# How Linkerd Transforms Code into Running Software

# **By Tarun Pothulapati**

## About Me

- 🔹 I'm Tarun Pothulapati 👋
- One of the Maintainers of <u>Linkerd</u>, which is a <u>CNCF</u> Incubated Service Mesh Project.
- Currently, Working at <u>Buoyant</u>.
- Prev: Intern at CNCF, working on Linkerd.
- Primarily writes Golang, with some Rust recently.
- Find me at <u>tarun.xyz</u>

## Automated Testing, Building and Deployment

- Increases Developer Velocity.
- Helps you ship with Confidence.
- Removes the failure points between writing code and deployment.
- Automate mundane stuff.
- Streamlined Delivery Process.

# CI/CD for OSS Projects

P.S: It's even more important

- Stakeholders are across companies and timezones.
- Standardized processes
   >> Individual Magic.
- Reduce burden on Maintainers.



Ultralight, ultrafast, security-first **service mesh** for Kubernetes.

- **4+** years in production
- 5,000+ Slack channel members
- **10,000+** GitHub stars
- **200+** contributors
- Weekly edge releases
- **Open governance**, neutral home





### Linkerd 2.x architecture



## Requirements

- Should accommodate docker, kubernetes and other container technologies.
- Integrates well with existing GitHub primitives i.e Checks, events, etc.
- Uses a simpler authn and authz model.
- A pipeline apps Ecosystem to re-use commonly needed workflow logics i.e docker push, etc.
- Builds on the same mantra of everything done in the Open.

## **GitHub Actions**

# Workflows

A configurable automated process made up of multiple jobs Workflows New workflow All workflows Contegration tests 2 Release 2 Static checks Lo Unit tests

# Builds

What happens when you raise a PR?

- Static Checks + Unit Tests + Integration Tests
- Invoked for all pull requests.

# **Release Workflow**

Code -> Artifacts

- Unit Tests + Release
- Invoked for tag pushes

## **Static Checks**



### •••

name: Static checks
on:
 pull\_request: {}
 push:
 paths-ignore:
 - '\*.md'
 - '\*\*/\*.md'
 branches:
 - main
jobs:
...



### •••

name: Unit tests
on:
 pull\_request: {}
 push:
 paths-ignore:
 - '\*.md'
 branches:
 - main
jobs:
...

## **Integration Tests**

\_ \_ \_

| puintequest                     |         |                                                        |         |
|---------------------------------|---------|--------------------------------------------------------|---------|
| atrix: docker_build             |         |                                                        |         |
| 🕑 Docker build (proxy)          | 1m 19s  | • Static CLI tests (windows) 3m 16s                    |         |
| Ø Docker build (controller)     | 1m 14s  | Matrix: integration_tests                              |         |
| Ø Docker build (metrics-api)    | 1m 11s  | <ul> <li>Integration tests (cluster-domain)</li> </ul> | 6m 22   |
| Ø Docker build (web)            | бт 42s  | Integration tests (deep)                               | 16m 22  |
| Ø Docker build (cni-plugin)     | 1m 24s  | Integration tests (external-issuer)                    | 8m 9:   |
| 🥏 Docker build (debug)          | 1m 2s   | Integration tests (external-prometheus-deep)           | 18m 43  |
| 🤣 Docker build (cli-bin)        | 12m 26s | Integration tests (external-resources)                 | 6m 55:  |
| 🥏 Docker build (grafana)        | 49s     | Integration tests (helm-deep)                          | 19m 29  |
| Ø Docker build (jaeger-webhook) | 1m 7s   | Integration tests (helm-upgrade)                       | 7m 55:  |
| 🥑 Docker build (tap)            | 1m 8s   | Integration tests (multicluster)                       | 11m 20: |
|                                 |         | Integration tests (uninstall)                          | 5m 29   |
|                                 |         | Integration tests (upgrade-edge)                       | 7m 17   |
|                                 |         | Integration tests (upgrade-stable)                     | 6m 55   |

Integration tests (cni-calico-deep)

19m 30s

## **Docker Builds**

- Linkerd involves multiple components of which some of them get individual Dockerfiles.
- Bash Scripts are available to make docker builds simpler both for the User and CI.
- <u>GitHub Action Cache</u> is used to speedup builds by caching layers and reusing them <u>across the branches hierarchy</u> <u>meaning external PR's can re-use main's cache</u> giving them a first-class experience.
- <u>Docker BuildKit</u> further improves build performance.
- All Docker images are also published as PR artifacts

### **Github Action Artifacts**

- Images are packaged into a zip file and are published as Action artifacts.
- These images can be loaded into a Kubernetes cluster by using a helper script.
- Makes it easy for users who can't run the whole build process locally.

#### Artifacts

Produced during runtime

| Name           | Size   |   |
|----------------|--------|---|
| image-archives | 1.1 GB | Û |

#### •••

tarun in dev in on kind-kind () linkerd2 on \$ tarun/ext-hint-anchors [\$?] via \$ v1.15.4
) ./bin/install-pr 5436

## Spinning Up Kubernetes Clusters

- Linkerd uses k3d as the default kubernetes distribution to run integration tests.
- Integration tests written in Golang take no dependency on the k8s dist, which means underlying k8s dists can always be swapped.
- Most of these distributions have a way to load locally built images into the cluster. `./bin/image-load` script makes it further easier.

# Written in Golang, Invoked from Bash

- Integration tests are written in Golang.
- These are always invoked from Bash with sane defaults, which can be overridden.
- Same bash scripts are used by CI and User.
   Providing a consistent experience to replicate CI failures locally.

#### •••

#### 

#### .

```
#!/usr/bin/env bash
bindir=$( cd "${BASH_SOURCE[0]%/*}" && pwd )
. "$bindir"/_test-helpers.sh
handle_tests_input "$@"
if [ -n "$test_name" ]; then
 start_test "$test_name"
else
 Note: cluster-domain, cni-calico-deep and multicluster require a specific cluster configuration and
are skipped by default\n\n'
 for test_name in "${default_test_names[@]}"; do
   start_test "$test_name"
 done
  if [ $exit_code -eq 0 ]; then
 printf '\n=== PASS: all tests passed\n'
 else
   printf '\n=== FAIL: at least one test failed\n'
 exit $exit_code
fi
```

#### •••

tarun in dev in on kind-kind () linkerd2 on # tarun/ext-hint-anchors [\$?] via <sup>35</sup> v1.15.4 > ./bin/tests --name multicluster /home/tarun/linkerd2/target/cli/linux-amd64/linkerd

### •••

```
name: Integration tests
on:
  pull_request: {}
    paths-ignore:
    - '*.md'
    - '**/*.md'
    branches:
    - main
env:
  GH_ANNOTATION: true
. . .
```

## Release

\_ \_\_\_

#### release.yml

on: push



| 📀 Docker build (proxy)       |
|------------------------------|
| Ocker build (controller)     |
| 🖉 Docker build (metrics-api) |
| 🖉 Docker build (web)         |
| 🥏 Docker build (cni-plugin)  |
| 📀 Docker build (debug)       |
| Ocker build (cli-bin)        |
| 🔮 Docker build (grafana)     |
|                              |

- Oocker build (jaeger-webhook)
- Ocker build (tap)

|         | Matrix: integration_tests                              |           |                         |                                     |                                   |                                             |
|---------|--------------------------------------------------------|-----------|-------------------------|-------------------------------------|-----------------------------------|---------------------------------------------|
| 8m 46s  | <ul> <li>Integration tests (cluster-domain)</li> </ul> | 5m 30s 🛛  | Pack Chocolatey release | e 2m 47s 🔹 —— 🔍 🥑 Create GH release | 24s 🔹 🚽 🖉 Linkerd website publish | 3s 🔹 —— 🔍 🥑 Linkerd website publish c 2m 5s |
| 8m 38s  | Integration tests (deep)                               | 15m 51s   |                         |                                     |                                   |                                             |
| 9m 2s   | Integration tests (external-issuer)                    | 7m 19s    |                         |                                     | 🖉 🖌 Helm chart deploy             | 41s                                         |
| 13m 41s | Integration tests (external-prometheus                 | . 15m 56s |                         |                                     |                                   |                                             |
| 7m 54s  | Integration tests (helm-deep)                          | 15m 24s   |                         |                                     |                                   |                                             |
| 3m 5s   | Integration tests (helm-upgrade)                       | 6m 55s    |                         |                                     |                                   |                                             |
| 14m 37s | Integration tests (uninstall)                          | 5m 31s    |                         |                                     |                                   |                                             |
| 1m 3s   | Integration tests (upgrade-edge)                       | 6m 34s    |                         |                                     |                                   |                                             |
| 8m 24s  | Integration tests (upgrade-stable)                     | 7m 9s     |                         |                                     |                                   |                                             |
| 9m 6s   | Integration tests (cni-calico-deep)                    | 15m 58s   |                         |                                     |                                   |                                             |
|         |                                                        |           |                         |                                     |                                   |                                             |
|         | ARM64 integration tests 18m 0                          | s •       |                         |                                     |                                   |                                             |
|         |                                                        |           |                         |                                     |                                   |                                             |
|         | Static CLI tests (windows) 2m 52                       |           |                         |                                     |                                   |                                             |

### 

name: Release
on:
 push:
 tags:
 \_ "\*"
env:
 GH\_ANNOTATION: true
jobs:
...

## **Release Workflow**

- Includes the same docker builds and Integration Tests.
- Some of the Integration Tests are also ran on a external ARM cluster. (The CI ssh's into the ARM VM in a cloud provider and runs the same scripts)
- Binaries are published into GitHub Releases and Chocolatey (Windows)
- Helm Charts are deployed into a GCP Bucket (Waiting for GH Packages to support Helm Charts)
- Website is updated about the release.
- Only thing done by the maintainer is to send out the release announcements ;)

# **GitHub Packages**

| 11 packages     11 pac |                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| Deproxy edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>⊻</b> 6130k |
| Published on Feb 17 by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>⊻</b> 5480k |
| Controller edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>⊻</b> 3250k |
| Web edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>⊻</b> 1270k |
| Gerafana edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>⊻</b> 1170k |
| Cri-plugin edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>↓</b> 102k  |
| Gebug edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <u>↓</u> 54.8k |
| Dublished 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <u>↓</u> 10.1k |
| metrics-api edge-21.3.3     Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <u>↓</u> 7.93k |
| German edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <u>↓</u> 2.69k |
| Gaeger-webhook edge-21.3.3<br>Published 3 days ago by Linkerd                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <u>↓</u> 1.95k |

## GitHub Container Registry (ghcr)

- No need to manage external registry secrets.
- OSS projects don't have to worry about paying and managing the ownership of the External Registry.
- Supports Multi-Arch
- For Linkerd, The migration from GCR(Google Container Registry) to GHCR just worked and was a very simple change.
  - controllerImage: gcr.io/linkerd-io/controller
  - + controllerImage: ghcr.io/linkerd/controller

## **Tips and Suggestions**

- Cache Docker Builds: Use <u>Github Actions cache</u>
- Embraze Parallelism: by dividing integration tests into independent jobs that can run across clusters.
- Use a lightweight Kubernetes distribution like Kind or K3d.
- Use a powerful language to write the tests, and then abstract them with Bash or Makefile, to make them user friendly and CI logic simpler.
- Use GitHub Action artifacts to publish build artifacts to reduce local builds.

## **Tips and Suggestions (Contd)**

- Use <u>GitHub Annotations</u> to make debugging test failures easier in the CI.
- Embrace GitHub Packages Registry. It just works and goes well with most OSS projects.

## **Using External Tools**

- All external tools have relevant scripts under `./bin` to retrieve and run them.
- This means that the CI has no expectations on the environment.
- If the binary is available, It will use it otherwise the script retrieves a specific version.

tarun in dev in on kind-kind () linkerd2 on B tarun/ext-hint-anchors [\$?] via 📽 v1.15.4
> ls ./bin -I "docker-\*" -I "test-\*" -I "\_\*" -I "\*-\*"
docker goimports k3d kubectl lint mkube shellcheck web
fmt helm kind linkerd markdownlint protoc tests win

| #!/usr/bin/env sh                                                                                                                                                                                                                                                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| set -eu                                                                                                                                                                                                                                                                                                                                      |
| k3dversion=v3.4.0                                                                                                                                                                                                                                                                                                                            |
| bindir=\$( cd "\${0%/*}" && pwd )<br>targetbin=\$( cd "\$bindir"/ && pwd )/target/bin<br>k3dbin=\$targetbin/.k3d-\$k3dversion                                                                                                                                                                                                                |
| <pre>if [ ! -f "\$k3dbin" ]; then     if [ "\$(uname -s)" = Darwin ]; then         os=darwin         arch=amd64     elif [ "\$(uname -o)" = Msys ]; then         os=windows         arch=amd64     else         os=linux         case \$(uname -m) in             x86_64) arch=amd64 ;;         arm) arch=arm64 ;;         esac     fi</pre> |
| <pre>mkdir -p "\$targetbin" curl -sfL -o "\$k3dbin" https://github.com/rancher/k3d/releases/download/\$k3dversion/k3d-\$os-\$arch chmod +x "\$k3dbin" fi</pre>                                                                                                                                                                               |
| "\$k3dbin" "\$@"                                                                                                                                                                                                                                                                                                                             |

# Thank You.

### Questions?

### Resources:

- Linkerd's GitHub
   Workflows
- Linkerd's <u>Build</u> docs
- Linkerd's <u>Test</u> Docs
- Linkerd's Release Docs