A closer look at Docker BuildKit and Buildx .

CNCF Meetup Linz

Public Cloud Group

Agenda.

01. Introduction
02. Docker Build
03. BuildKit
04. Mounts
05. Buildx
06. Docker Build Cloud
07. Questions

About Me

- Software Engineering Master @ **FH Hagenberg**
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https://github.com/sophher/cncf-docker

Goal of the Talk

- Containerized Angular App
- Lint, unit tests and build completely with Docker
- Hosted on Github
- Available on Github Codespaces
- Cloud only
- Fast and reproducible

Docker Build

- **Build, Ship and Run Any App, Anywhere**

- **Dockerfile describes the container image**
  - Base Image is picked with `FROM`
  - Application files are added with `COPY`
  - Installations and other commands can be executed with `RUN`
  - Arguments and environment variables can be defined with `ARG` and `ENV`

- **Executed with the Docker Build CLI**
  - `docker build --file Dockerfile --tag app .`

- **Build context must be given**
  - Folder, where docker gets its files from (most often ".")
  - Files can be excluded with `.dockerignore` (hashes)

DEMO 1

Docker Build

- Angular demo app
- Local build, test and lint
- Container image build with Docker

Docker BuildKit

- New build Engine of the Docker CLI
- Standalone version available
- Default since Docker Engine v23.0
- In older versions available with
  - `DOCKER_BUILDKIT=1 docker build .`
  - `/etc/docker/daemon.json`

```
{
  "features": {
    "buildkit": true
  }
}
```

- Docker daemon must be running
- Runs a build container in the background

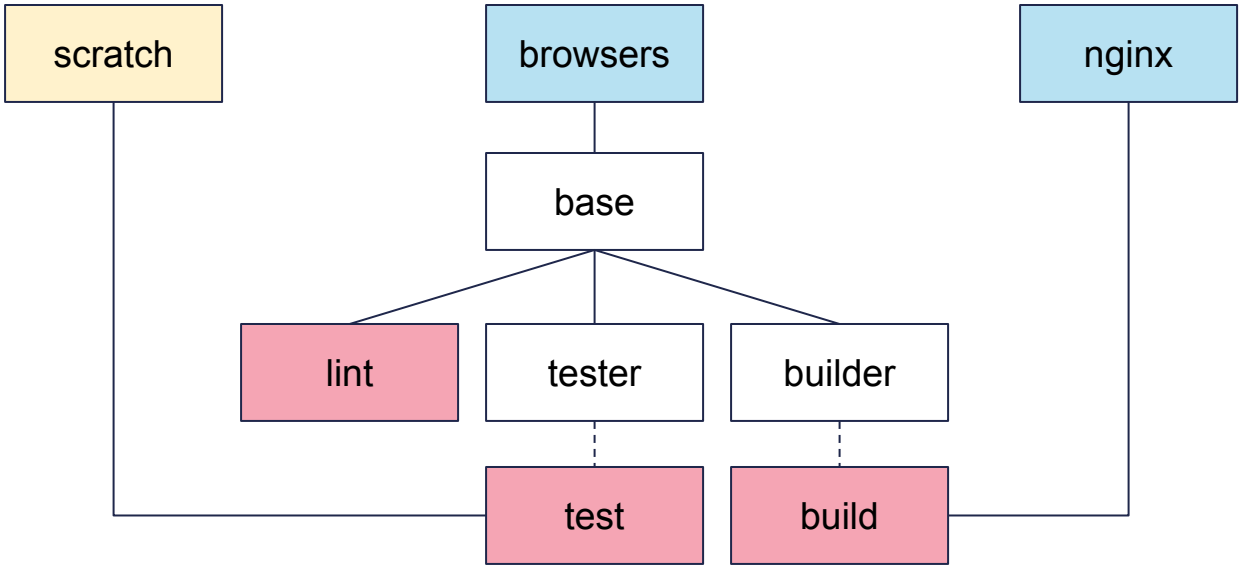
Multi-Stage Builds

- **Multiple Stages**
  - `FROM <image/stage> AS <stage>`
- **Copy files from previous stage**
  - `COPY --from=<stage>`
- **Build stage can be targeted**
  - `docker build --target <stage>`
- **Dependency Tree**
  - Enables build and download parallelization of images and stages
- **Build Layer Cache**
  - Each command (`RUN`, `COPY`, …) is cached in a layer
  - Disable the whole cache with `--no-cache`
  - Bust a cache layer and its dependents with an `ARG CACHE_BUST` and timestamp
  - `docker build --build-arg CACHE_BUST=$(date +%s) .`

Output Types

- **Docker image (default)**
- **OCI image layout**
  - `docker buildx build --output type=oci,dest=<path/to/output> .`
  - Outputs the image layers locally in a tarball
- **Cacheonly**
  - `docker buildx build --output type=cacheonly .`
  - No output
  - Useful for tests and deployments, that only have exit codes
- **Local**
  - `docker buildx build --output type=local,dest=<path/to/output> .`
  - Outputs the whole file system as folders and files
  - To pick files use `FROM scratch` with `COPY --from`
- **Tar**
  - Same as local, but the file system is compressed in a tarball
  - `docker buildx build --output type=tar,dest=<path/to/output> .`

Dependency Tree



DEMO 2

BuildKit

- Lint
- Test
- Build

Bind Mounts

- **Mount local folders into the build container**
- **Two options: read-only and read-write**
  - `RUN --mount=type=bind,source=.,target=/usr/src,ro`
  - `RUN --mount=type=bind,source=.,target=/usr/src,rw`
- **Scoped to a RUN command**
- **Not written to disk (!!!)**
  - Changes are lost when the `RUN` block is finished
  - Files to extract must be copied to an unmounted destination

Cache Mounts

- **Specify a folder, which is persistent for multiple builds or stages**
  - `RUN --mount=type=cache,id=pnpm,target=/root/.local/share/pnpm`
  - When used in multiple `RUN` commands, use an `id` as the identifier
- **Saved in the Docker cache, not in a local folder**
- **Clean with prune**
  - `docker builder prune --filter type=exec.cachemount`

Secret Mounts

- **Secret Mounts are not saved in a build layer**
- **Secret Environment Variable**
  - `RUN --mount=type=secret,id=kube`
  - `docker build --secret id=kube,env=KUBECONFIG .`
- **Secret File**
  - `RUN --mount=type=secret,id=aws`
  - `docker build --secret id=aws,src=$HOME/.aws/credentials .`
- **Secrets are mounted as files (both ENV and File)**
  - `/run/secrets/<id>`

Devcontainer

- **Development environment in a container**
- **Visual Studio Code connects remotely to this container**
- **Configured via committable JSON file in the workspace**
  - `./devcontainer/devcontainer.json`
- **Image or Dockerfile can be used as the dev environment**
  - Target can be specified
  - The same stage as in the CI/CD system can be used
- **Visual Studio Code extensions and settings are configurable**
- **Ports can be forwarded**
- **Post build steps are available**
  - e.g. `pnpm install`

GitHub Codespaces

- Online Visual Studio Code for GitHub
- Executed on a Cloud Agent
- Capable of automatic Devcontainer boot
- Secure development agents, that can be audited
- Fast onboarding

DEMO 3

Mounts

- Bind Mount
- Cache Mount
- Devcontainer
- GitHub Codespaces

Docker Buildx

- **Extended Capabilities for BuildKit**
- **Mostly experimental**
  - Continuous integration in the default build CLI
- **Multiple Platforms**
  - `docker buildx build --platform linux/amd64,linux/arm64 .`
  - QUEMU support
- **Local and Cloud Builders**
  - Multiple builders for multiple platforms and parallelization
- **Build multiple targets with bake**
  - `docker buildx bake`
  - Bakefile
  - Hashicorp Configuration Language (HCL) possible
  - Variables and Functions
  - Target Definitions
  - Group Definitions

DEMO 4

Buildx

- Docker bake
- Local Builder

Docker Build Cloud

- **Buildx Agents in the Cloud**
  - Available for multiple platforms out of the box
  - High parallelization
  - No agent setup needed
- **Docker Cache in the Cloud**
  - CI agents and local clients can use the cache
- **Tightly integrated in the Docker CLI**
  - GUI Docker Desktop
  - CLI Plugin https://github.com/docker/buildx-desktop (!!!)

GitHub Actions

- **CI/CD System for GitHub**
- **Actions for Docker Build Cloud are available**
  - `docker/login-action@v3`
  - `docker/setup-buildx-action@v3`
  - `docker/build-push-action@v6`
  - `docker/bake-action@v6`
- **Configurable with workspace yaml file**
  - `./.github/workflows/<name>.yml`

DEMO 5+6

Docker Build Cloud

- Docker Cloud build on dev system
- Docker Cloud build with GitHub Actions

Why build with Docker? – Pros

- **Build Infrastructure as Code**
  - Tools and versions are defined in the Dockerfile
  - Local and CI tooling are exactly the same
  - Pull Requests are easy when tool versions have to change
  - Builds are reproducible
- **Build agent images can be kept minimal**
  - Only Git and Docker must be installed
  - Can be run on different systems
- **Caching can be leveraged for faster builds**
  - Cloud caches for even more cache hits locally and on CI
- **Fast onboarding**
  - No local tool installation necessary
  - No version mismatches
  - No setup needed when using Codespaces + Devcontainer

Why not build with Docker? – Cons

- **Verbosity and awkward workarounds**
  - Output Types and FROM scratch
  - Cachebust
  - Mounts
- **Monorepo build tools and Docker daemon**
  - Docker in Docker
  - Daemonless (podman/buildah)
- **CI/CD only easy with Docker Build Cloud**
  - Build Agent Cleanup necessary (cache)
  - CPU and memory for Docker must be limited
  - Parallelization is difficult
- **Dockerfile maintenance**
  - Use Renovate or Dependabot
- **Dockerfile duplications in multi-repos**
  - No include statement
  - Base Image needed

Questions?

https://github.com/sophher/cncf-docker

GET IN TOUCH WITH US

Let's work together.

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