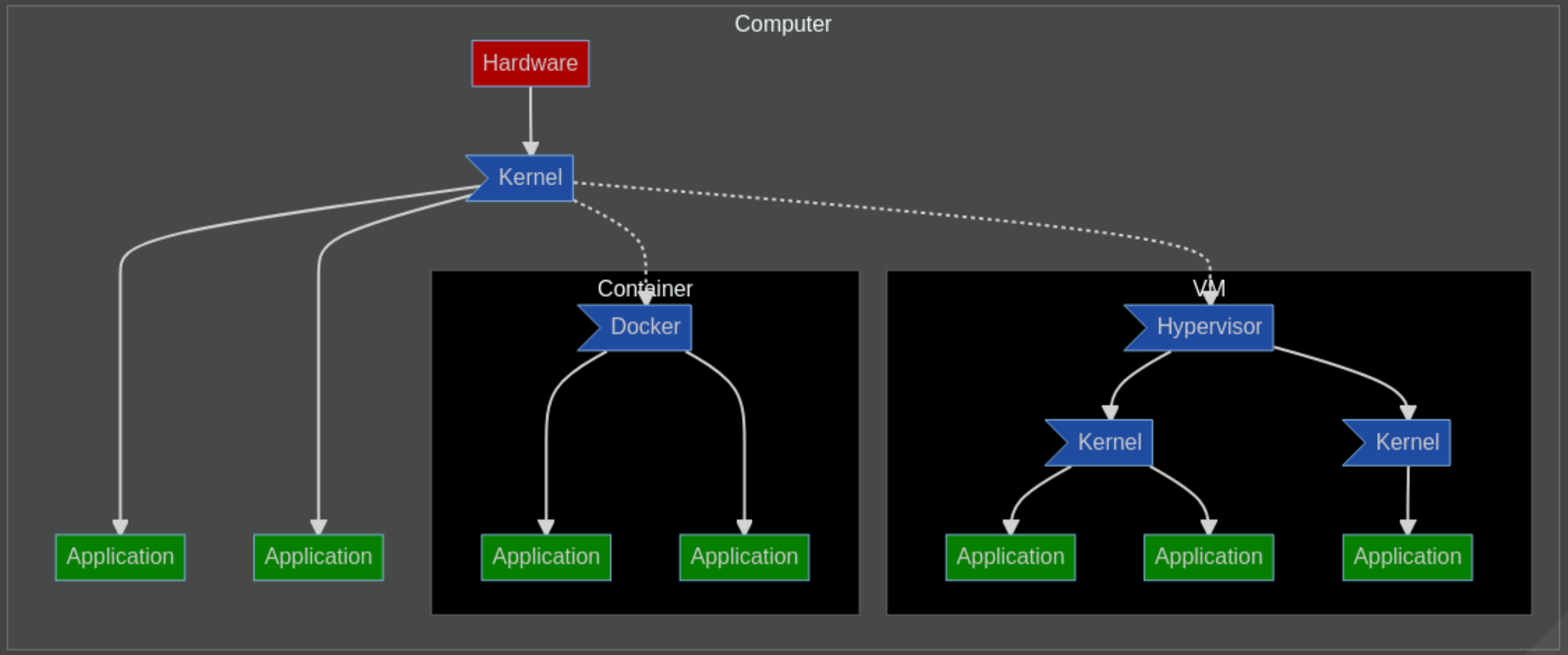
Introduction to Singularity

https://github.com/frubino/singularity-introduction

Containers

- alternative to full VM
- also called application containers
- allows to isolate an application (or system) without the overhead of a VM
- in general they share the Kernel running with the host and the rest is fully isolated
- they are used to package applications to improve reproducibility and security


Computer
Hardware
Kernel
Application
Application
Container
Docker
Application
Application
VM
Hypervisor
Kernel
Kernel
Application
Application
Application

Technologies for Containers

- Docker 
  - most used, a lot of information available online
- Singularity 
  - essentially targeted at HPC
- Kubernetes (Clusters)
  - needed to deploy multiple instances, load balance
- LXC (whole system, shared kernel only)
  - differs in the way that is more similar to a VM

Differences Docker/Singularity (1/2)

- Docker runs and builds as ***root***
  - files created owned by it
- Docker **is completely isolated** from the *filesystem*
  - you can update **fully** the system
  - and save again the image
  - so you need to *mount* host directories/files explicitly

Differences Docker/Singularity (2/2)

- Singularity runs as ***you***
  - but builds as ***root***
- The *root filesytem* is read-only
  - you **cannot** change the image
  - but **you can access** your home directory transparently

The take away message is that given an image, it is ***much easier*** to use Singularity for HPC tasks.

How do you get an image?

- both have a hub where users exchange built images
- you can use a Docker image in Singularity but not *viceversa*
- images are essentially created in steps that are run
  - in general you can image them as an *archive* file of the system
  - minus the kernel/boot/swap/devices portion
- building is fairly simple, if you have a file that defines the build

Build images (1/2)

Normally it is needed to build a container image, be it Docker of Singularity. In general there are 2 options if you do not have full access to the system. Keep in mind that you need high permissions on a system to build an image.

Build images (2/2)

1. build the image in Docker on your system
   - upload to the official Docker Hub, pull the image with Singularity `singularity pull docker://IMAGE`
   - or export with `docker image save IMAGENAME` and use `singularity build docker-archive://`
2. build a Singularity image using an online system and pull it (Cloud/Remote Build)

Cloud Build (1/2)

- Possible online using Sylabs Cloud
- found some information on Building Singularity images – Introduction to containers and Singularity
- let's use the **scratch** partition

Cloud Build (2/2)

1. create account and a token at https://cloud.sylabs.io/tokens
2. login on command line `singularity remote login` with the token
3. `singularity build -r IMAGENAME Singularity.def` to build the image
4. this makes the image from a base Docker image

Test an Image (1/3)

1. pull a simple image `singularity pull docker://alpine_latest`
2. `singularity shell alpine_latest` to open a shell
3. check that we are inside Alpine Linux `cat /etc/os-release`
4. we can read files in the usual place, but cannot modify the image `touch /test`

Test an Image (2/3)

1. run `ls` in the current directory
2. make a subdirectory `mkdir -p sin-test` and enter it `cd sin-test`
3. run `singularity shell ../alpine_latest`
4. run `ls ..` to list the content of the directory from before

Test an Image (3/3)

- You will notice that the rest of the files are missing, besides `sin-test`, because **only** the `$HOME` directory and the current directory are attached to the container when run. You can always use the `-B` option to attach another directory

Build your Image (1/3)

You need to create a *definition* file where you:

- define the base image
- list all commands to run to prepare the image
- add pre- or post- build commands

Build your Image (2/3)

Example for Prokka

```
# define that we want to start from a Docker image
Bootstrap: docker
# we want the last miniconda image as base
From: continuumio/miniconda3:latest

%environment
    # when the image is run we want this to be executed
    export PATH=/opt/conda/envs/prokka/bin:$PATH

%post
    # these are commands to build out image
    export PATH=/opt/conda/envs/prokka/bin:$PATH

    conda create --name prokka -c bioconda -c conda-forge -c defaults prokka==1.14.6
```

Build your Image (3/3)

Assuming you copied the example before in a file called `Singularity.def`, you can run:

```
singularity build -r prokka-1_14_6.sif Singularity.def
singularity exec prokka-1_14_6.sif prokka --help
```

You can see that you can now run *Prokka*

Build from a Docker file (1/3)

- Why?
  - you already have something prepared
  - Cloud build does not seem to support copying data into the image
  - testing on your system first
  - no more build time in Cloud build
  - other restrictions

Build from a Docker file (2/3)

Usually has the name `Dockerfile` it is similar to file needed for Singularity. You need to install Docker on your computer (and you need Admin privileges).

```
# Base image
FROM docker.io/continuumio/miniconda3:latest
# Install Prokka
RUN conda create --name prokka -c bioconda -c conda-forge -c defaults prokka==1.14.6
# Set the PATH Prokka's *bin*
ENV PATH /opt/conda/envs/prokka/bin:$PATH
```

Build from a Docker file (3/3)

```
# build
sudo docker build -t prokka:1.14.6 .
# test
sudo docker run --rm -it prokka:1.14.6 prokka --help
# Save images
sudo docker image save prokka:1.14.6 | gzip > prokka-1.14.6.tar.gz
# copy to Kelvin
scp prokka-1.14.6.tar.gz -i YOUKEY USER@kelvin1.qub.ac.uk
# convert into Singularity Image
singularity build prokka-1_14_6.sif docker-archive://prokka-1.14.6.tar.gz
```

Repository

- `prokka.def` the above example in **Singularity**
- `mgkit.def` for a more complex build in Cloud Build
- `Dockerfile` the equivalent in Docker of `prokka.def`
- `Singularity-Slides.md` these slides source
- `Singularity-Slides.pdf` the slides
- `diagram1.md` the diagram source

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Some Links

- Docker Hub
- Singularity Resources
- Cloud Build
- Dockerfile Reference

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