Twistlock™

How We Used Kubernetes to Host a CTF Competition

Liron Levin
Ariel Zelivansky

Who we are

- Ariel Zelivansky / Security Research Leader
  - Vulnerability research on open source projects, CVEs & blog
  - Best security practices for Twistlock platform

- Liron Levin / Twistlock Chief Architect
  - Ph.D. on distributed network algorithms BGU
  - Designs and builds Twistlock platform

Agenda

1. What is CTF + the challenge
2. Why K8S/Cloud
3. Infrastructure/Engineering
4. Securing the infrastructure
5. Results
6. Key takeouts

What’s a CTF?

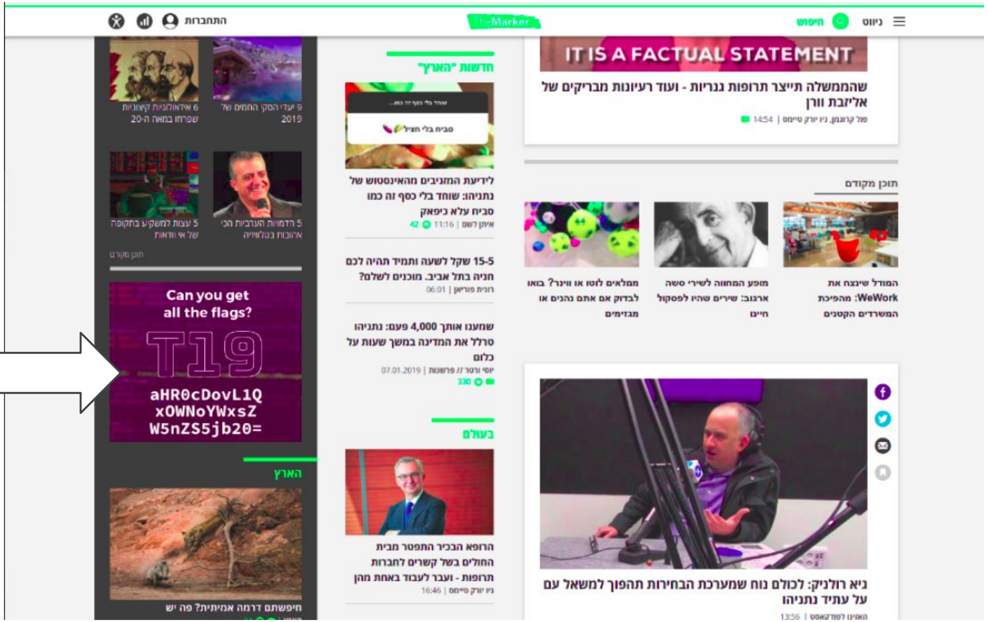
- “Capture the flag” challenge
  - Jepoardy style/Attack defense/Wargames (OTW)
- Good for education, conventions

Twistlock CTF - Why?

- Good PR among security professional
- Find good researchers
- Making 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 מגדימים

גיא 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 וודאות

תוכן מקודם

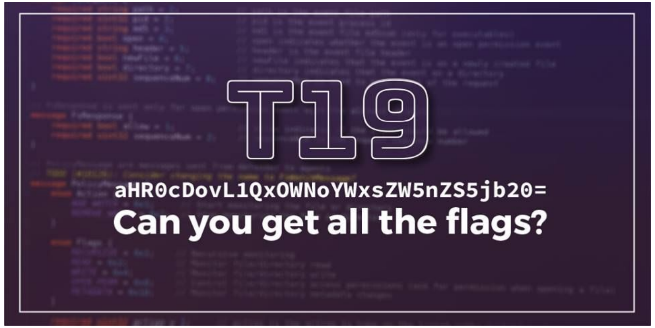
Can you get all the flags?

T19

aHR0cDovL1QxOWNoYWxsZW5nZS5jb20=

הארץ

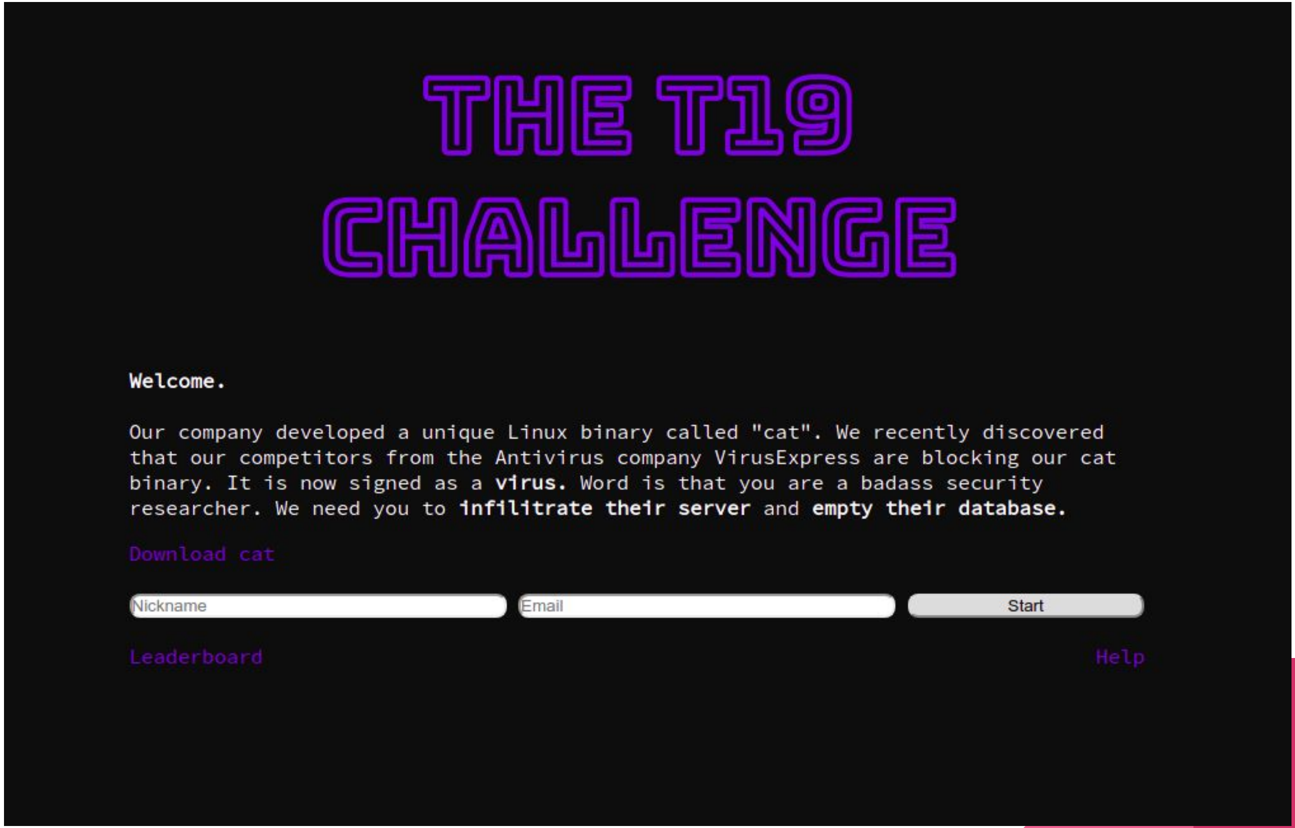
חיפשתם דרמה אמיתית? פה יש



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



THE T19 CHALLENGE

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Download cat

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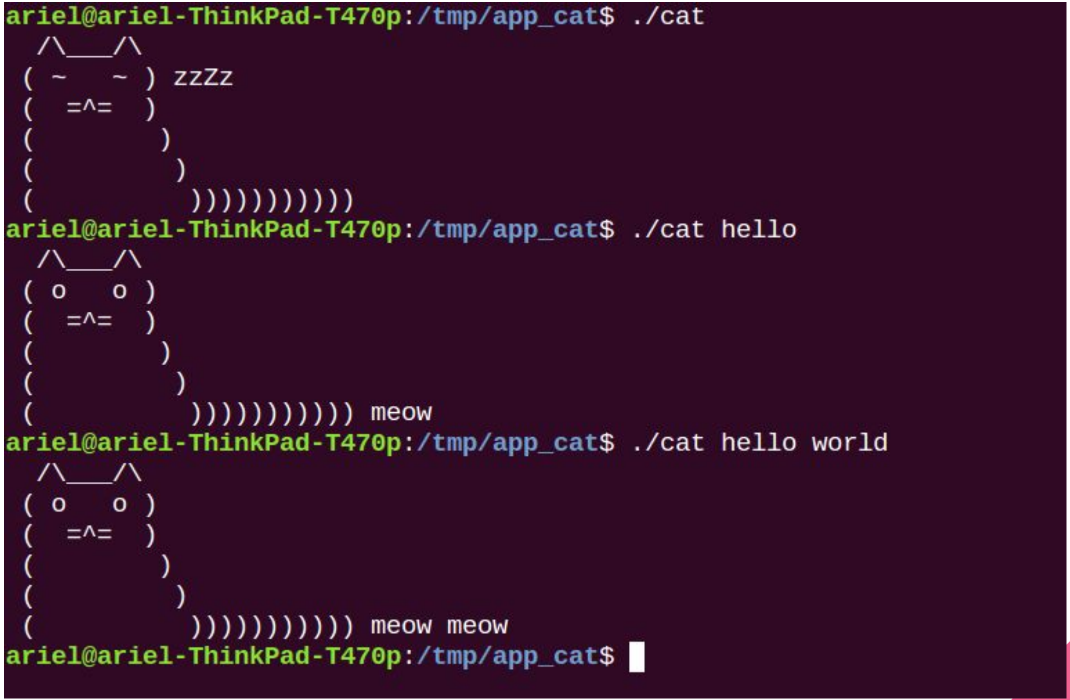

```
ariel@ariel-ThinkPad-T470p:/tmp/app_cat$ ./cat
  /\___/\
 ( ~   ~ ) zzZz
 (  =^=  )
 (        )
 (         )
 (          )))))))))))
ariel@ariel-ThinkPad-T470p:/tmp/app_cat$ ./cat hello
  /\___/\
 ( o   o )
 (  =^=  )
 (        )
 (         )
 (          ))))))))))) meow
ariel@ariel-ThinkPad-T470p:/tmp/app_cat$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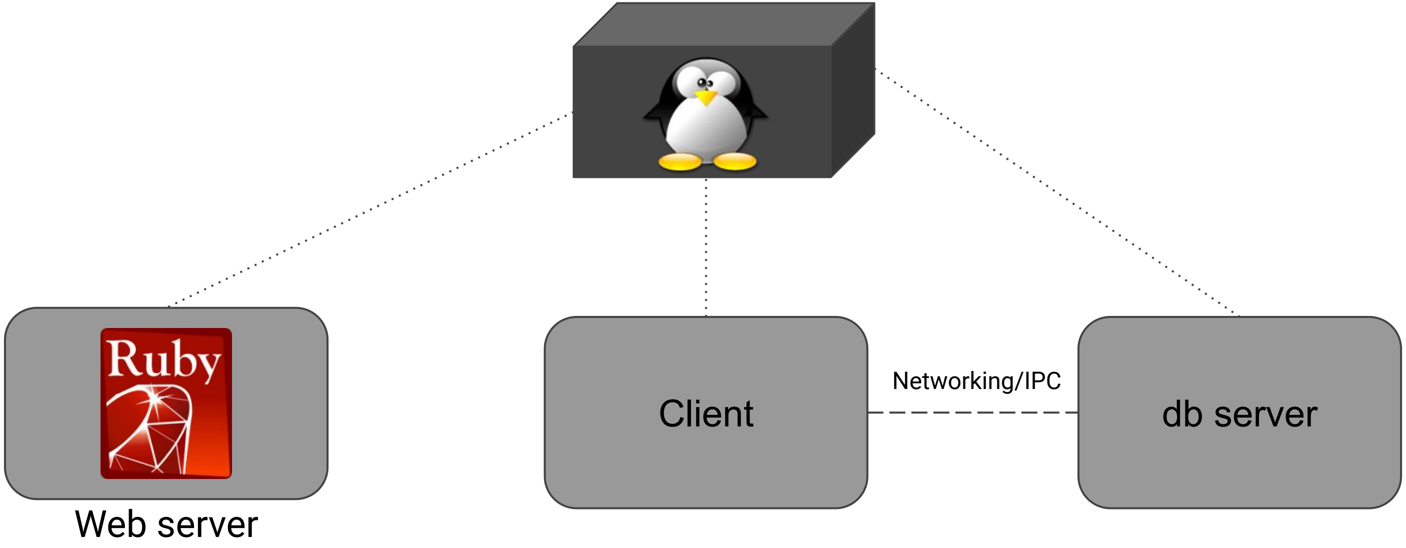

The challenge



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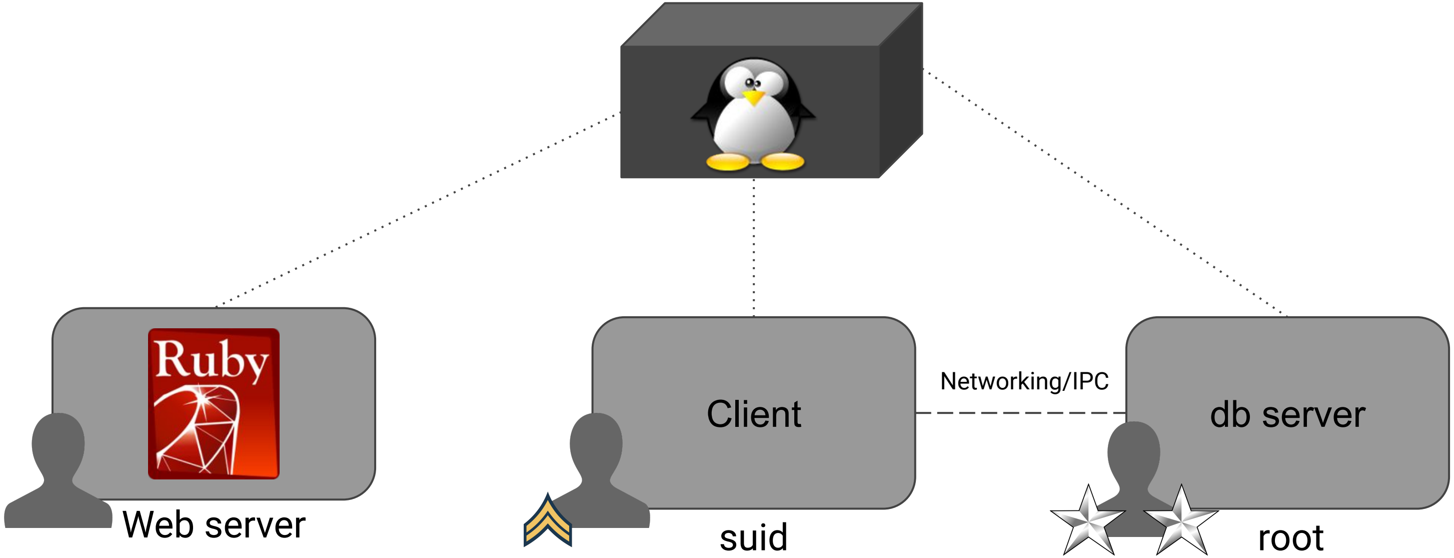

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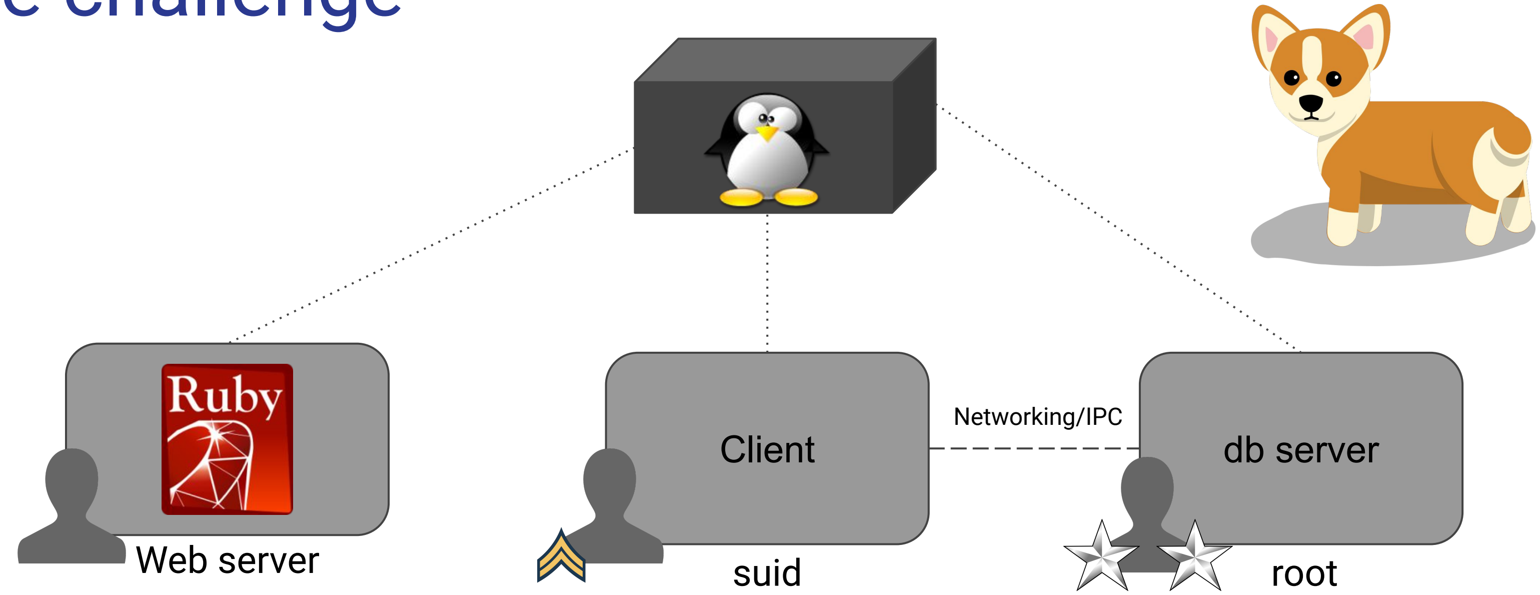

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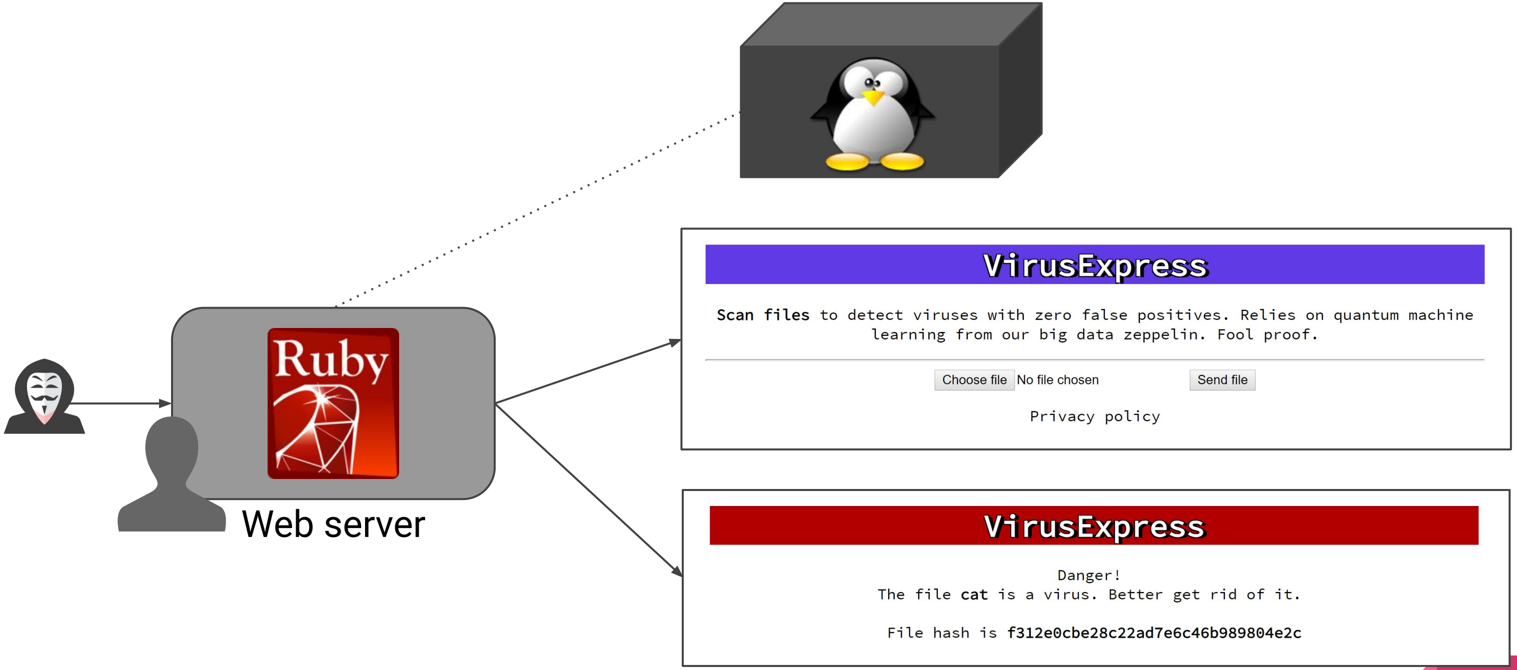


VirusExpress

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

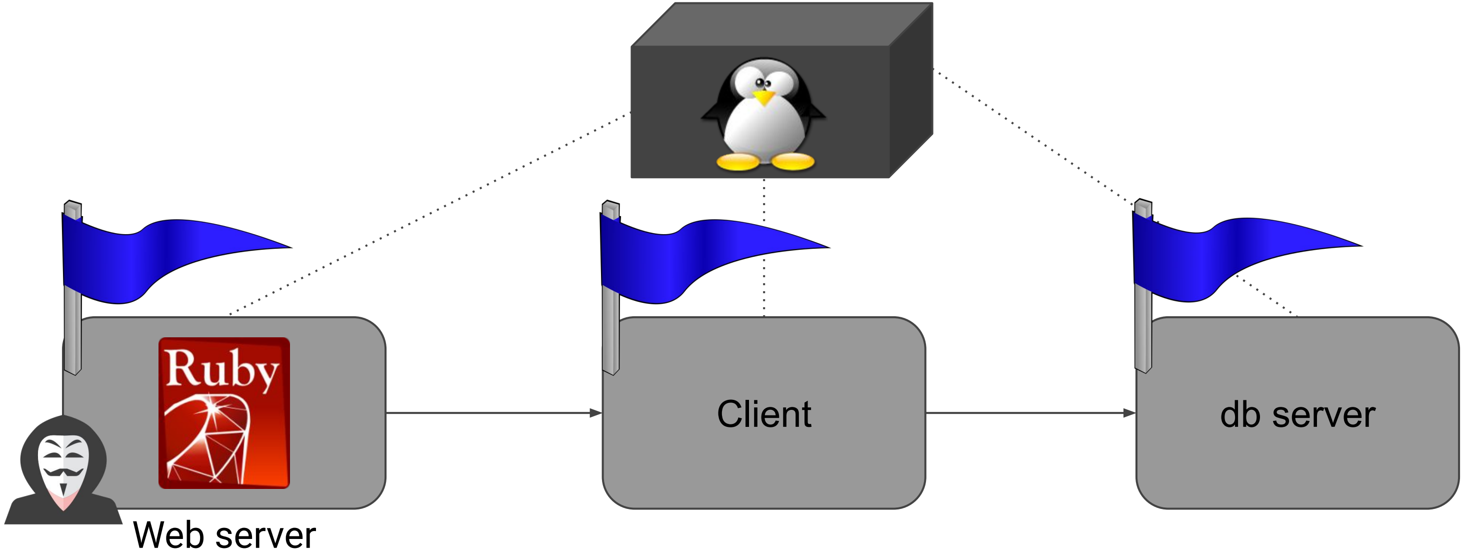
Privacy policy

VirusExpress

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

File hash is **f312e0cbe28c22ad7e6c46b989804e2c**

The challenge



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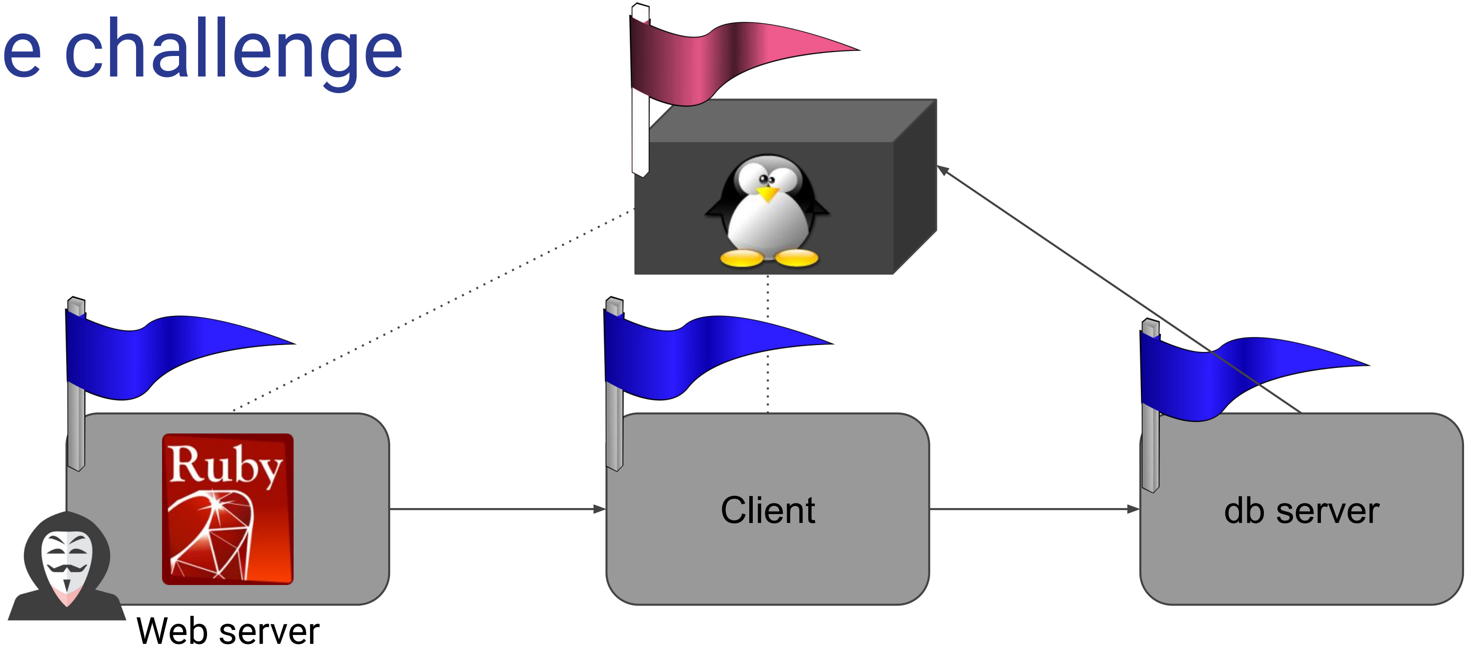
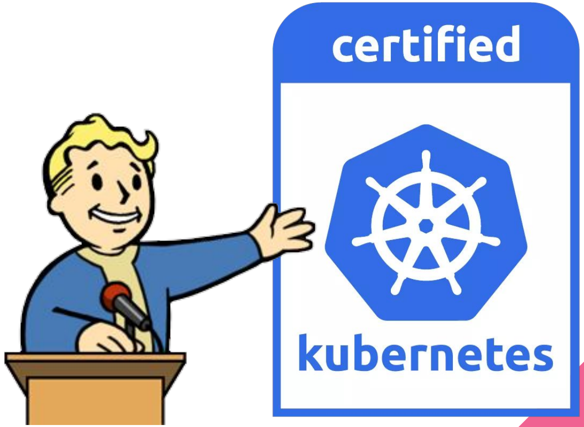


Why cloud?

- Machines hosted on our side
  - Impossible to cheat (by reading memory/docker exec)
  - Control and monitor all instances
- Learning opportunity for cloud security

Why Kubernetes?

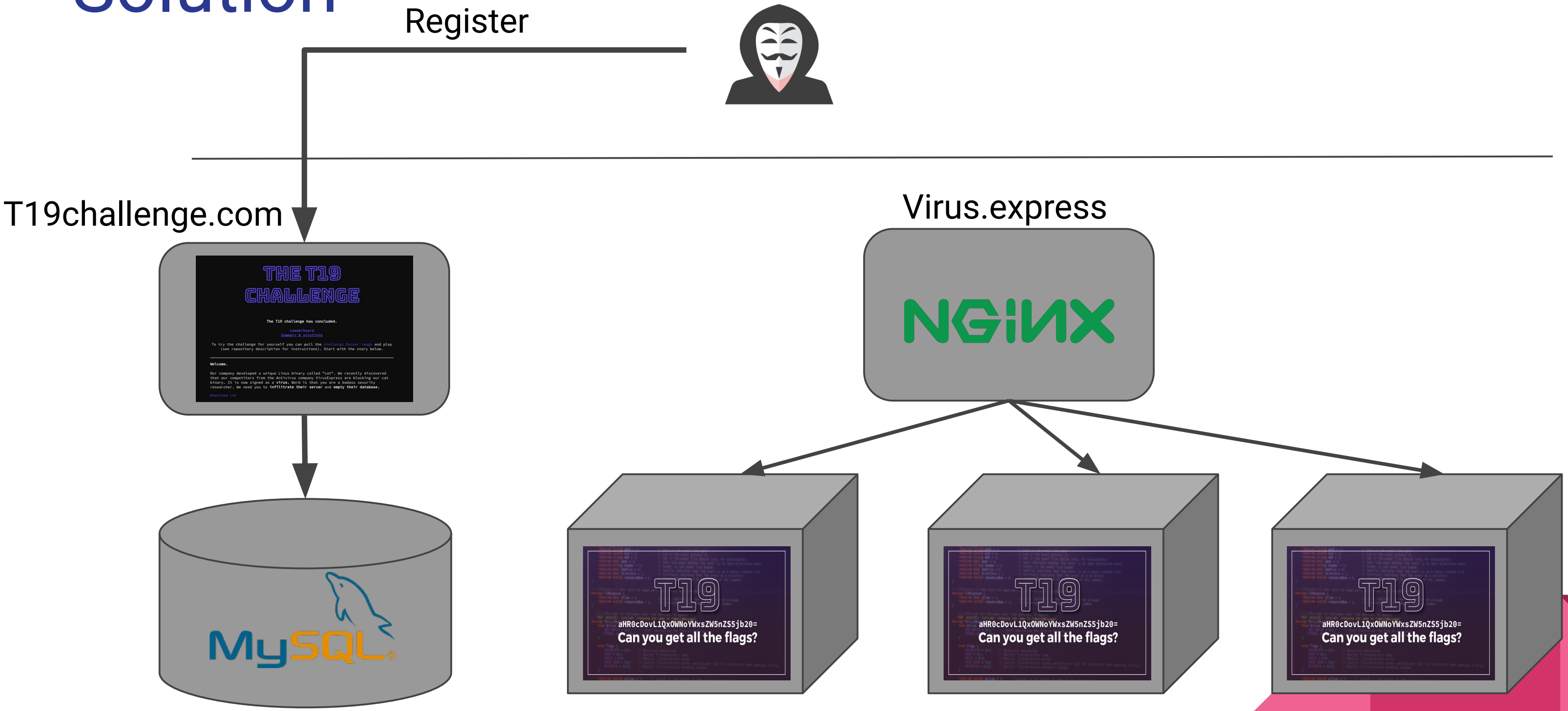
- Easy to scale
- Easy to update (hotfix)
- Easy configuration management (configuration as code)
- Good baseline security



Engineering requirements

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

Solution



Register
T19challenge.com
Virus.express
NGINX
MySQL
T19
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Can you get all the flags?
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Leaderboard
Summary & solutions

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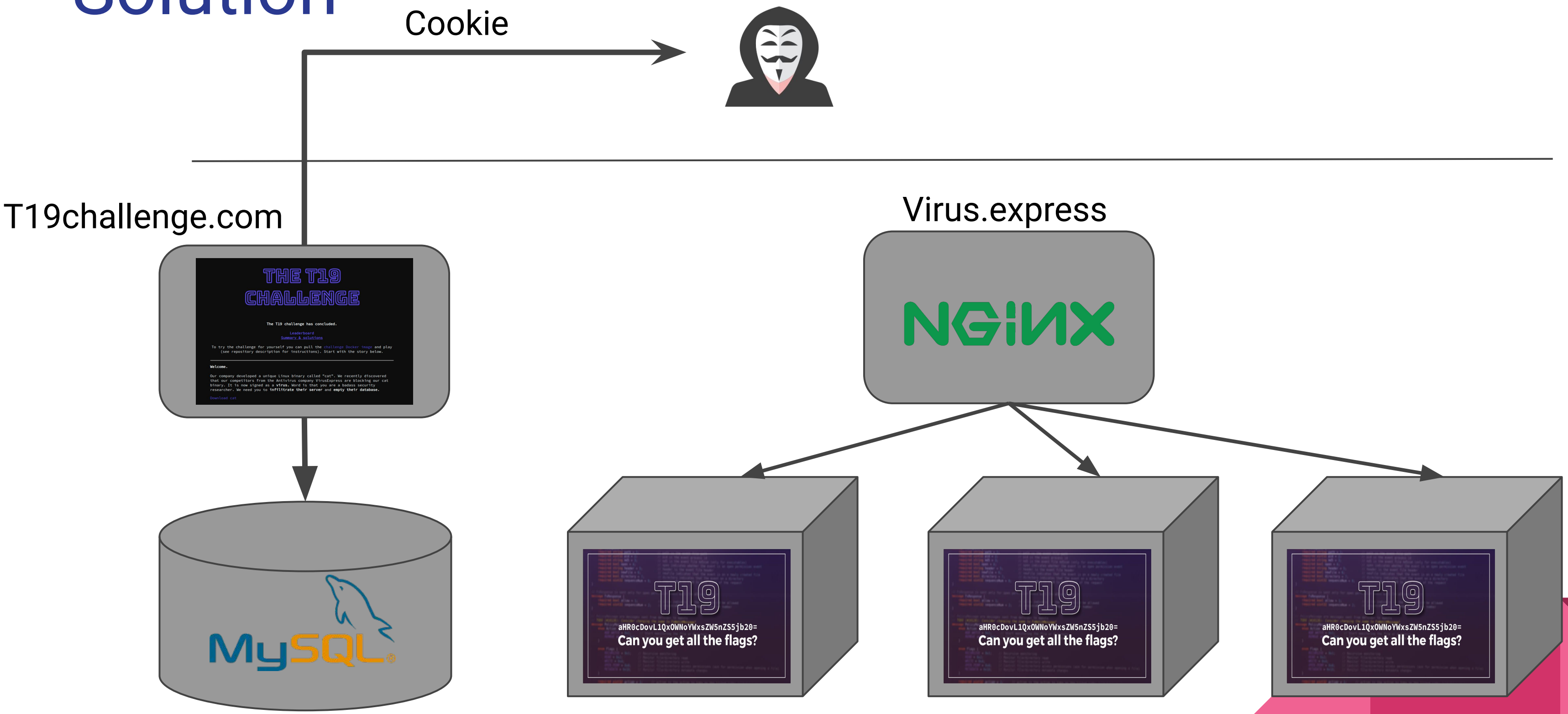
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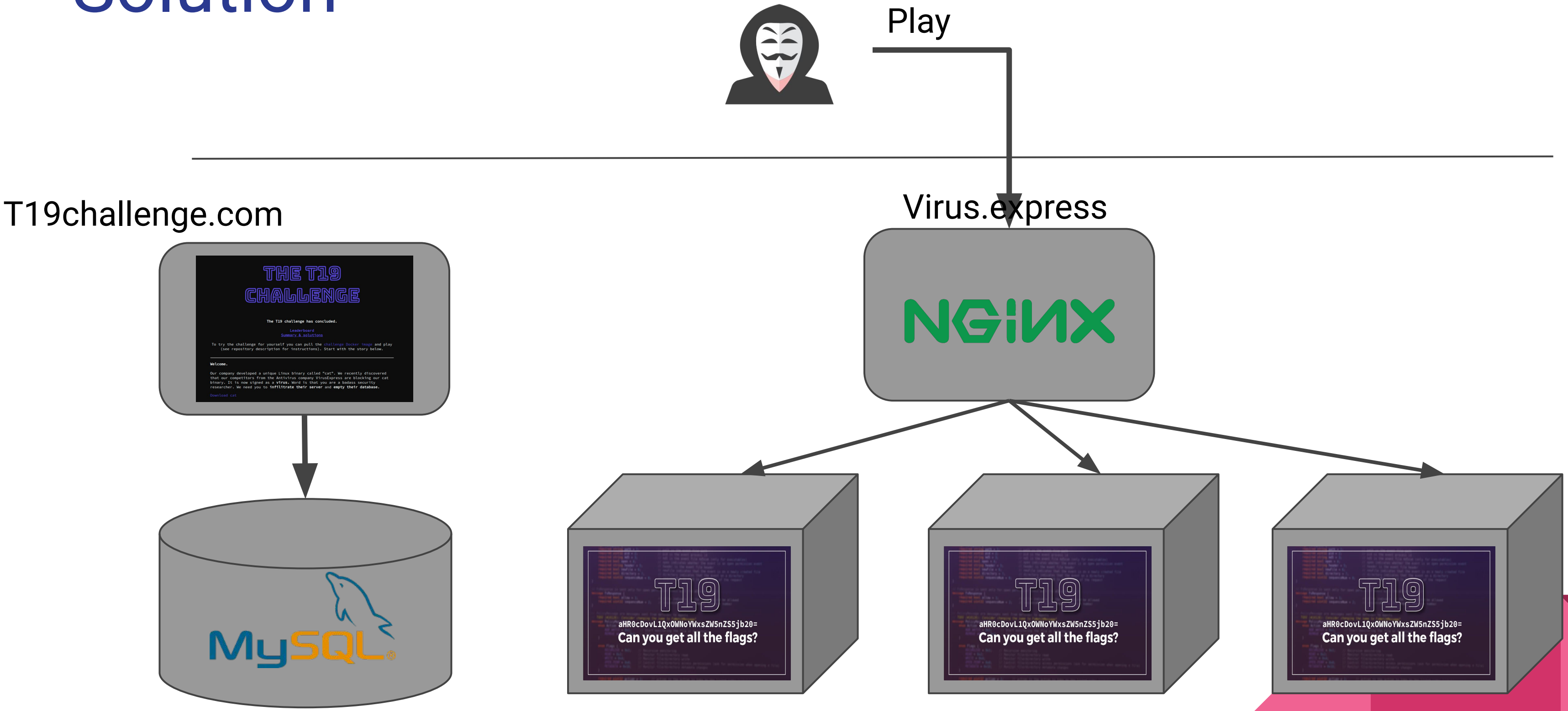

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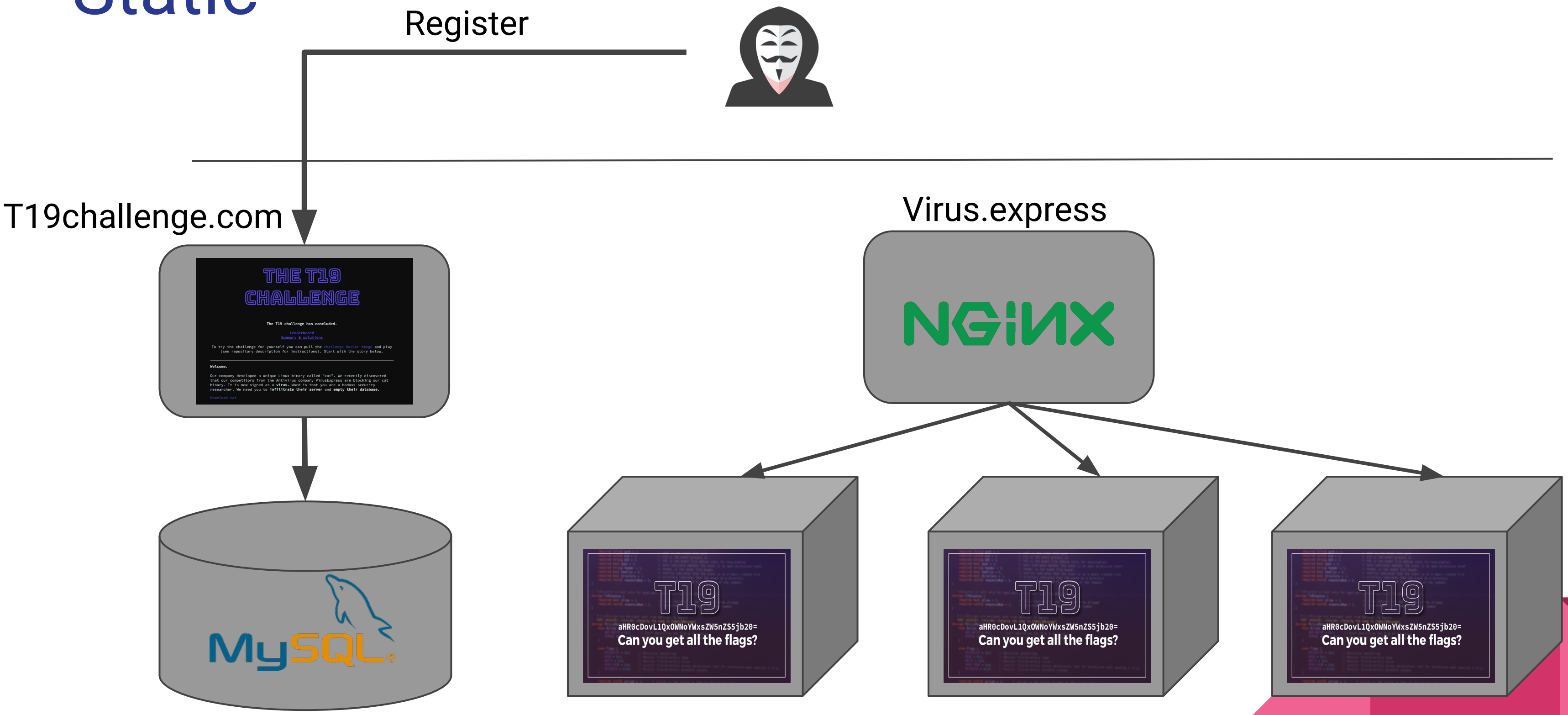
Possible solutions

1. Statically allocate all resources -

Static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Possible solutions

1. Statically allocate all resources - Expensive, does not scale

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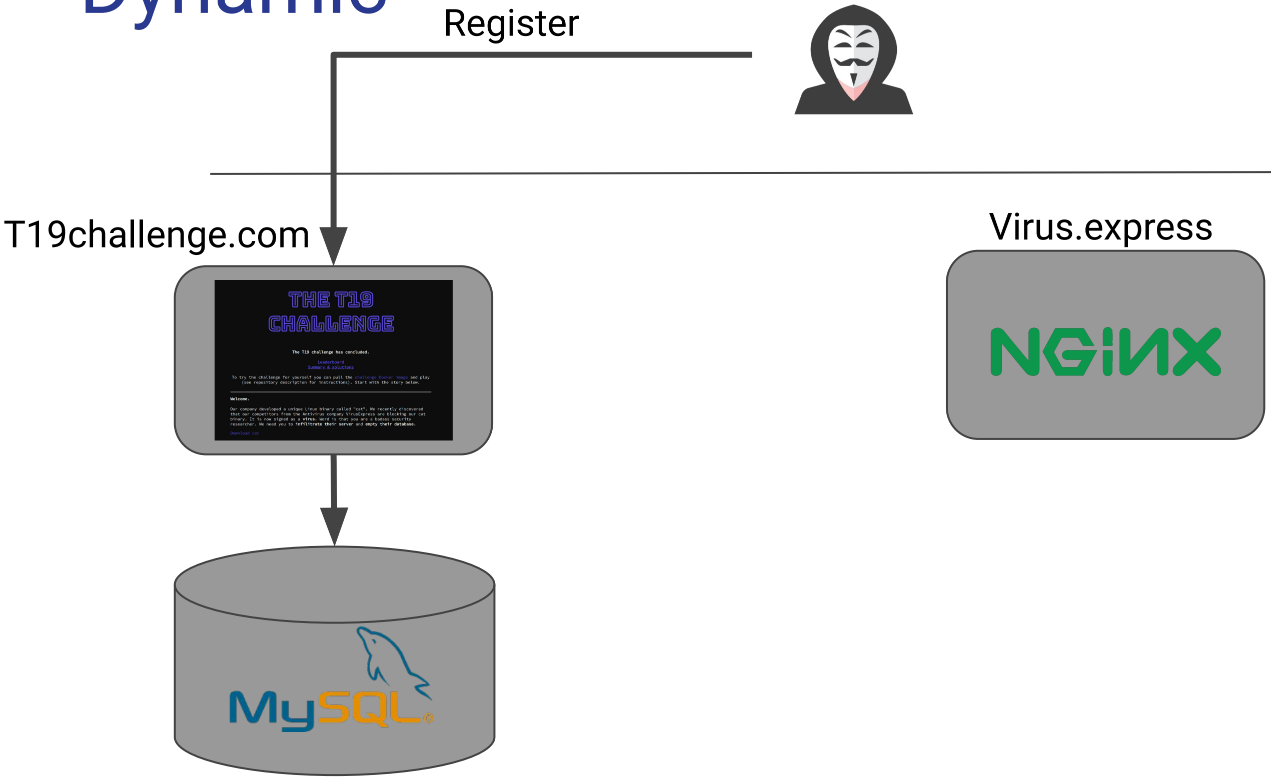
2. On demand allocate pods + services -

Dynamic



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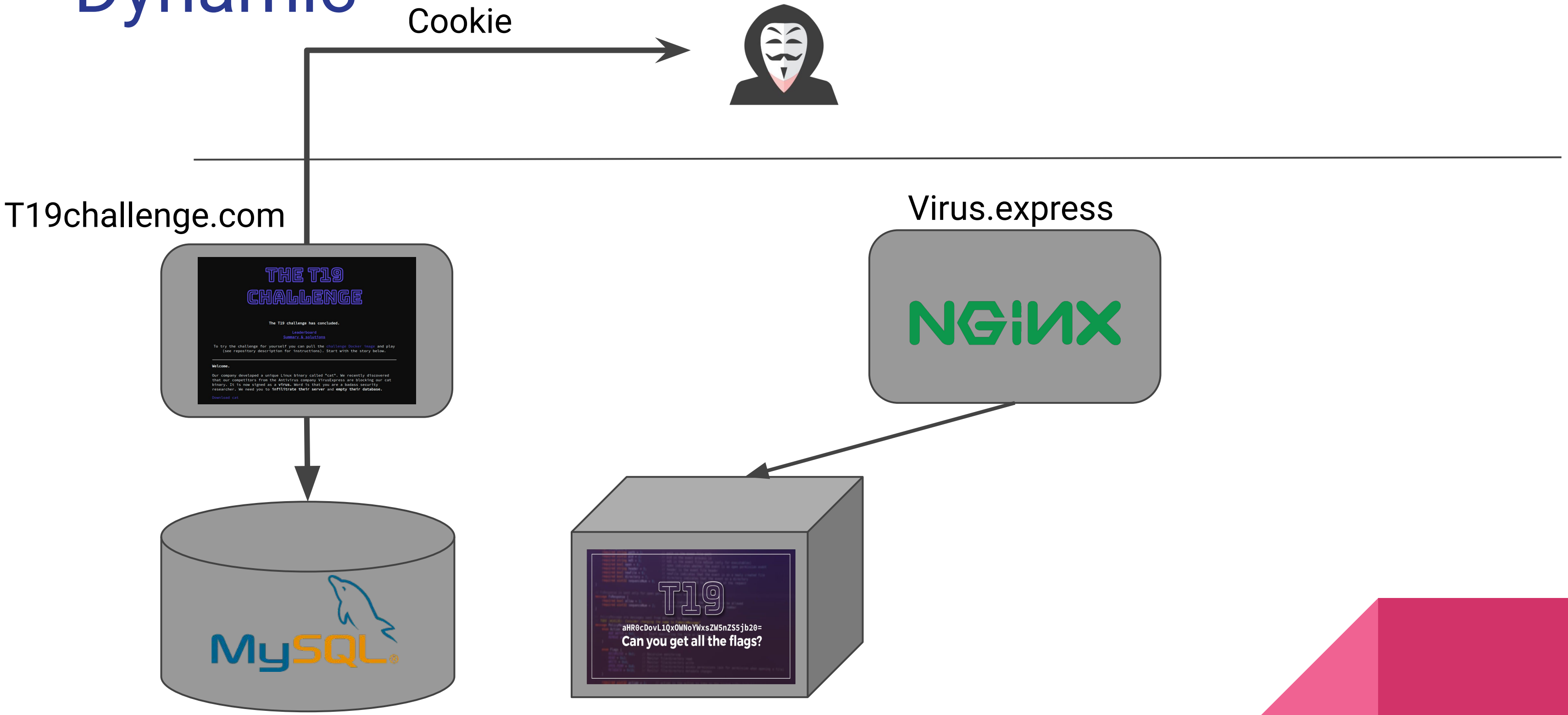

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Possible solutions

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

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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)

Allocate all services (>k before) before creating pods

```
kind: Service
apiVersion: v1
metadata:
  name: ctf-1
spec:
  clusterIP: 10.245.0.3
  selector:
    app: ctf-1
  ports:
  - protocol: TCP
    port: 13337
    targetPort: 13337
```

How it works

ID	Cluster-ip	
eba871ba9e58739c687e084a68f34500	10.245.0.3	...
76846a1eb5ec91e974831af1baa9e76d	10.245.0.4	...
d88ec62c1ea5b46df814f122a4641a94	10.245.0.5	...
...	10.245.0.5	
...	...	

The load-balancer

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: nginx-config
data:
  nginx.conf: |
    http {
    limit_req_zone $binary_remote_addr zone=one:10m rate=1r/s;
    map $cookie_t19userid $backend {
    default ";

    eba871ba9e58739c687e084a68f34500 http://10.245.0.3:13337;
    76846a1eb5ec91e974831af1baa9e76d http://10.245.0.4:13337;
    d88ec62c1ea5b46df814f122a4641a94 http://10.245.0.5:13337;
```

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
```

Freeing unused resources

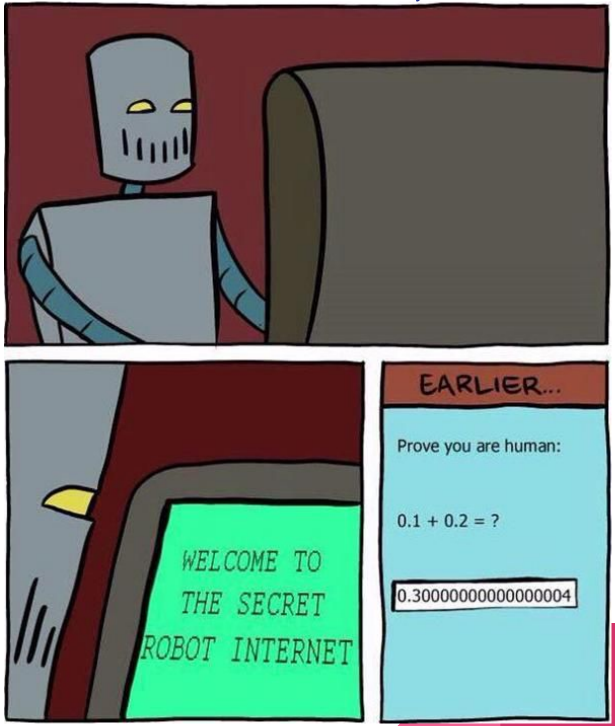
- Each CTF app takes ~20mb
- We expected ~2k registrations ~40GB RAM
- How do you detect (and shutdown) idle instance?
  - /var/log/nginx/access.log

Security challenges - WHAT IF

- Too many registration (resource exhaustion) - should delete?
- One pod interfere other pods (DOS)
- Attacker breaks out of the pod (container breakout)
- Compromise network assests
- Compromised the cluster (game over)

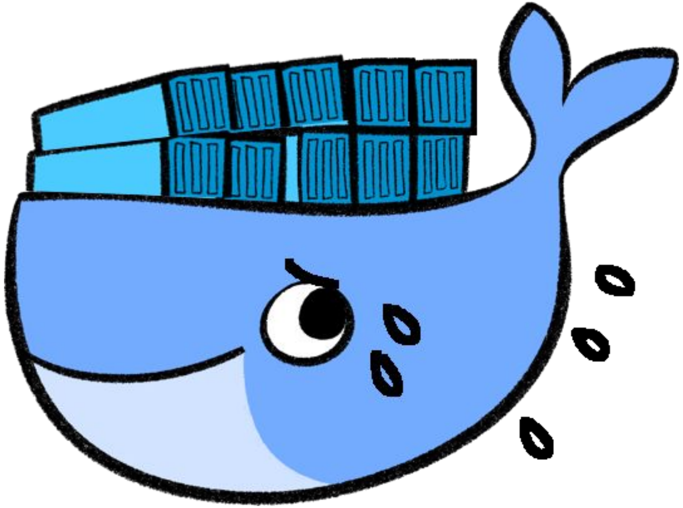
Too many registration (should delete?)

- Entry barriers: base64
- Doomsday solution: Captcha



Local resource exhaustion

- CPU/memory exhaustion (deliberate or accidental)
- Resource abuse $$$ (e.g. cryptomining)



Local resource exhaustion - solution

- Pod security policy

```
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"
```

Host compromised

- Misconfiguration (host mount/secrets)
- CVE-2019-5736 -
  Execution of malicious containers allows for container escape and access to host filesystem

Container breakout - “solution”

- 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)
- [Optional] Userns
- [Optional] Additional sandbox - Gvisor

Cluster takeover

- Capturing all the flags in BSidesSF CTF by pwning our infrastructure https://hackernoon.com/capturing-all-the-flags-in-bsidessf-ctf-by-pwning-our-infrastructure-3570b99b4dd0
- SSRF in Exchange leads to ROOT access in all instances https://hackerone.com/reports/341876
- Access cloud services ($$) or steal sensitive data (images)

Cluster takeover - mitigations

- Isolated environment (project)
- 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

Try to solve?

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

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