Docker deep dive

How we leverage the Docker stack

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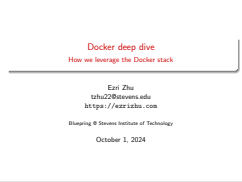
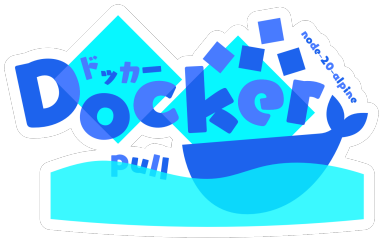
Bluepring @ Stevens Institute of Technology

October 1, 2024



1. Hello, my name is Ezri Zhu I am a second year computer science undergrad at the Stevens Institute of Technology
2. I have been the VP of tech at blueprint since last year. There will be a Q&A at the end, tho feel free to interrupt me during the presentation for questions.



- Dockerfile, Docker Images
- Docker Container
- Docker Registry
- Docker-compose

Logo credit: https://github.com/Aikoyori/ProgrammingVTuberLogos/

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1. In this talk I will do a overview of the different components of a typical docker deployment, then we'll get into how exactly we're leveraging Docker at Blueprint

What's Docker for? - The Bigger Picture

Docker simplifies software development and deployment by packaging applications and their dependencies into portable containers, that their behavior are the same across different environment.

- Developer develops their application
- Developer writes a Dockerfile, defining how to package their application in a docker container
- Developer builds the Dockerfile into an image, pushes to a registry
- Developer pulls the image from the registry on the deployment server
- At the same time, developer 2 can also pull the same image and test it on their machine

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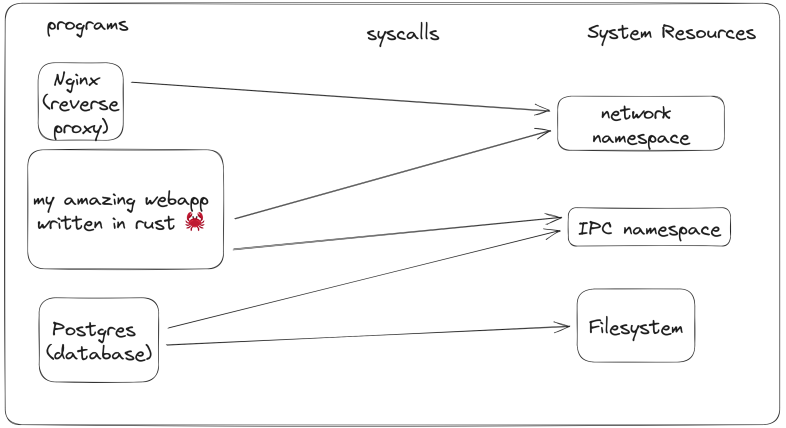
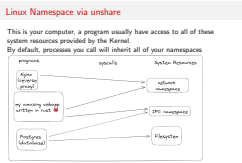
1. I will first give you a quick overview of how docker is used in a typical development cycle
2. We're mostly software developers here, and I am sure most of you have ran into the issue where someone's application doesn't work on someone elses computer
3. Those issues are usually solved by dependency issues, a certain python application may rely on a bunch of other python dependencies, and your systems package manager may also provide these packages but under different versions, thus also breaking seeemly working deployments
4. With docker, you define exactly what the environment is, from the base OS image that the container is built from, to unpacking your application

Linux Namespace via unshare

This is your computer, a program usually have access to all of these system resources provided by the Kernel.
By default, processes you call will inherit all of your namespaces

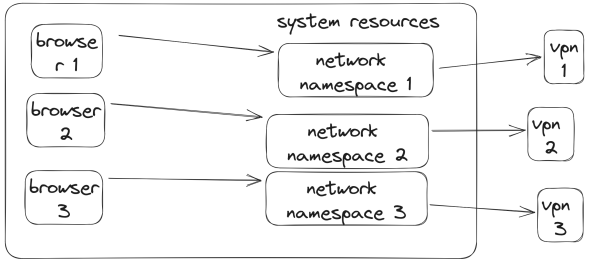




1. This is your computer, a program usually have access to all of these system resources provided by the Kernel.
2. By default, processes you call will inherit all of your namespaces, just like how when you prefix a command with sudo, it will inherit all of root's permissions
3. Here, you will notice three programs, a nginx reverse proxy, a postgres database, and my amazing webapp written in rust
4. As you can see, nginx is able to reverse proxy the webapp because they both share a network namespace
5. Then, the webapp is able to communicate with the postgres database via a socket, so that's done in the IPC namespace
6. There are other namespaces (PID, filesystem mounts, control groups, users), but we will pretend they don't exist for now for the sake of simplicity.

Linux Namespace via unshare

TD's Computer (he's a bit paranoid)

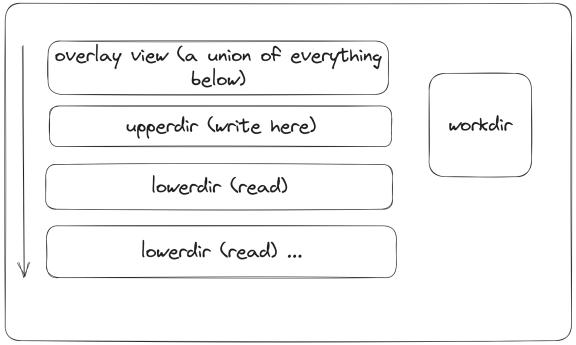


Linux Namespace via unshare

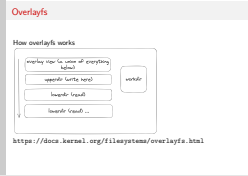
1. Here is an example of linux namespaces being used in the real world
2. TD has a computer and he really doesn't want to be tracked by ad companies and other organizations on the internet.
3. So he has three VPN setup in three separate linux network namespaces.
4. He then spawns a browser in each of the three namespaces, where he will work on different things.
5. This allows him to have three different IP addresses on the browser.

Overlayfs

How overlayfs works



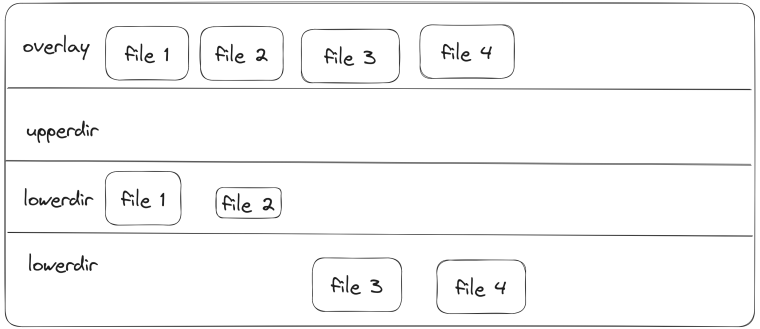
https://docs.kernel.org/filesystems/overlayfs.html



1. Overlayfs at minimum uses four directories, a lowerdir, a upperdir, a workdir, and a directry to mount the merged view of everything
2. lowerdir contains everything that were already in the system, and overlayfs will not write to it
3. the merged directory, which we labled as overlay view on the diagram, is where we will be interacting with overlayfs
4. upperdir is where overlayfs will write changes to when they are made in the merged directory.
5. workdir is where overlay stage changes to as it is copying files up from lowerdir to upperdir

Overlayfs

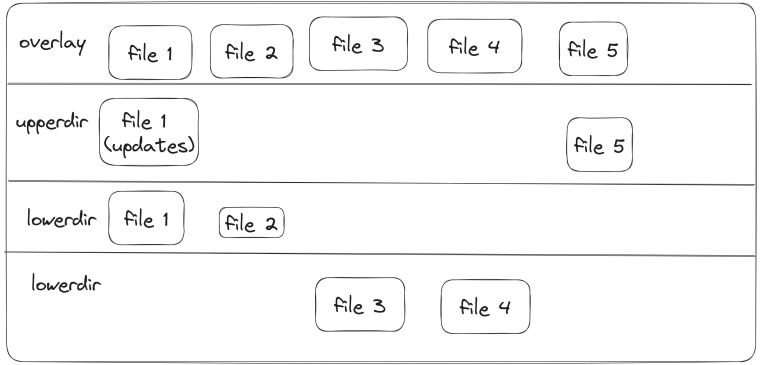
Beginning state

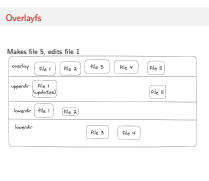


1. For example, we have two directories, lowerdir 1, and lowerdir 2, and they each contains two files
2. You don't need to have two lower-directories, and when you first start overlayfs with two lowerdirs, it will just merge the two
3. You will have to give overlayfs three empty directories, one for the upperdir, one for the workdir, and one to mount the overlay view to
4. after overlayfs is mounted to the overlay view, you are able to see the four files from the two lower directories in from the overlay view

Overlayfs

Makes file 5, edits file 1

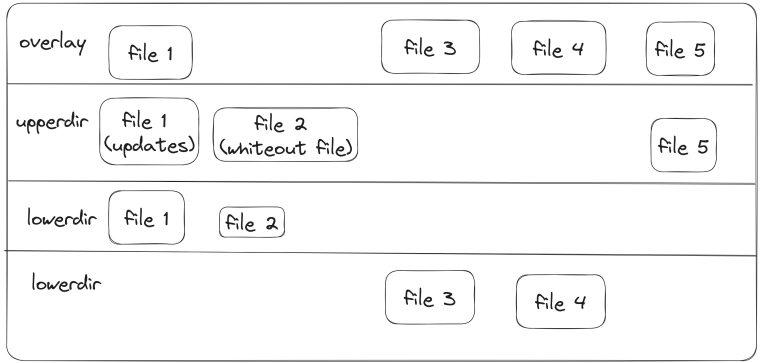




1. Here we'll make a new file called file 5, and we will edit file 1
2. As you can see, overlayfs writes the updated file 1, and creates file 5 in upperdir, leaving lowerdir alone. However, the changes are reflected in the overlay view

Overlayfs

Deletes file 2



1. Here, we will delete file two. For file deletions, overlayfs will write a character device at the location of the file that it is removing, and the file will disappear from the overlay view
2. You probably didn't understand all of that, but the main takeaway is that overlayfs allows us to stack filesystems on top of each other like a hamburger, and if we want to add some files, we just add a lettuce on the top with more files, if we want to remove some files, we add a lettuce on the top with a hole at where the file is
3. And that's how docker images are built, its just a big hamburger of layers of filesystem states

Overlayfs

```
mount -t overlay overlay \
-o "lowerdir=$lowerdir1,$lowerdir2,upperdir=$upperdir,workdir=$workdir" "$overlay"
```


Overlayfs

And this is how you start an overlay mount

Overlayfs

```
$ docker pull postgres
Using default tag: latest
latest: Pulling from library/postgres
a803e7c4b030: Pull complete
009c876521a0: Pull complete
9c412905cca2: Pull complete
6463d4bf467a: Pull complete
bd8b983728ed: Pull complete
febc167f3560: Pull complete
d73c81c4ade3: Pull complete
34b3b0ac6e9e: Pull complete
9bd86d074f4e: Pull complete
406f63329750: Pull complete
ec40772694b7: Pull complete
7d3dfa1637e9: Pull complete
e217ca41159f: Pull complete
Digest: sha256:f1aaf6f8be5552bef66c5580efbd2942c37d7277cd0416ef4939fa34bf0baf31
Status: Downloaded newer image for postgres:latest
docker.io/library/postgres:latest
```


1. And this is also how docker works, when you build a container, each line in the dockerfile is being written to it's own upperdir, with everything preceding are just lowerdirs in a merged view
2. So when you pull a docker image and run it, each layer is just a lowerdir, and your container is mounted on the overlay view

Dockerfile

A Quick Example

```
FROM node:20
WORKDIR /app
COPY . .
RUN npm i
RUN npm run build
EXPOSE 3000
CMD ["npm", "run", "start"]
```


Dockerfile

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WORKDIR /app
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1. This is a pretty standard Dockerfile for a node application, packed by npm
2. First, we pull the node:20 image, maintianed by the nice people over at nodejs, this allows us to pin our node version to be at 20
3. Second, we set the working directory to /app, this is the same as doing cd in the container

Building a docker image

docker build -t ghcr.io/stevensblueprint/project:ezri-latest .

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2. Docker images are named via labels, a image can have mutlple labels
3. Each image has a hash, it's basically the image's unique ID
4. But we can also give it a more human readable name, consisted of a path and a tag
5. usually a path denotes what the application is, such as the name of the repository
6. and a tag denotes the version that the application is

Building a docker image

```
docker build -t app .
docker tag app ghcr.io/stevensblueprint/project:ezri-latest
docker tag app ghcr.io/stevensblueprint/project:latest
docker tag app ghcr.io/stevensblueprint/project:staging
```


Building a docker image
docker build -t app .
docker tag app ghcr.io/stevensblueprint/project:ezri-latest
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Pushing a docker image

```
docker push ghcr.io/stevensblueprint/project:ezri-latest
docker push ghcr.io/stevensblueprint/project:latest
docker push ghcr.io/stevensblueprint/project:staging
```


Pushing a docker image
docker push ghcr.io/stevensblueprint/project:ezri-latest
docker push ghcr.io/stevensblueprint/project:latest
docker push ghcr.io/stevensblueprint/project:staging

1. Now, we can use docker push to push it to the docker registery
2. In our case, we're using ghcr.io, which is the github container registry
3. That's basically a place where we store our container images, and we can pull them from other places

Launching a docker container

docker run –name app-test -p 8080:8080
ghcr.io/stevensblueprint/project:ezri-latest
Full options here:
https://docs.docker.com/reference/cli/docker/container/run/

Launching a docker container
docker run –name app-test -p 8080:8080
ghcr.io/stevensblueprint/project:ezri-latest
Full options here:
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Writing a docker compose file

```yaml
services:
  redis:
    image: redis:latest
    restart: always
    ports:
      - "6379:6379"
  api:
    build:
      dockerfile: Dockerfile
      context: .
    restart: always
    ports:
      - "8080:8080"
    depends_on:
      - redis
```


Launching a docker compose

docker compose up (-d)
docker compose down
docker compose ps
docker compose logs

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Recap

Dockerfile: Defines a docker image
Docker Image: A portable runtime environment
Docker registry: A place to store docker images
Docker container: A running instance of a docker image
Docker compose: A collection of docker containers and its dependencies

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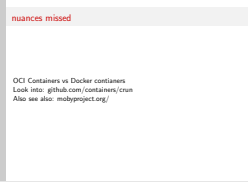
nuances missed

OCI Containers vs Docker contianers
Look into: github.com/containers/crun
Also see also: mobyproject.org/



1. docker is not the only way to do linux contianers, but for the sake of simplicity this ppt only talked ab dockers
2. Feel free to also ask about how we're using github actions to build and test, and deploy docker containers in our CI/CD workflow

related tech

firecracker MVM (orig): firecracker-microvm.github.io firecracker MVM (flyio): fly.io/blog/sandboxing-and-workload-isolation
v8 isolates (cf talk) www.infoq.com/presentations/cloudflare-v8
v8 isolates (cf security)
developers.cloudflare.com/workers/reference/security-model
v8 isolates (deno edition) deno.com/blog/anatomy-isolate-cloud
v8 isolates (deno but diff) blog.val.town/blog/first-four-val-town-runtimes
Nix, Flakes, NixOS

related tech
firecracker MVM (orig): firecracker-microvm.github.io firecracker MVM (flyio): fly.io/blog/sandboxing-and-workload-isolation
v8 isolates (cf talk) www.infoq.com/presentations/cloudflare-v8
v8 isolates (cf security)
developers.cloudflare.com/workers/reference/security-model
v8 isolates (deno edition) deno.com/blog/anatomy-isolate-cloud
v8 isolates (deno but diff) blog.val.town/blog/first-four-val-town-runtimes
Nix, Flakes, NixOS

1. basically other ways we run/scale applications
2. happy to talk ab them after the talk

Thank you!

Questions?

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