Twistlock™

How We Used Kubernetes to Host a CTF Competition

Liron Levin
Ariel Zelivansky

Who we are

- Ariel Zelivansky / Security Research Lead
  - Vulnerability research on open source projects, CVEs & blog
  - Best security practices for Twistlock platform
- Liron Levin / Chief Architect
  - Ph.D. on distributed network algorithms BGU
  - Designs and builds Twistlock platform

Agenda

1. What is a CTF
2. Why K8S
3. Engineering
4. Securing the infrastructure
5. Results
6. Key takeouts

What’s a CTF?

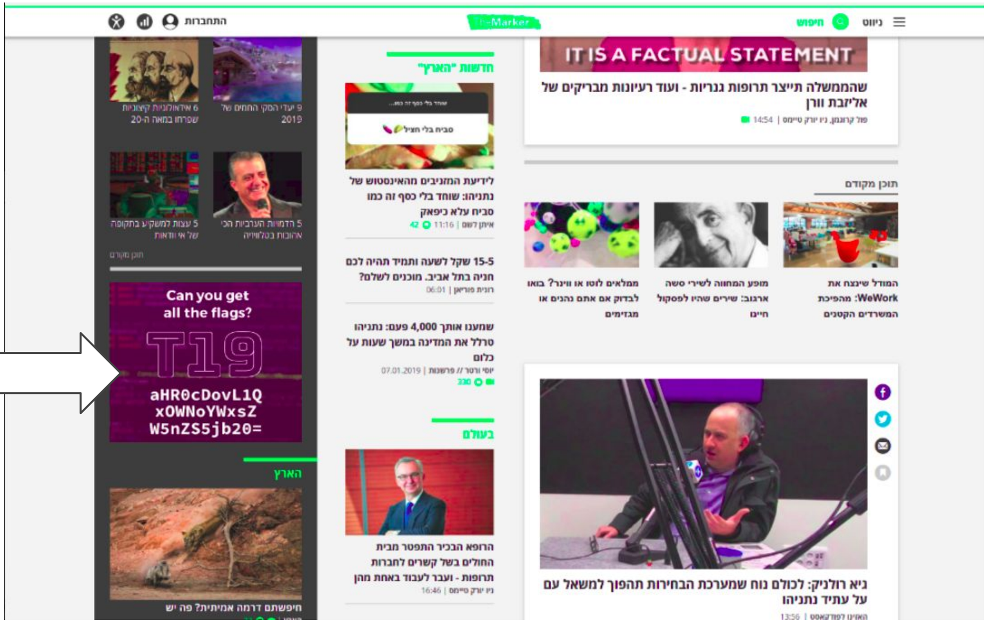
- “Capture the flag” challenge
  - Jeopardy style/Attack defense/Wargames (OTW)
- Good for education, conventions

Twistlock CTF - Why?

- Find good security researchers
- Creating challenges forces us to learn a lot
- Fun!

Advertised!

- Reddit for CTFs (securityCTF)
- Local news sites
- Facebook/Whatsapp groups



IT IS A FACTUAL STATEMENT

שהממשלה תייצר תרופות גנריות - ועוד רעיונות מבריקים של אליזבת וורן
פול קרוגמן, ניו יורק טיימס | 14:54

תוכן מקודם

המודל שינצח את WeWork: מהפיכת המשרדים הקטנים

מופע המחווה לשירי ססה ארגוב: שירים שהיו לפסקול חיינו

ממלאים לוטו או ווינר? בואו לבדוק אם אתם נהנים או מגזימים

ניא רולניק: לכולם נוח שמערכת הבחירות תהפוך למשאל עם על עתיד נתניהו
האזינו לפודקאסט | 13:56

חדשות "הארץ"

לידיעת המזניבים מהאינסטוש של נתניהו: שוחד בלי כסף זה כמו סביח עלא כיפאק
איתן לשם | 11:16 42

15-5 שקל לשעה ותמיד תהיה לכם חניה בתל אביב. מוכנים לשלם?
רונית פוריאן | 06:01

שמענו אותך 4,000 פעם: נתניהו טרלל את המדינה במשך שעות על כלום
יוסי ורטר // פרשנות | 07.01.2019
330

בעולם

הרופא הבכיר התפטר מבית החולים בשל קשרים לחברות תרופות - ועבר לעבוד באחת מהן
ניו יורק טיימס | 16:46

9 יעדי הסקי החמים של 2019

6 אידאולוגיות קיצוניות שפרחו במאה ה-20

5 הדמויות הערביות הכי אהובות בטלוויזיה

5 עצות למשקיע בתקופה של אי ודאות

תוכן מקודם

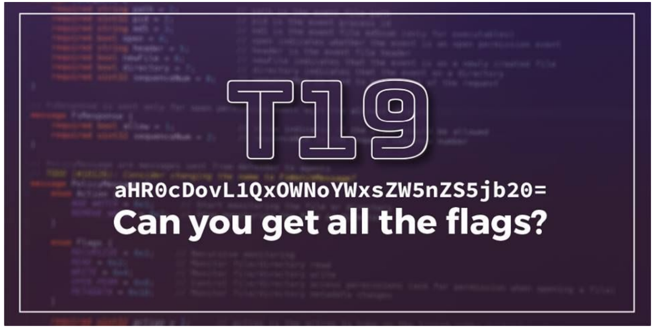
Can you get all the flags?

T19

aHR0cDovL1Q
xOWNoYWxsZ
W5nZS5jb20=

הארץ

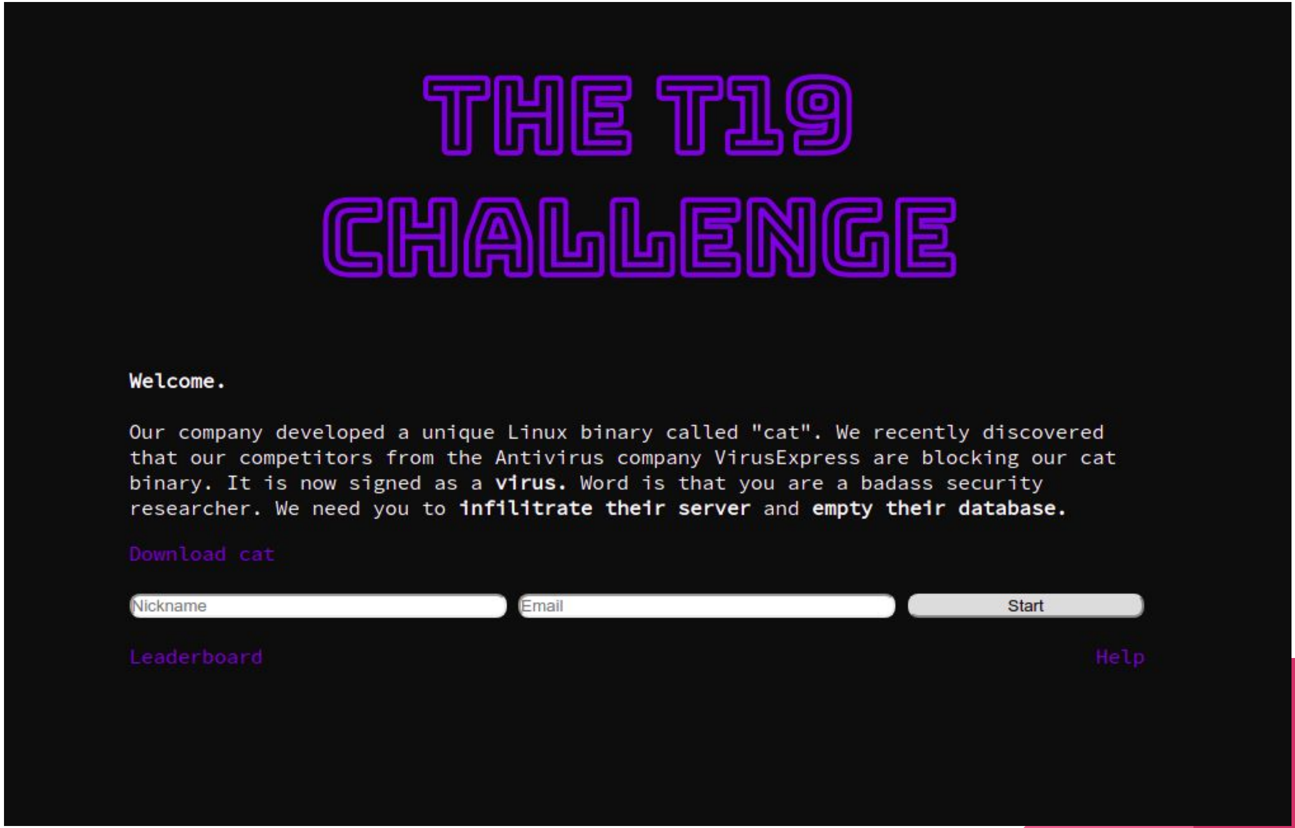
חיפשתם דרמה אמיתית? פה יש



Making it interesting

- Wargame style
- Same machine - multiple challenges!
  - Different users, need to **escalate permissions**
  - Flags hidden as files
- Different challenge subjects - web/scripting, reverse-engineering, Linux internals, modern exploitation…

The challenge



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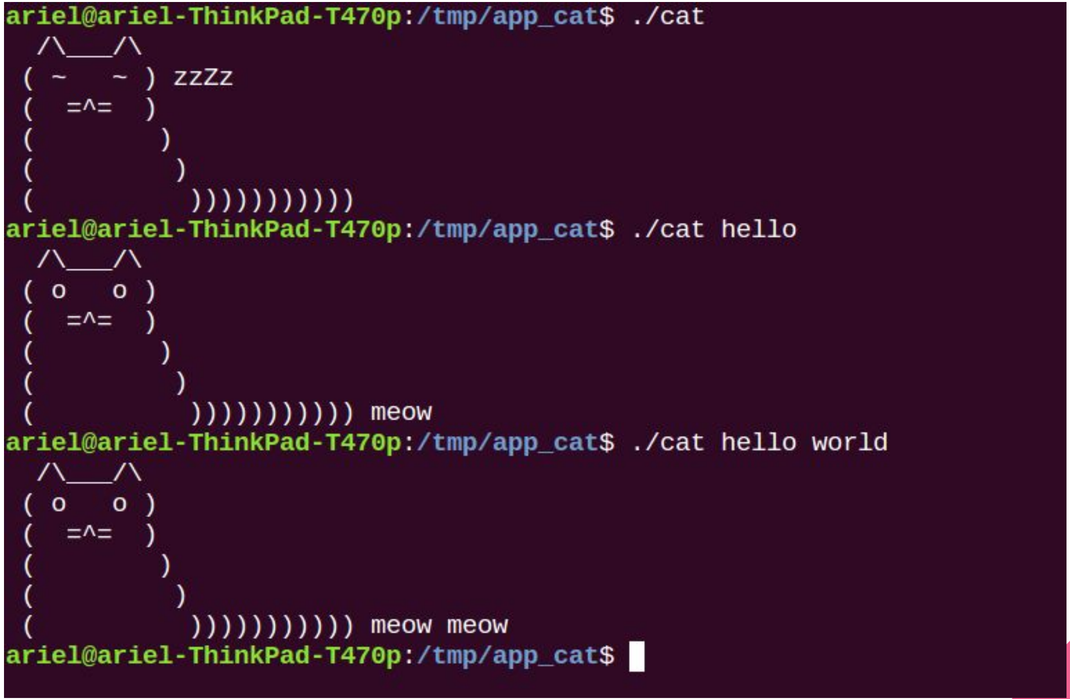
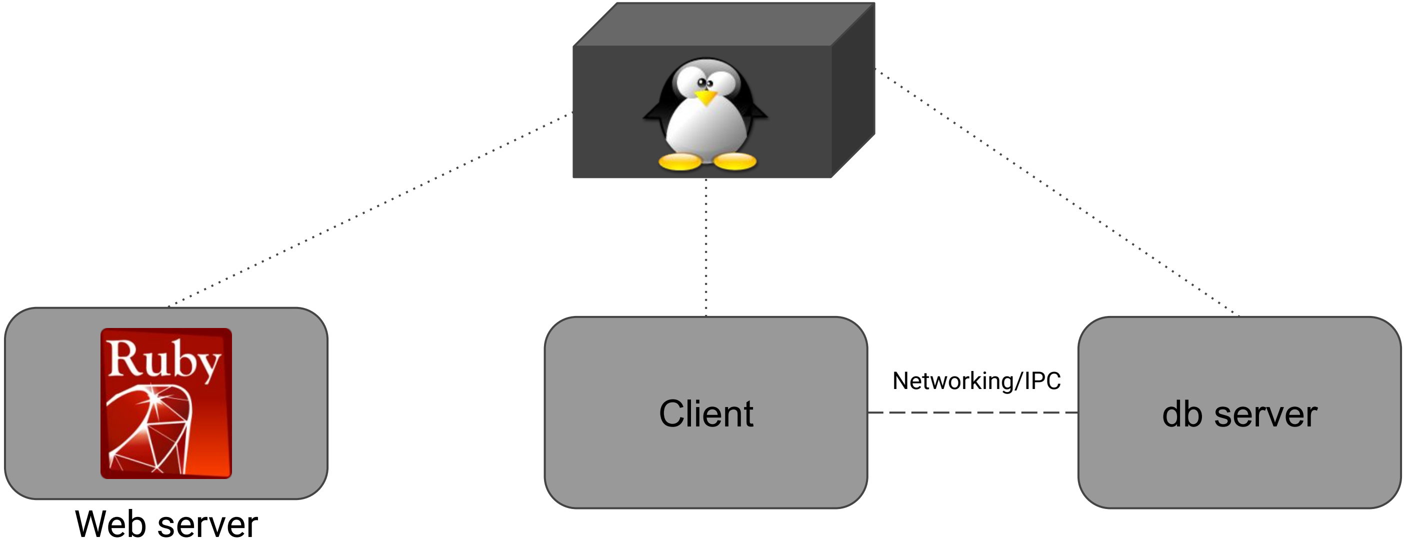


```
ariel@ariel-ThinkPad-T470p:/tmp/app_cat$ ./cat
  /\___/\
 ( ~   ~ ) zzZz
 (  =^=  )
 (        )
 (         )
 (          )))))))))))
ariel@ariel-ThinkPad-T470p:/tmp/app_cat$ ./cat hello
  /\___/\
 ( o   o )
 (  =^=  )
 (        )
 (         )
 (          ))))))))))) meow
ariel@ariel-ThinkPad-T470p:/tmp/app_cat$ ./cat hello world
  /\___/\
 ( o   o )
 (  =^=  )
 (        )
 (         )
 (          ))))))))))) meow meow
ariel@ariel-ThinkPad-T470p:/tmp/app_cat$ 
```

The challenge



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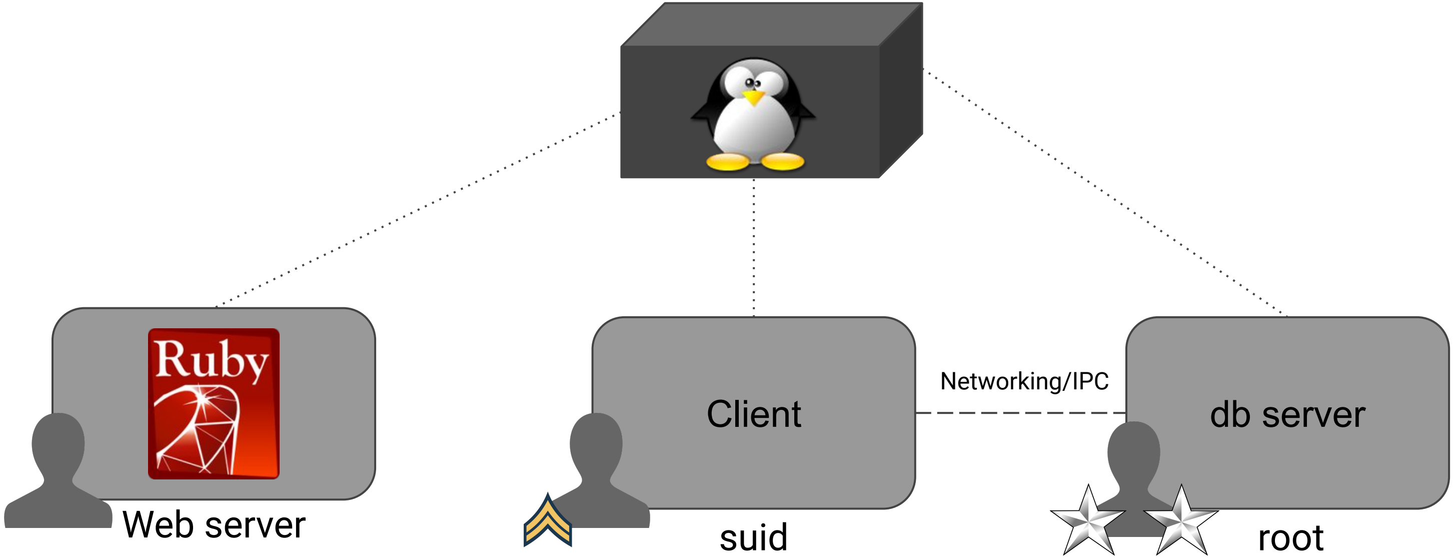

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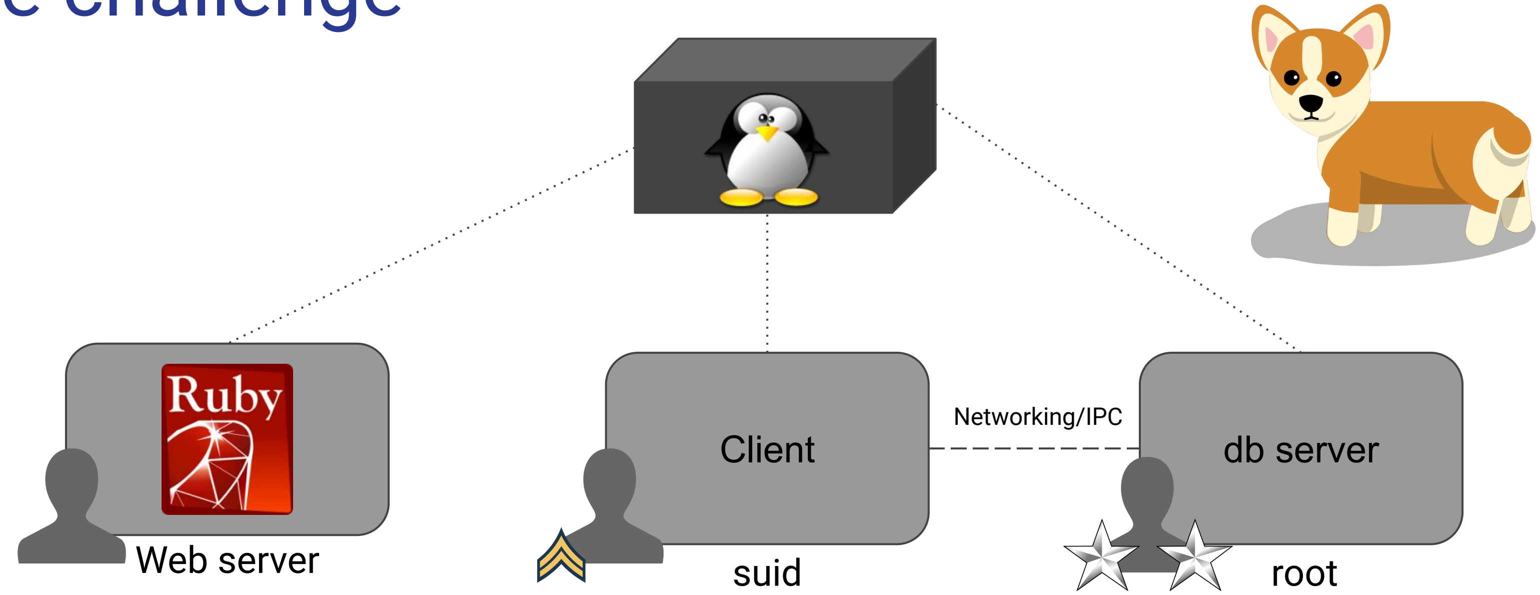

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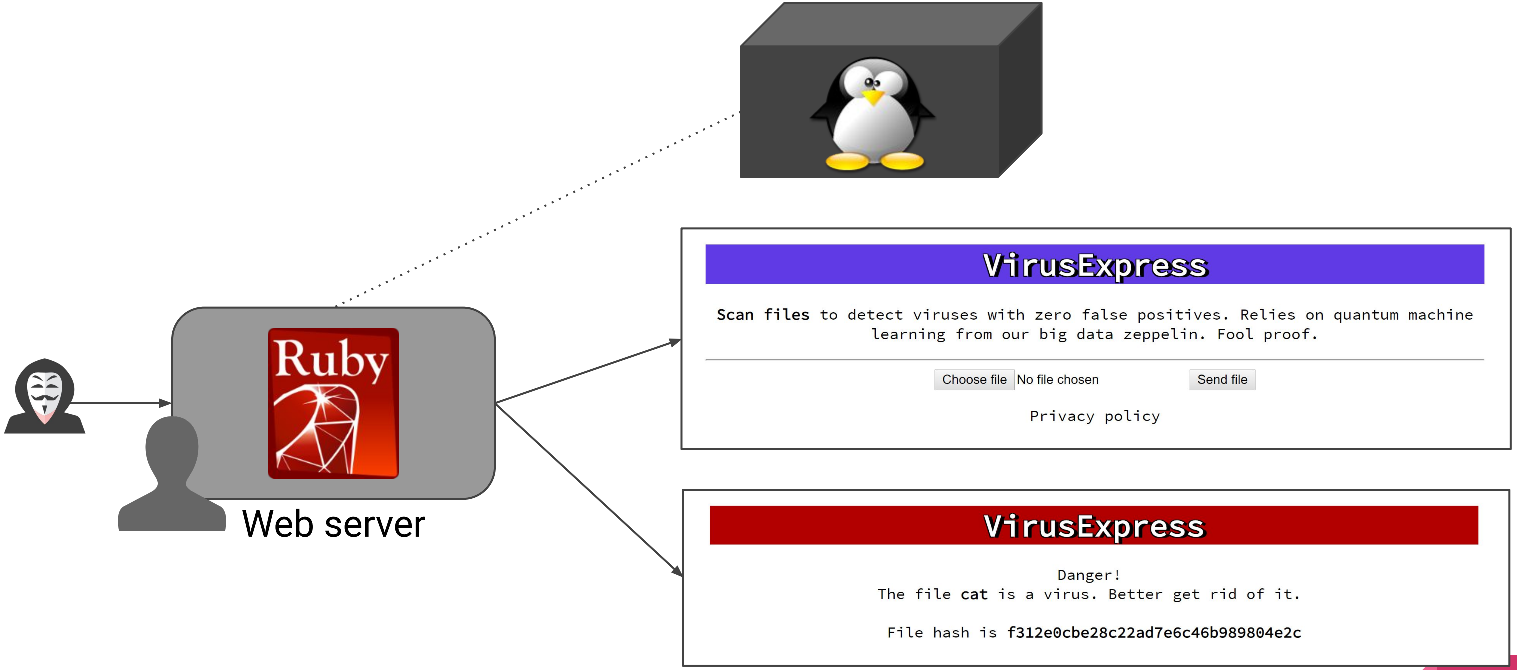


VirusExpress

Scan files to detect viruses with zero false positives. Relies on quantum machine learning from our big data zeppelin. Fool proof.

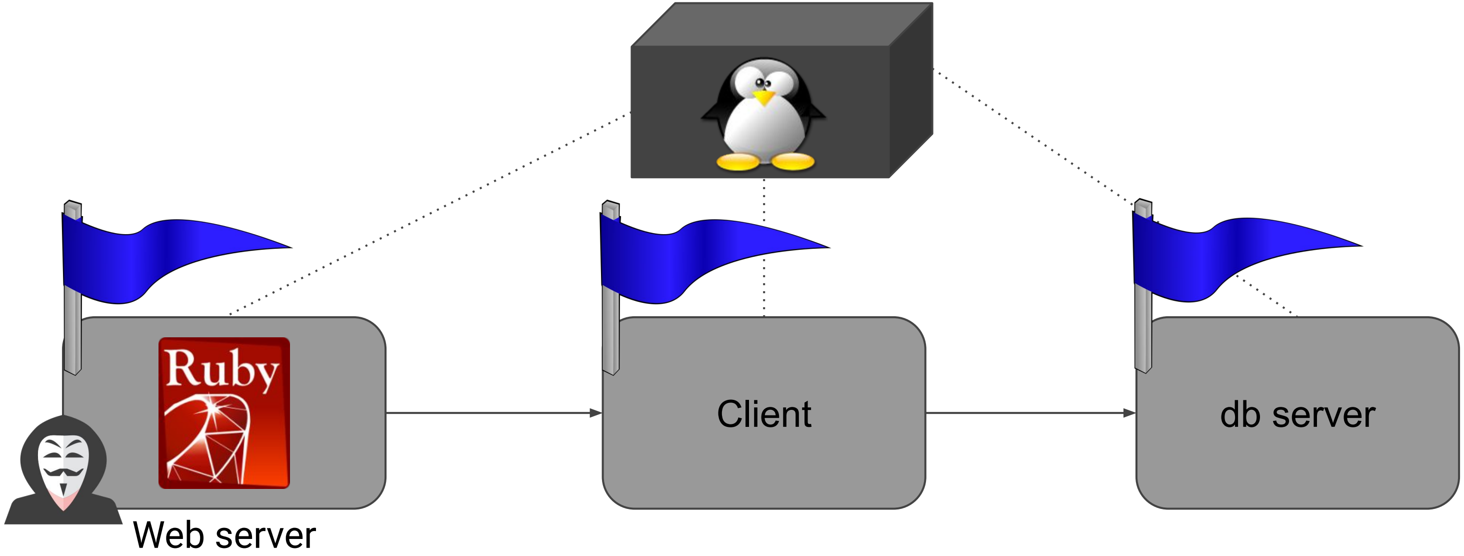
Privacy policy

VirusExpress

Danger!
The file **cat** is a virus. Better get rid of it.

File hash is **f312e0cbe28c22ad7e6c46b989804e2c**

The challenge



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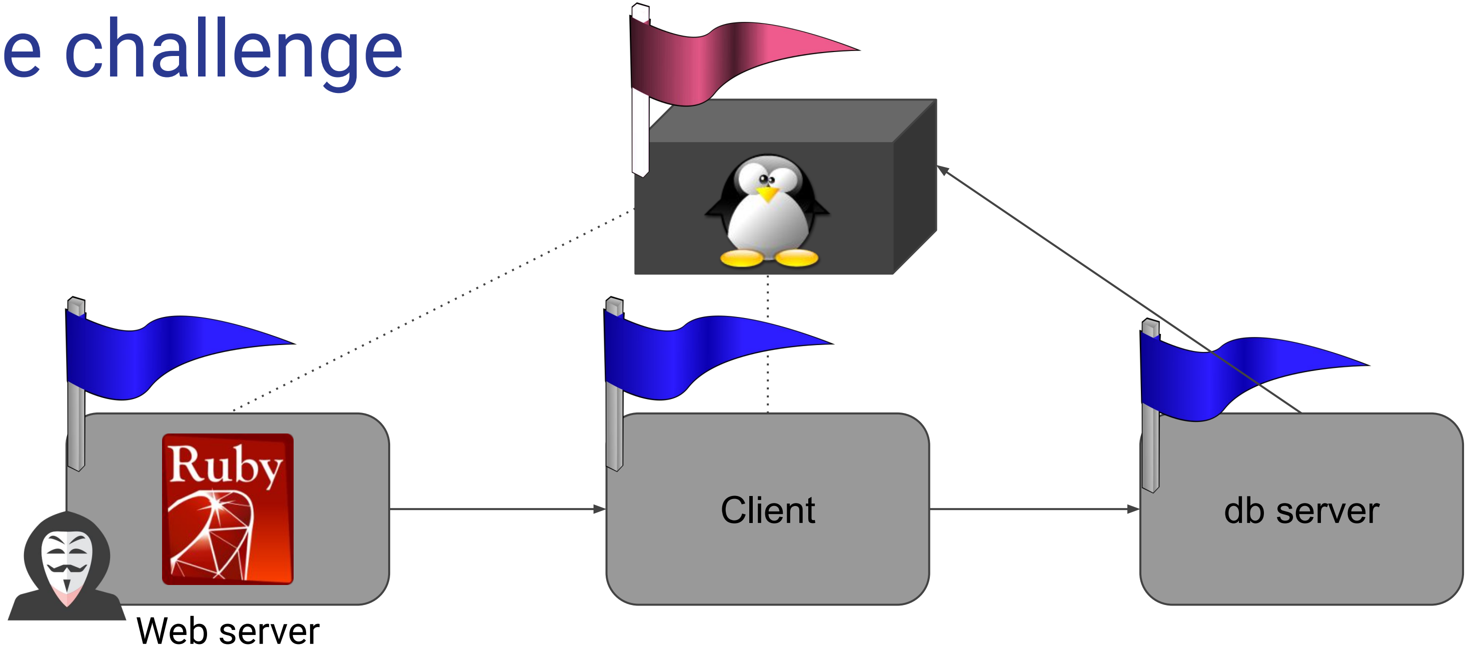
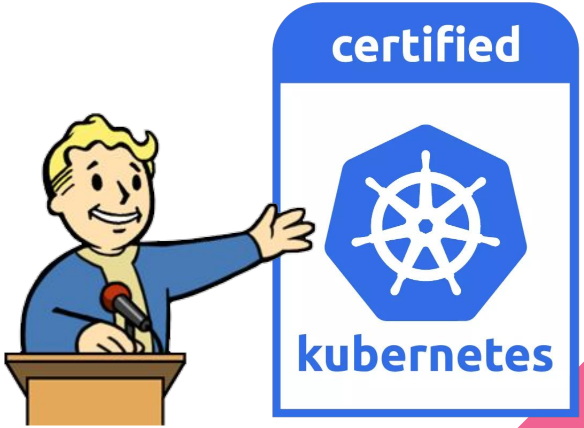


Why cloud?

- Machines hosted on our side
  - Impossible to cheat (by reading memory/docker exec)
  - Control and monitor all instances
- Researching cloud attack patterns

Why Kubernetes?

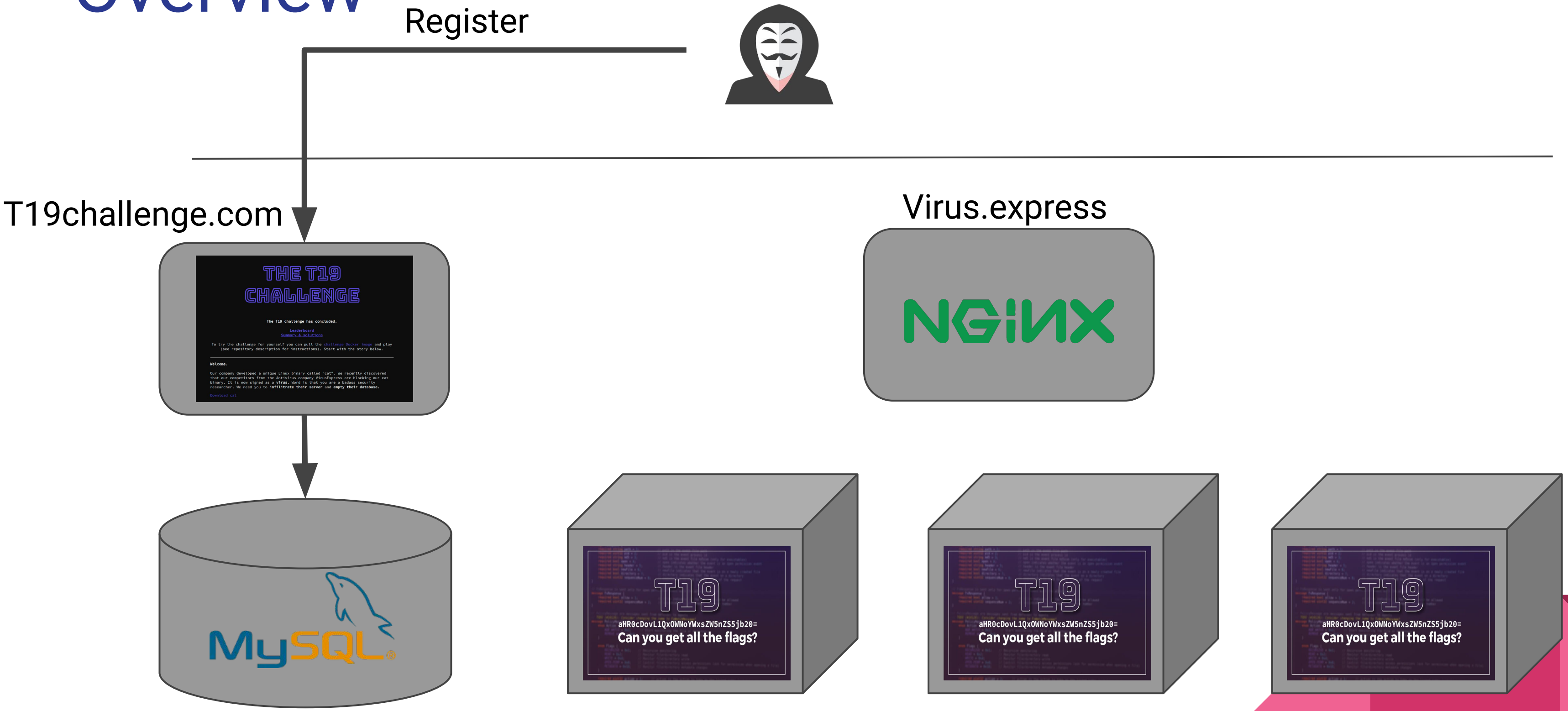
- Easy to scale
- Easy to update (hotfix)
- Easy configuration management (configuration as code)
- Good baseline security



Engineering requirements

1. Simple (but not simplistic)
2. Cheap / Cost effective (time + resources)
3. Reproducible and partially automated*
4. Secure* by default

Overview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Leaderboard
Summary & solutions

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Download cat

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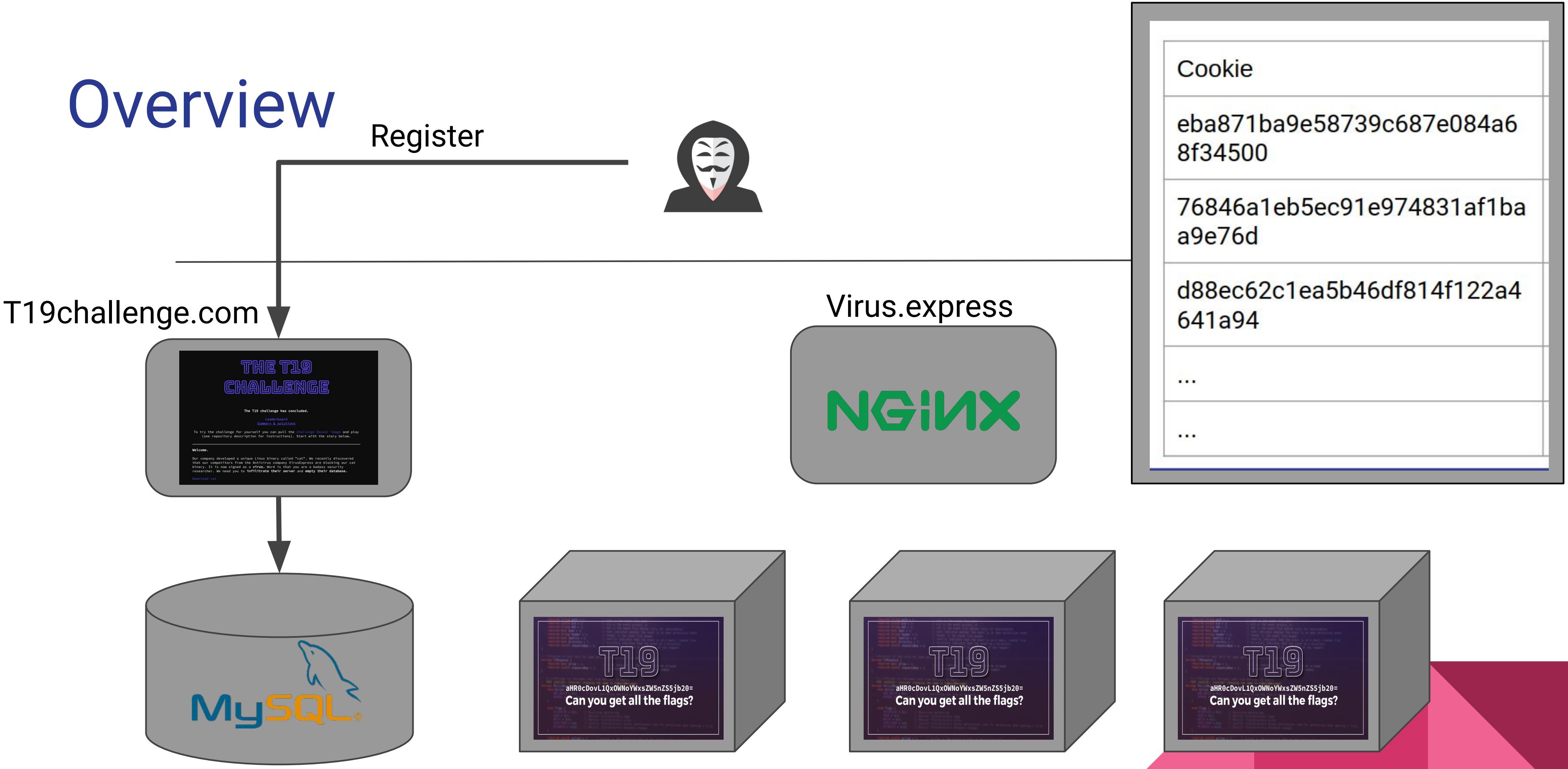
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d88ec62c1ea5b46df814f122a4641a94
...
...

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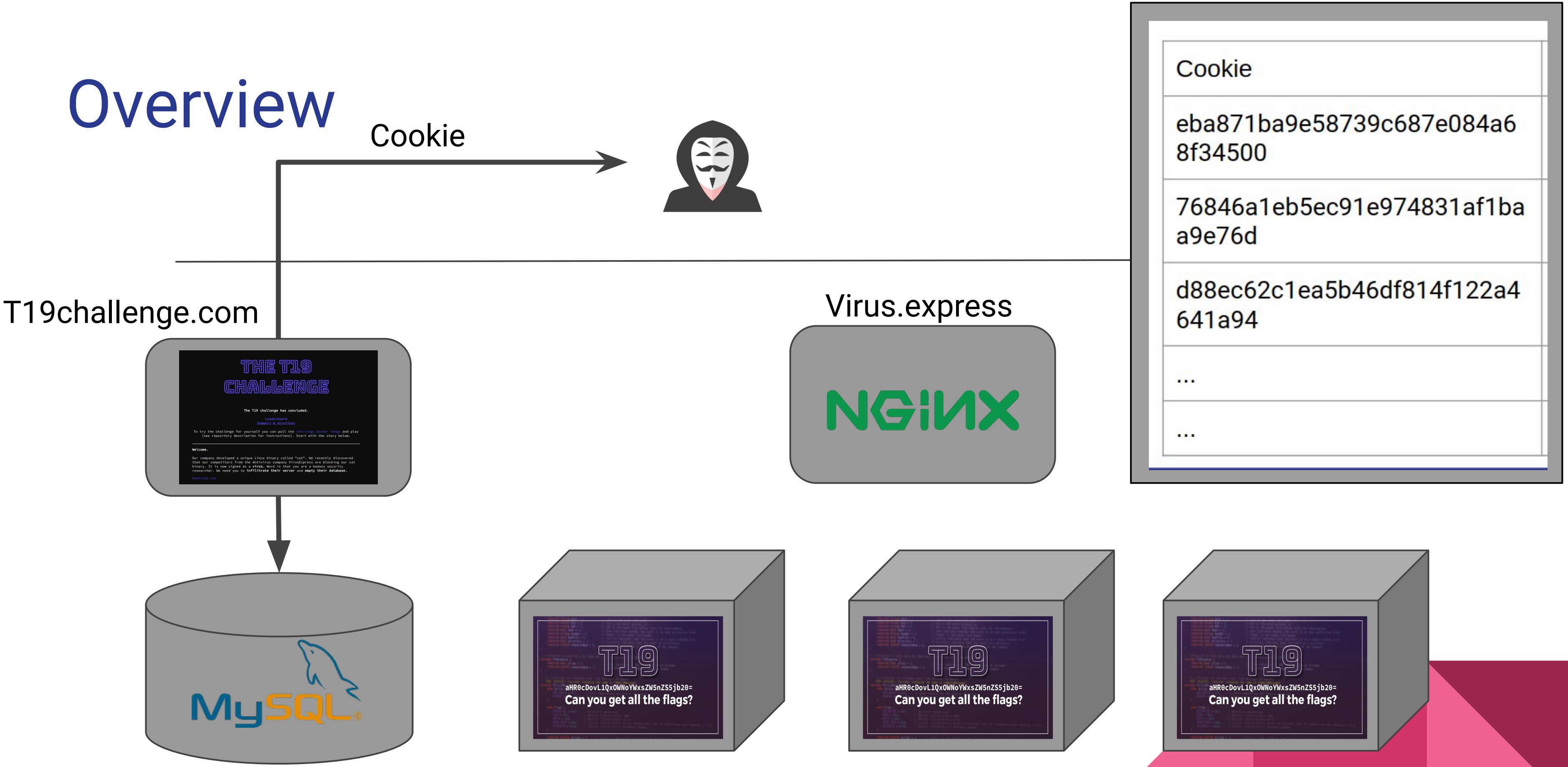
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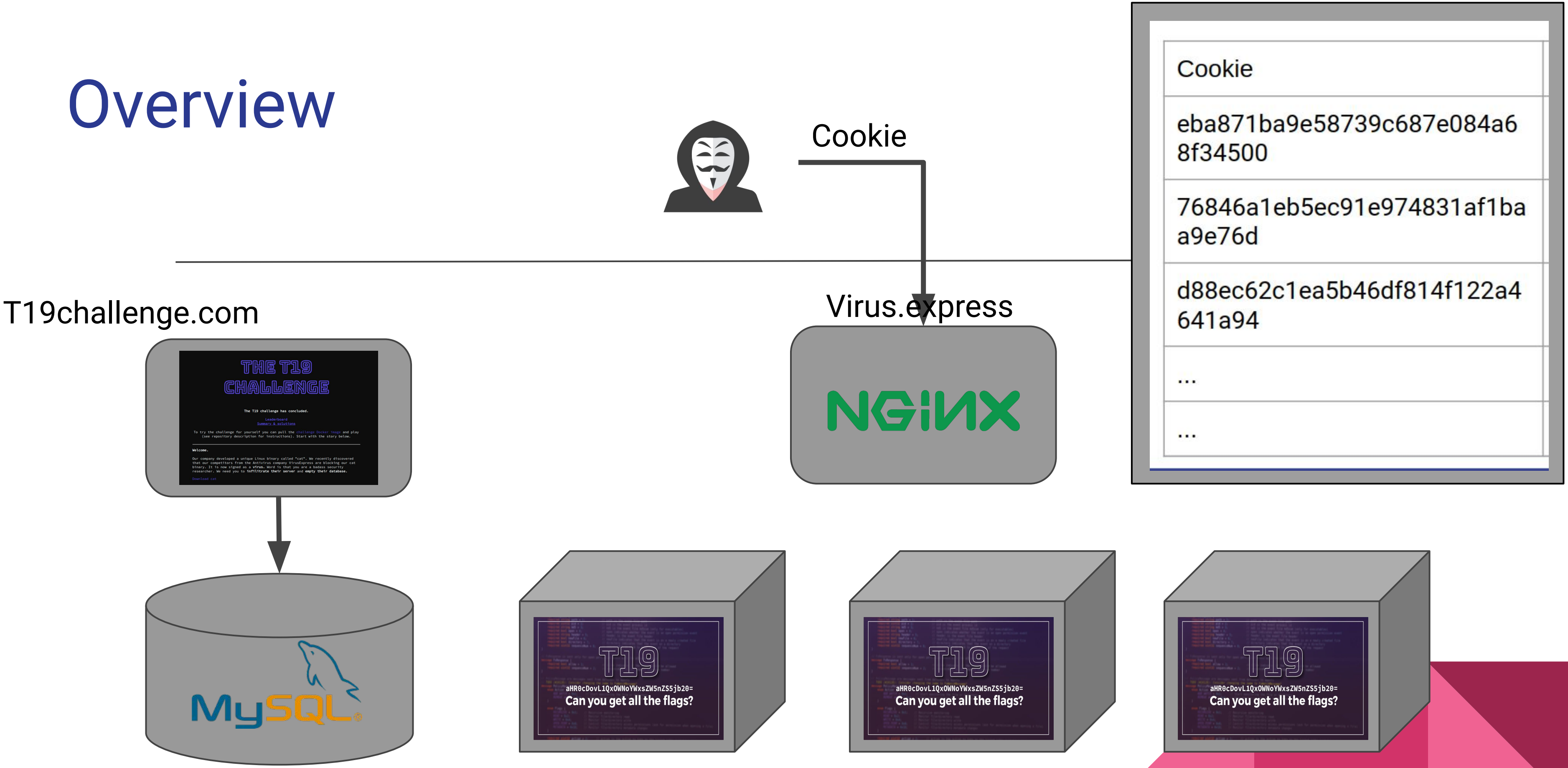

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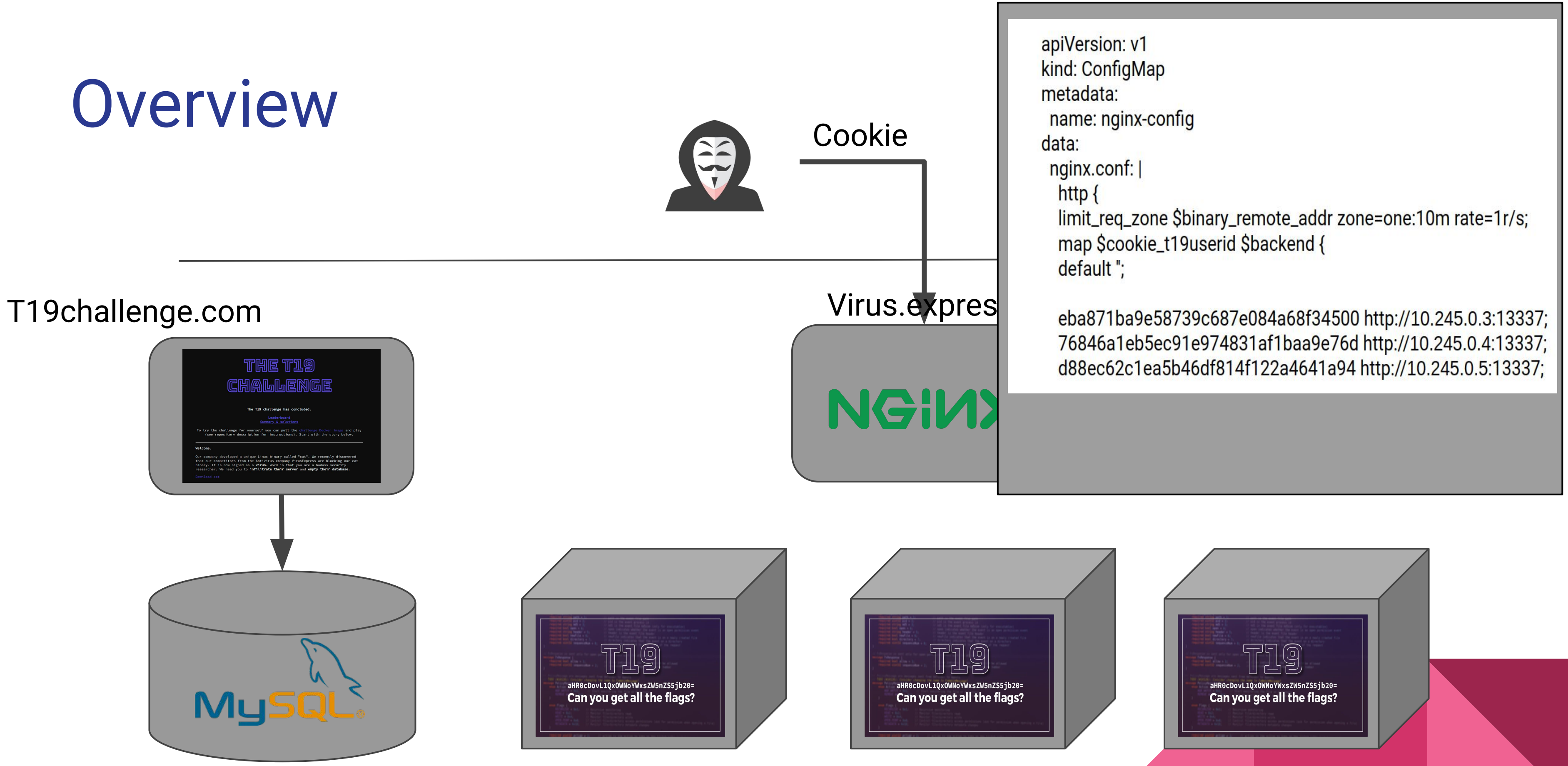

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Virus.expres

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kind: ConfigMap
metadata:
 name: nginx-config
data:
 nginx.conf: |
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  default '';

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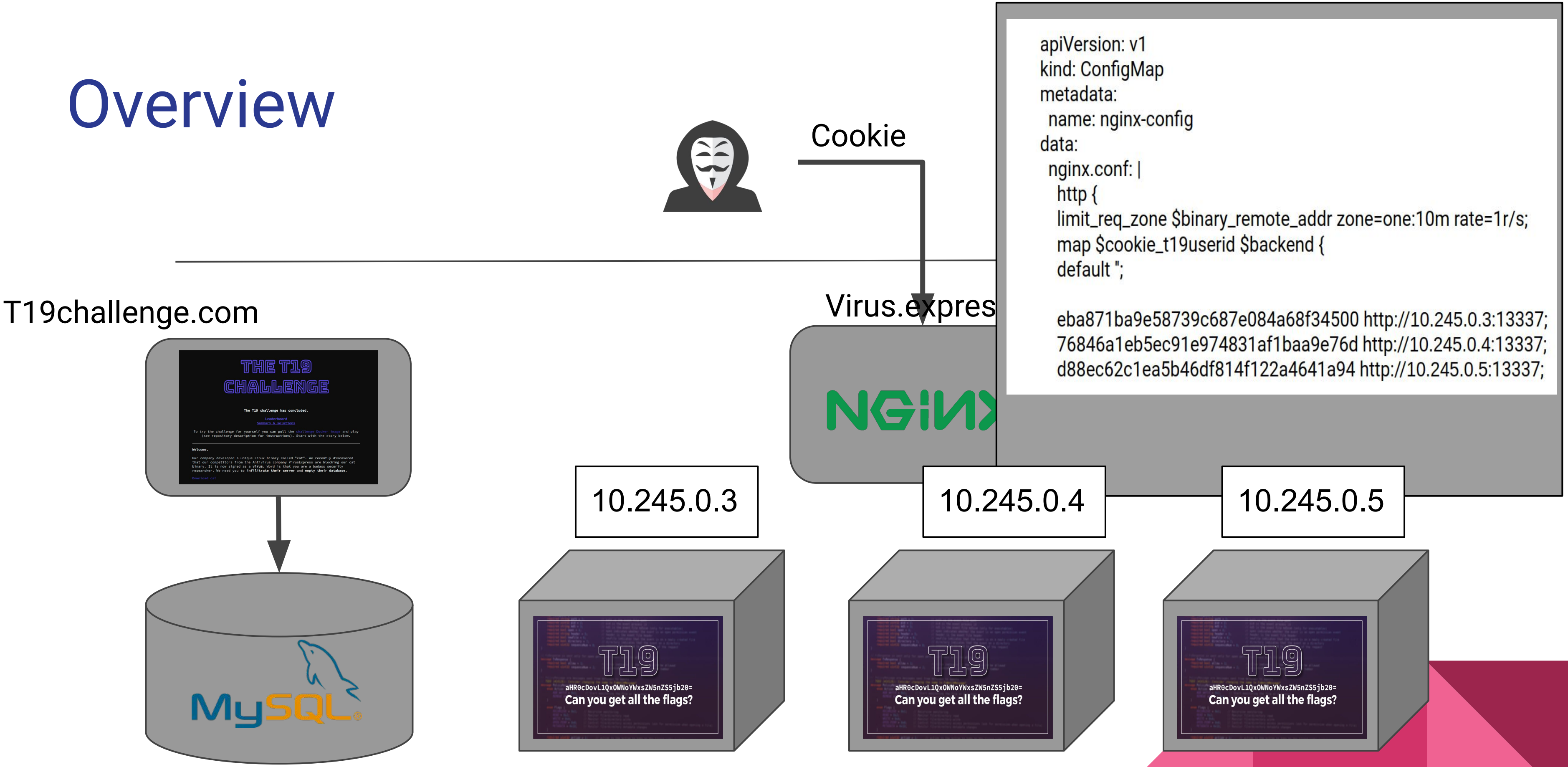
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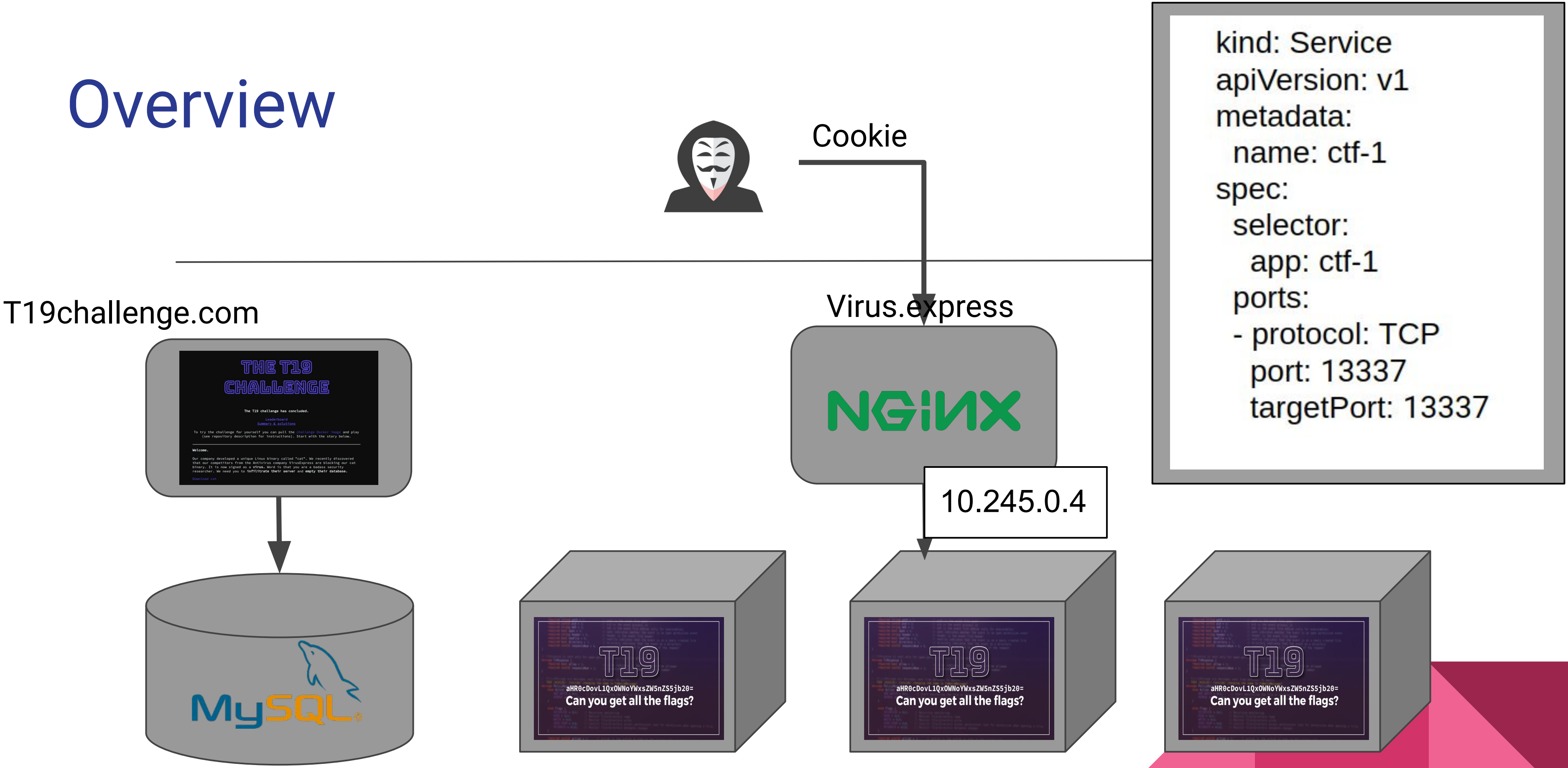
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```
kind: Service
apiVersion: v1
metadata:
  name: ctf-1
spec:
  selector:
    app: ctf-1
  ports:
  - protocol: TCP
    port: 13337
    targetPort: 13337
```

Infrastructure setup

1. Statically allocate all resources -
   Expensive, non-deterministic
2. On demand allocate pods + services -
   Complex, require nginx change + k8s access
3. Hybrid - statically allocate services + dynamically allocate pods

Pre-allocated service IPs

Predefined service subnet (--service-cidr=10.245.0.0/16)

Create all services (>k before) before creating pods

```
kind: Service
apiVersion: v1
metadata:
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spec:
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  selector:
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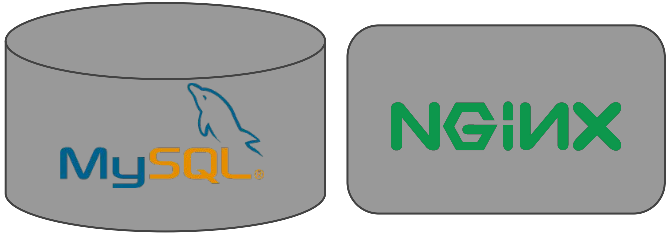
Static storage and load balancer

Cookie	Cluster-ip
eba871....	10.245.0.3
76846a...	10.245.0.4
d88ec6...	10.245.0.5
...	10.245.0.5
...	...



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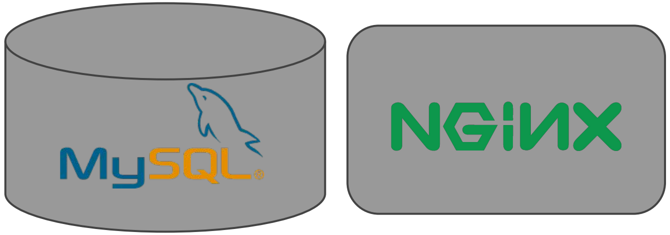

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```

On demand* pod allocation

Create pods on demand (or in batches)

```
kind: Deployment
metadata:
  name: ctf-1
  labels:
    app: ctf-1
spec:
    spec:
      containers:
      - name: ctf-1
        image: twistlock/t19
        ports:
        - containerPort: 13337
```

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kind: Deployment
metadata:
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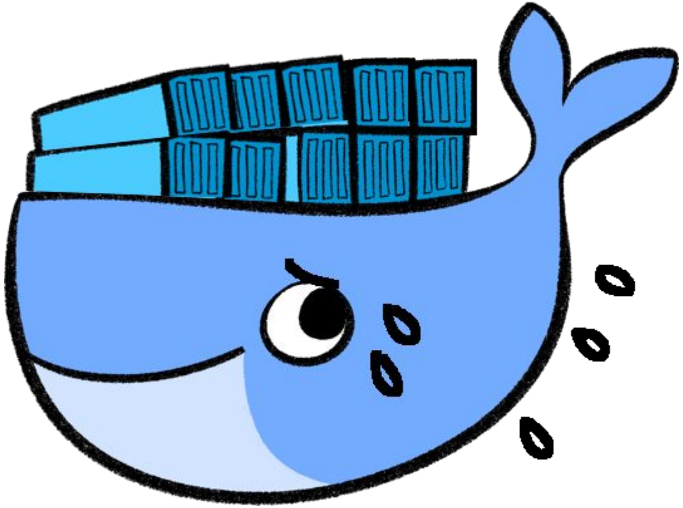
```

Security challenges

- Local resource exhaustion - Crypto miners
- Attacker breaks out of the pod
- Cluster compromised - Steal sensitive data (images)

Local resource exhaustion

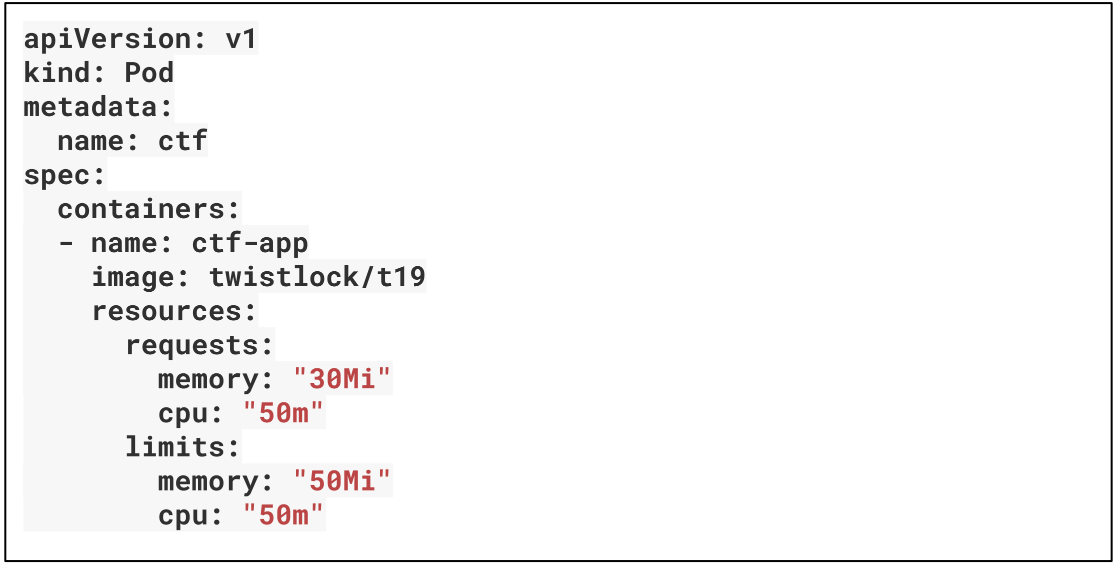
- The risk:
  - Block other participates
  - $$
- Possible causes:
  - CPU/memory exhaustion
    (deliberate or accidental)
  - Resource abuse $$$ (e.g. cryptomining)



Local resource exhaustion - mitigations

- Block outgoing ports used for crypto miners (30303,8545,18080,18081…)

- Pod security policy (cgroups)



```
apiVersion: v1
kind: Pod
metadata:
  name: ctf
spec:
  containers:
  - name: ctf-app
    image: twistlock/t19
    resources:
      requests:
        memory: "30Mi"
        cpu: "50m"
      limits:
        memory: "50Mi"
        cpu: "50m"
```

Container breakout

- The risk:
  - Bypass the challenge
  - Abuse the machine or environment
- Possible causes:
  - Misconfiguration (host mount/secrets)
  - Runc CVE-2019-5736 -
    Execution of malicious containers allows for container escape and access to host filesystem

Container breakout - mitigations

- Classic container - No mounts/secrets - simple app
- Default container profile (no additional LINUX capabilities + seccomp)
- Container optimized OS - read only root partition (CVE-2019-5736 mitigation)
- User namespaces*

Cluster takeover

- Capturing all the flags in BSidesSF CTF by pwning our infrastructure
    - Fetch private docker images by fetching credentials from metadata api
    - Use default service account token to access API server (solved)
- SSRF in Exchange leads to ROOT access in all instances
    - Takeover cluster by fetching credentials from metadata api

Cluster takeover - mitigations

- Completely isolated environment
- RBAC
- automountServiceAccountToken: false
- Metadata concealment / Network policies

Network policy

```
kind: NetworkPolicy
spec:
  podSelector:
    matchLabels:
      app: t19
  policyTypes:
  - Ingress
  - Egress
  egress:
  - to:
    - ipBlock:
        cidr: 0.0.0.0/0
        except:
        - 169.254.169.254/32
  ingress:
  - from:
    - podSelector:
        matchLabels:
          app: t19-nginx
```

Challenge conclusion

- 8 participants solved
  - 6 found 4th flag
- Excellent write-ups with solutions
- Links and finalists
- Challenge coins molded

Key takeouts

- Good engineering == cost saving
- Good security …
- Kubernetes is a great platform to host a live CTF
  - Little effort to deploy once built
  - Easy to monitor
  - Easy to scale
  - Hotfix on pods
- Future ideas
  - Networking CTF - more than one container in pod, need to hack via network
  - Attack/defense CTF on Kubernetes

Try to solve?

- http://t19challenge.com/
- Follow the instructions to run
- Don’t cheat and good luck!
- See you in T20?

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Thank you!

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