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

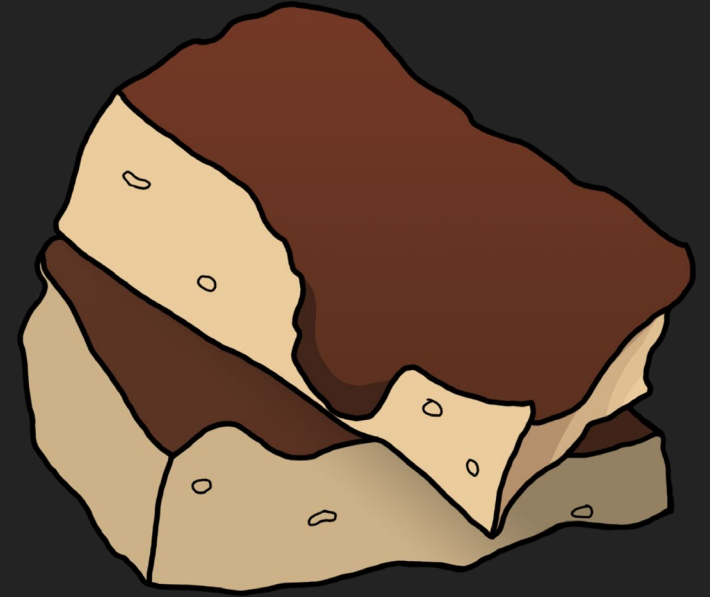- Running the CTF

- Learnings

- Future work

Whoami

- Mikkel Albrechtsn

- Software engineering student @ SDU

- Software developer

- Infrastructure enthutiast

- 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
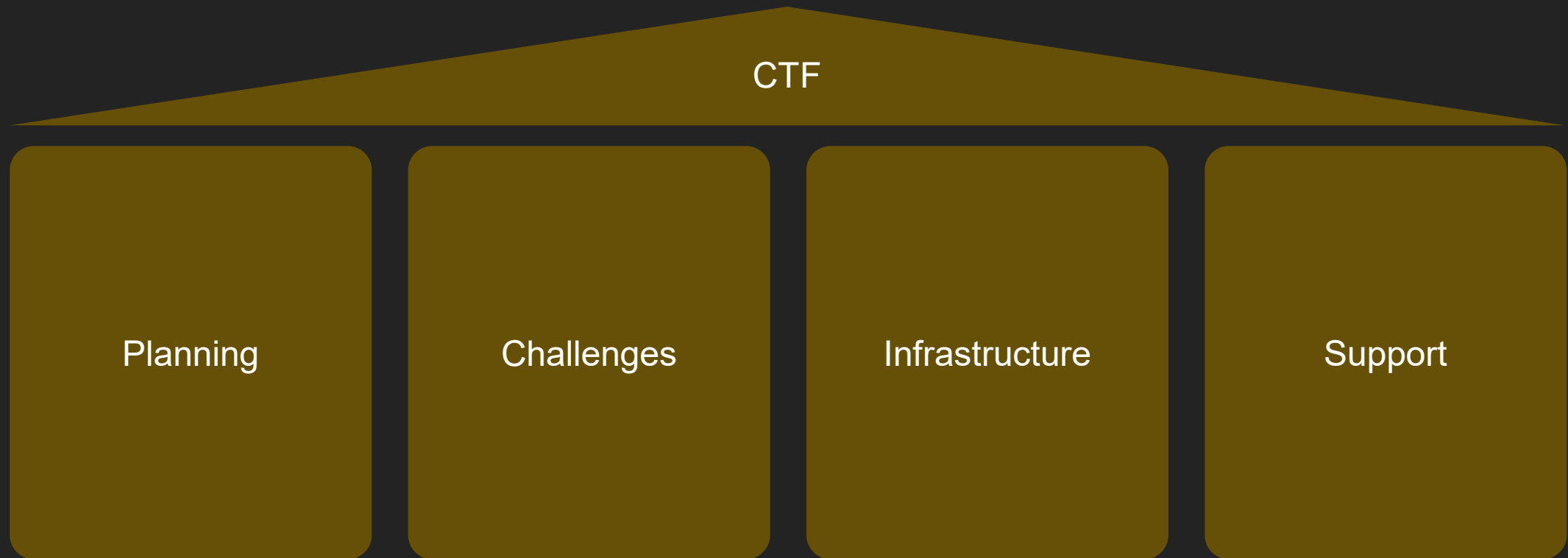
Infrastructure

What does a CTF consist of
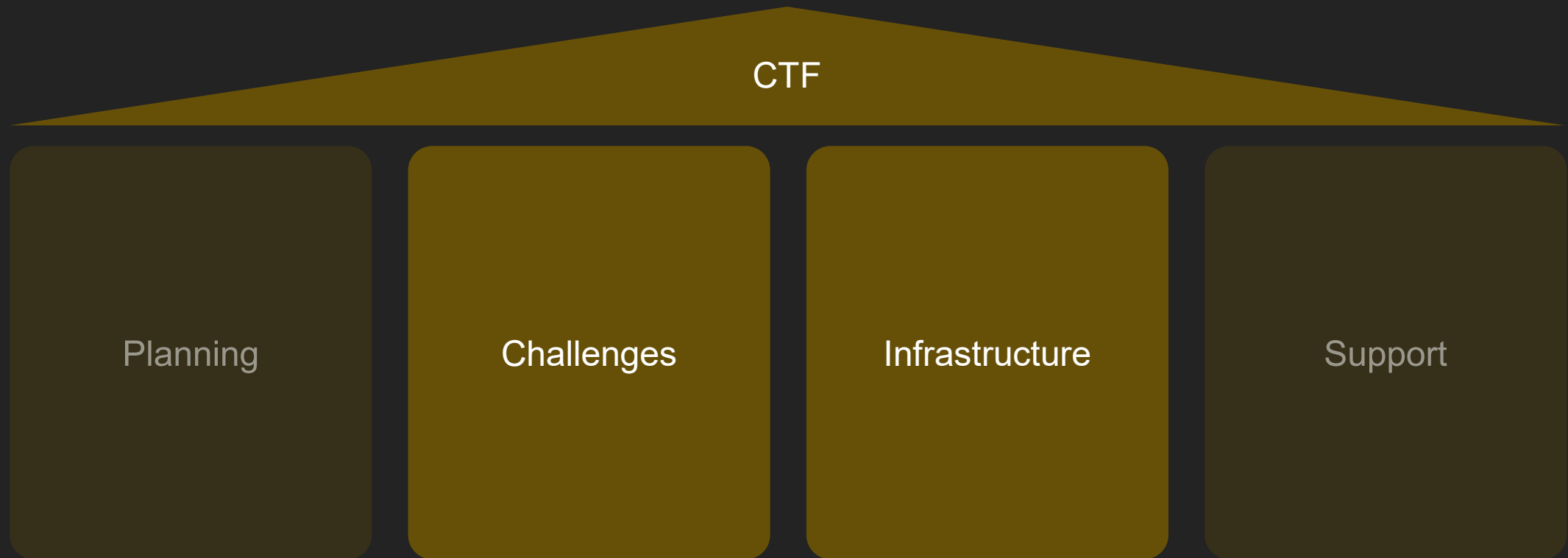
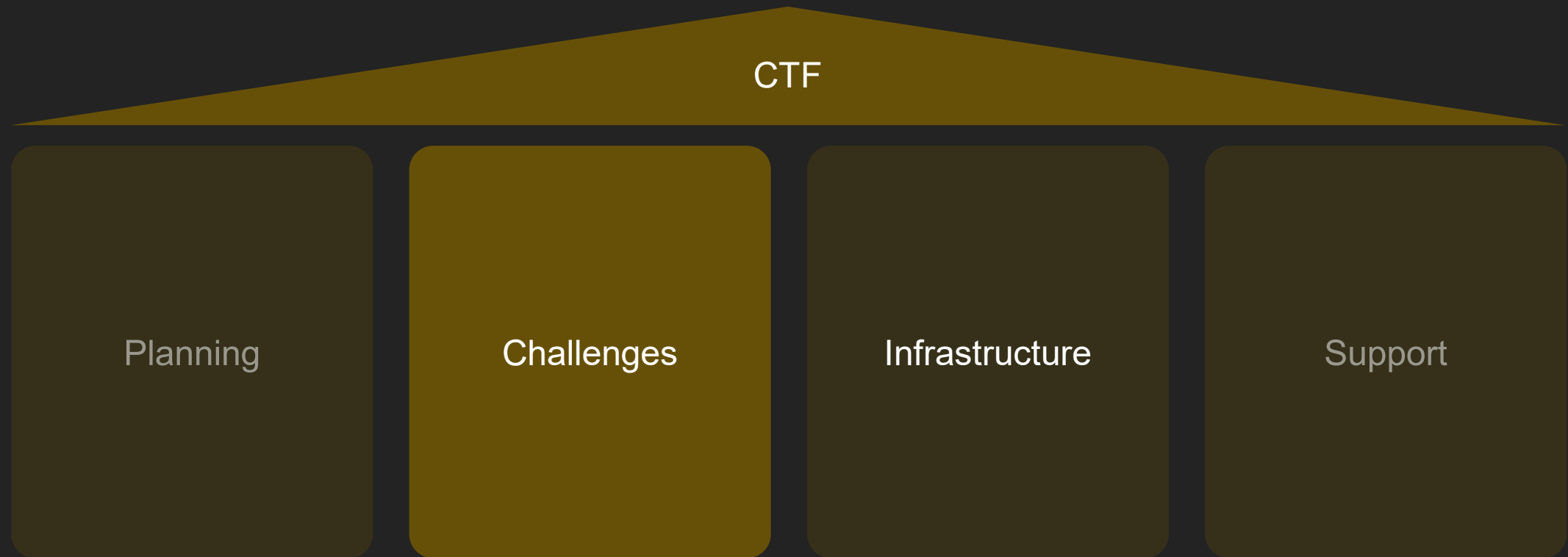| Planning | Challenges | Infrastructure | Support |

What does a CTF consist of

CTF

Planning

Challenges

Infrastructure

Support

What does a CTF consist of

CTF

Planning

Challenges

Infrastructure

Support

What does a CTF consist of

CTF

Planning

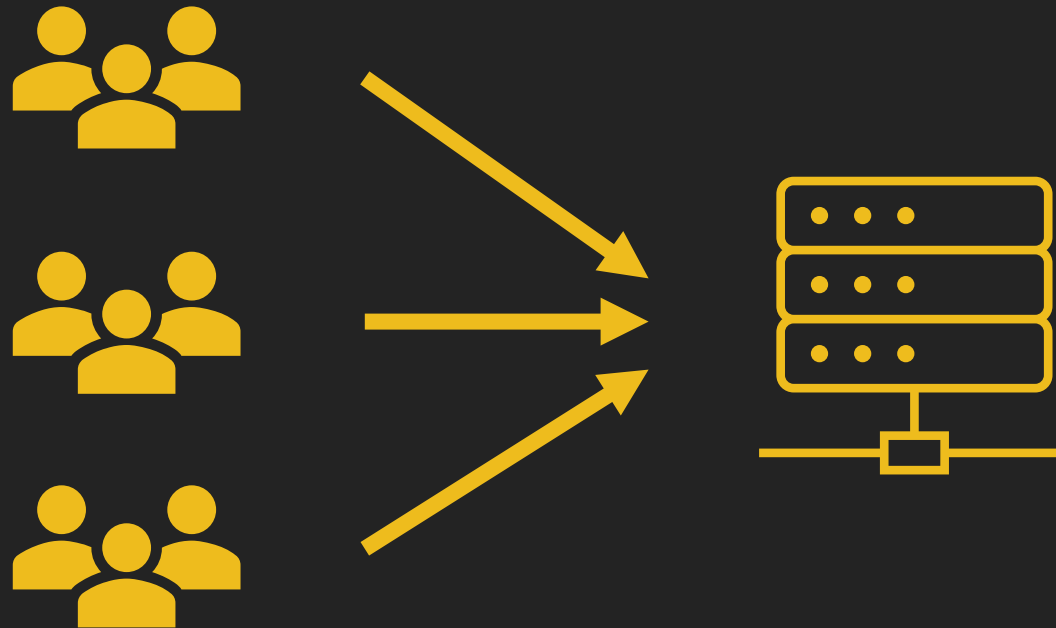Challenges

Infrastructure

Support

What does a CTF consist of

- 3 Types of challenge
  - **Static**

What does a CTF consist of

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

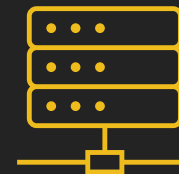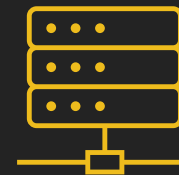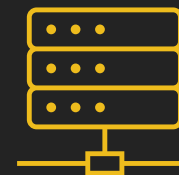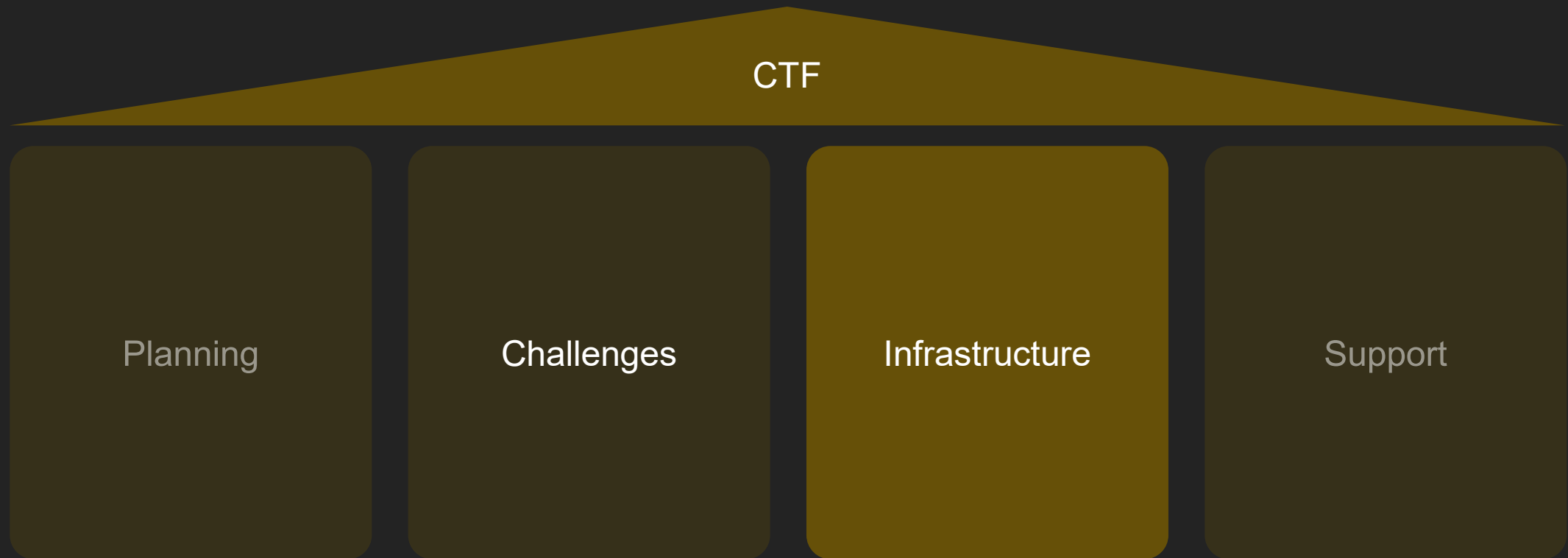# What does a CTF consist of

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

What does a CTF consist of

CTF

Planning

Challenges
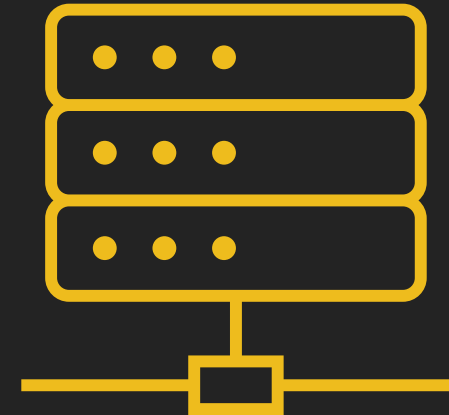
Infrastructure

Support

What does a CTF consist of

- Scoreboard

- Challenge remotes
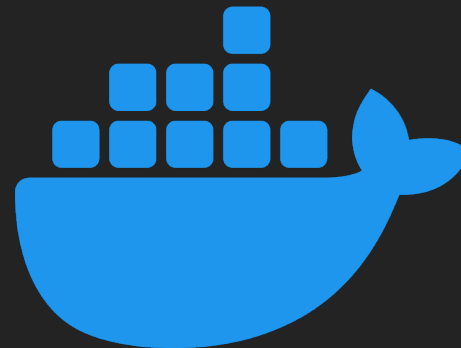
Existing platforms

- Scoreboard
  - CTFd
  - rCTF
  - noCTF

Existing platforms

- 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

- Recilians

It all starts with Kubernetes

- Container orchestrator

- Scalability

- Recilians

- Hetzner

It all starts with Kubernetes

Kubernetes cluster
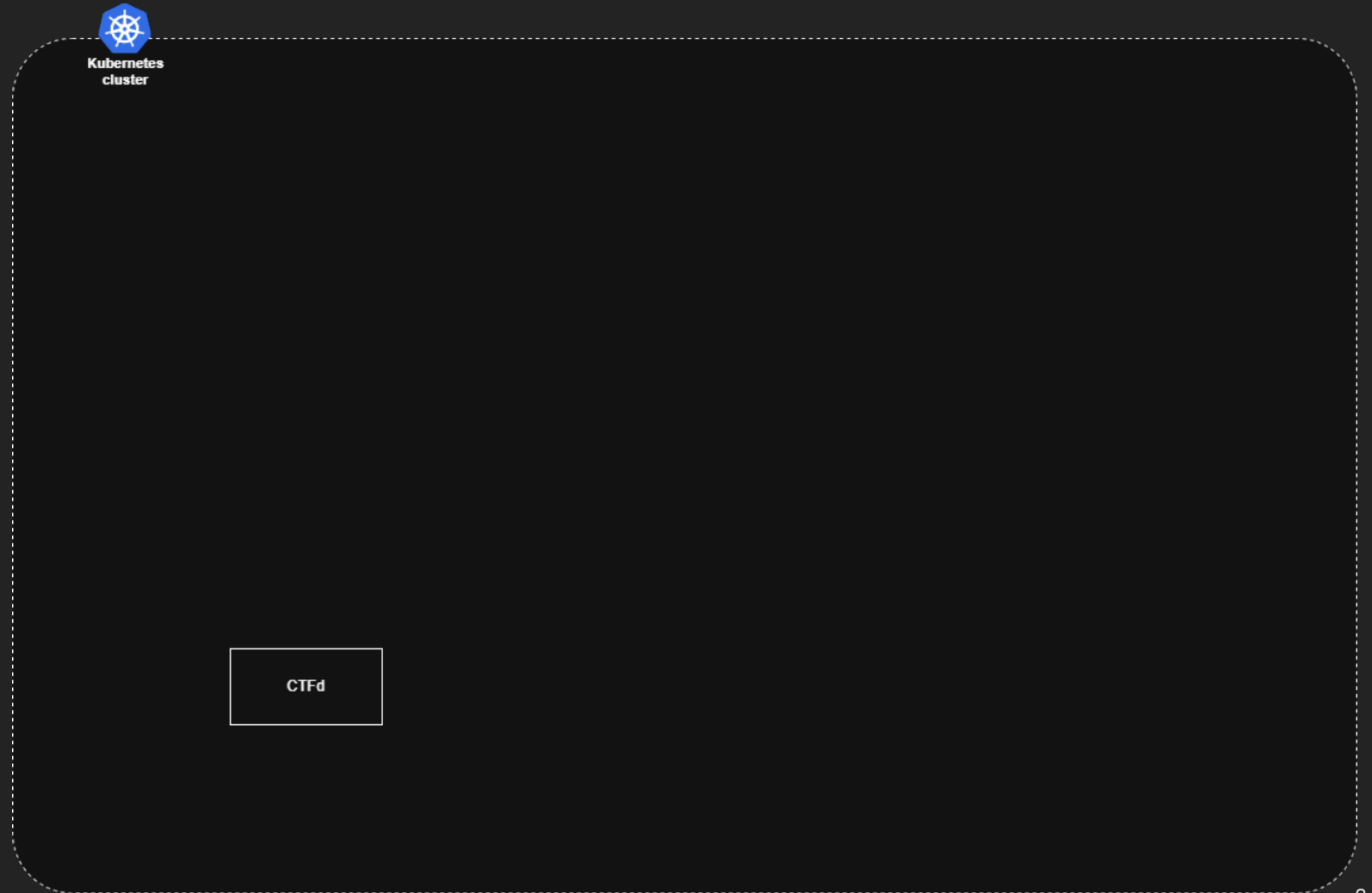
To CTFd or not to CTFd

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
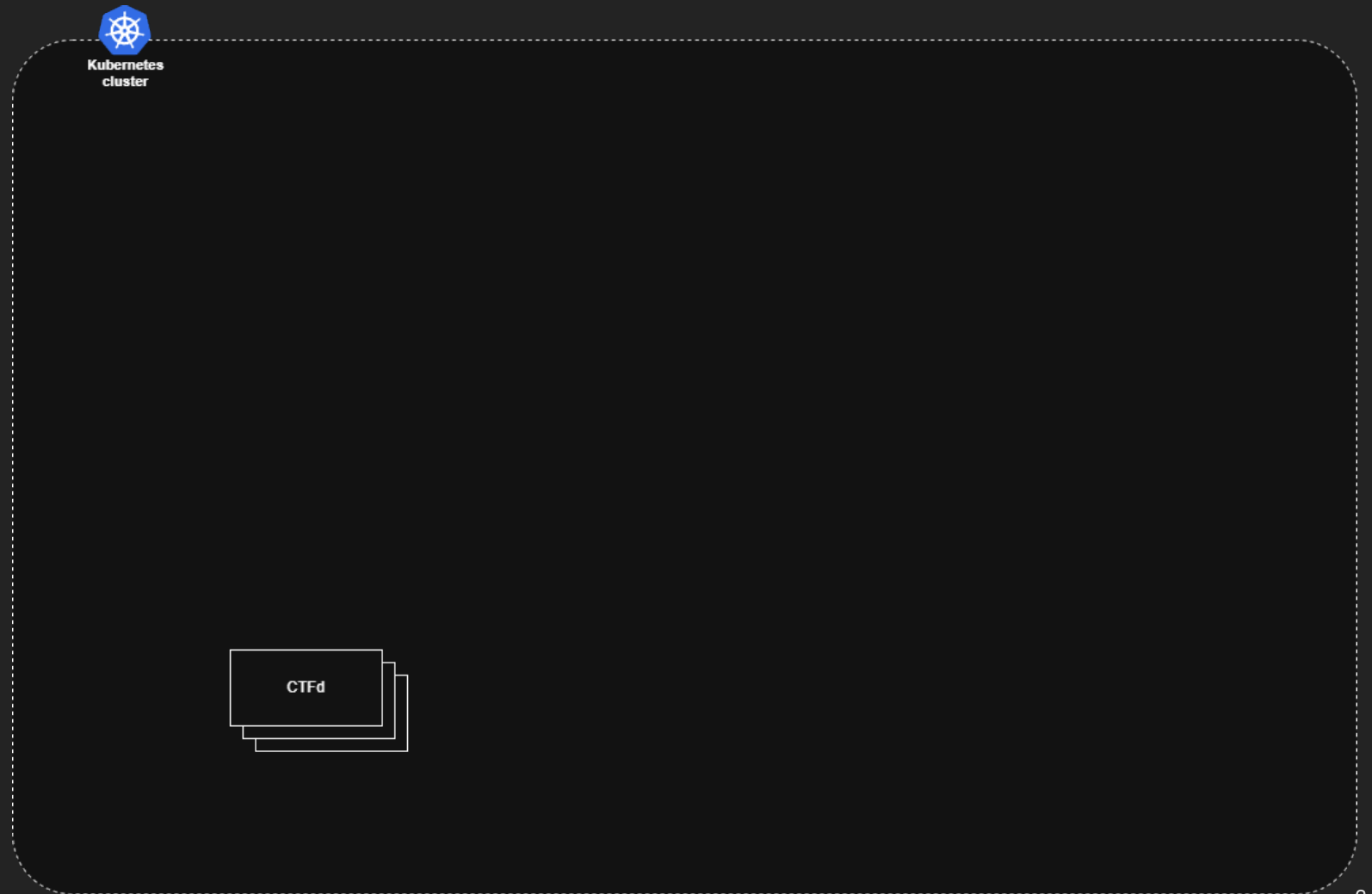
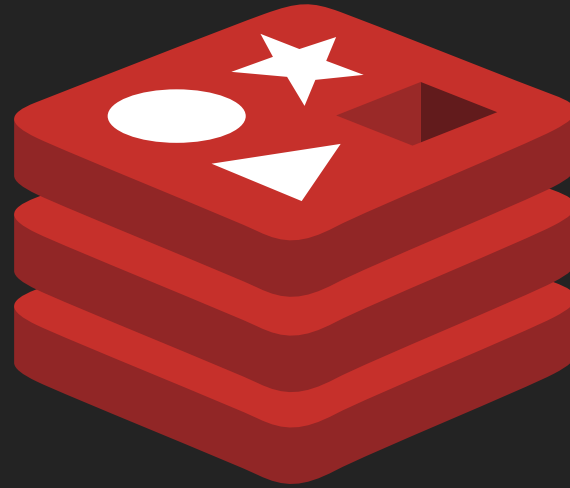- Very standard

- Hard to theme

To CTFd or not to CTFd

Kubernetes
cluster

CTFd

To CTFd or not to CTFd

Data storage

MariaDB

S3

Data storage

Data storage

Instancing

Kube-ctf

Instancing

Kube-ctf

Instancing

CTFd $\longrightarrow$ Kube-ctf

Instancing

CTFd ⟶ **Kube-ctf**

Instancing

Instancing

CTFd ➤ **Kube-ctf** ➤

Instancing

CTFd → Kube-ctf →

Instancing

Kube-ctf

Instancing

Challenge starting

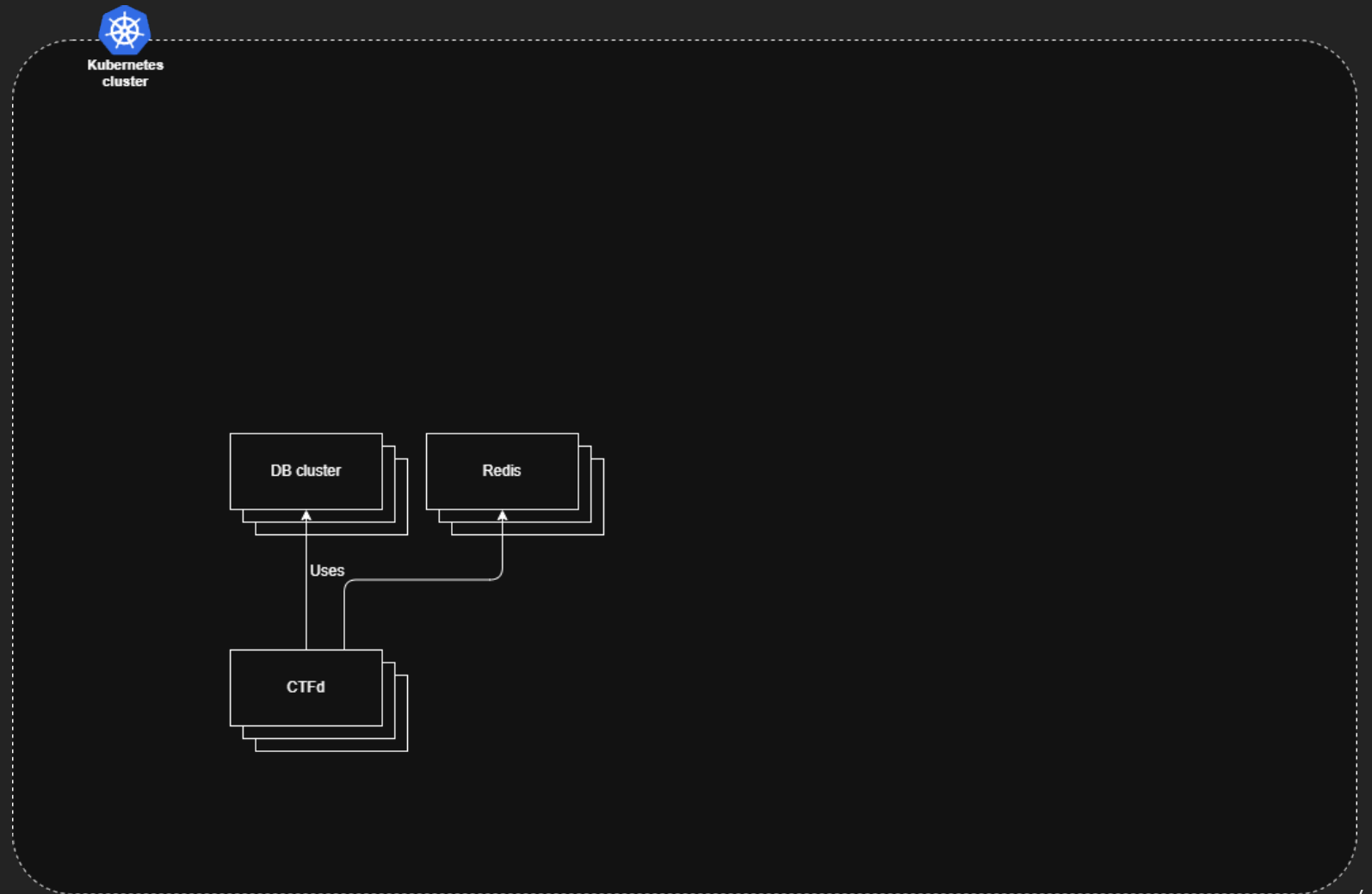CTFd → Kube-ctf → Kubernetes
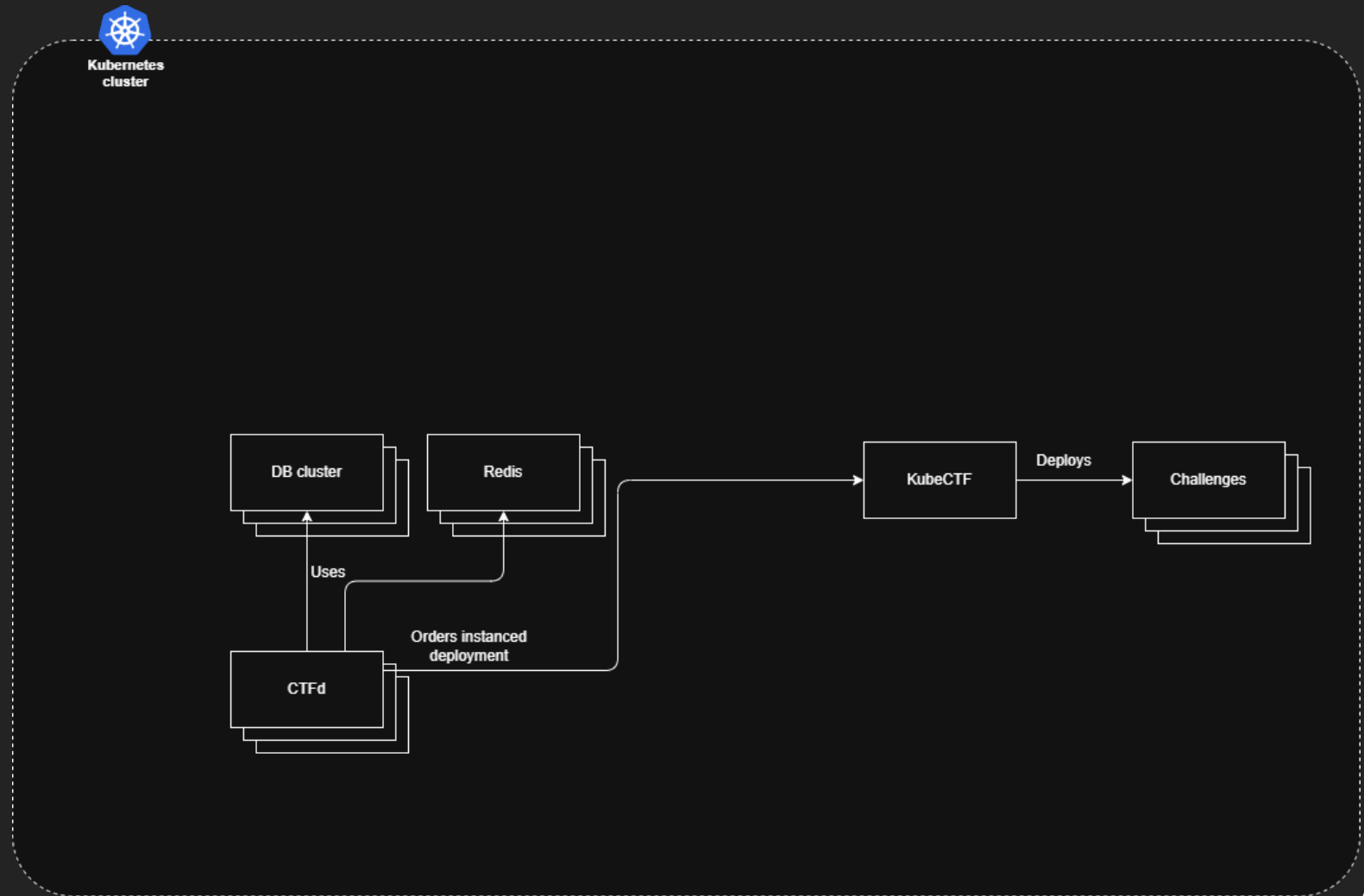
Instancing

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
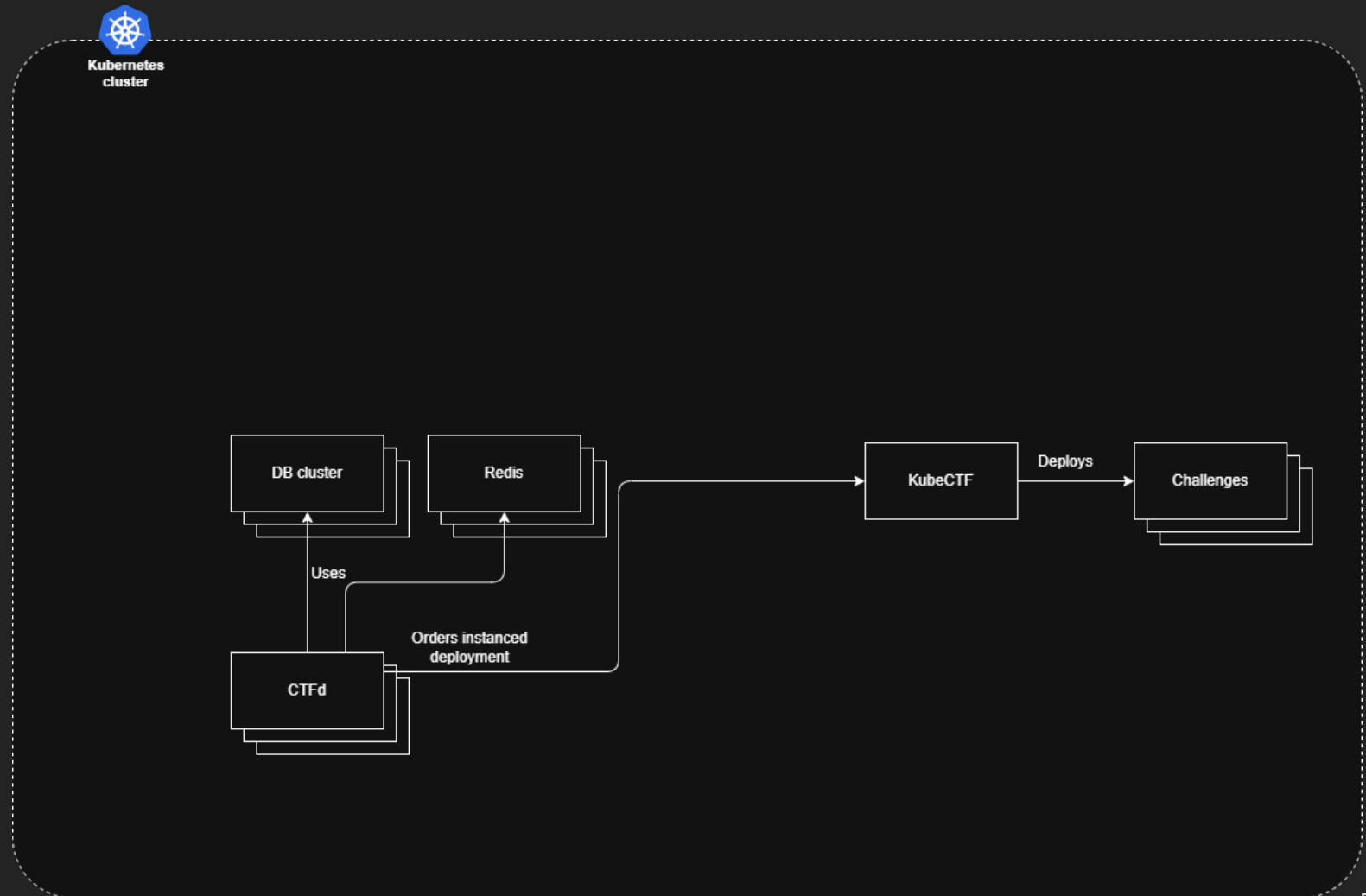

CTFd manager
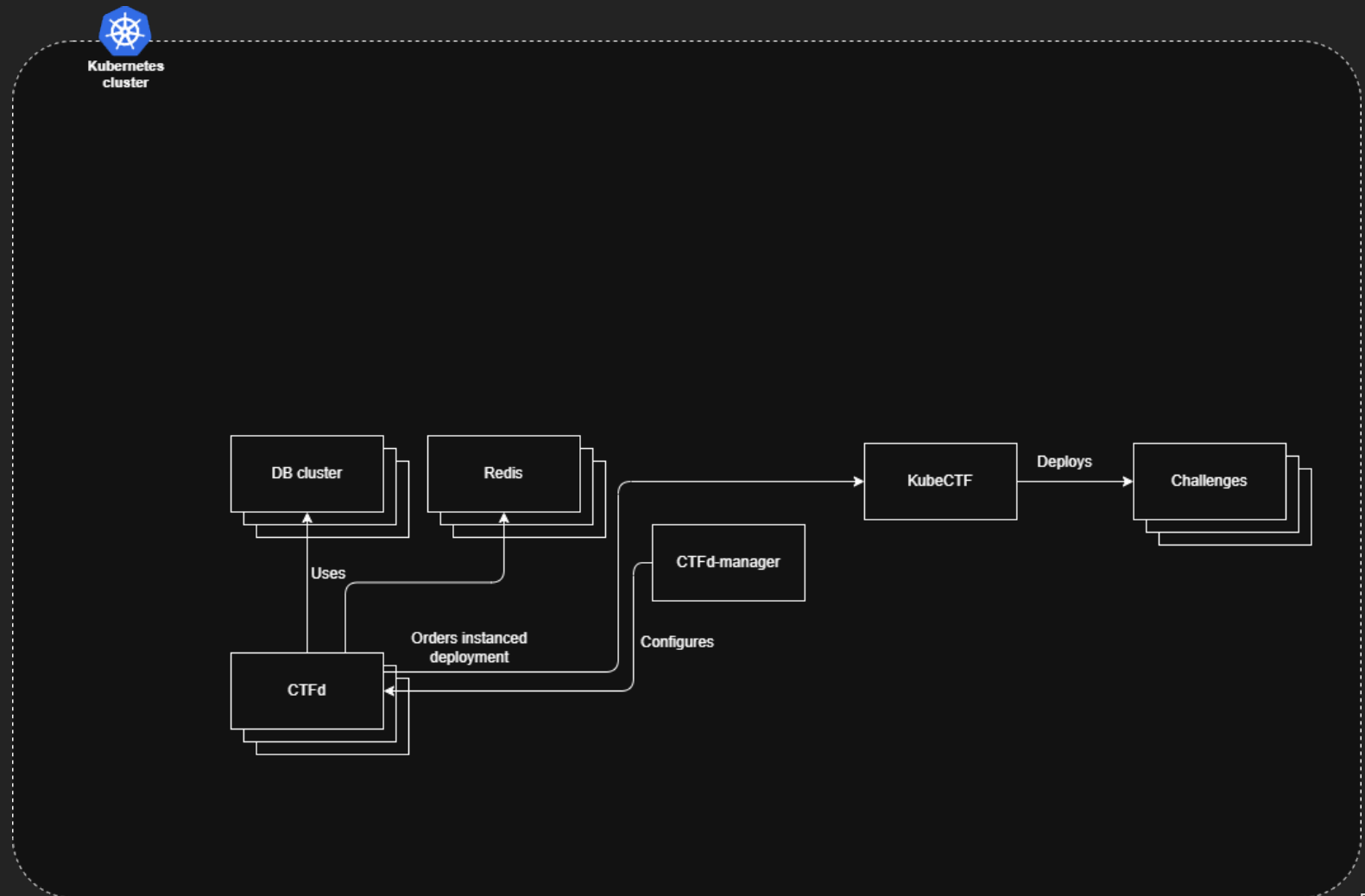
Automating CTFd

CTFd manager

Automating CTFd

Automating CTFd

Going GitOps
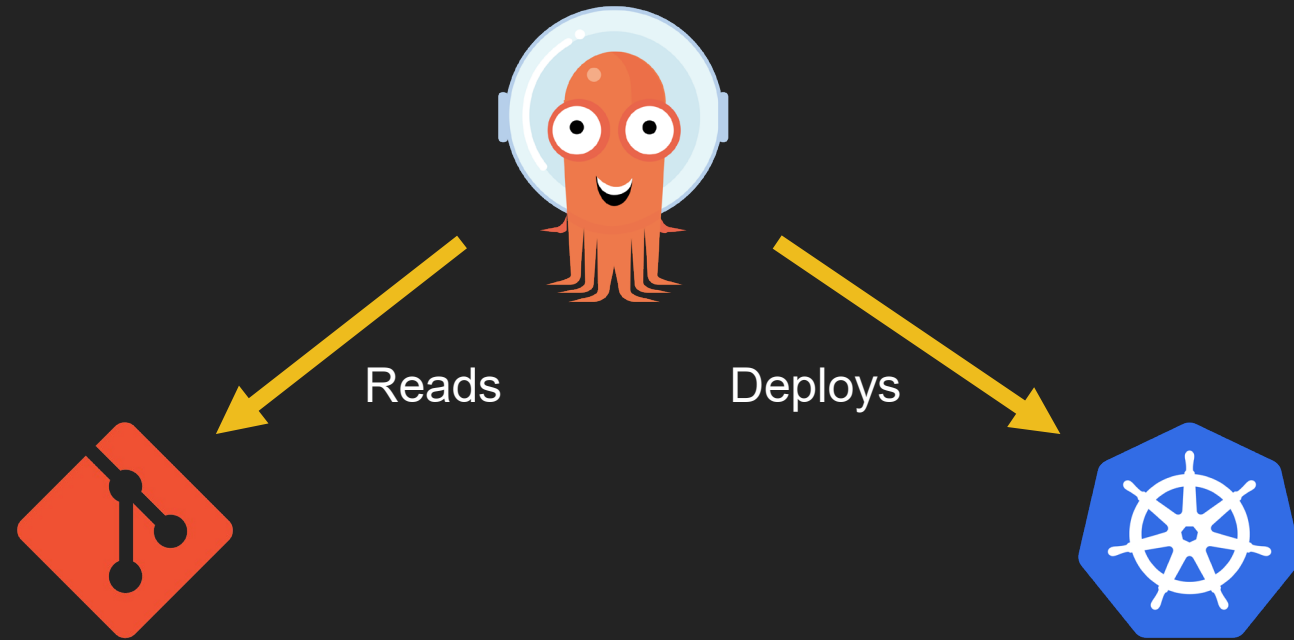
- Automating continuous deployment

Going GitOps

- ArgoCD

Going GitOps

Reads   Deploys

Going GitOps

Reads   Deploys
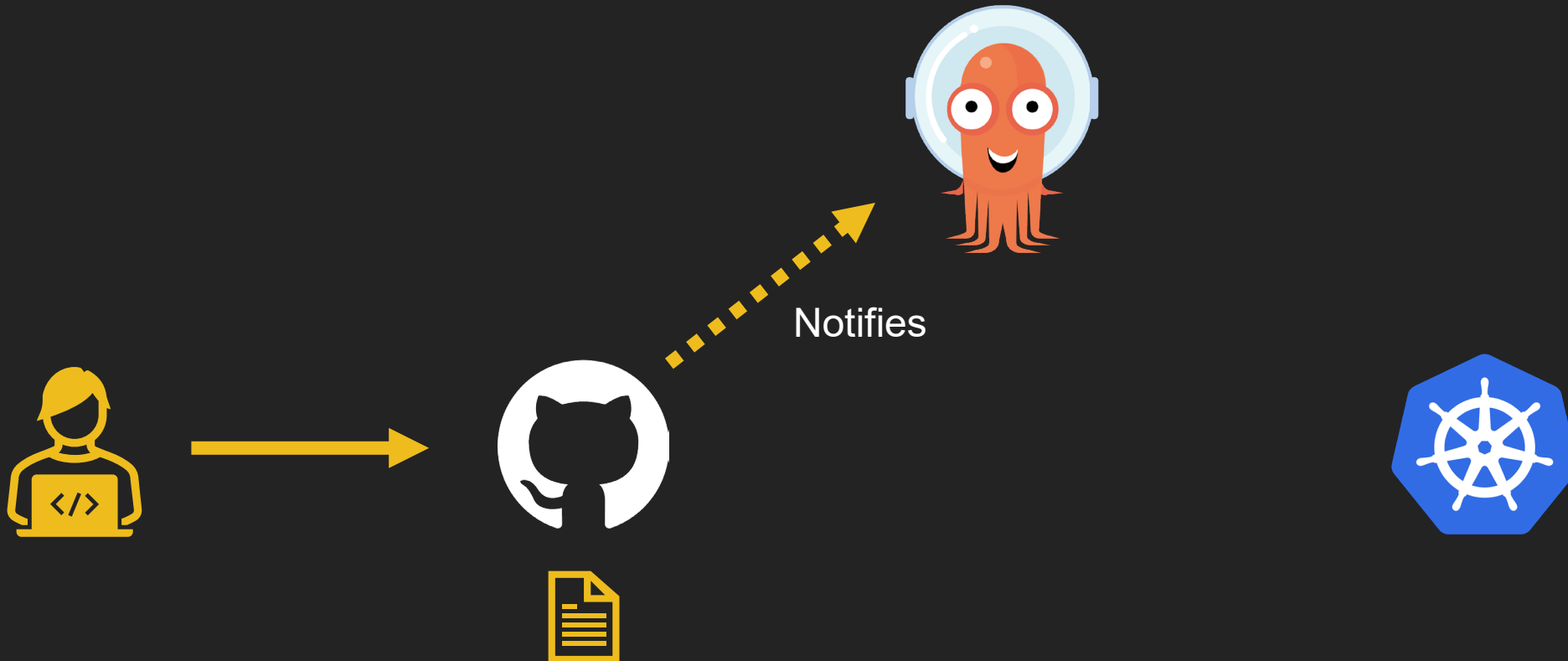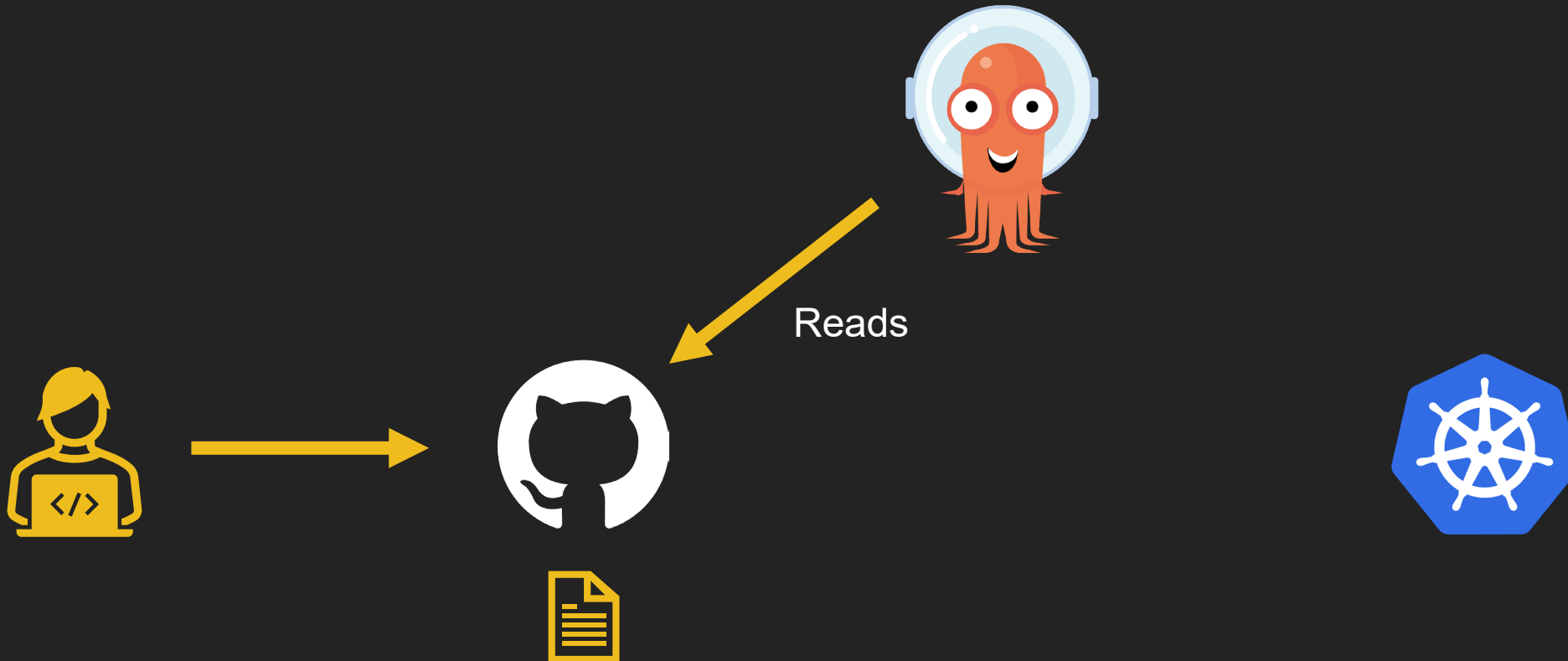
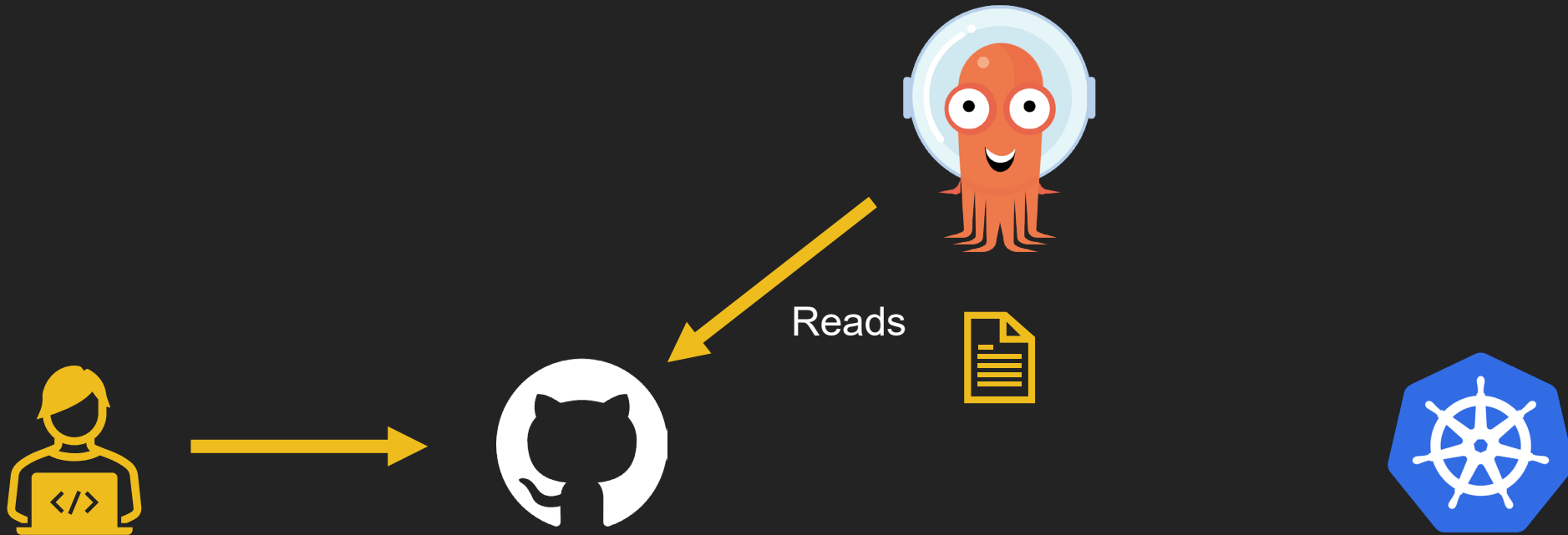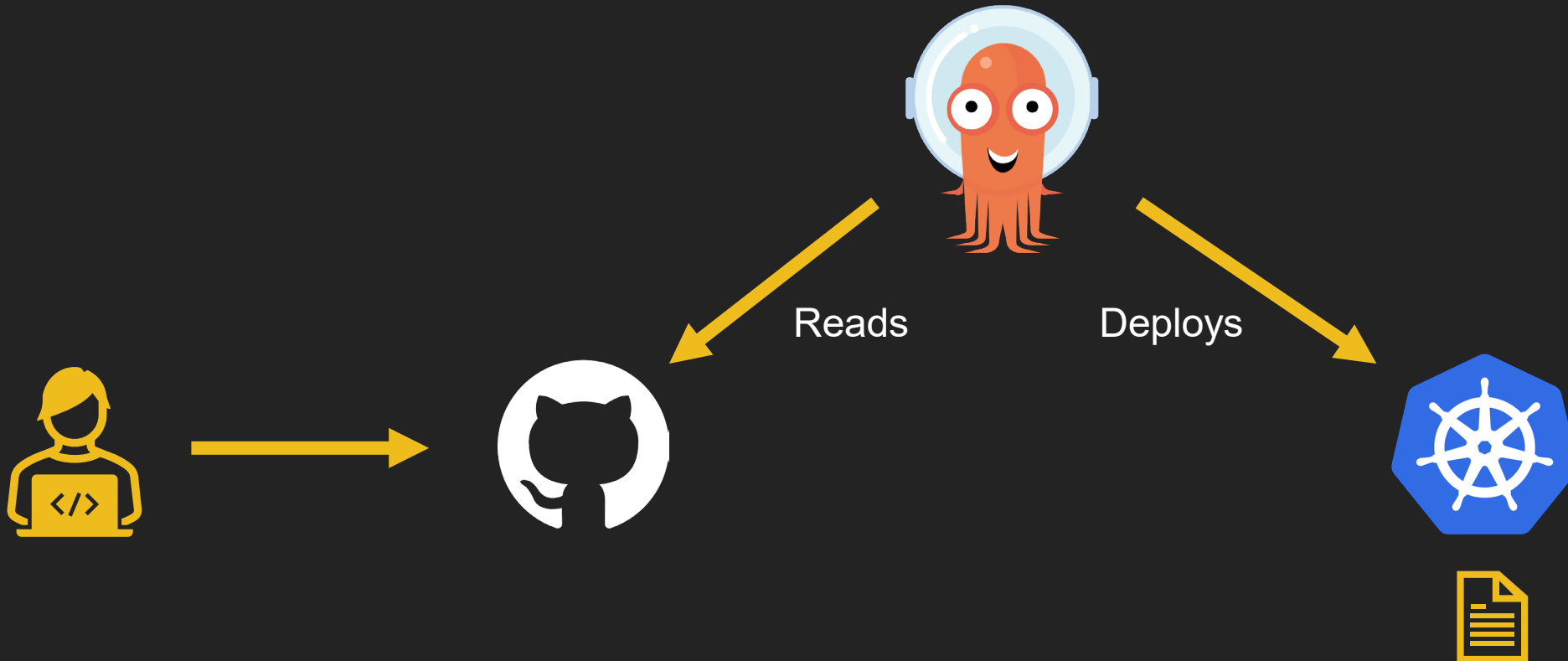# Going GitOps

Going GitOps

Going GitOps

Going GitOps

Notifies

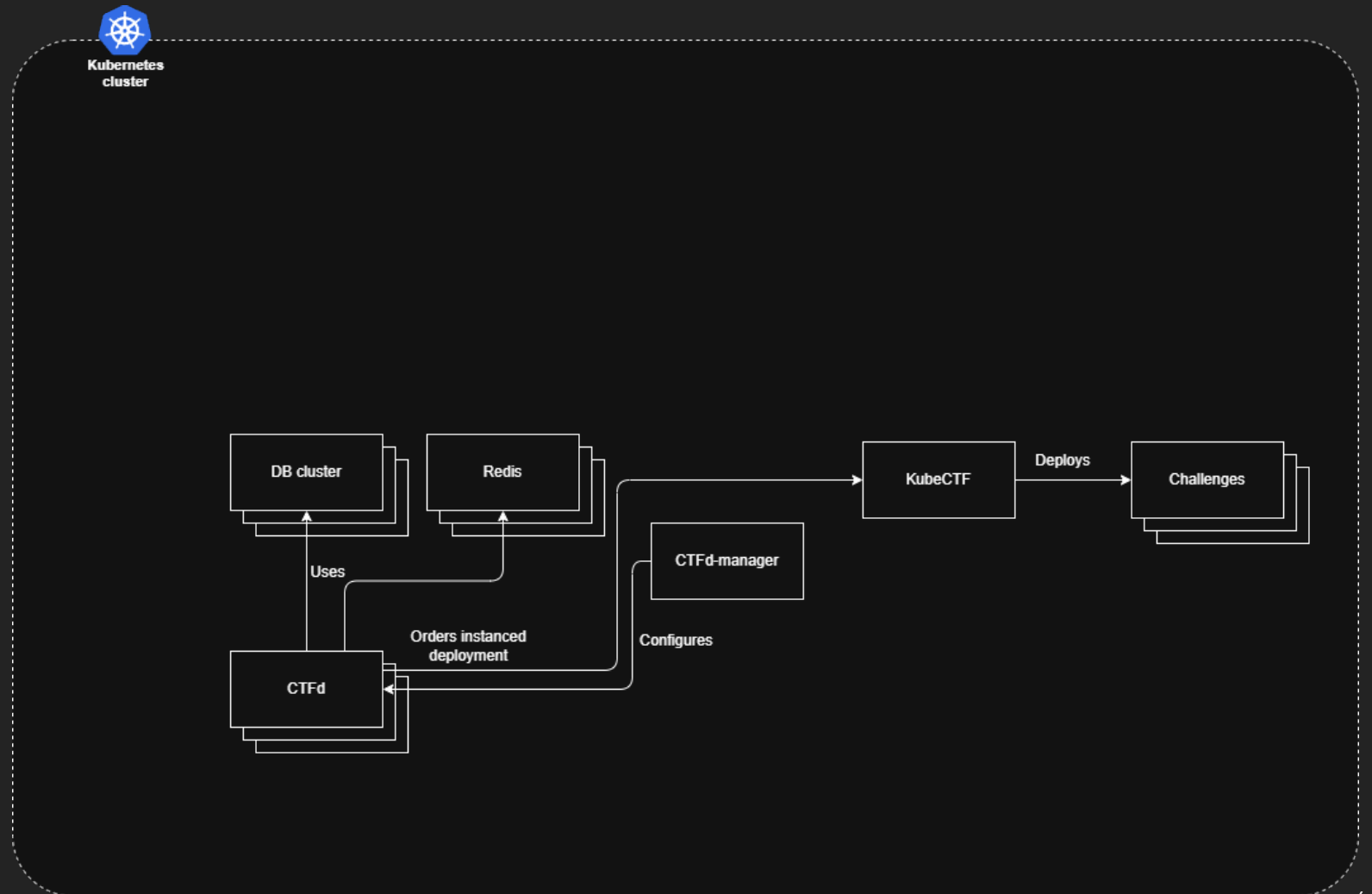# Going GitOps

Reads

Going GitOps

Reads

Going GitOps

Reads

Deploys
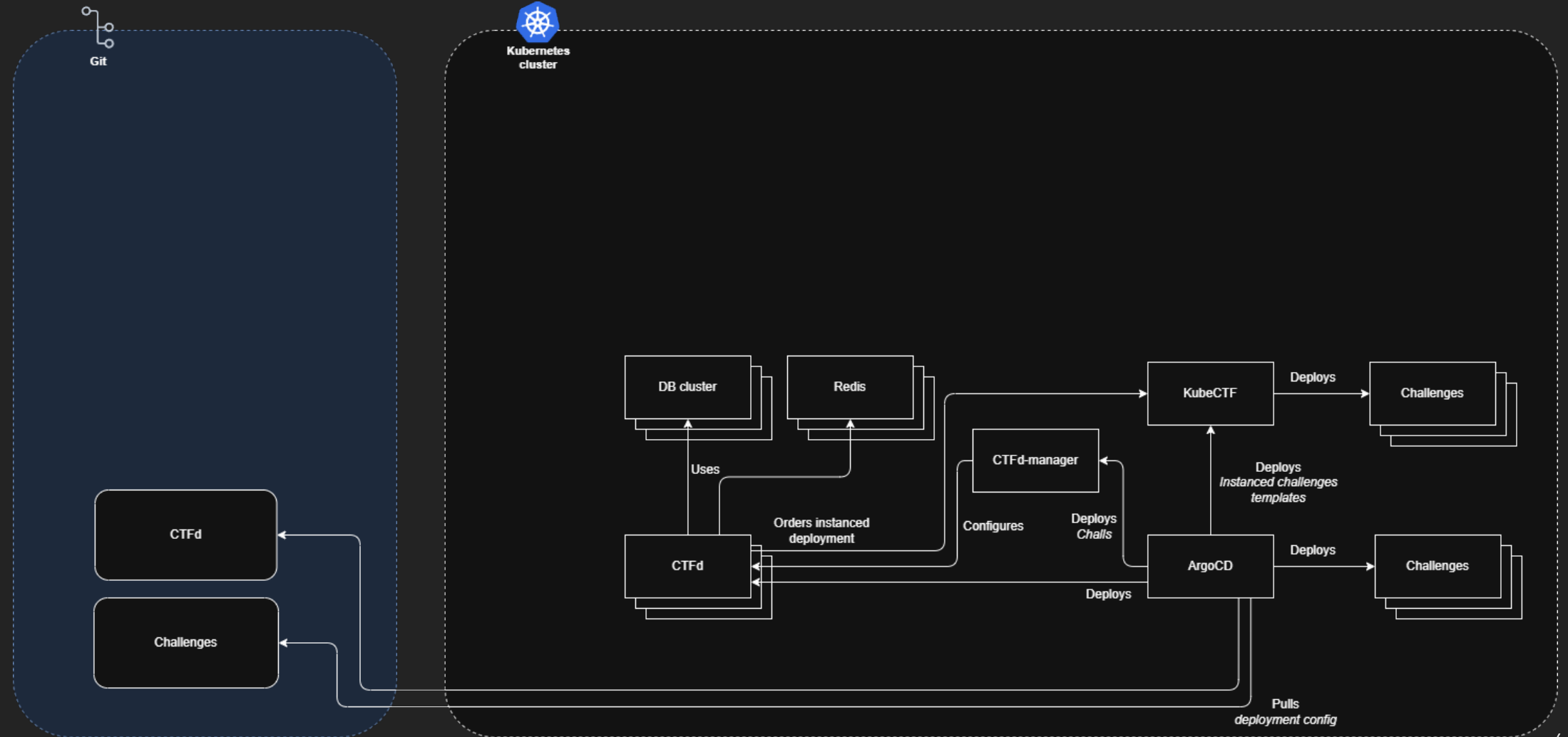
Going GitOps

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

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
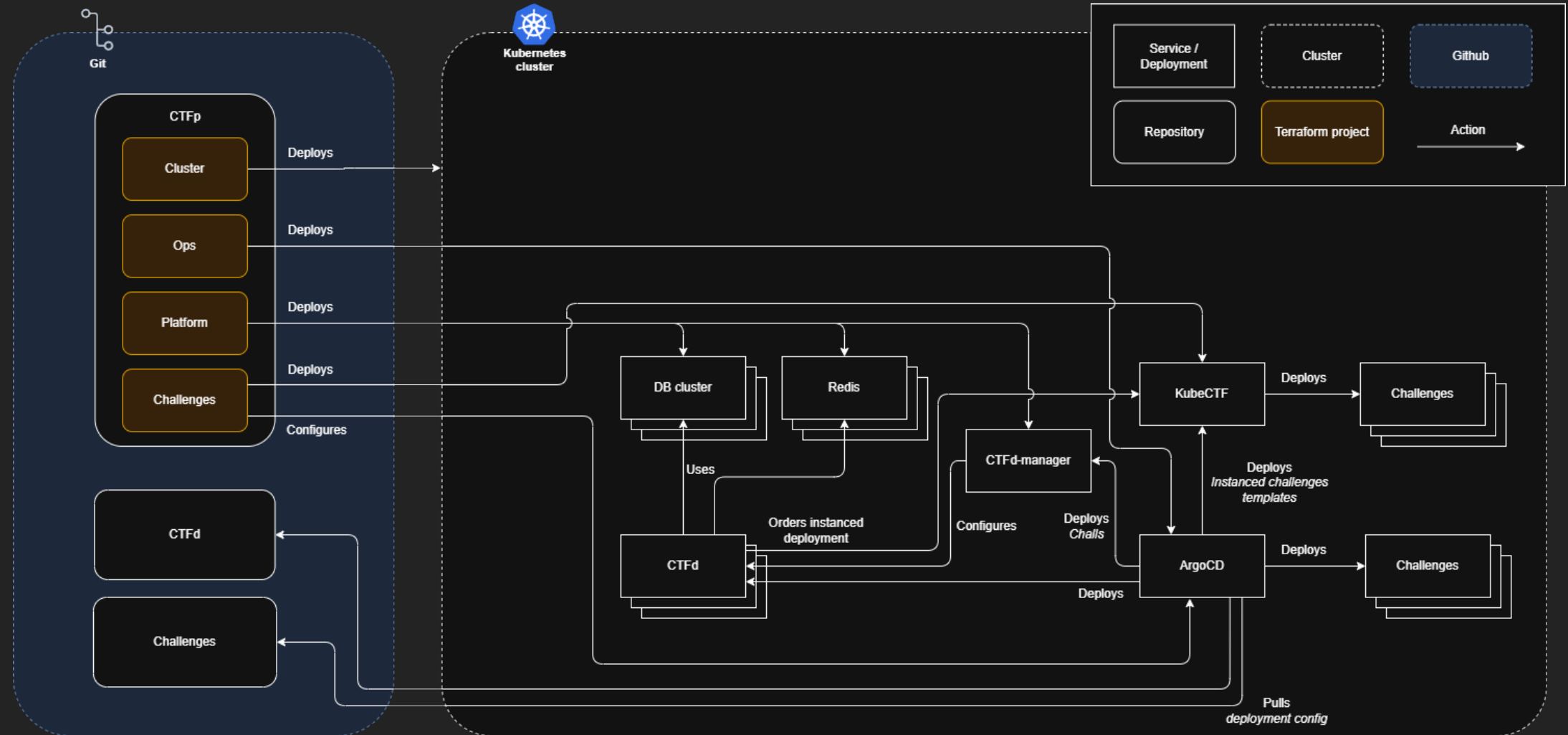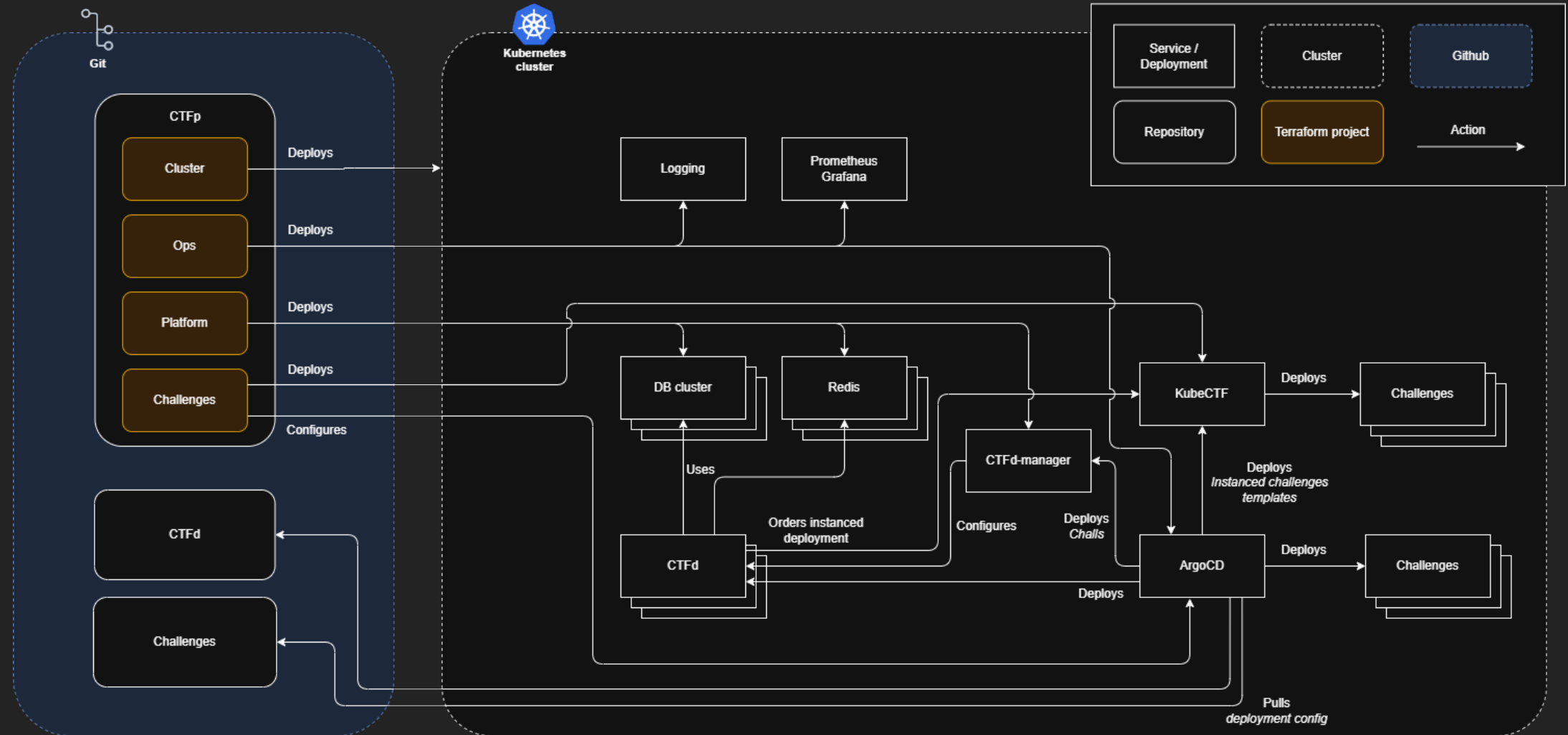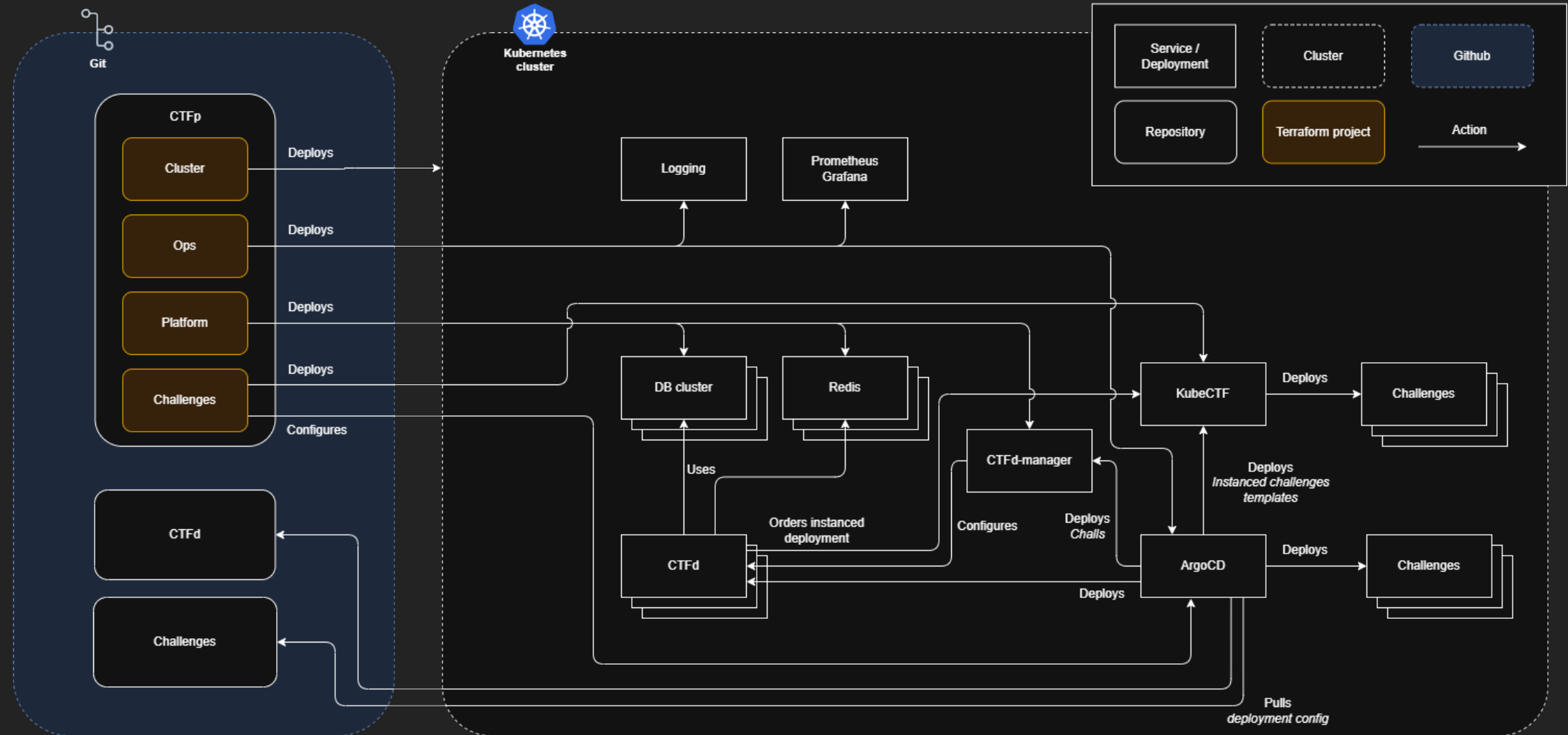
- Standardized schema

- 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_nOt_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

Challenge Repository

- Challenge directory

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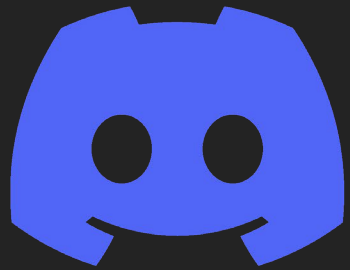
Automated deployment

Discord integration

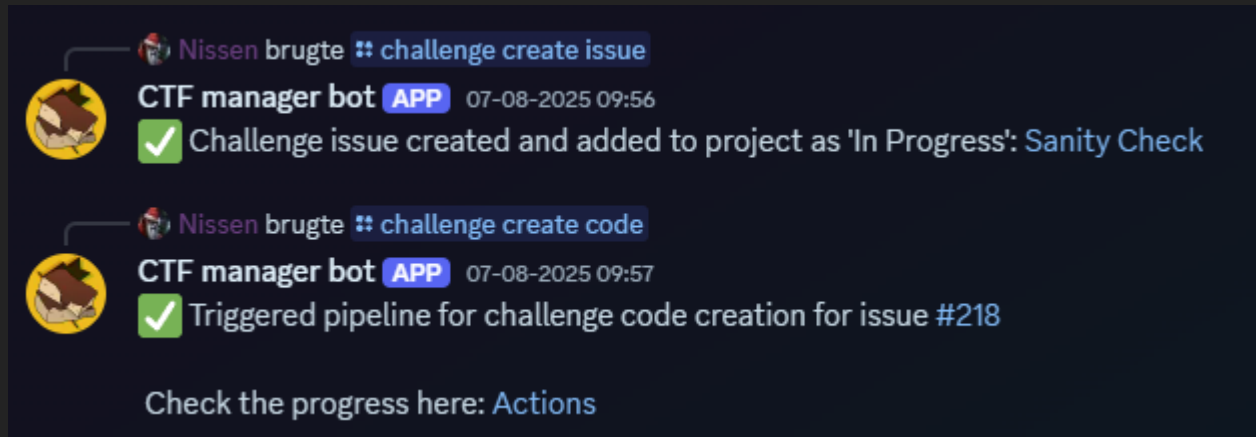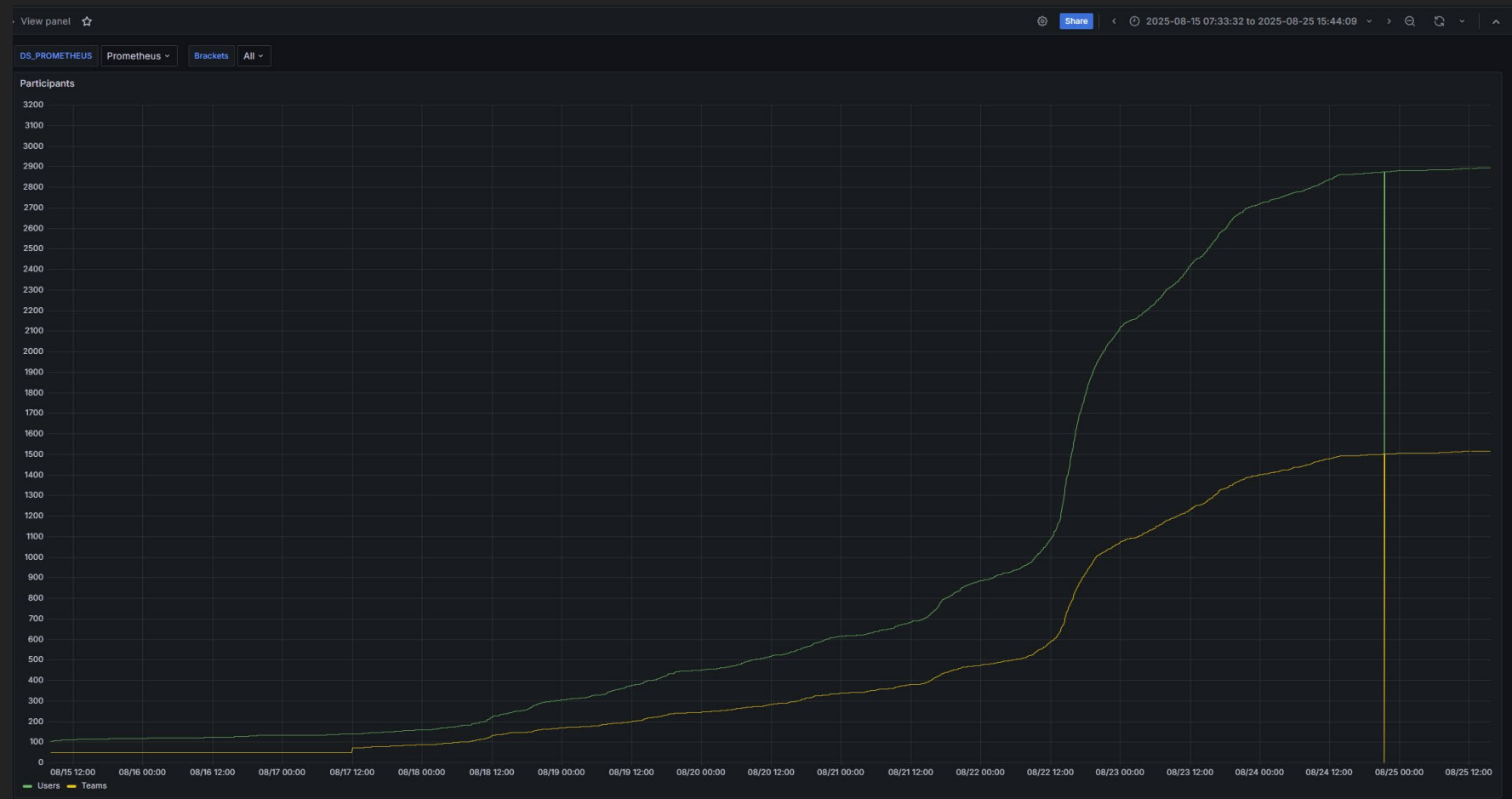# Running the CTF

BrunnerCTF 2025

- **Jeopardy CTF**

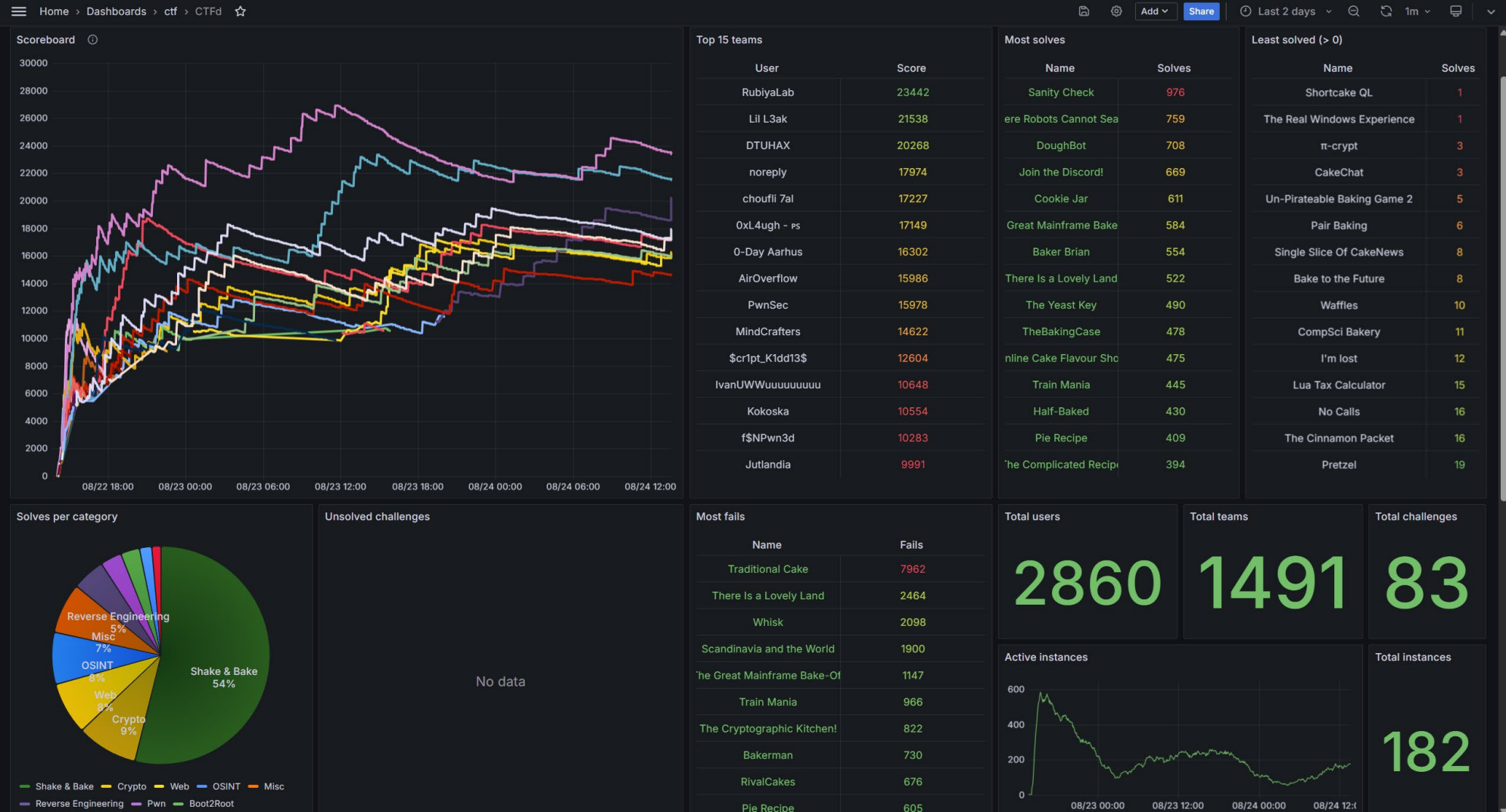- **22 – 24 august**

- **14:00 CEST - 14:00 CEST**

The stats

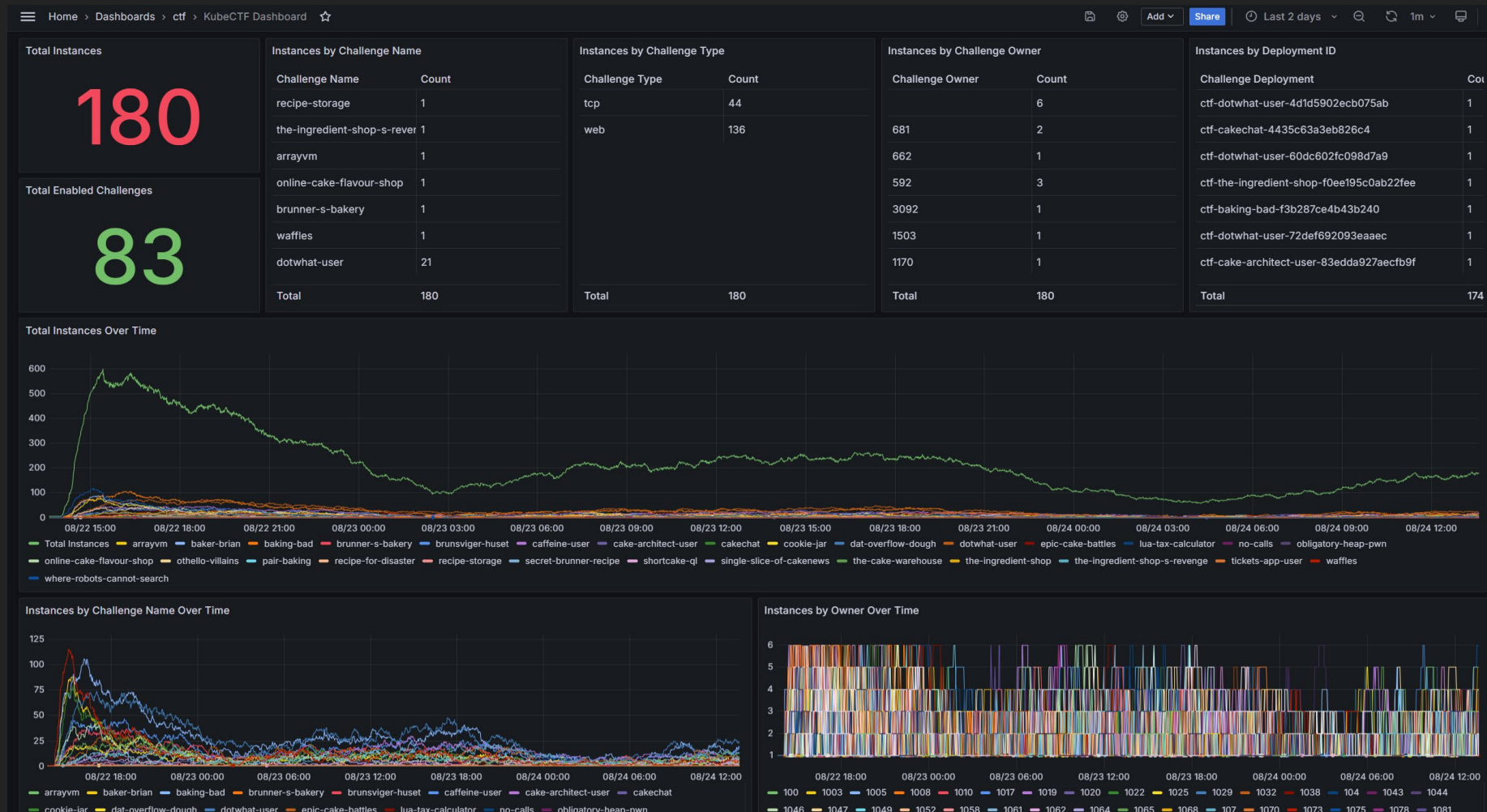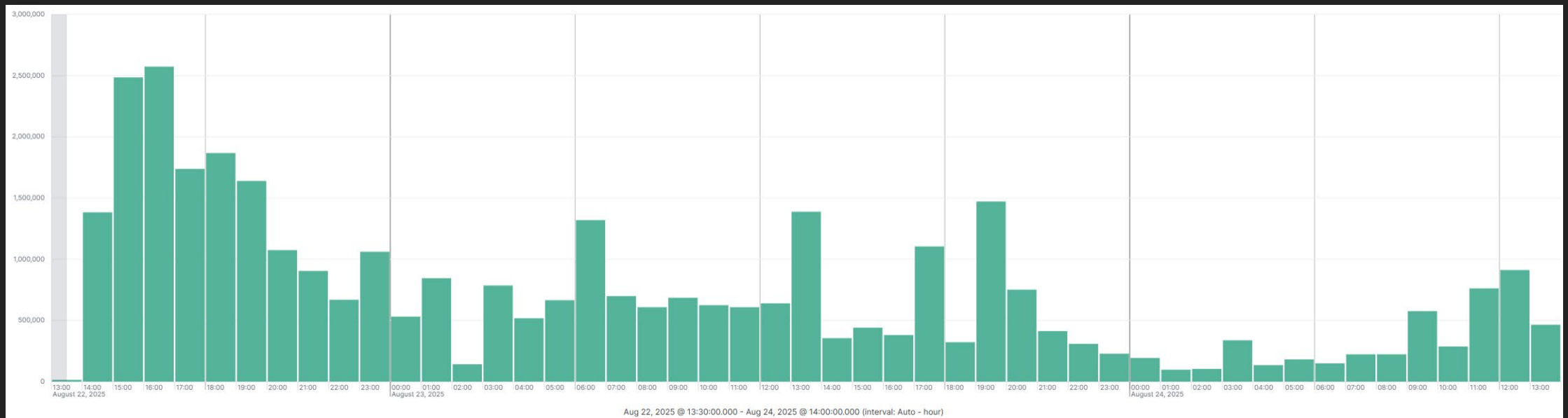- 2800 users

- 1158 teams

The stats

The stats

The stats

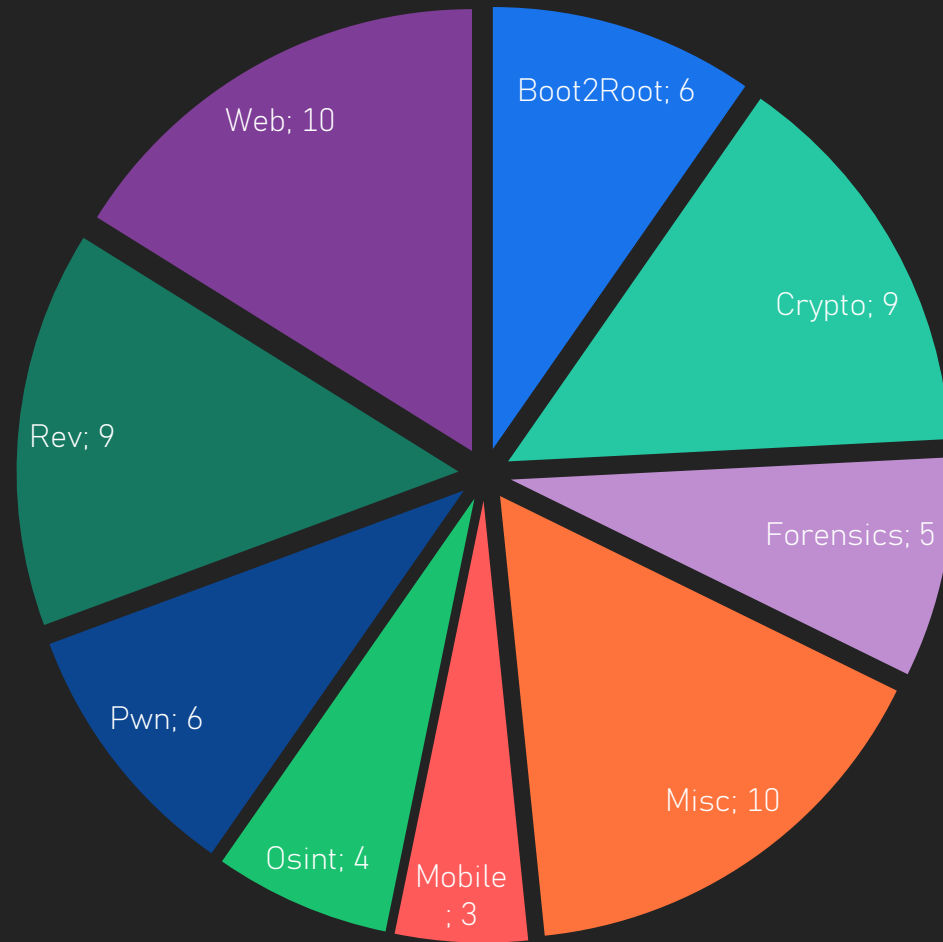# The stats

The `stats`

- 35 million requests

- 2.666 r/s

The stats

Traefik user agents - PROD ⓘ

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

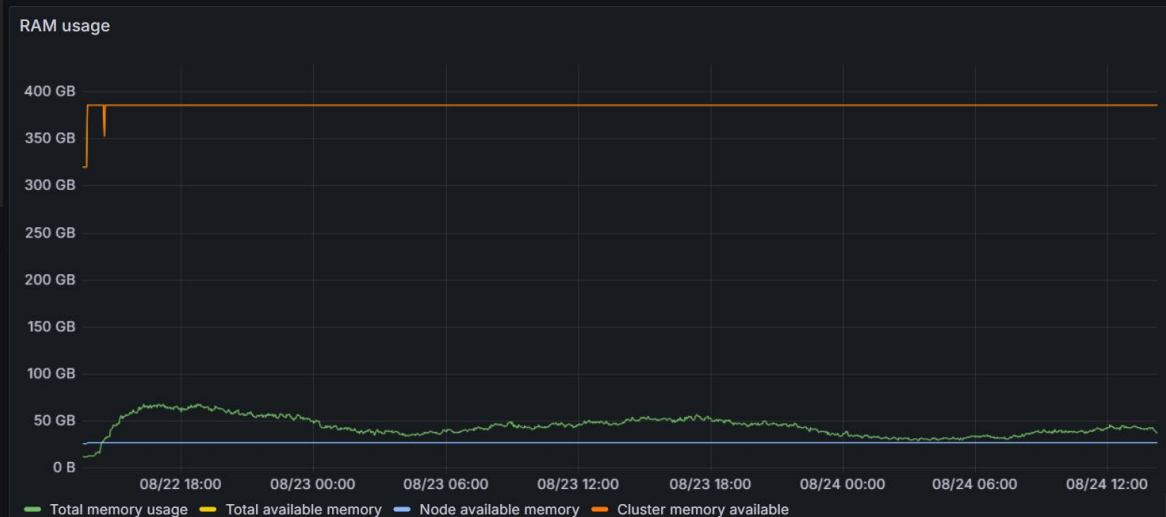- Are we down?

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

Want to learn more?

- blog.themikkel.dk

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