

IaC and GitOps in CTF Platforms

How We Automated CTF Platform And
Challenge Deployment For BrunnerCTF 2025

Mikkel Albrechtsen

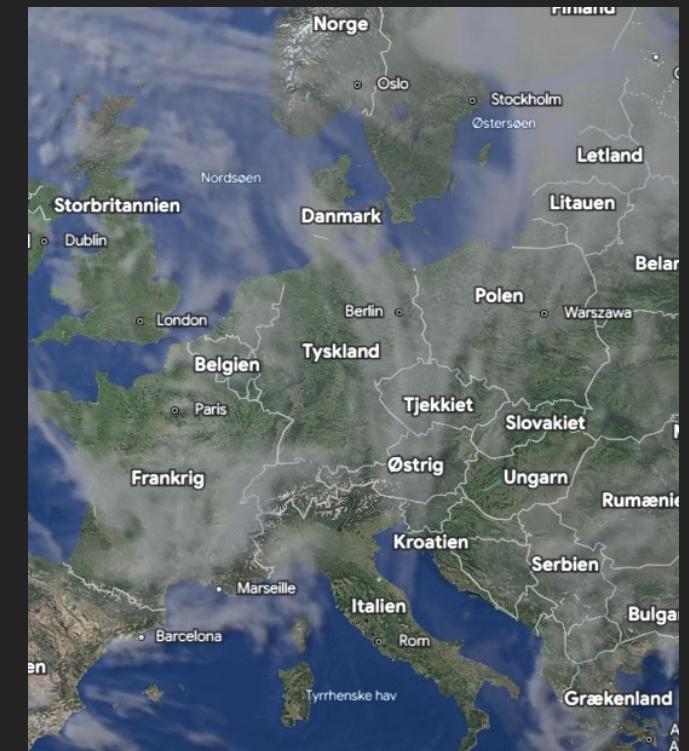


Agenda

- Whois
- CTF platforms
- My vision
- BrunnerCTF 2025 infrastructure & challenges
- Running the CTF
- Learnings
- Future work

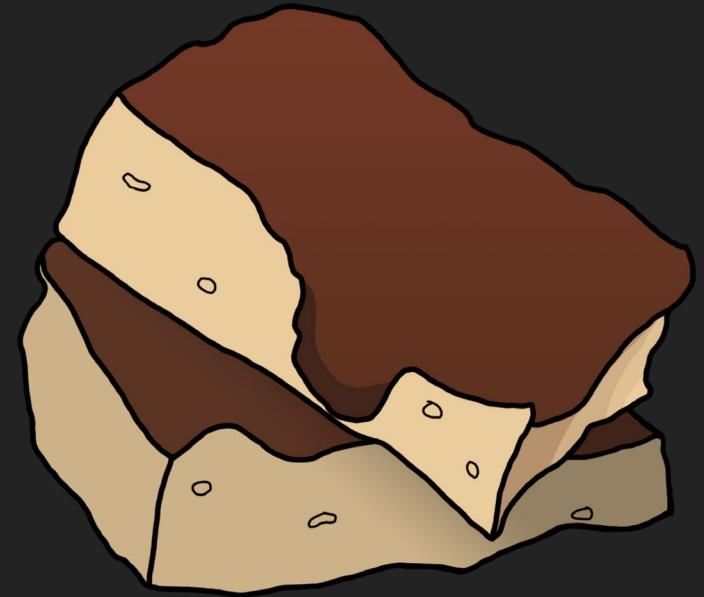
Whoami

- Mikkel Albrechtsn
- Software engineering student @ SDU
- Software developer
- Infrastructure enthusiast
- Admin in Brunnerne



Brunnerne

- Danish CTF Team
- Members from all corners of Denmark and life
- CTFTime: 206
- Website: brunnerne.dk



CTFs & CTF Platforms

What does a CTF consist of

- Four pillars

What does a CTF consist of

Planning

What does a CTF consist of

Planning

Challenges

What does a CTF consist of

Planning

Challenges

Infrastructure

What does a CTF consist of

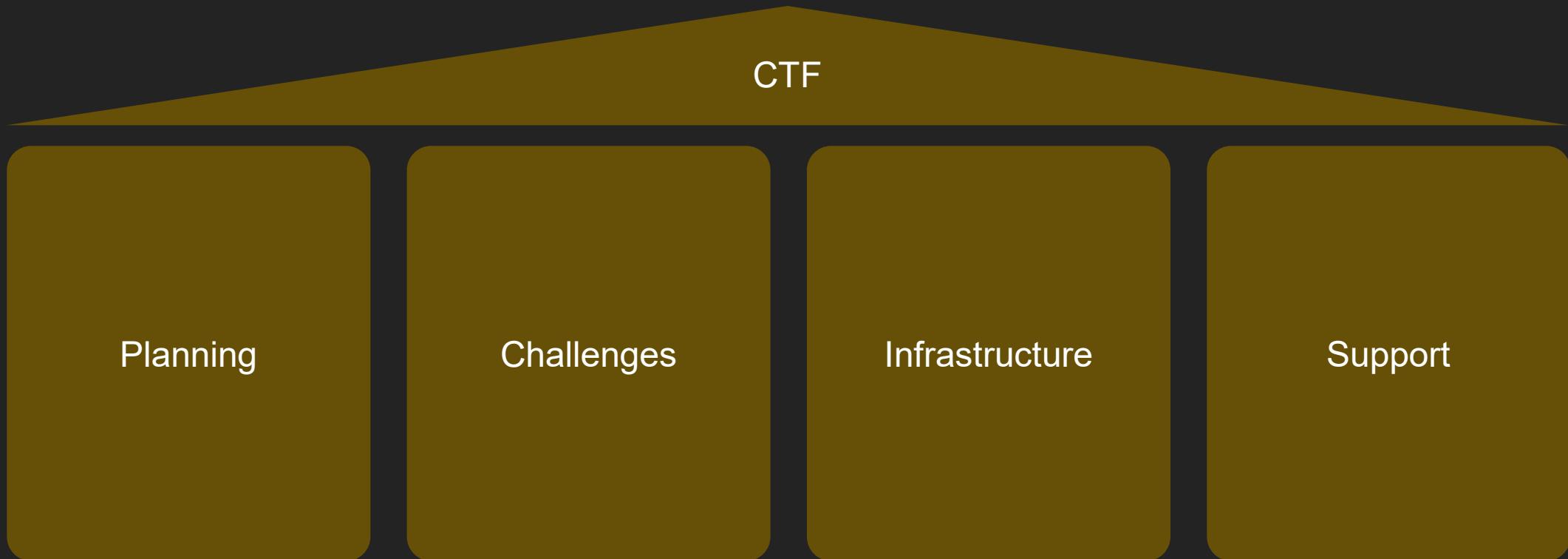
Planning

Challenges

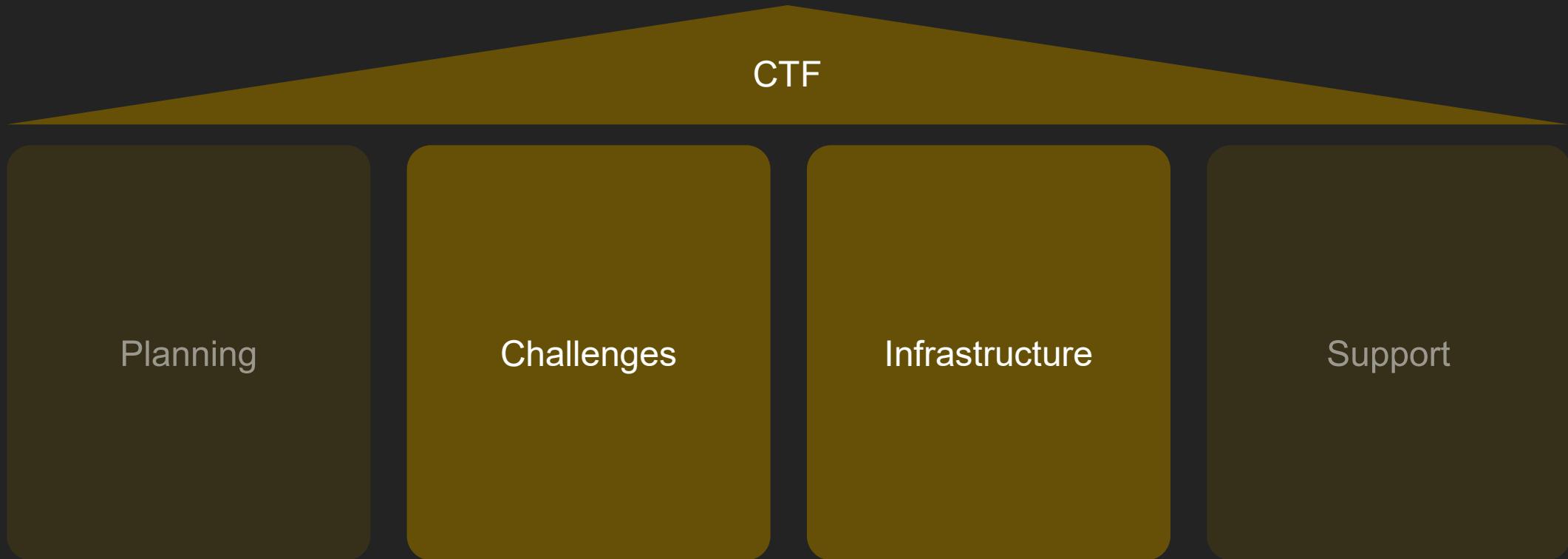
Infrastructure

Support

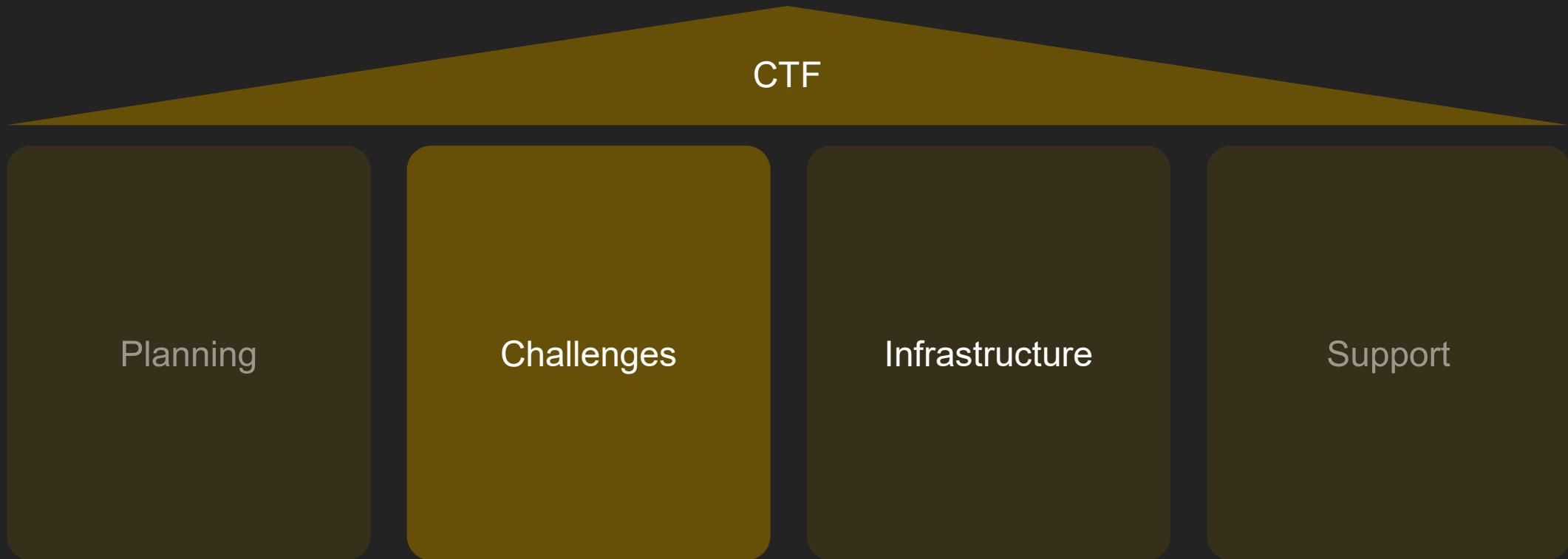
What does a CTF consist of



What does a CTF consist of



What does a CTF consist of



What does a CTF consist of

Challenges

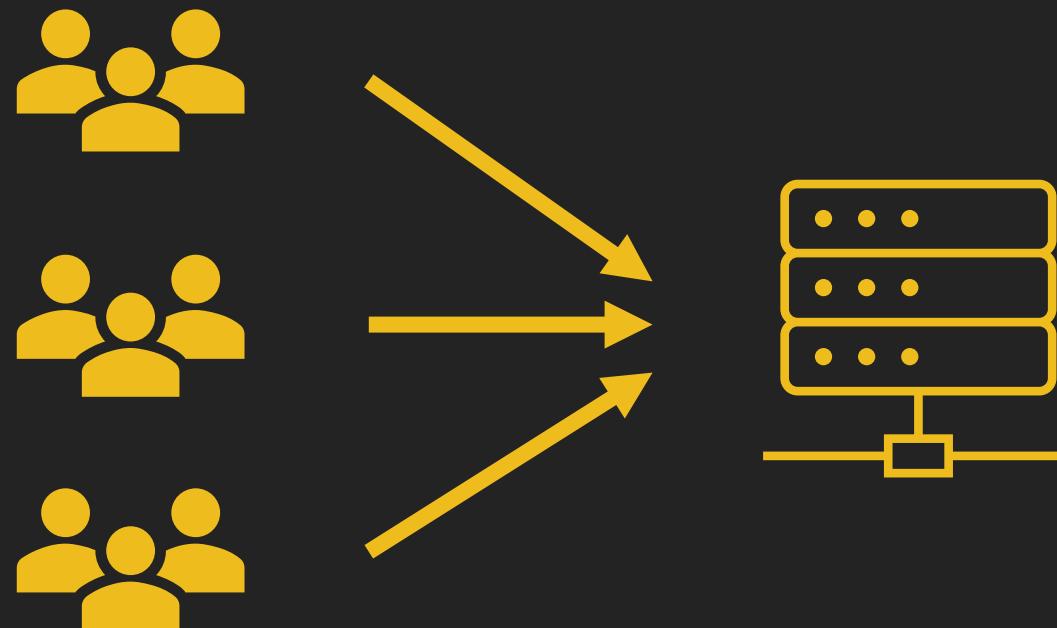
- 3 Types of challenge
 - **Static**



What does a CTF consist of

Challenges

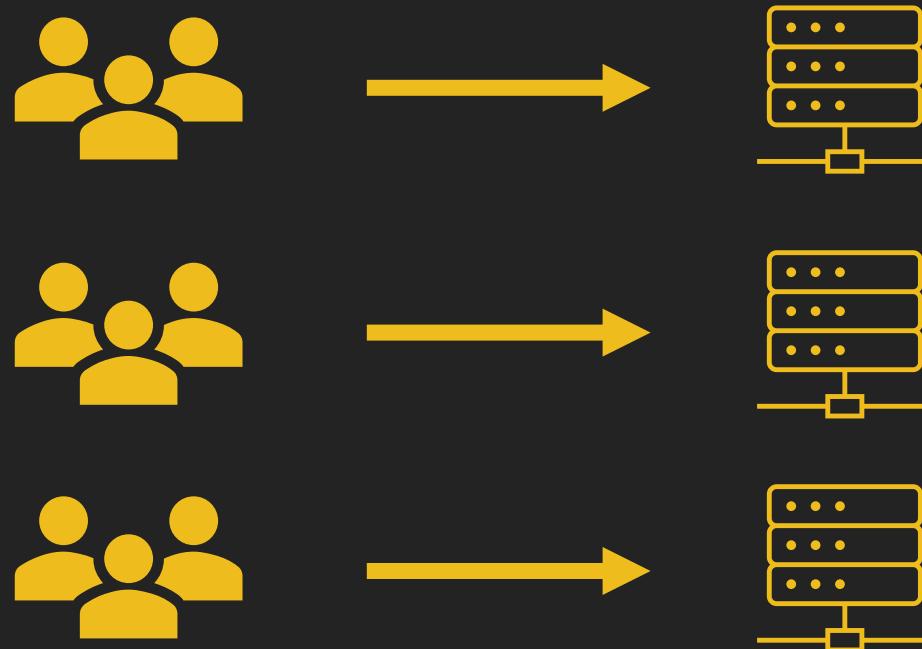
- 3 Types of challenge
 - Static
 - **Shared**



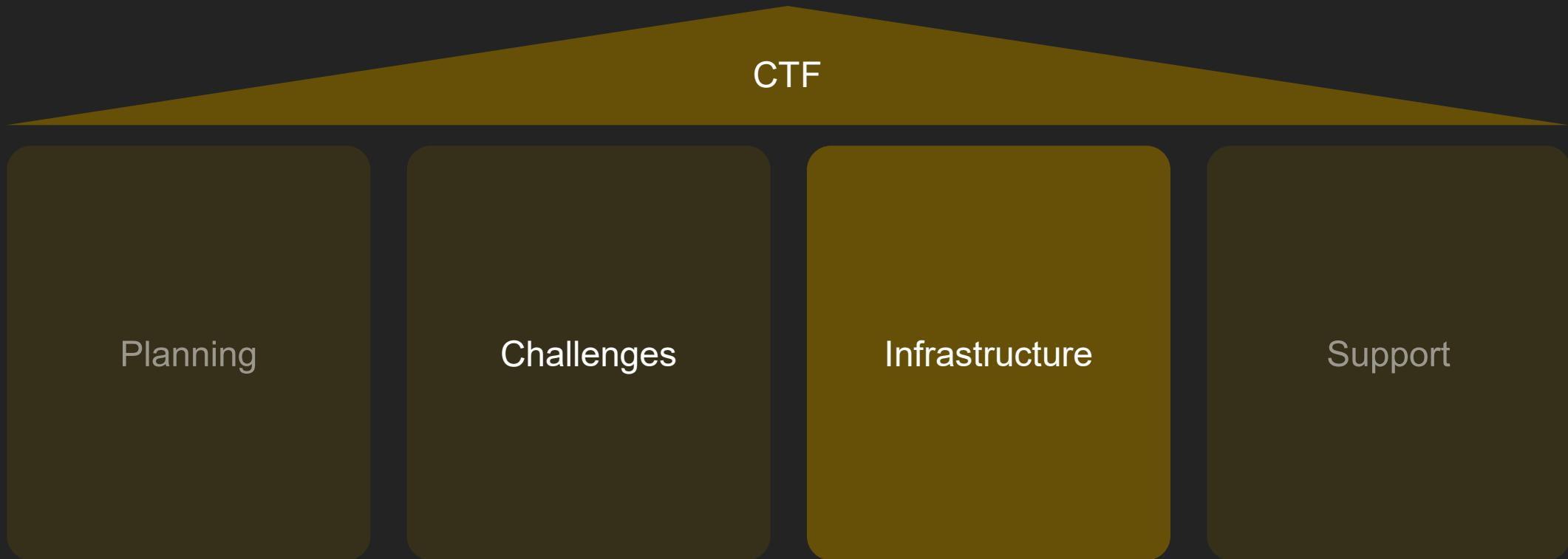
What does a CTF consist of

Challenges

- 3 Types of challenge
 - Static
 - Shared
 - **Instanced**



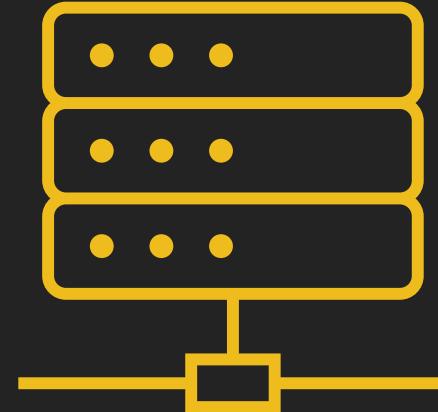
What does a CTF consist of



What does a CTF consist of

Infrastructure

- Scoreboard
- Challenge remotes



Existing platforms

Infrastructure

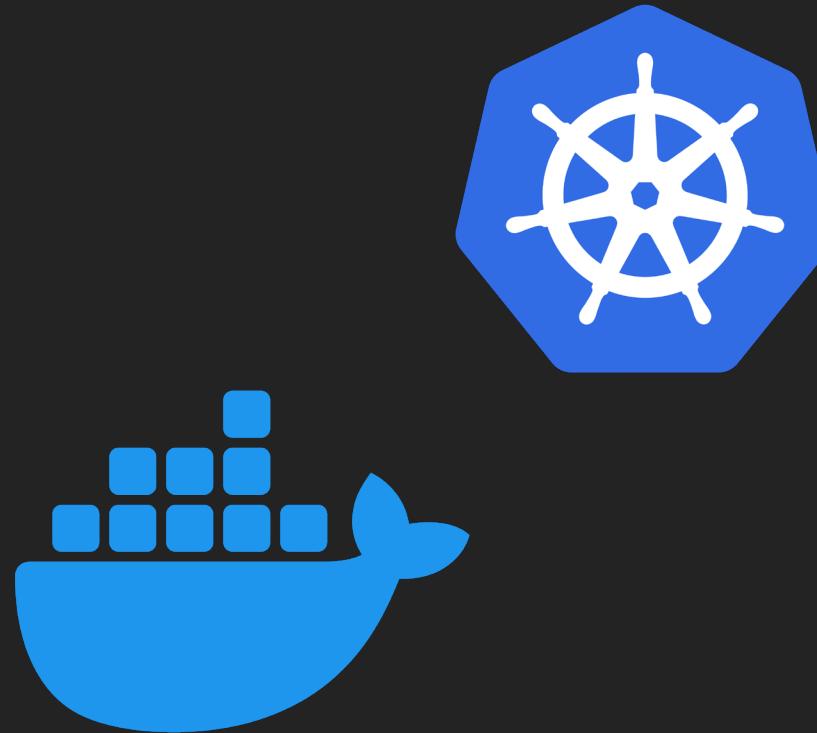
- Scoreboard
 - CTFd
 - rCTF
 - noCTF



Existing platforms

Infrastructure

- Challenge remote
 - kCTF
 - Kube-ctf
 - Custom platforms



DownUnderCTF

- Large CTF
 - 91,66 weight
 - 1667 teams
- Infrastructure blogs
- noCTF
- Kube-ctf



My vision

- Jeopardy style CTF
- Instanced remotes (supporting static, shared & instanced)
- No bottlenecks
- Automation
 - DevOps
 - GitOps
- Surviving the first 5 minutes

BrunnerCTF 2025 infrastructure



It all starts with Kubernetes

- Container orchestrator
- Scalability
- Reciliants



It all starts with Kubernetes

- Container orchestrator
- Scalability
- Recilians
- Hetzner



It all starts with Kubernetes



To CTFd or not to CTFd



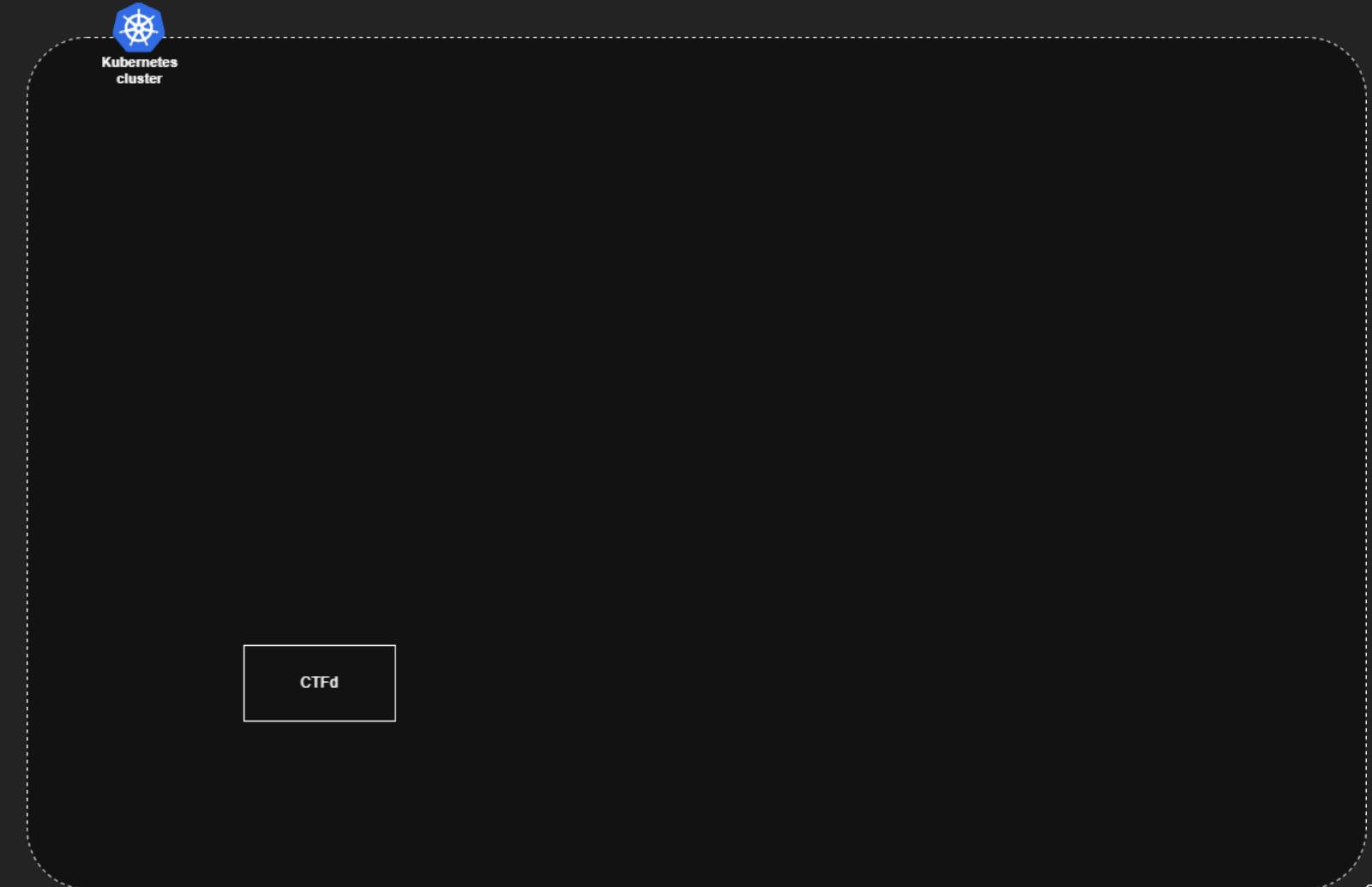
Pros

- Well-established
- Knowledge in the team
- Used in large CTFs
- Customizable themes and plugins

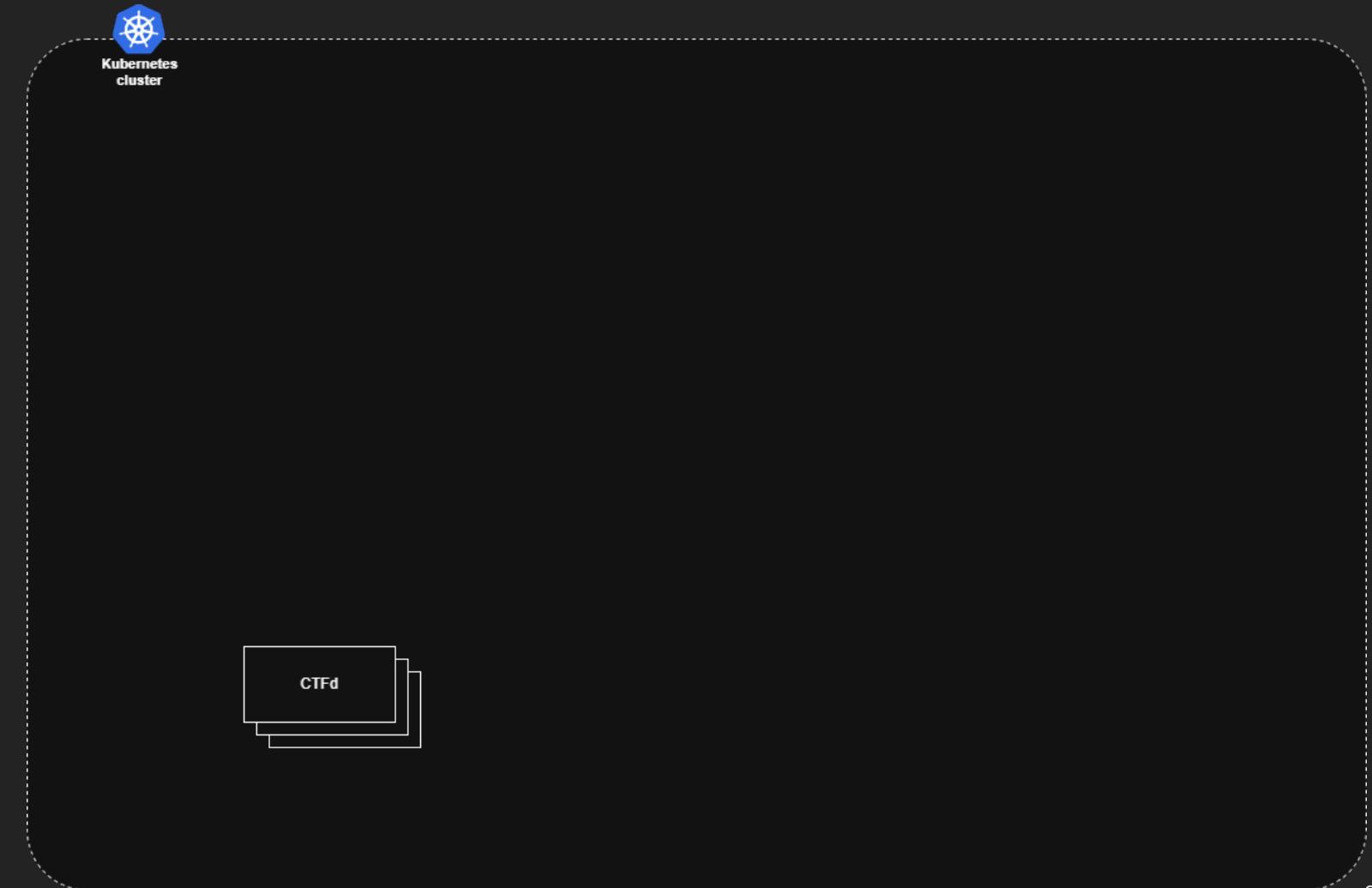
Cons

- Not scalable out of the box
- Has been the source of many issues
- Very standard
- Hard to theme

To CTFd or not to CTFd



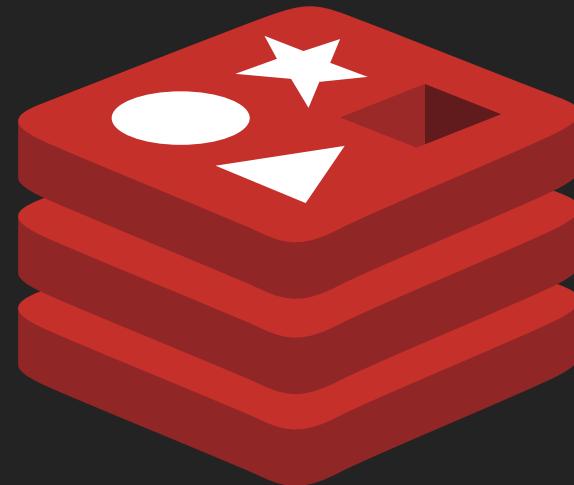
To CTFd or not to CTFd



Data storage

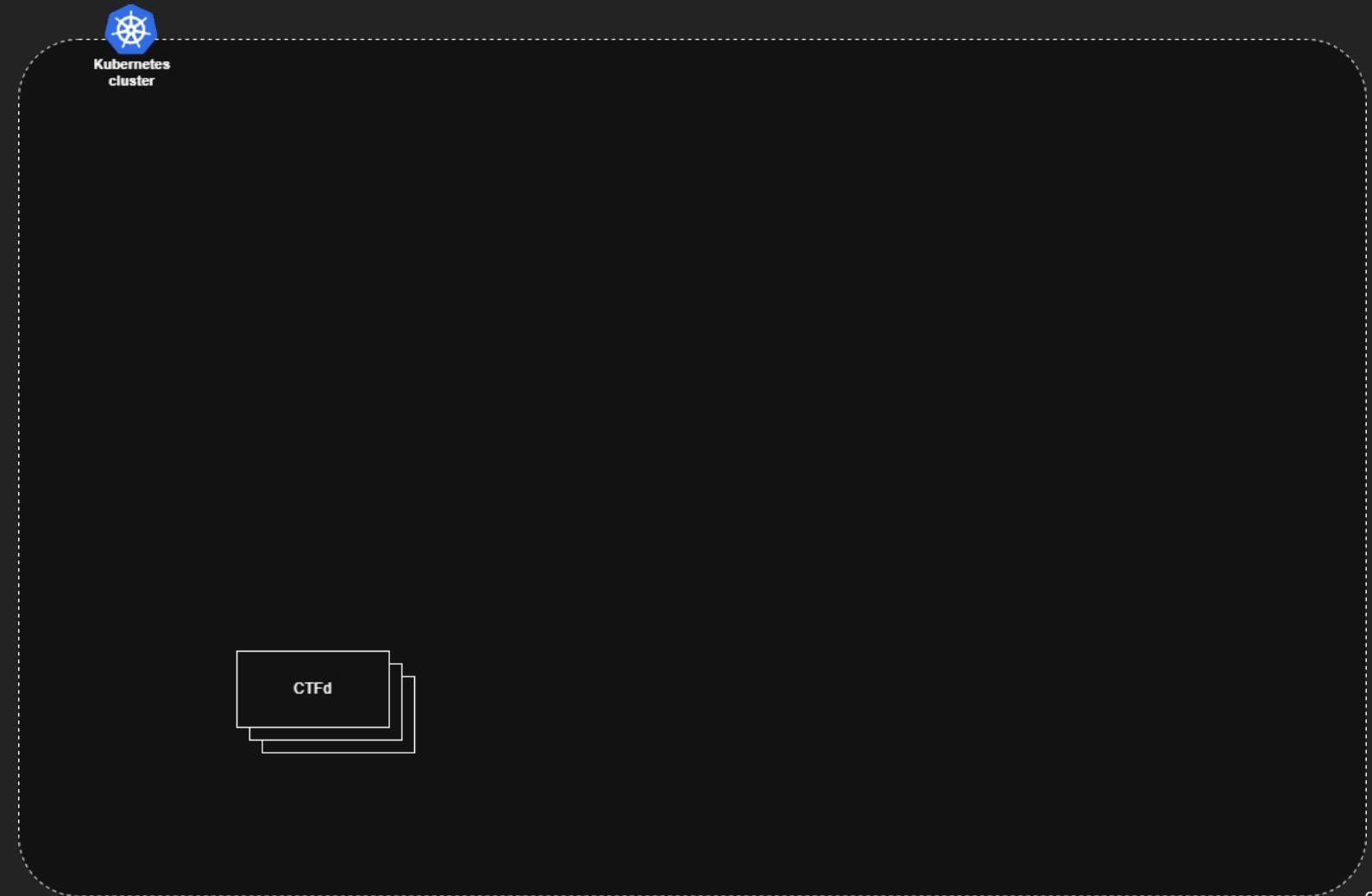


MariaDB

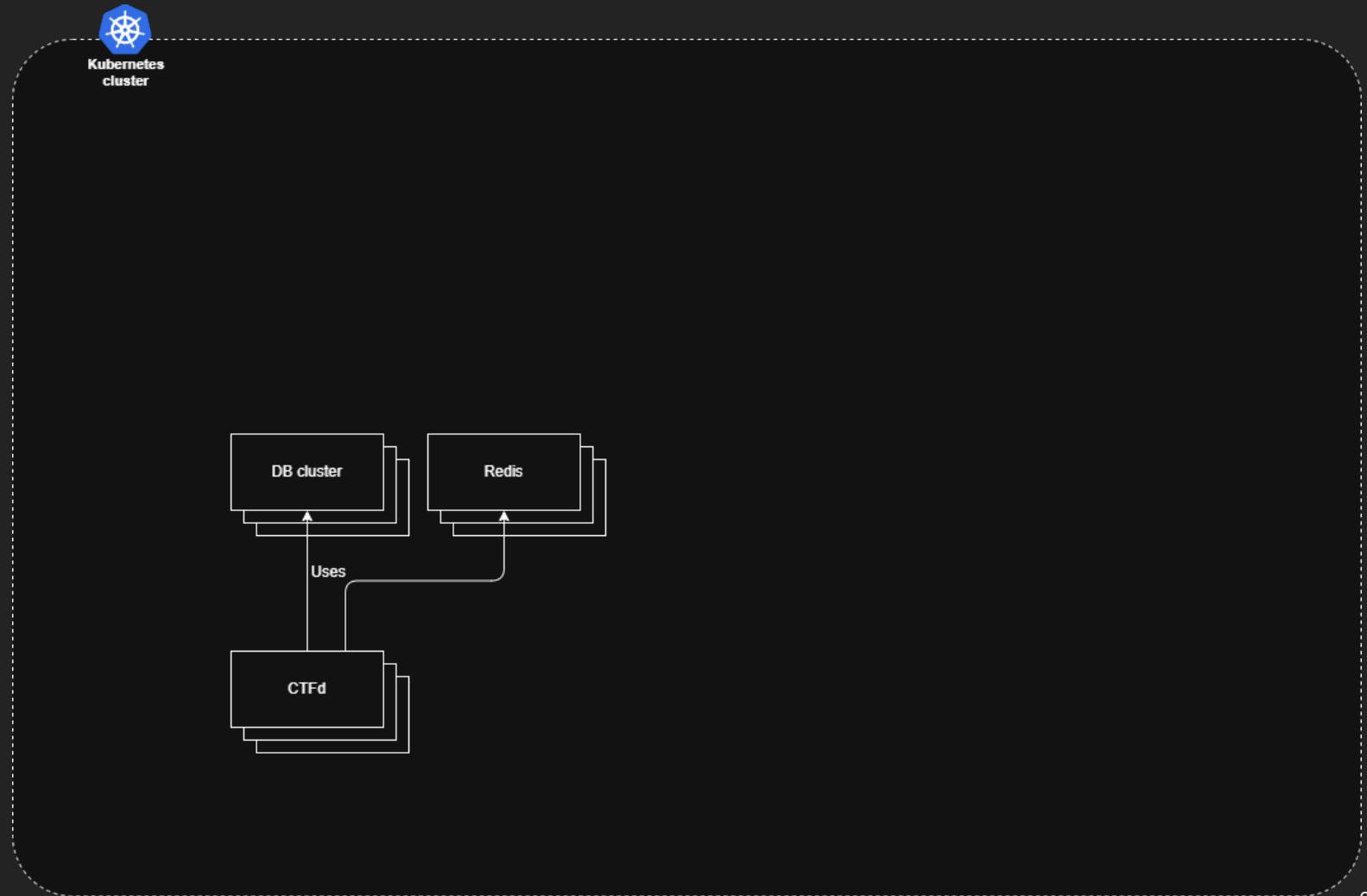


S3

Data storage



Data storage



Instancing

Kube-ctf

Instancing



Kube-ctf



Instancing



Kube-ctf



Instancing



Kube-ctf



Instancing



Kube-ctf



Instancing



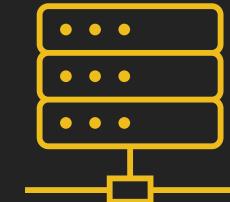
Kube-ctf



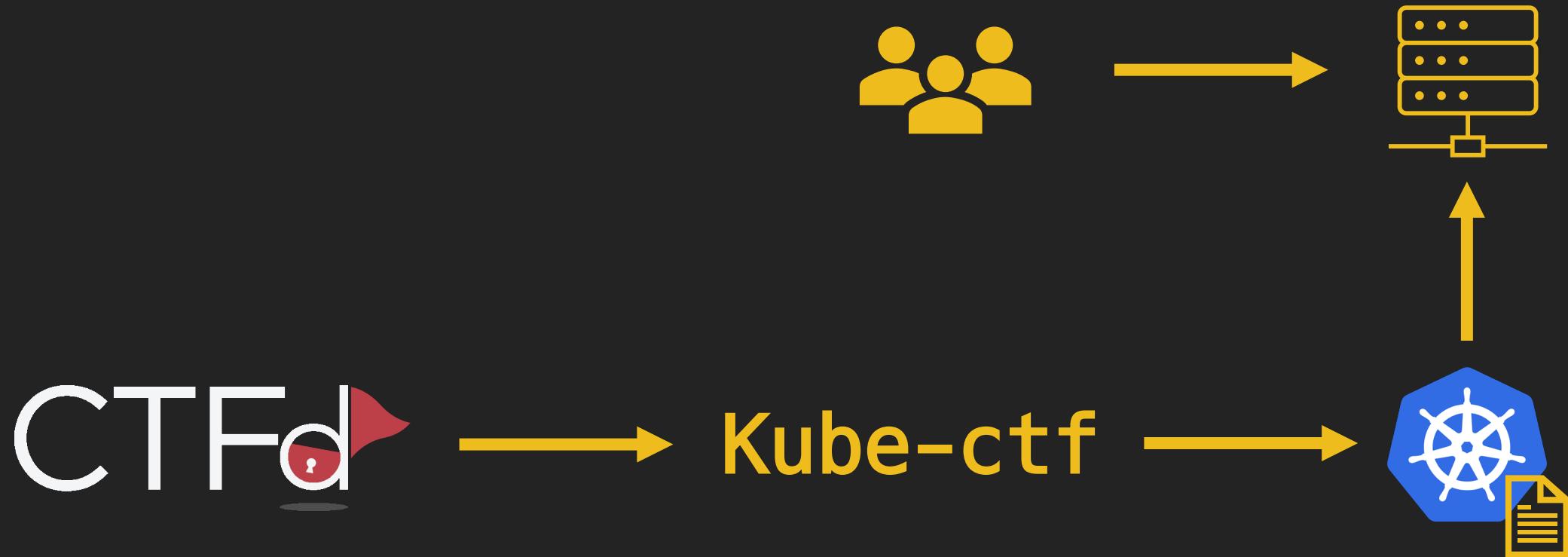
Instancing



Kube-ctf



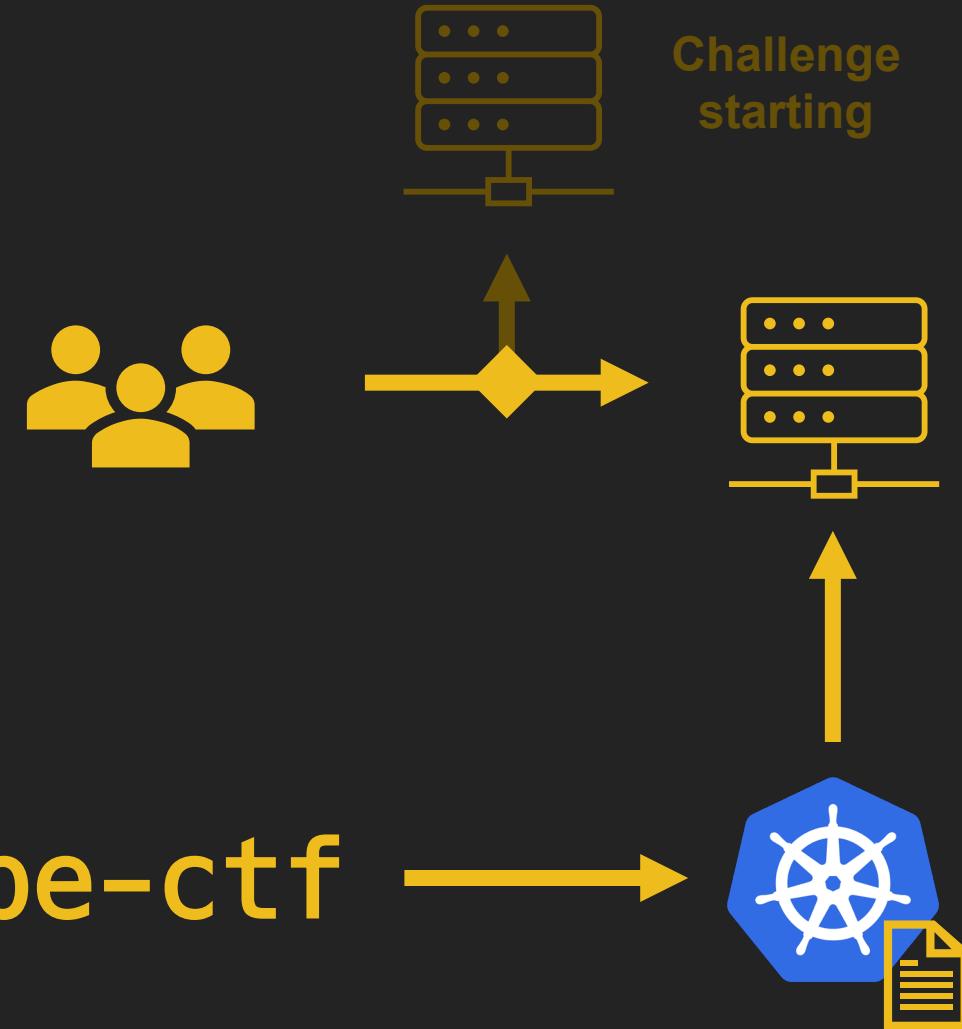
Instancing



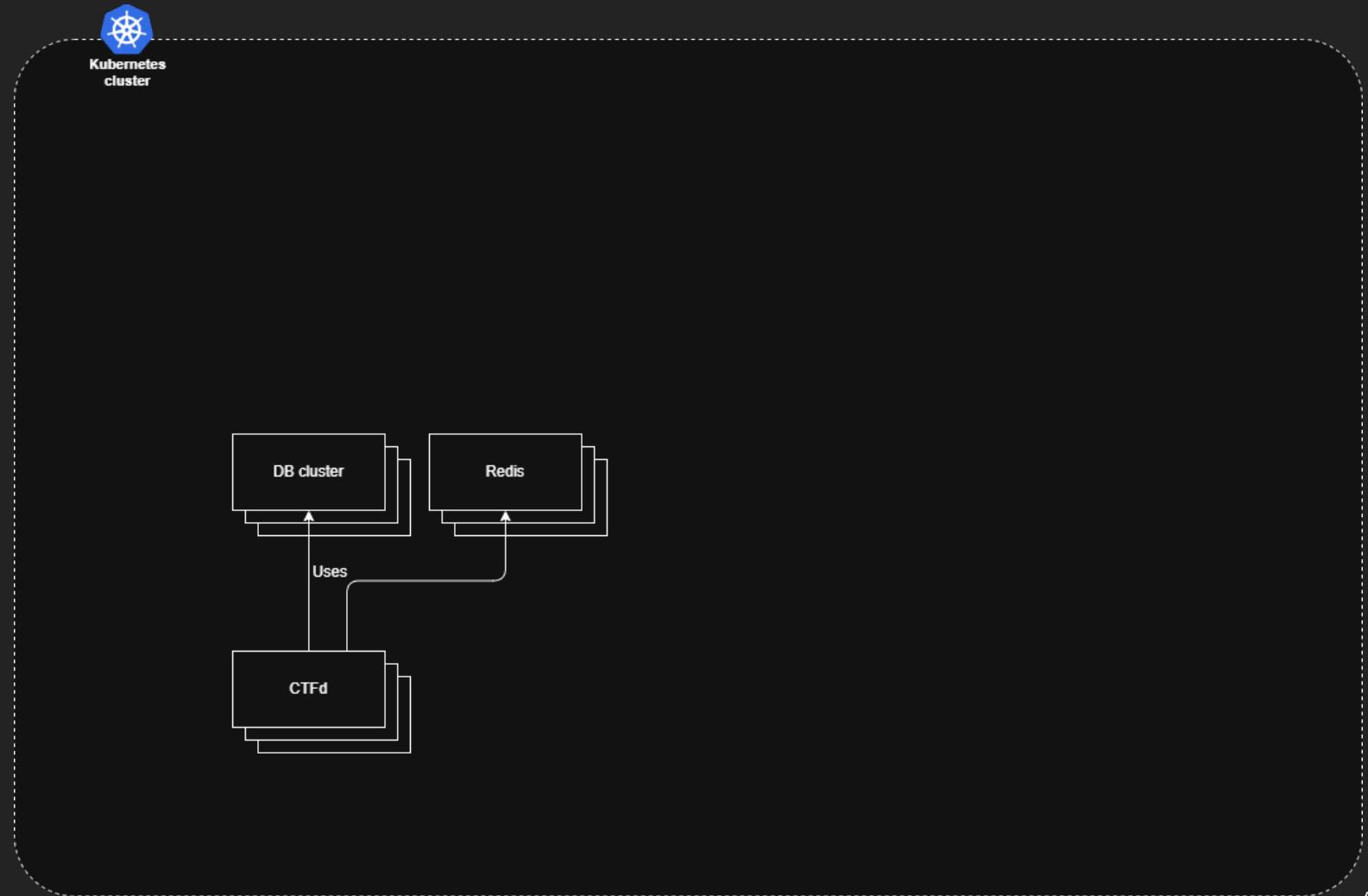
Instancing



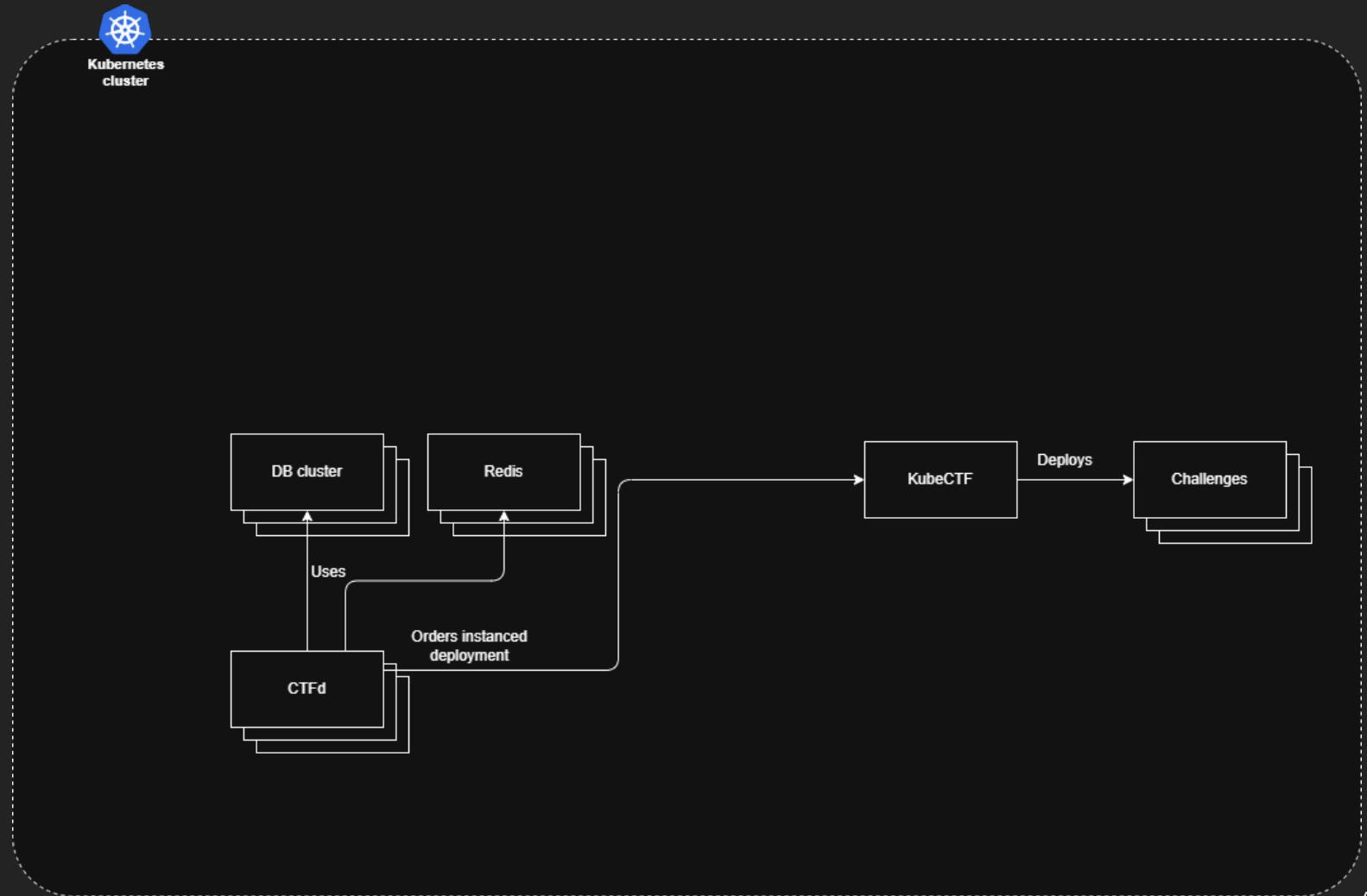
Kube-ctf



Instancing



Instancing



Automating CTFd

- Why manually upload challenges?
- Should everyone have access to the CTFd dashboard?



Automating CTFd



CTFd manager



Automating CTFd



CTFd manager



Automating CTFd



CTFd manager



Automating CTFd



CTFd manager ←



Automating CTFd



CTFd manager ←



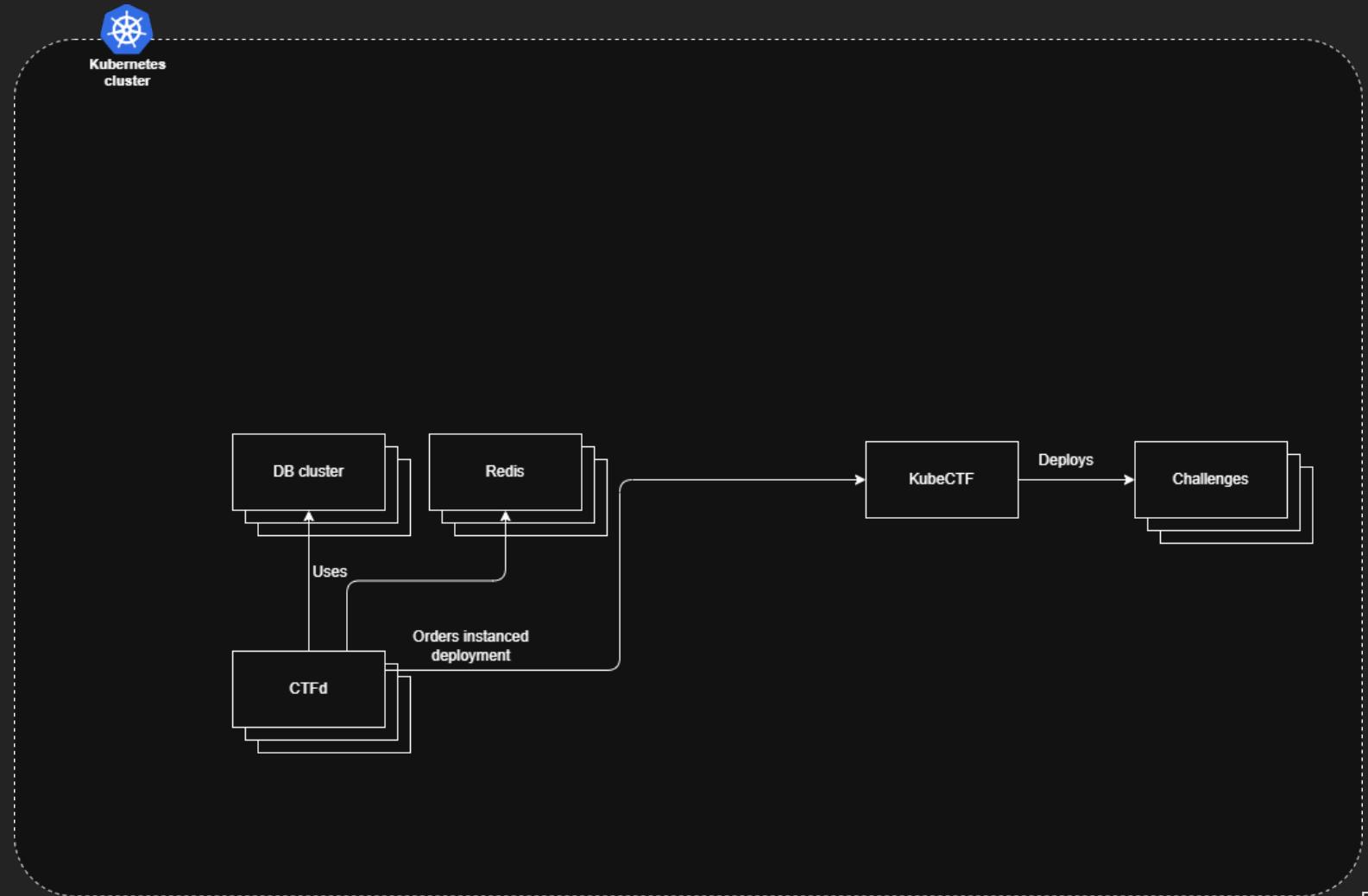
Automating CTFd



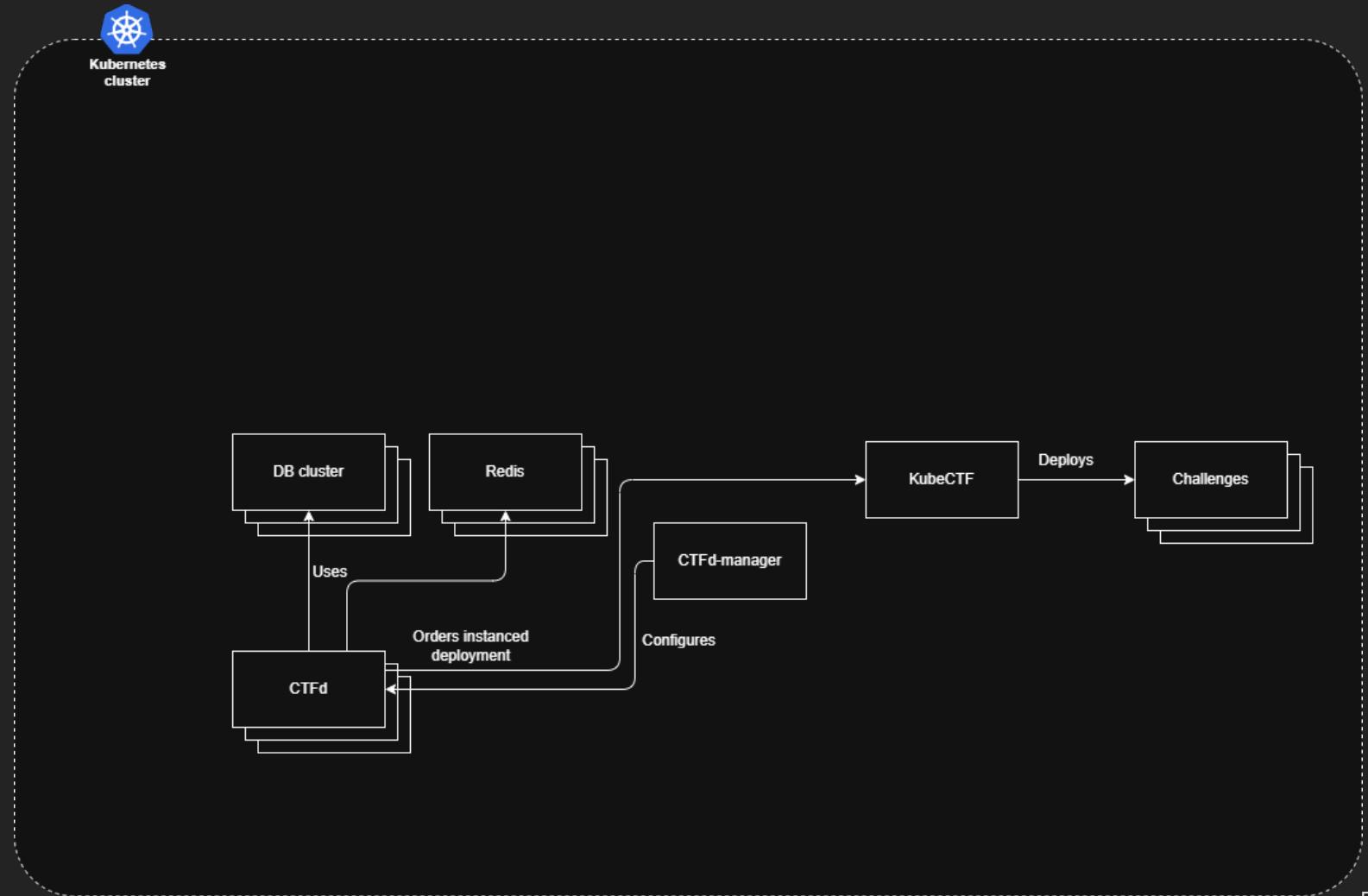
← CTFd manager ←



Automating CTFd



Automating CTFd



Going GitOps

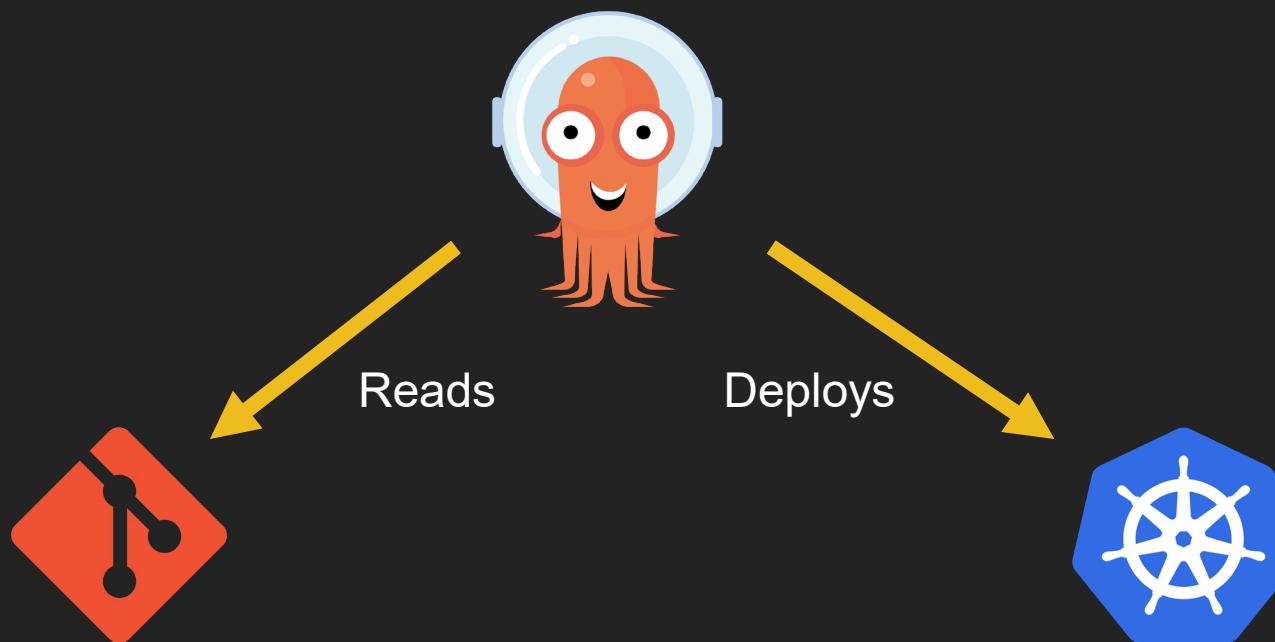
- Automating continuous deployment

Going GitOps

- ArgoCD



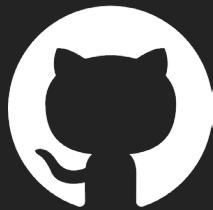
Going GitOps



Going GitOps



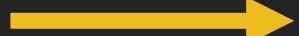
Going GitOps



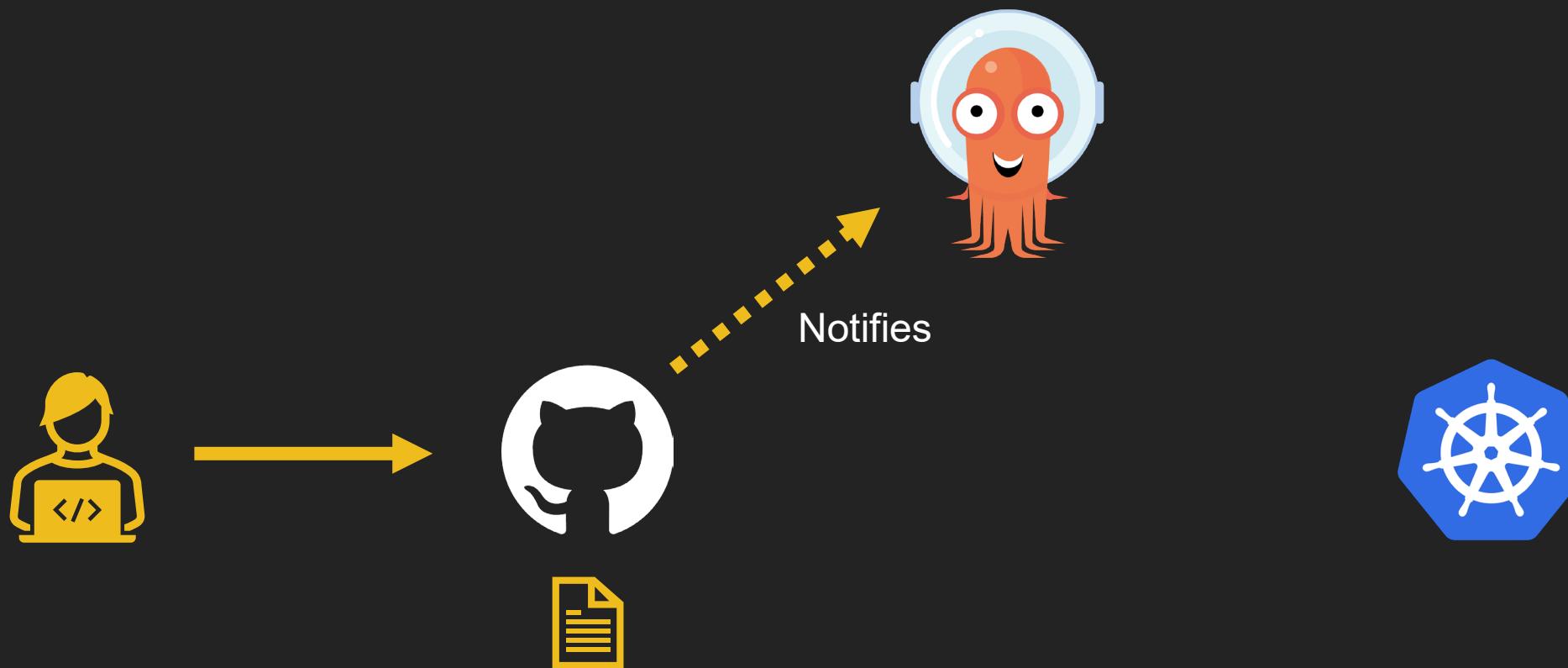
Going GitOps



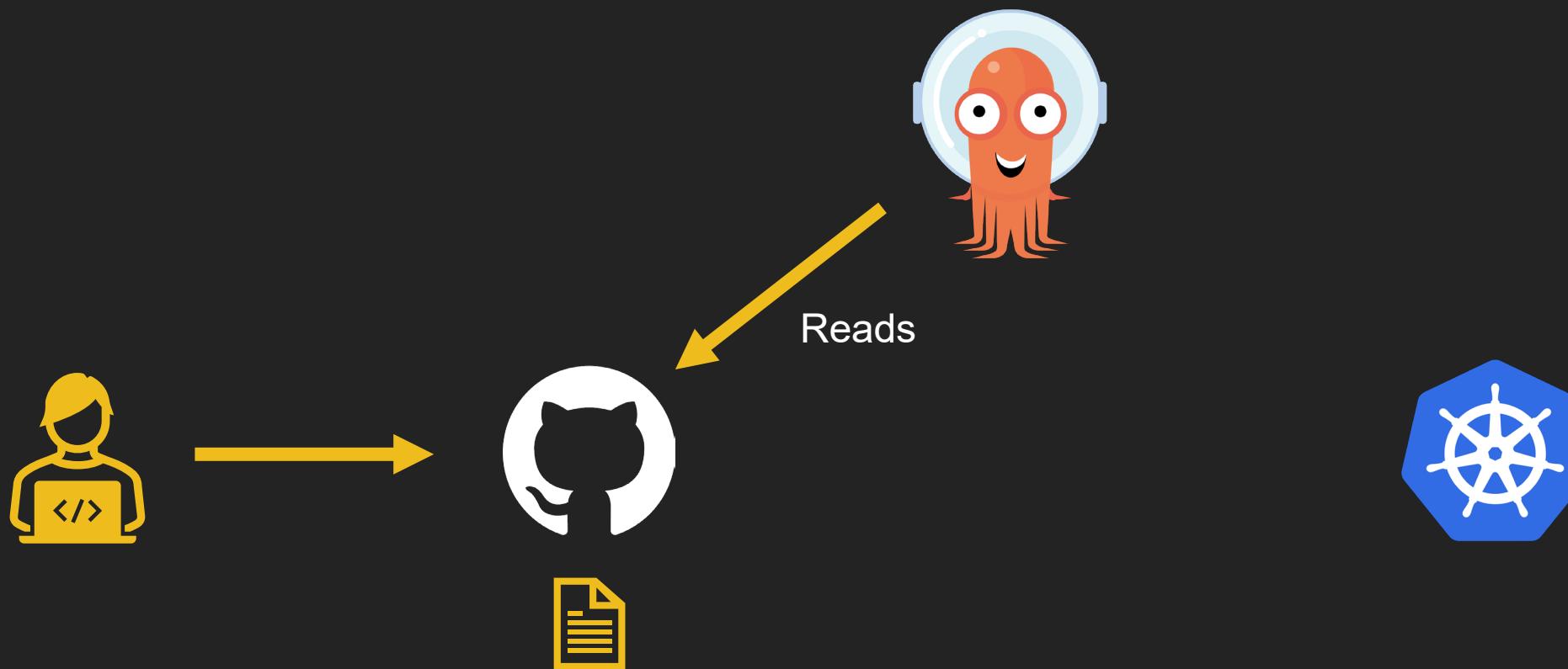
Going GitOps



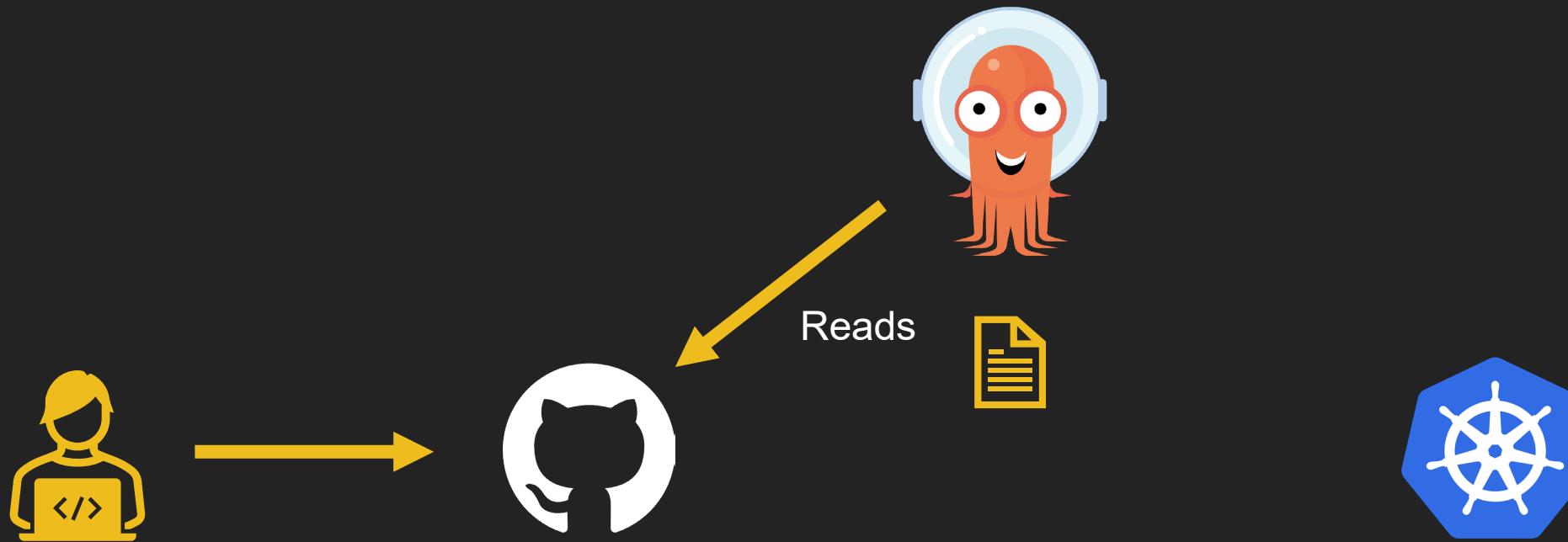
Going GitOps



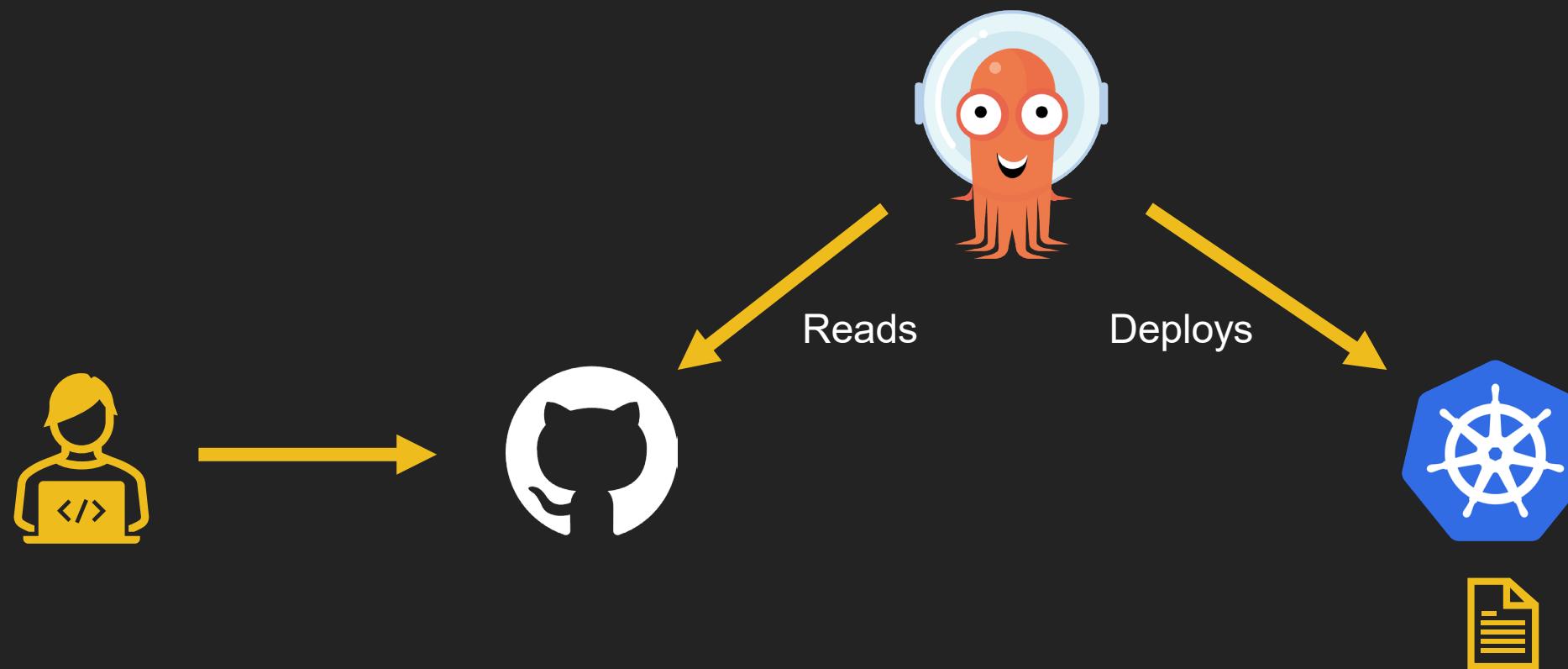
Going GitOps



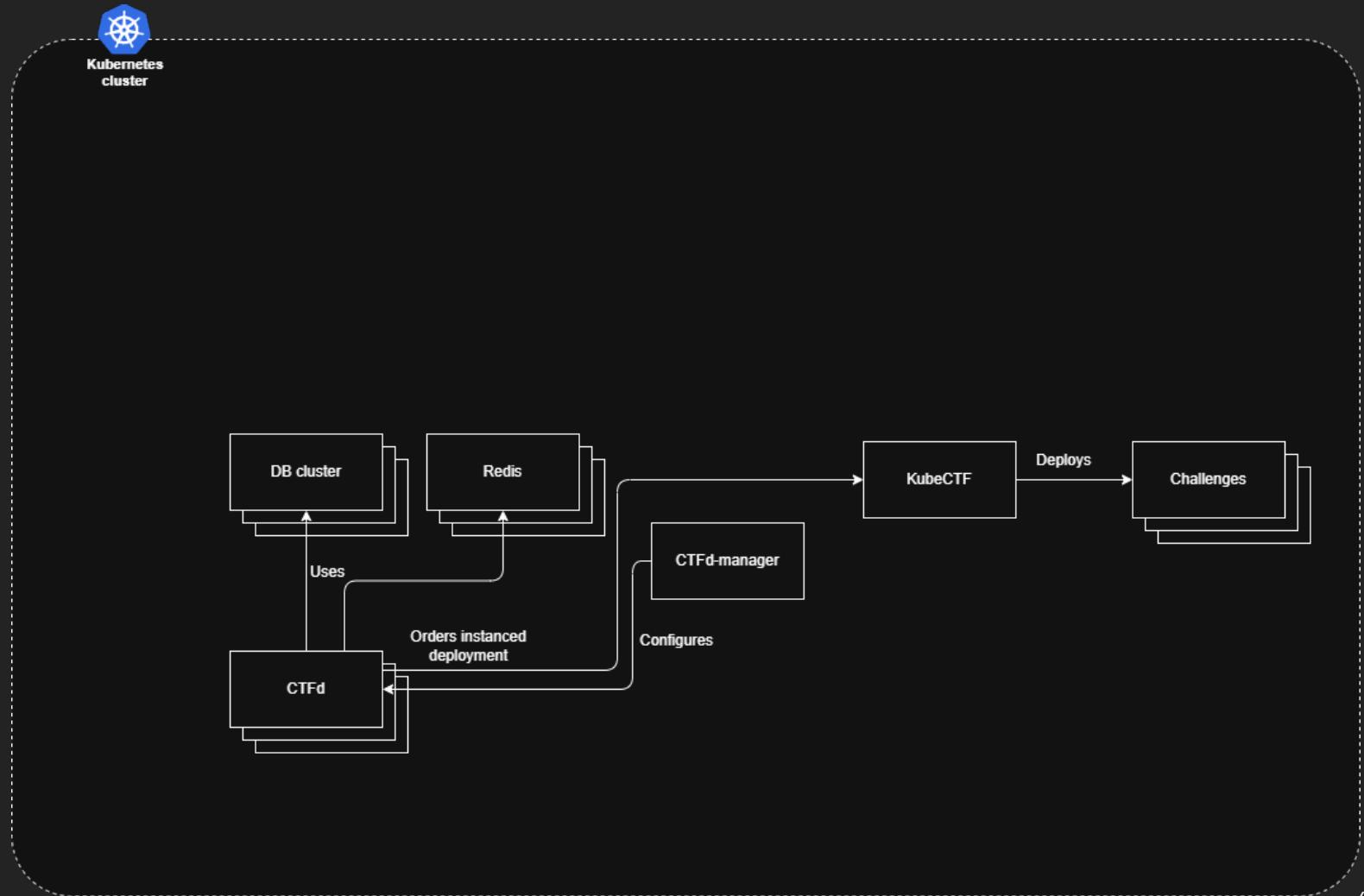
Going GitOps



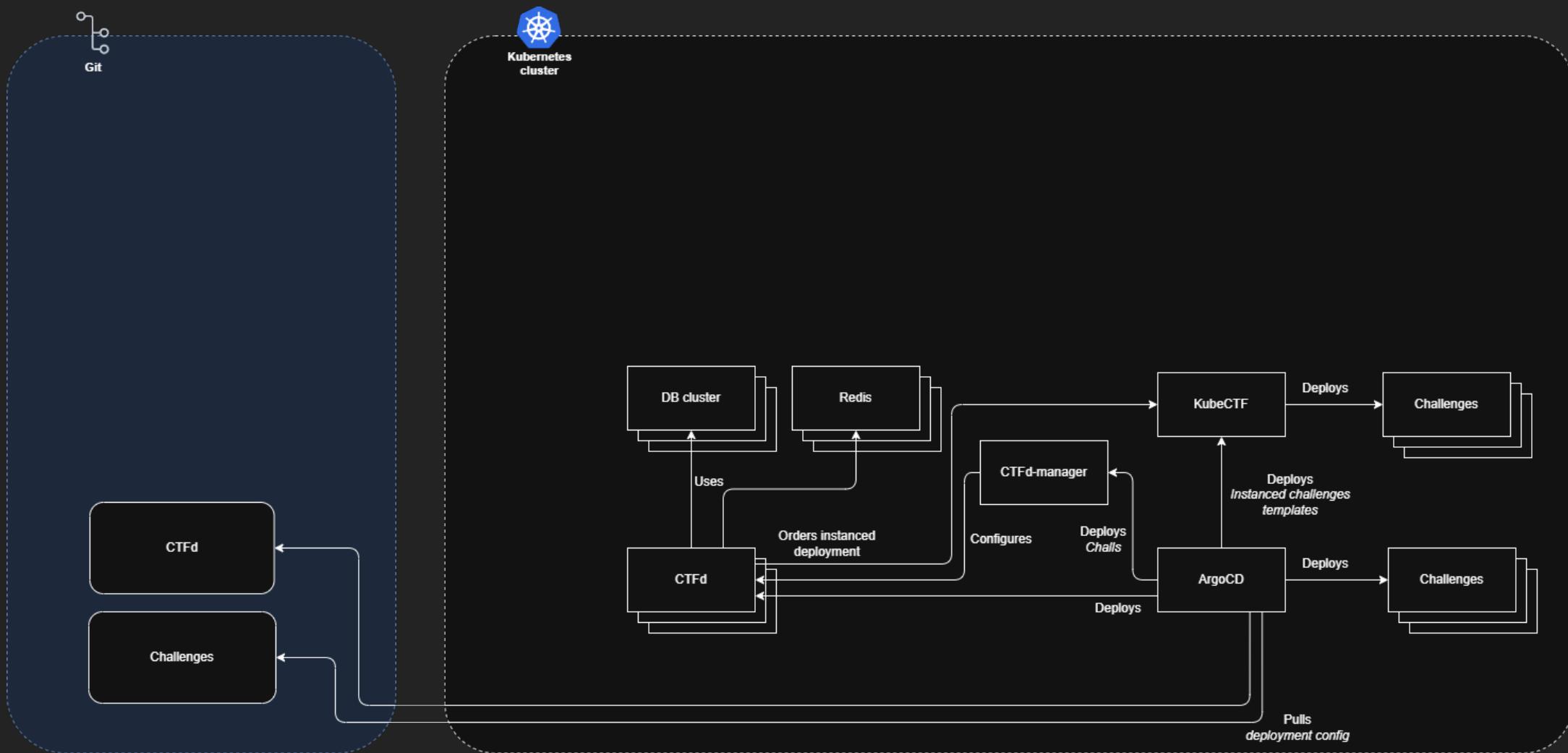
Going GitOps



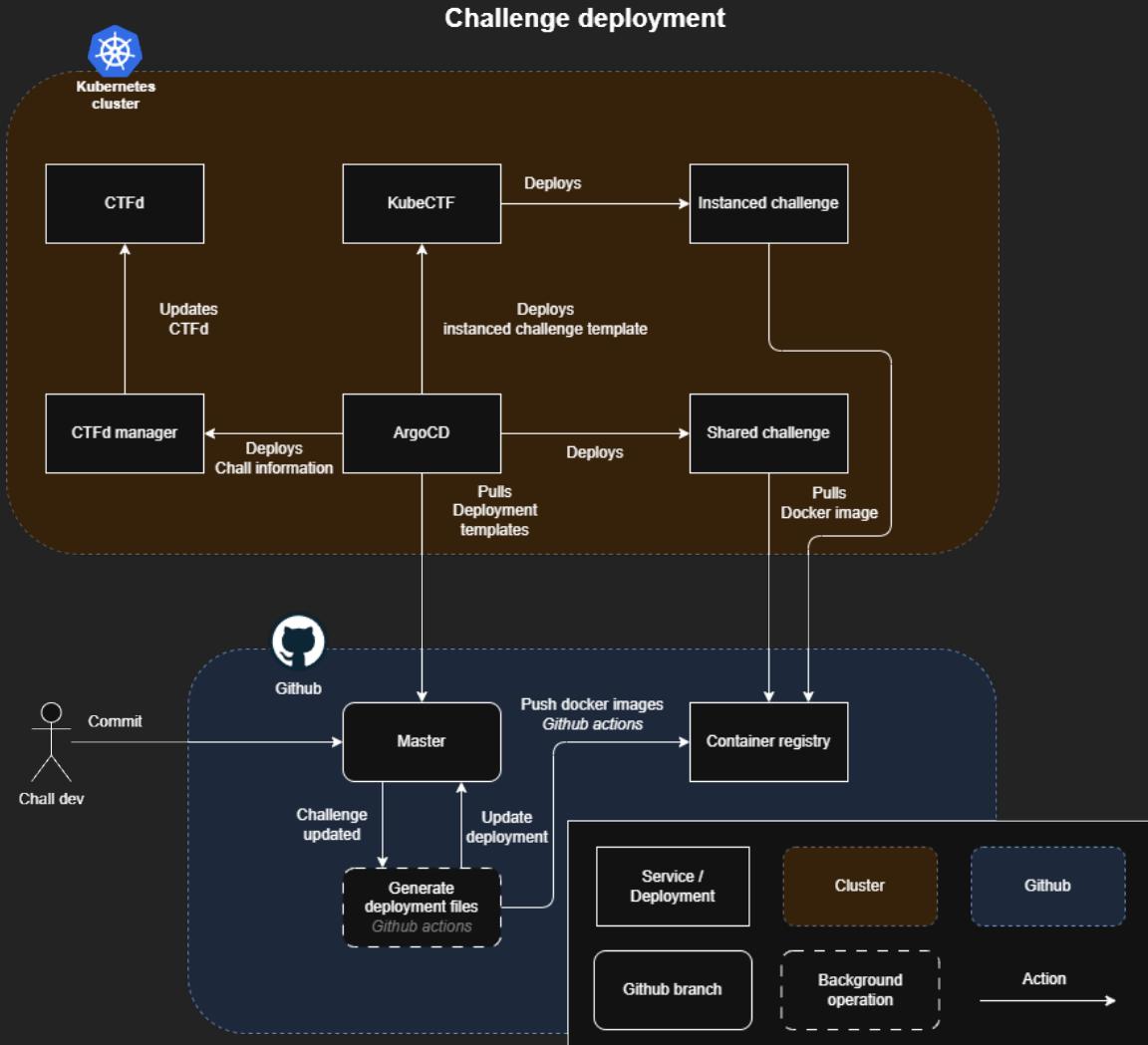
Going GitOps



Going GitOps



Going GitOps



Automating everything

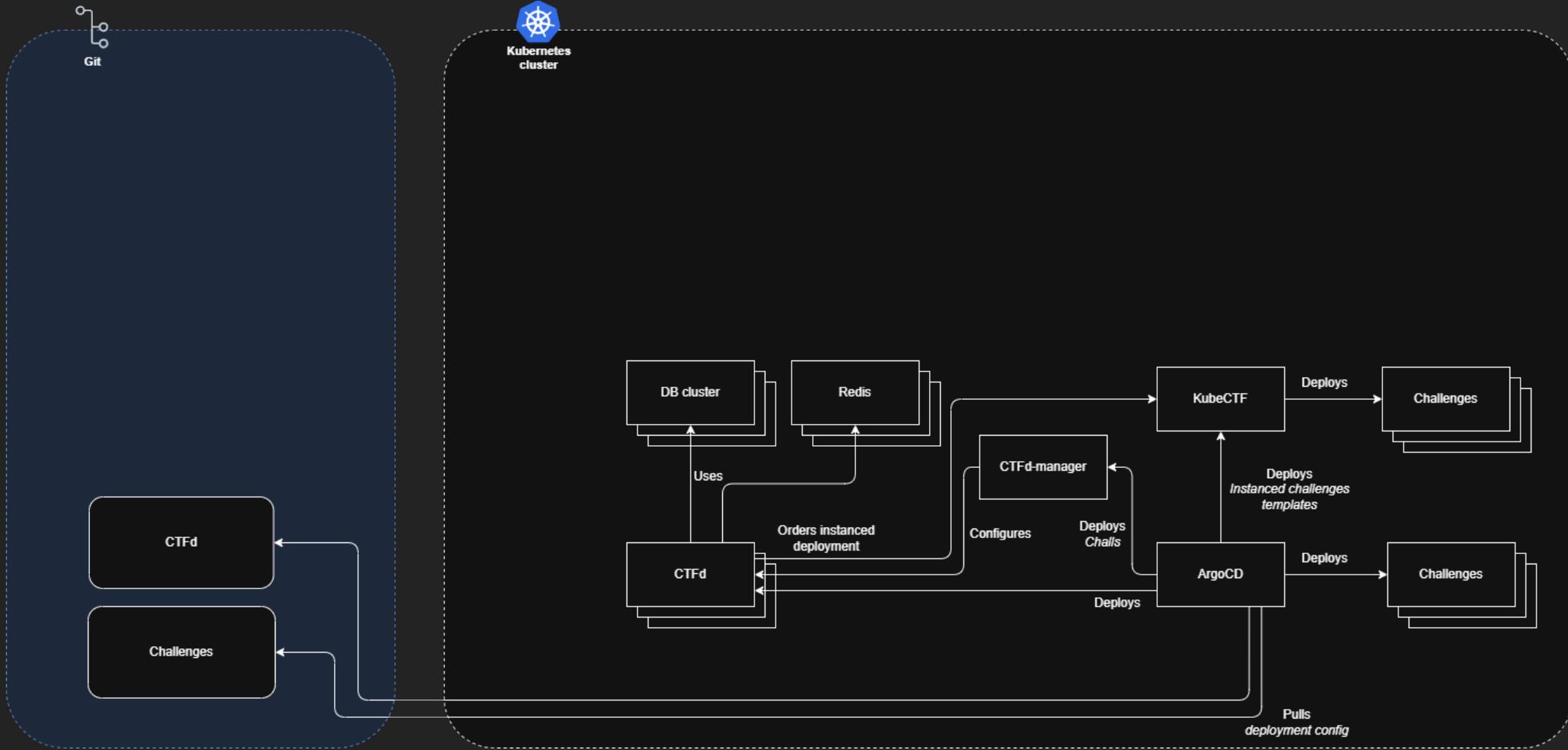
- A lot of moving parts

Automating everything

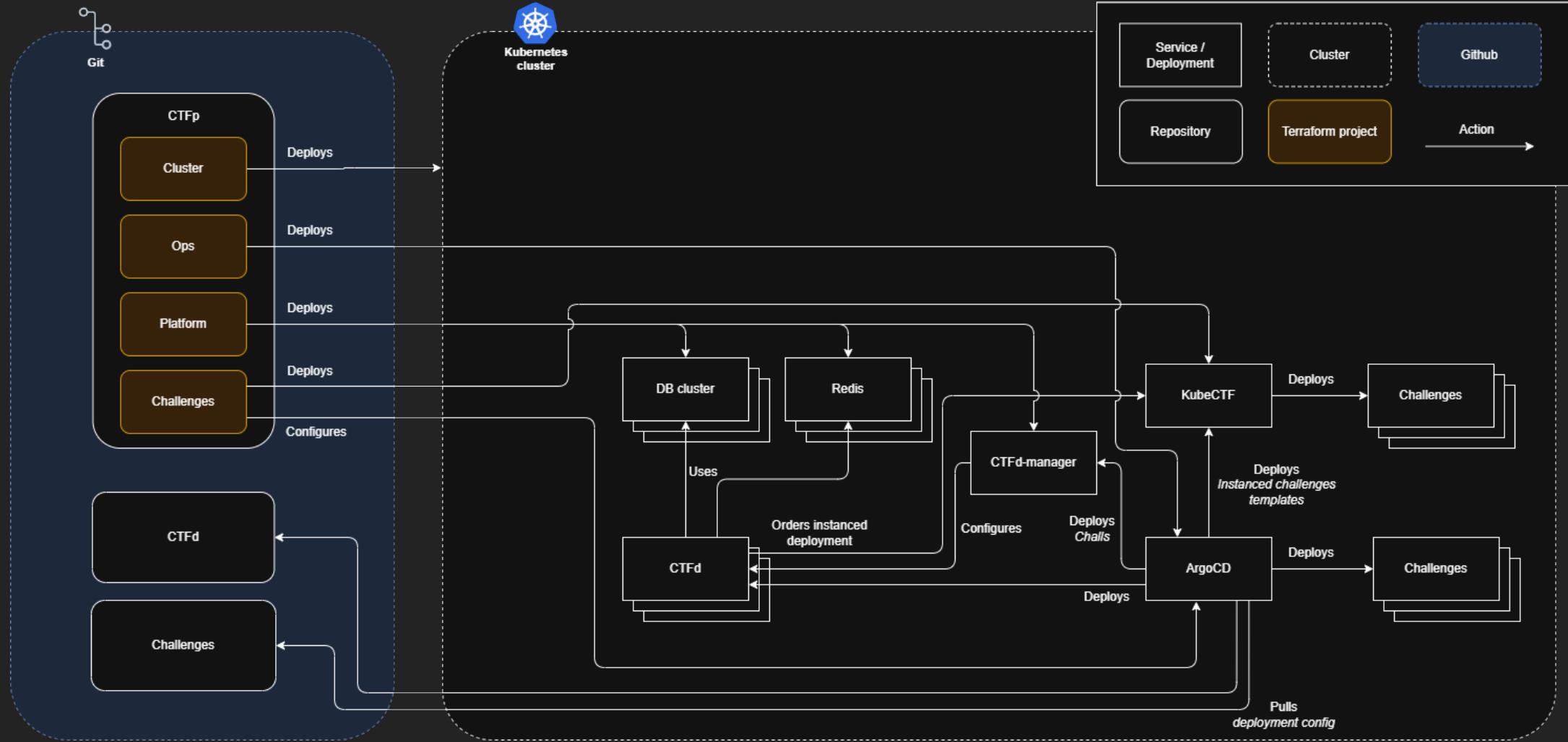
- A lot of moving parts
- Terraform as orchestrator



Automating everything



Automating everything



Monitoring



Monitoring

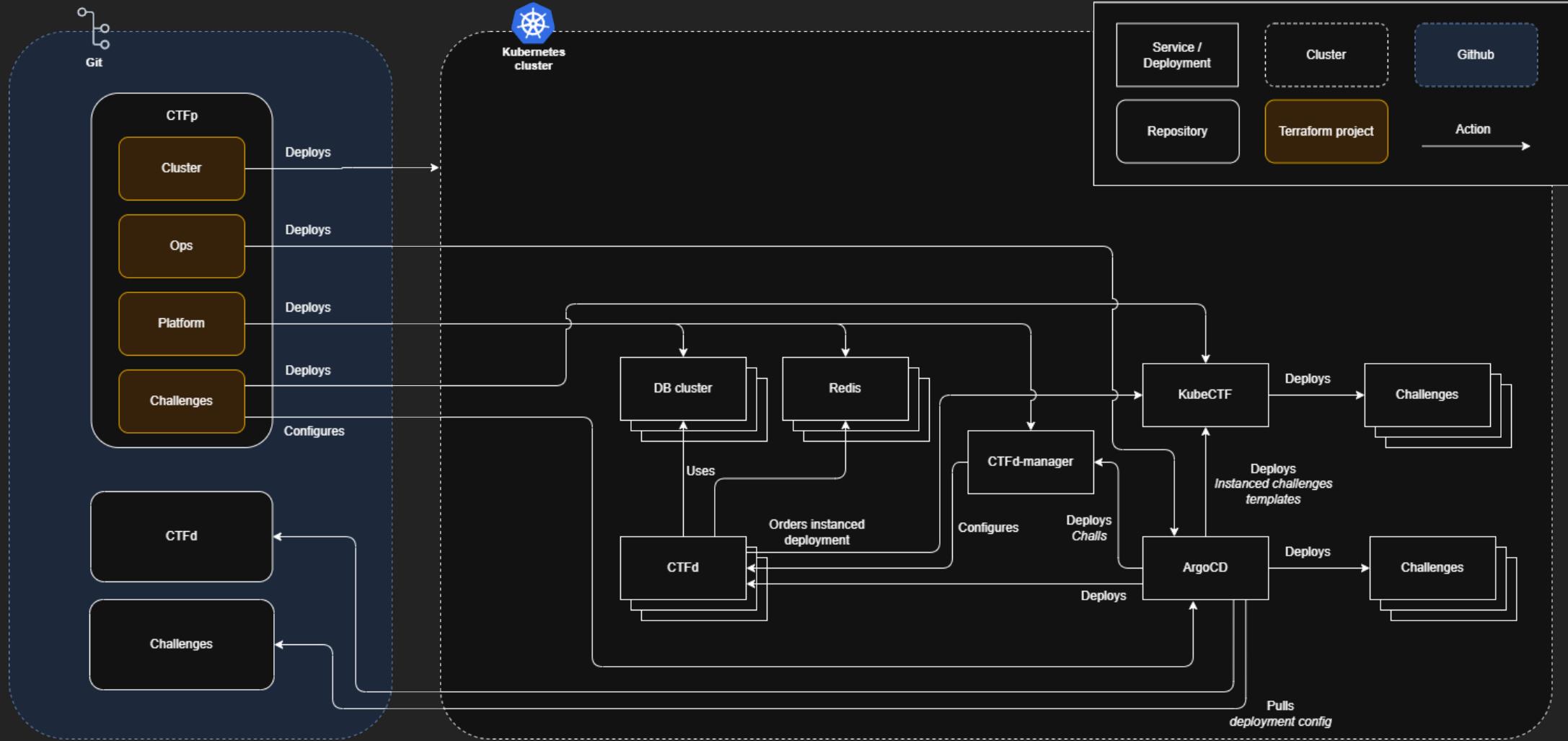


Prometheus

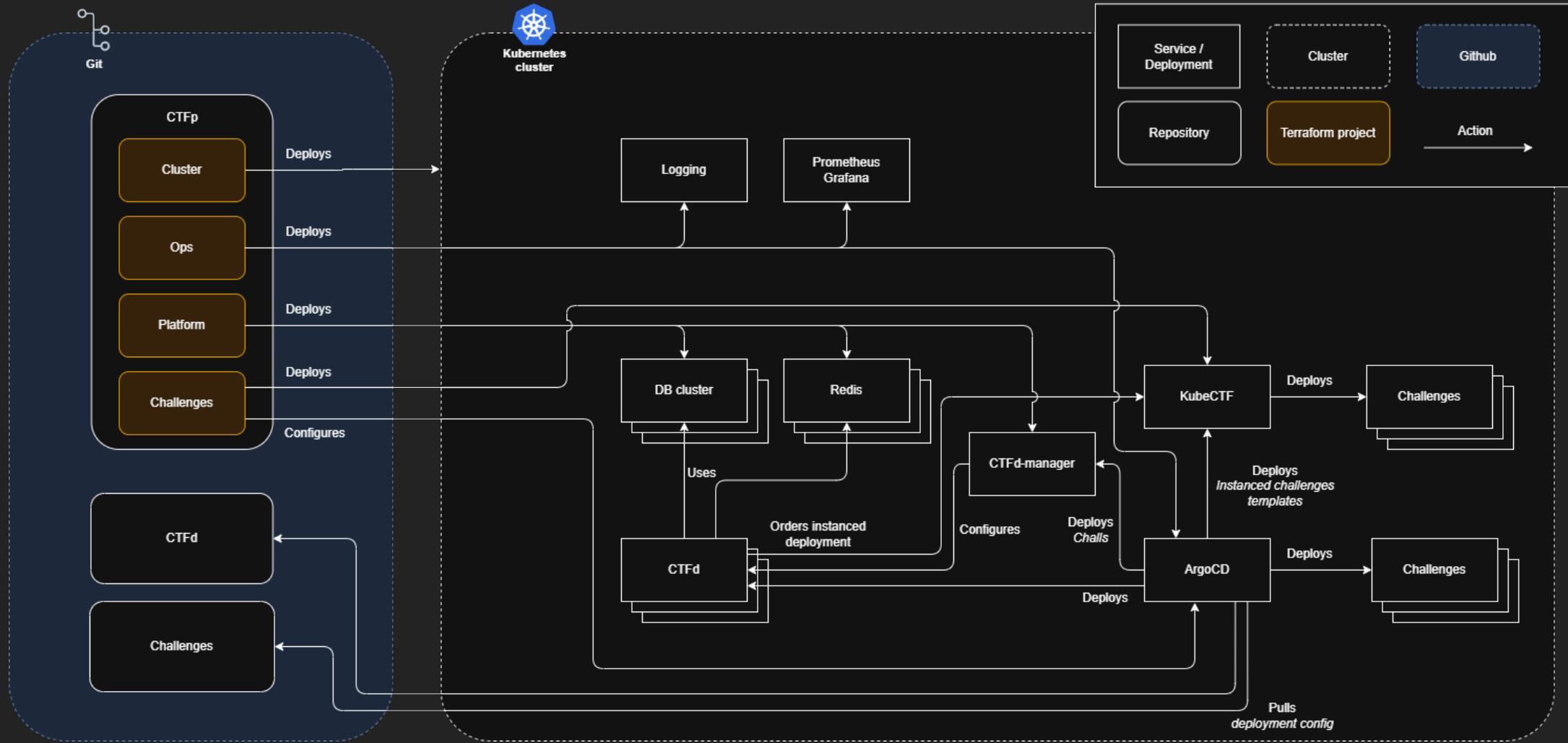


elastic

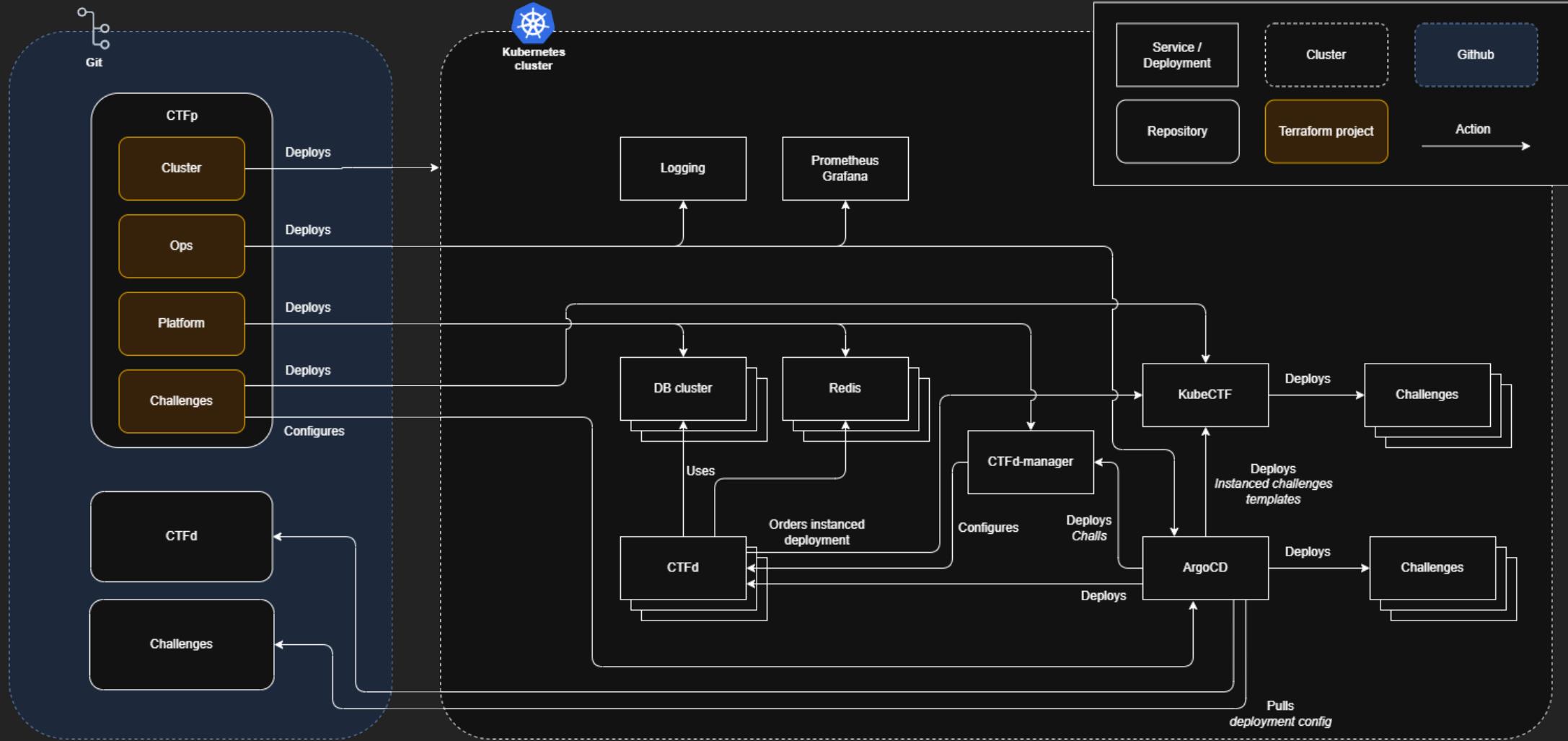
Monitoring



Monitoring



The platform



Challenges

Scaling the number of developers

- 20 challenge developers
- Not sustainable with hands on infrastructure

Standardizing

Challenge
Schema

Challenge
Repository

Challenge Schema

- Standardized schema

- Developer responsibility

- Platform agnostic

- Challenge metadata

- Docker data

```
enabled: True
name: Where Robots Cannot Search
slug: where-robots-cannot-search
author: The Mikkel
category: web
difficulty: beginner
min_points: 30
points: 30
type: instanced
instanced_type: web
flag: brunner{r0bot5_sh0u1d_n0t_637_h3re_b0t_You_g07_h3re}
tags:
  - Web
description_location: description.md
dockerfile_locations:
  - location: src/Dockerfile
  context: src/
  identifier: None
```

Challenge Repository

- Structured handling of all challenges
- Easy administration
- Challenge toolkit
- Challenge bootstrapping

```
.
├── challenges/
│   ├── web
│   ├── forensics
│   ├── rev
│   ├── crypto
│   ├── pwn
│   ├── boot2root
│   ├── osint
│   ├── misc
│   └── blockchain
└── beginner/
    └── challenge-1
├── pages/
│   └── page-1/
├── template/
└── challenge-toolkit/
    <other files>
```

Challenge Repository

Create challenge

create-chall.yml

142 workflow runs

This workflow has a `workflow_dispatch` event trigger.

Event ▾ Status ▾ Branch ▾ Actor ▾

Run workflow

Create challenge pwn-3 by Olexmeister
Create challenge #167: Manually run by [AlexanderKoefoed](#)

Create challenge pwn-2 by Olexmeister
Create challenge #166: Manually run by [AlexanderKoefoed](#)

Create challenge Getting Access by Quack
Create challenge #165: Manually run by [Quackers711](#)

Create challenge Spicy Cookies by Quack
Create challenge #164: Manually run by [Quackers711](#)

Create challenge IDOR by Quack
Create challenge #163: Manually run by [Quackers711](#)

Create challenge OPTIONS by Quack
Create challenge #162: Manually run by [Quackers711](#)

Create challenge POST by Quack
Create challenge #161: Manually run by [Quackers711](#)

Create challenge Cookies by Quack
Create challenge #160: Manually run by [Quackers711](#)

Create challenge Intro-Headers by Quack
Create challenge #159: Manually run by [Quackers711](#)

Create challenge Intro-CSS by Quack
Create challenge #158: Manually run by [Quackers711](#)

Use workflow from
Branch: **develop**

Existing issue to link the challenge to. Leave empty to create a new issue.

0

Name of the challenge *

Author of the challenge - Your alias *

Category of the challenge *

web

Difficulty of the challenge *

beginner

Type of the challenge *

static

Type of the instance

none

Flag of the challenge. Format: brunner{.*}, dynamic or null *

Run workflow

Nov 27, 9:28 PM GMT+1

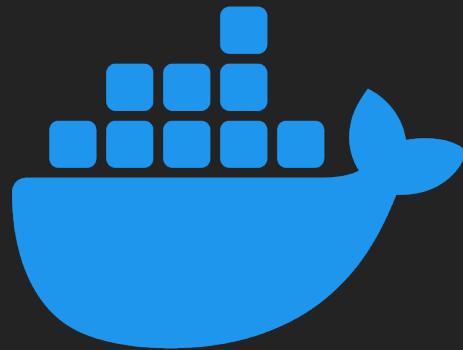
1m 25s

Challenge Repository

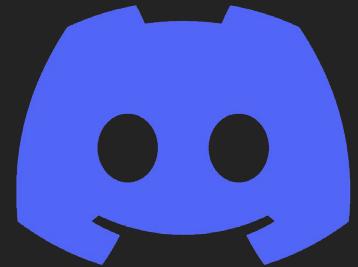
- Challenge directory

```
•
  ├── handout/
  ├── k8s/
  ├── solution/
  ├── src/
  ├── template/
  ├── challenge.yml
  ├── description.md
  └── README.md
      └── version
```

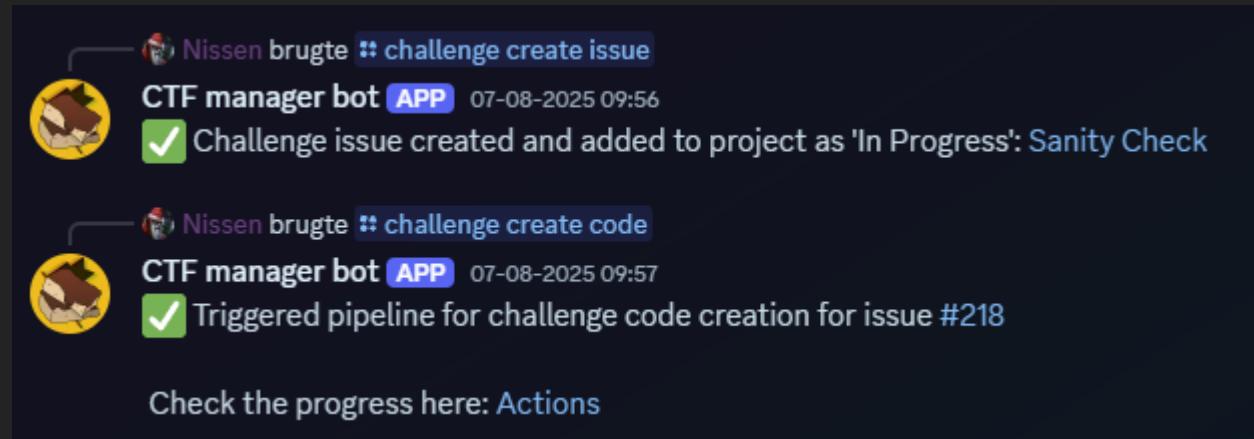
Automated deployment



Discord integration



Discord



Nissen brugte ⚡ challenge create issue
CTF manager bot APP 07-08-2025 09:56
✓ Challenge issue created and added to project as 'In Progress': Sanity Check

Nissen brugte ⚡ challenge create code
CTF manager bot APP 07-08-2025 09:57
✓ Triggered pipeline for challenge code creation for issue #218

Check the progress here: Actions

This image is a screenshot of a GitHub Actions log. It shows two successful pipeline triggers. The first trigger was for 'challenge create issue', and the second was for 'challenge create code'. Both triggers were performed by the 'CTF manager bot' application on August 7, 2025, at 09:56 and 09:57 respectively. Each trigger is accompanied by a green checkmark icon and a message indicating the challenge issue was created and added to the project as 'In Progress', specifically for the 'Sanity Check' project. At the bottom of the log, there is a link to 'Check the progress here: Actions'.

Running the CTF

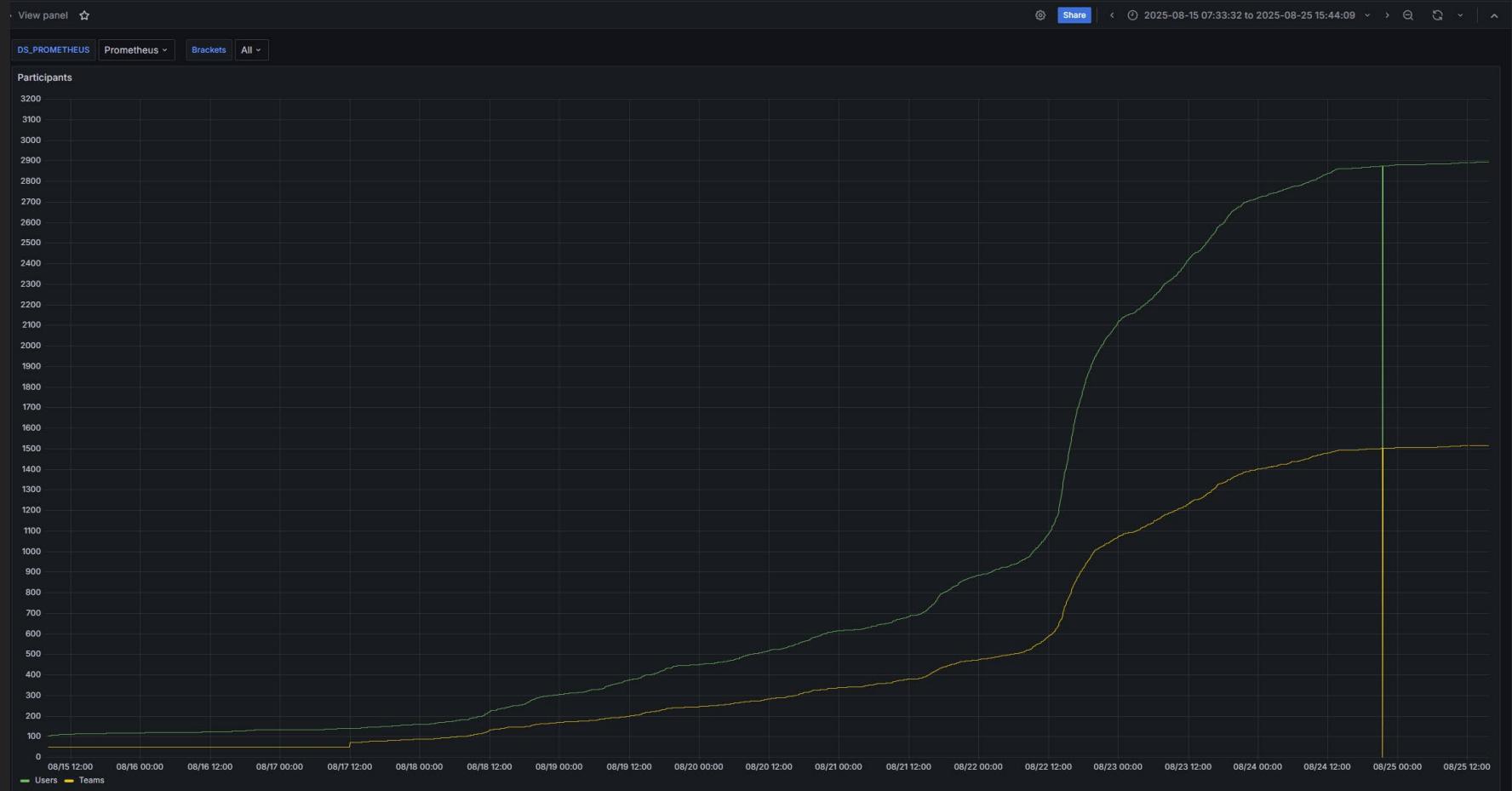
BrunnerCTF 2025

- Jeopardy CTF
- 22 – 24 august
- 14:00 CEST - 14:00 CEST

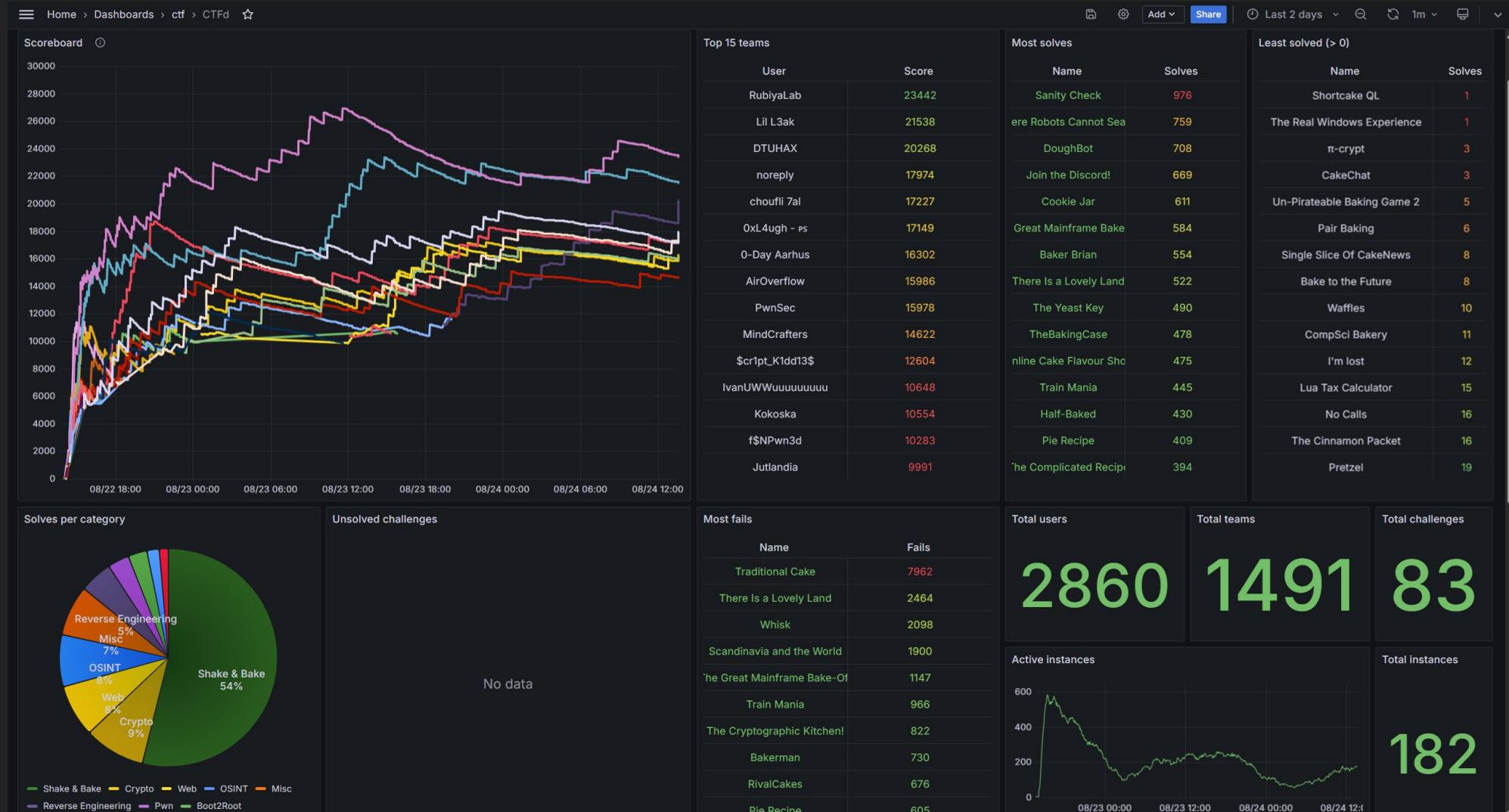


The stats

- 2800 users
- 1158 teams



The stats



The stats



The stats

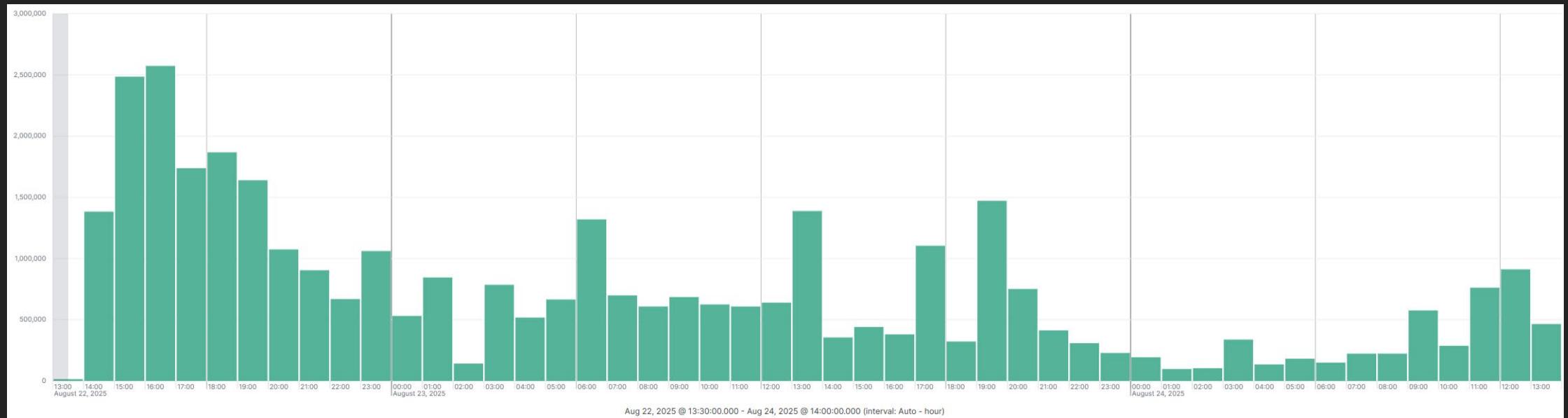


The stats



The stats

- 35 million requests
- 2.666 r/s

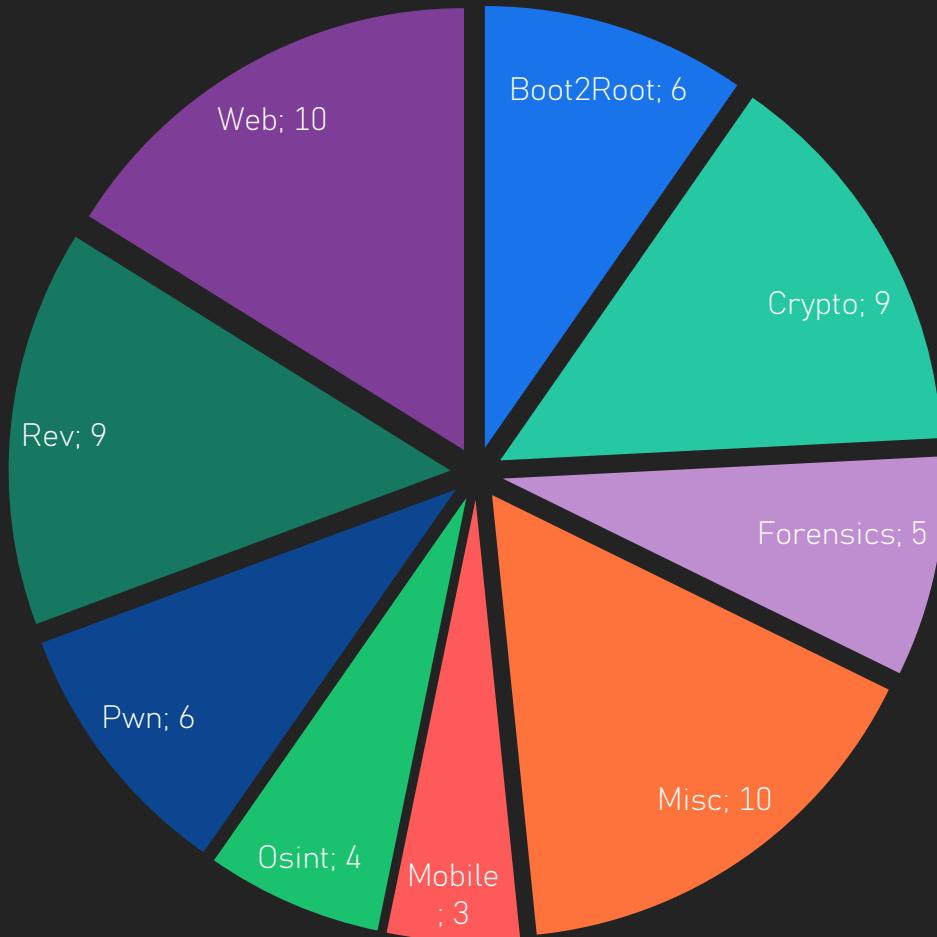


The stats

Traefik user agents - PROD ⓘ					
gobuster/3.6 Count of records	Fuzz Faster U Fool v2.1.0-dev Count of records	feroxbuster/2.11.0 Count of records	Mozilla/5.0 (Windows NT 10.0; Win64; x64) ... Count of records	Mozilla/5.0 (Windows NT 10.0; Win64; x64) ... Count of records	
9,499,688	8,826,321	4,703,058	2,802,792	1,424,836	
gobuster/3.7 Count of records	DirBuster-1.0-RC1 (http://www.owasp.org/inde... Count of records	Mozilla/5.0 (X11; Linux x86_64; rv:128.0) Gecko/20100101 ... Count of records	Fuzz Faster U Fool v2.1.0 Count of records	Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1) Count of records	
1,083,374	625,806	445,850	438,504	312,003	
feroxbuster/2.5.0 Count of records	Wfuzz/3.1.0 Count of records	Mozilla/5.0 (X11; Linux x86_64) AppleWebKit/537.36 (KHTML... Count of records	python-requests/2.32.3 Count of records	gobuster/3.0.1 Count of records	
311,658	282,337	270,675	254,664	253,383	
feroxbuster/2.10.4 Count of records	gobuster 2.0.1 Count of records	Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:141.0) ... Count of records	Mozilla/5.0 (Windows NT 10.0; Win64; x64) ... Count of records	Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:142.0) ... Count of records	
220,563	210,618	169,924	159,918	158,974	
Mozilla/5.0 (Windows NT 10.0; Win64; x64) ... Count of records	Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) ... Count of records	Fuzz Faster U Fool v1.1.0 Count of records	gobuster/3.8 Count of records	Other Count of records	
139,910	132,830	130,679	117,088	2,889,966	

Challenges

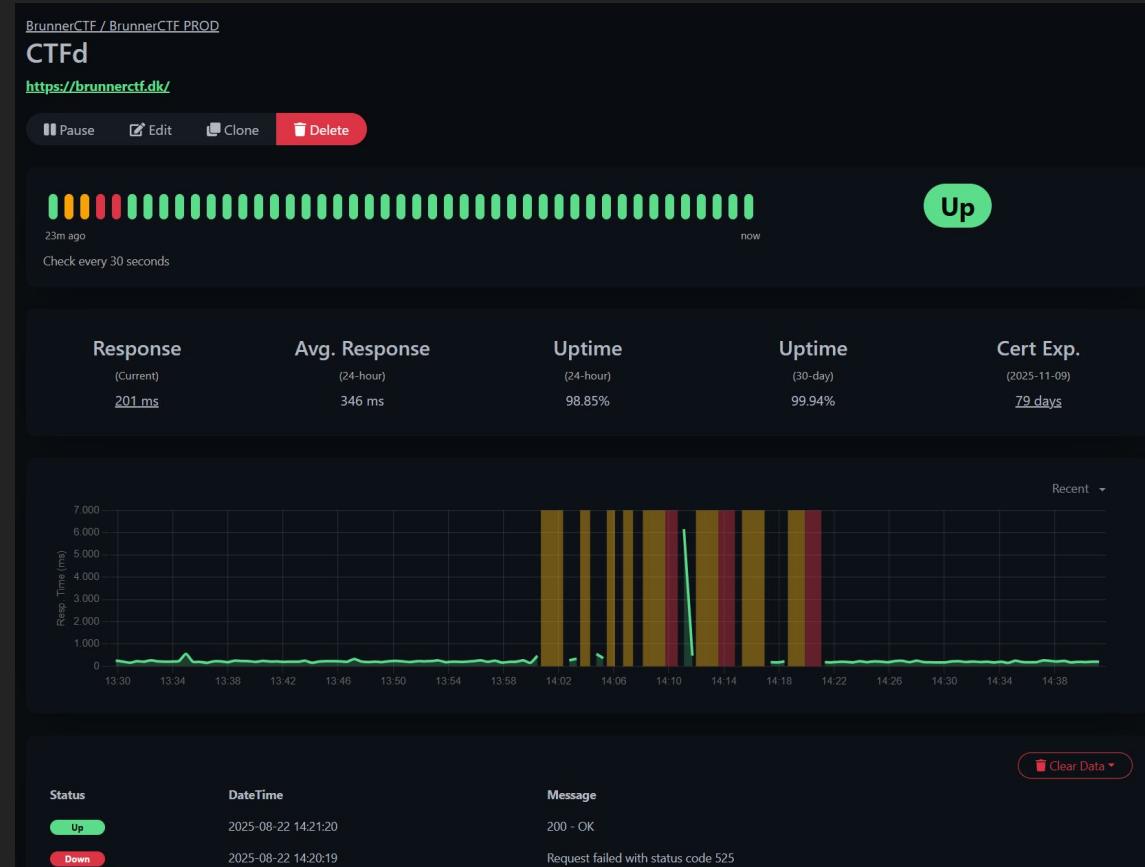
- 83 challenges
- 10 categories



Surviving the first 5 minutes

Surviving the first 5 minutes

- Are we down?



Surviving the first 5 minutes



- Are we down?

Resources



Surviving the first 5 minutes



- Are we down?



Learnings

Instancing

- Issues with shared remotes
- TCP giving no logs
- Instancing allows for isolating teams ressource wise
- Good performance, and lots of headroom for scaling
- Everything instanced



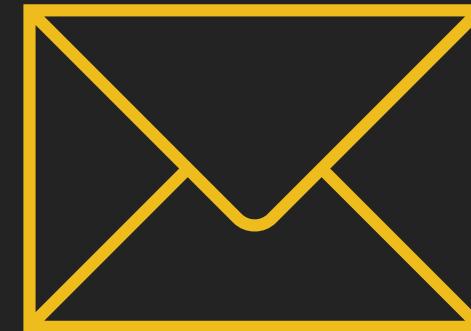
CTFd and clustering

- Trying to achieve 100% uptime
- CTFd not being able to handle clustered Redis



Emails

- When Google starts blocking your emails
- Switching email domain



Brevo

Alerting

- Customizing alerts
- Not enough alerts, and alerts too late



Pricing

- Hetzner
- 265.18€
 - Prod: 127.45€
 - Staging: 137.73 €



Control planes - 3x CPX31 (4 vCPU, 8GB RAM)
Agents - 3x CCX33 (8 dedicated vCPU, 32 GB RAM)
Challs - 8x CPX51 (16 vCPU, 32 GB RAM)

Future work

Improvements

- Simplify challenge deployment
- Challenge schema
- Discord bot
- CTFd
 - List of all challenges running – Better insight into instances

Large files



S3



Cheat detection

- Dynamic flags





Going open source

CTF Pilot

- github.com/ctfpilot
- ctfpilot.com



CTF
Pilot

Want to learn more?

- blog.themikkeldk



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Mikkel Albrechtsen

