 80:80 --name web mywebsite
docker container ls
```

- Now **on your local computer**, open a browser
  - http://bee42-win-XX.westeurope.cloudapp.azure.com

Kill the container again

- Do some housekeeping and kill the container again

⌨ Exercise

- Kill and remove the container

```
docker container kill web
docker container rm web
```

Dockerfile

Describe how to build Docker images

- A `Dockerfile` is a text file with the description how to build a specific Docker image.
- Make the result repeatable by others.
- Or could you describe how to modify the IIS start page?

Build your first Dockerfile

- Now put the pieces together and write a `Dockerfile` for the `mywebsite` image

Exercise

- Open an editor and create a `Dockerfile`

```
FROM microsoft/iis:nanoserver
COPY iisstart.htm C:\inetpub\wwwroot
```

- Now build a new Docker image

```
docker image build -t bettersite .
```

- List Docker images and check image sizes

Check what you have built

- Run a new container with the new image

⌨ Exercise

- Run your better website

```
docker container run -d -p 80:80 --name web bettersite
```

- Check the web site in your browser.

What went wrong?

- The IIS still publishes the standard welcome page. But why?
- Let's inspect the image to understand what happened

Exercise

- Inspect the `bettersite` image

```
docker image inspect bettersite
```

- You may find a line with

```
"#(nop) COPY file:6ef0...1d5c in C:inetpubwwwroot "
```

- Seems that we have problems with Windows paths.

https://blog.sixeyed.com/windows-dockerfiles-and-the-backtick-backslash-backlash/

Escape the problem

- In a `Dockerfile` you can use a `\` backslash for line continuation.
- To produce a real backslash we have to use two `\\` backslashes.
- A better way is to switch to the PowerShell escape sign backtick.
- This is done with a comment in the first line.

Exercise

- Open an editor and edit the `Dockerfile`

```
# escape=`
FROM microsoft/iis:nanoserver
COPY iisstart.htm C:\inetpub\wwwroot
```

https://docs.docker.com/engine/reference/builder/#/escape

Rebuild your Docker image

- Rebuild and run

⌨ Exercise

- Kill the old web container, then rebuild and run a new container

```
docker container kill web
docker container rm web
docker image build -t bettersite .
docker container run -d -p 80:80 --name web bettersite
```

- Check the web site in your browser.

Other useful commands

- Show disk usage
- Clean up old images and containers

⌨ Exercise

- Cleanup your host system and check sizes before and afterwards

```
docker system df
docker system prune
docker system df
```

Secure remote

Docker access via TLS

Working with Docker remote API

- Docker remote API on port 2375 is not encrypted
- Protect your Docker Engine
  - nobody else from the Internet can connect to it
  - no other Container can connect to it
- Use TLS certificates for client and server

DockerTLS

- OpenBSD LibreSSL tools
- PowerShell script to automate TLS cert generation
- A small containerized helper to create TLS certs for Docker Engine

http://stefanscherer.github.io/protecting-a-windows-2016-docker-engine-with-tls/

DockerTLS

Preparation steps

Exercise

- Open a PowerShell terminal as administrator
- Create a folder for the client certs

```
mkdir ~\.docker
```

- Retrieve all local IP addresses

```
$ips = ((Get-NetIPAddress -AddressFamily IPv4).IPAddress) -Join ','
Write-Host $ips
```

Run DockerTLS

Exercise

- Retrieve the public IP address

```
nslookup bee42-win-XX.westeurope.cloudapp.azure.com
```

- Run the dockertls container with local and public IP address (replace `x.x.x.x`)

```
docker container run --rm `
-e SERVER_NAME=bee42-win-XX.westeurope.cloudapp.azure.com `
-e IP_ADDRESSES=$ips,x.x.x.x `
-v "C:\ProgramData\docker:C:\ProgramData\docker" `
-v "$env:USERPROFILE\.docker:C:\Users\ContainerAdministrator\.docker" `
stefanscherer/dockertls-windows
```

Check what you have created

Exercise

- Check client certs

```
dir ~\.docker
```

- Check server certs and `daemon.json`

```
dir C:\ProgramData\docker\certs.d
cat C:\ProgramData\docker\config\daemon.json
```

Activate TLS and test connection

⌨ Exercise

- Activate the changes in `daemon.json`

```
Stop-Service docker
dockerd --unregister-service   # get rid of -H options in command line
dockerd --register-service
Start-Service docker
```

- Test the TLS protected connection

```
docker --tlsverify -H 127.0.0.1:2376 version
```

Prepare remote access

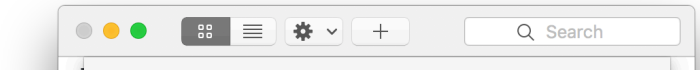
Exercise

- Open firewall

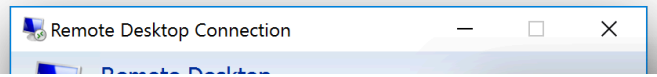
```
& netsh advfirewall firewall add rule name="Docker TLS" `
  dir=in action=allow protocol=TCP localport=2376
```

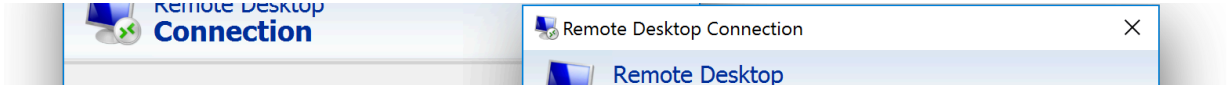
- Copy client certs back to your local machine

```
docker --tlsverify -H bee42-win-XX.westeurope.cloudapp.azure.com:2376 version
```


Search


Edit Desktop
PC Name:
dog2017-win-XX.westeurope.cloudapp


Remote Desktop Connection


Connection
Remote Desktop Connection
Remote Desktop


This PC

Networking

Networking modes

- **Network Address Translation (NAT)**
  - each container will receive an IP address from an internal, private IP prefix
- **Transparent**
  - directly connected to the physical network
- **Overlay**
  - used to connect container endpoints across multiple container hosts
- **L2 Bridge**
  - access to physical network with MAC address translation

Listing networks

- Default network is `nat`, there is also a `none` network.

Exercise

- List all networks on the host

```
ipconfig
```

- The `vEthernet (HNS Internal NIC)` ethernet adapter is used by Docker containers
- List all container networks

```
docker network ls
```

Networking modes

Exercise

- Run a container with network

```
docker container run microsoft/nanoserver ipconfig
```

- Run a container without a network

```
docker container run --network none microsoft/nanoserver ipconfig
```

DNS in Container network

- Container can lookup each other with DNS

⌨ Exercise

- Run IIS again, as well as an interactive container

```
docker container run --name iis -p 80:80 -d microsoft/iis:nanoserver
docker container run -it microsoft/nanoserver powershell
```

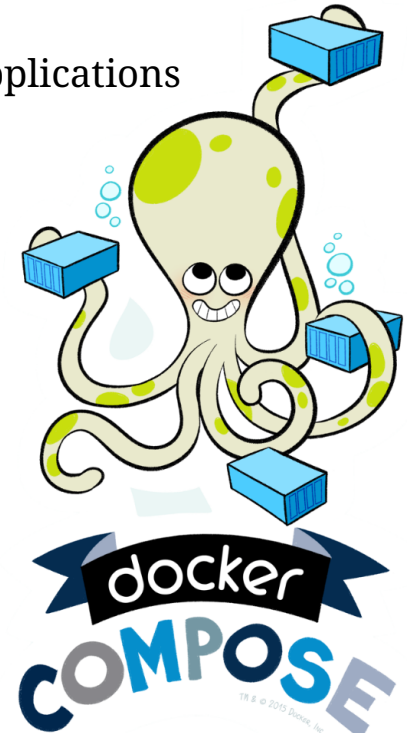
- Now inside the container, try to access the IIS web server by its DNS name

```
Invoke-WebRequest http://iis
```

- Don't forget to kill and remove the IIS container again.

Using Docker Compose

- A tool from Docker
- Define and run multi-container applications



Installing Docker Compose

- Docker for Mac/Docker for Windows already has Docker Compose installed
- Installation on Windows Server 2016

⌨ Exercise

- If you have Chocolatey package manager

```
choco install docker-compose
```

- Otherwise download binary manually from https://github.com/docker/compose/releases

The Compose file

- Docker Compose uses a `docker-compose.yml` file to define multiple services
- Define services in a Compose file

```
version: '2.1'
services:
  web:
    image: microsoft/iis:nanoserver
    ports:
      - 80:80
```

- Always append this to use the default nat network

```
networks:
  default:

    external:
      name: nat
```

Building images with Compose

- Docker Compose can use a `Dockerfile` per service to build an image locally
- Use `build:` instead of `image:`

```
version: '2.1'
services:
  web:
    build: .
    ports:
      - 80:80
```

Networking with Compose

- The service names can be used to lookup them with DNS

```
services:
  web:
    image: microsoft/iis:nanoserver
    ports:
      - 80:80

  client:
    image: microsoft/nanoserver
    command: powershell -Command Invoke-WebRequest http://web
```

Practice DNS lookups with Compose

- We replay the manual test of IIS and a client container with Compose.

⌨ Exercise

- Create a new folder

```
mkdir dnstest
cd dnstest
```

- Create a `docker-compose.yml` file to test DNS lookups

```
notepad docker-compose.yml
```

Exercise

- Create the `docker-compose.yml` with these two services

```
version: '2.1'
services:
  web:
    image: microsoft/iis:nanoserver
    ports:
      - 80:80

  client:
    image: microsoft/nanoserver
    command: powershell -Command Sleep 2 ; Invoke-WebRequest http://web
    depends_on:
      - web

networks:
  default:
    external:
      name: nat
```

Run the first containers with Compose

- Compose can run all containers defined with one command

Exercise

- Check the usage of `docker-compose`

```
docker-compose --help
```

- Run all containers

```
docker-compose up
```

- Press `[CTRL] + C` to stop all containers
- If client could not invoke the web request, try it again.

Run containers in the background

- Compose can run containers in detached mode in background

⌨ Exercise

- Run all containers in the background

```
docker-compose up -d
```

- Check which containers are running

```
docker-compose ps
```

- Check the output of the client in its logs

```
docker-compose logs -t client
```

Networking resources

- Container Networking
- Use Docker Compose and Service Discovery on Windows
- Overlay Network Driver with Support for Docker Swarm Mode on Windows 10

Dockerfile best practices

Use single backslash

- Use the `escape` comment

```
# escape=`
FROM microsoft/iis:nanoserver
COPY iisstart.htm C:\inetpub\wwwroot
```

- The `CMD` instruction is JSON formatted. You still need double backslash there.
- Alternative: Use "unix" slashes where ever you can.
  A lot of programs can handle it.

Use PowerShell

- The default shell in Windows containers is `cmd.exe`.
- Using PowerShell gives you much more features eg. porting Linux Dockerfiles to Windows
  - Download files from the Internet
  - Extract ZIP files
  - Calculate checksums
- Example

```
# escape=`
FROM microsoft/windowsservercore
RUN powershell -Command Invoke-WebRequest 'http://foo.com/bar.zip' `
                        -OutFile 'bar.zip' -UseBasicParsing
RUN powershell -Command Expand-Archive bar.zip -DestinationPath C:\
```

Switch to PowerShell

- Use the `SHELL` instruction to set PowerShell as default shell.
- So you don't have to write `powershell -Command` in each `RUN` instruction.
- Use `$ErrorActionPreference = 'Stop'` to abort on first error.
- Use `$ProgressPreference = 'SilentlyContinue'` to improve download speed.

```
FROM microsoft/nanoserver

SHELL ["powershell", "-Command", `
  "$ErrorActionPreference = 'Stop'; $ProgressPreference = 'SilentlyContinue';"]
```

Using PowerShell in Dockerfile

- A full example to use PowerShell by default.

```
# escape=`
FROM microsoft/windowsservercore

SHELL ["powershell", "-Command", `
  "$ErrorActionPreference = 'Stop'; $ProgressPreference = 'SilentlyContinue';"]

RUN Invoke-WebRequest 'http://foo.com/bar.zip' -OutFile 'bar.zip' -UseBasicParsing
RUN Expand-Archive bar.zip -DestinationPath C:\
RUN Remove-Item bar.zip
```

Using PowerShell in Dockerfile

- A full example to use PowerShell by default.

```
# escape=`
FROM microsoft/windowsservercore

SHELL ["powershell", "-Command", `
  "$ErrorActionPreference = 'Stop'; $ProgressPreference = 'SilentlyContinue';"]

RUN Invoke-WebRequest 'http://foo.com/bar.zip' -OutFile 'bar.zip' -UseBasicParsing
RUN Expand-Archive bar.zip -DestinationPath C:\
RUN Remove-Item bar.zip
```

- What's wrong with it?

Download a temporary file

- Each `RUN` instruction builds one layer of your image.

Download a temporary file

- Each `RUN` instruction builds one layer of your image.
- Removing a file of a previous layer does not shrink your final Docker image.

Download a temporary file

- Each `RUN` instruction builds one layer of your image.
- Removing a file of a previous layer does not shrink your final Docker image.
- Combine multiple commands to have an atomic build step for eg.
  - Download - Extract - Remove

```
# escape=`
FROM microsoft/windowsservercore

SHELL ["powershell", "-Command", `
  "$ErrorActionPreference = 'Stop'; $ProgressPreference = 'SilentlyContinue';"]

RUN iwr 'http://foo.com/bar.zip' -OutFile 'bar.zip' -UseBasicParsing ; `
    Expand-Archive bar.zip -DestinationPath C:\ ; `
    Remove-Item bar.zip
```

But ...

- Use multiple `RUN` instructions while developing a Docker image
- You can benefit of layer caching.
- Downloading 1GB ZIP and doing the extract command wrong is painful.

But ...

- Use multiple `RUN` instructions while developing a Docker image
- You can benefit of layer caching.
- Downloading 1GB ZIP and doing the extract command wrong is painful.
- Experimental feature
  - `docker build --squash`
  - Squash all layers into one.
  - Use multiple `RUN` instructions to keep Dockerfile readable.
  - Docker still caches individual layers to make subsequent builds fast.

Resources for Dockerfile on Windows

- Best practises for writing Dockerfiles
- Dockerfile on Windows
- Optimize Windows Dockerfiles

Persisting data using volumes

Using volumes

- A container is not able to persist data for you.
- If you kill a container and run a new container it starts in a fresh environment.
- Volumes can be used to persist data outside of containers.

Exercise

- Write a small Dockerfile that reads and writes a file at runtime.

```
FROM microsoft/nanoserver
CMD cmd /c dir content.txt & echo hello >content.txt
```

- Build and run the container. Run it again.

```
docker build -t content .
docker run content
```

Prepare the image to have a volume mount point

- Now we prepare the Dockerfile with a workdir to add a volume at runtime.

⌨ Exercise

- Add a `WORKDIR` to have an empty folder inside the container.

```
FROM microsoft/nanoserver
WORKDIR /data
CMD cmd /c dir content.txt & echo hello >content.txt
```

- Build and run the container. Run it again.

```
docker build -t content .
docker run content
```

Adding a volume from host

- The file `content.txt` is still not persisted.
- Now add a volume from the host with the `-v` option.

Exercise

- Run the container with a volume mount point.

```
docker run -v "$(pwd):C:\data" content
```

- It shows the same output, but look at the host directory. Run another container.

```
dir
docker run -v "$(pwd):C:\data" content
```

Use the VOLUME instruction

- There is a `VOLUME` instruction in Dockerfiles.

Exercise

- Add a `VOLUME` to make it more readable.

```
# escape=`
FROM microsoft/nanoserver
VOLUME C:\data
CMD cmd /c dir c:\data\content.txt & echo hello >c:\data\content.txt
```

- Build and run the container. Run it again. Does it behave different?

```
docker build -t content .
docker run content
```

Windows volumes in practice

Empty directory

- You can mount a volume only into an empty directory.
- The `microsoft/iis` default folder `C:\inetpub\wwwroot` is not empty.

Real path problem

- Some applications try to get the **real path** of a file.
- They often fail at the reparse point.
- Use a mapped drive as a workaround.

Use a mapped drive

- This is a workaround to run Node.js sources mounted from the host

```
# escape=`
FROM stefanscherer/node-windows:7.7.3-nano

RUN npm install -g nodemon

VOLUME C:\code
RUN set-itemproperty -path `
    'HKLM:\SYSTEM\CurrentControlSet\Control\Session Manager\DOS Devices' `
    -Name 'G:' -Value '\??\C:\code' -Type String
WORKDIR G:\

CMD ["nodemon.cmd", "--debug=5858", "app.js"]
```

- The Node.js app is running in `G:\`, you still use `C:\code` for your volume.

Third-party volume driver plugins

- Tech Preview: Windows Containers Docker Volume plugin from NimbleStorage

Dockerizing a Windows application into containers

MusicStore example

- https://github.com/docker/labs/tree/master/windows/modernize-traditional-apps/modernize-aspnet
- https://github.com/aspnet/MusicStore

Thanks!

Questions?

Dieter Reuter @Quintus23M, email: dieter.reuter@bee42.com

108 / 108