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eBPF for Security

Liz Rice | @lizrice

Chief Open Source Officer, Isovalent | CNCF Governing Board | OpenUK Board

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What is  eBPF ?

Makes the kernel programmable

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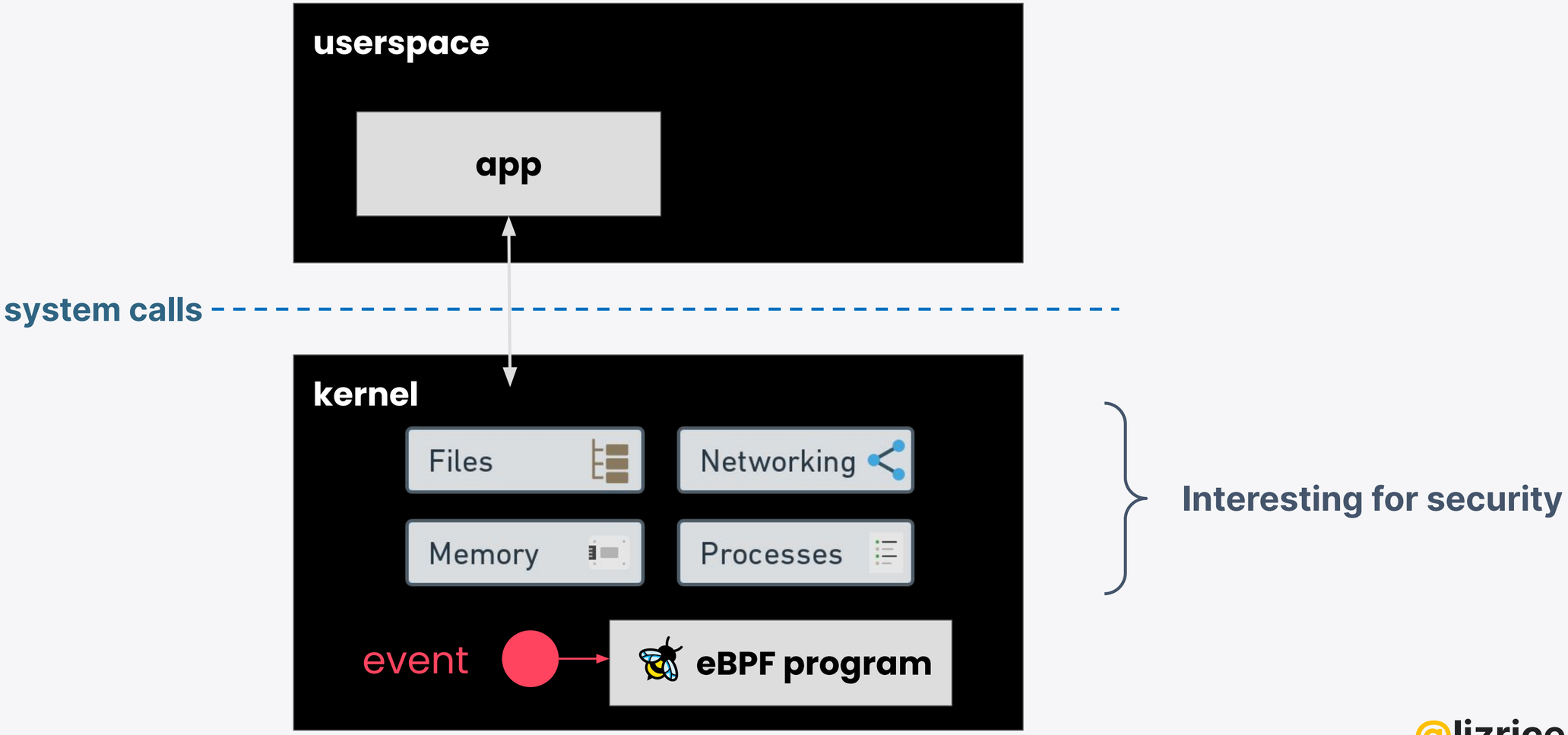
Run custom code in the kernel



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eBPF Hello World

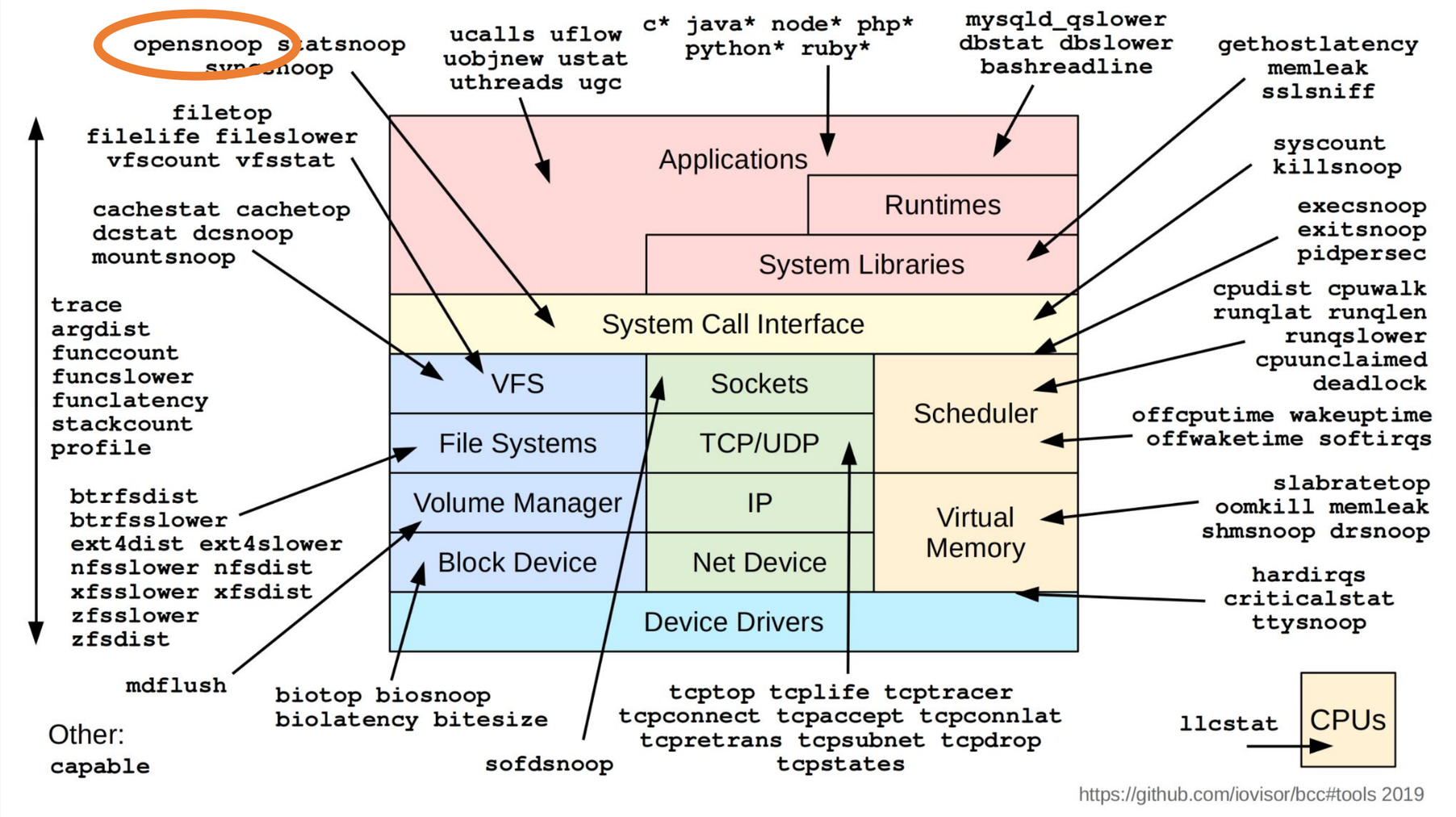
```
SEC("kprobe/sys_execve")
int hello(void *ctx)
{
    bpf_trace_printk("Hello World!");
    return 0;
}
```

\+ userspace code to load eBPF program

Info about process that called execve syscall

```
$ sudo ./hello
   bash-20241   [004] d...  84210.752785: 0: Hello World!
   bash-20242   [004] d...  84216.321993: 0: Hello World!
   bash-20243   [004] d...  84225.858880: 0: Hello World!
```

eBPF tracing tools from iovisor/bcc



https://github.com/iovisor/bcc#tools 2019

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eBPF tracing - opensnoop

```
~/bcc/libbpf-tools$ sudo ./opensnoop
PID    COMM               FD ERR PATH
5040   node               21   0 /proc/5132/cmdline
5040   node               21   0 /proc/6460/cmdline
5040   node               21   0 /proc/6460/cmdline
6461   opensnoop          18   0 /etc/localtime
5040   node               21   0 /proc/5132/cmdline
5040   node               21   0 /proc/6460/cmdline
5060   node               23   0 /home/liz/.vscode-server/data/User/workspaceStorage/48b53
5040   node               21   0 /proc/5132/cmdline
5040   node               21   0 /proc/6460/cmdline
5040   node               21   0 /proc/5132/cmdline
5040   node               21   0 /proc/6460/cmdline
…
```

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eBPF and Kubernetes

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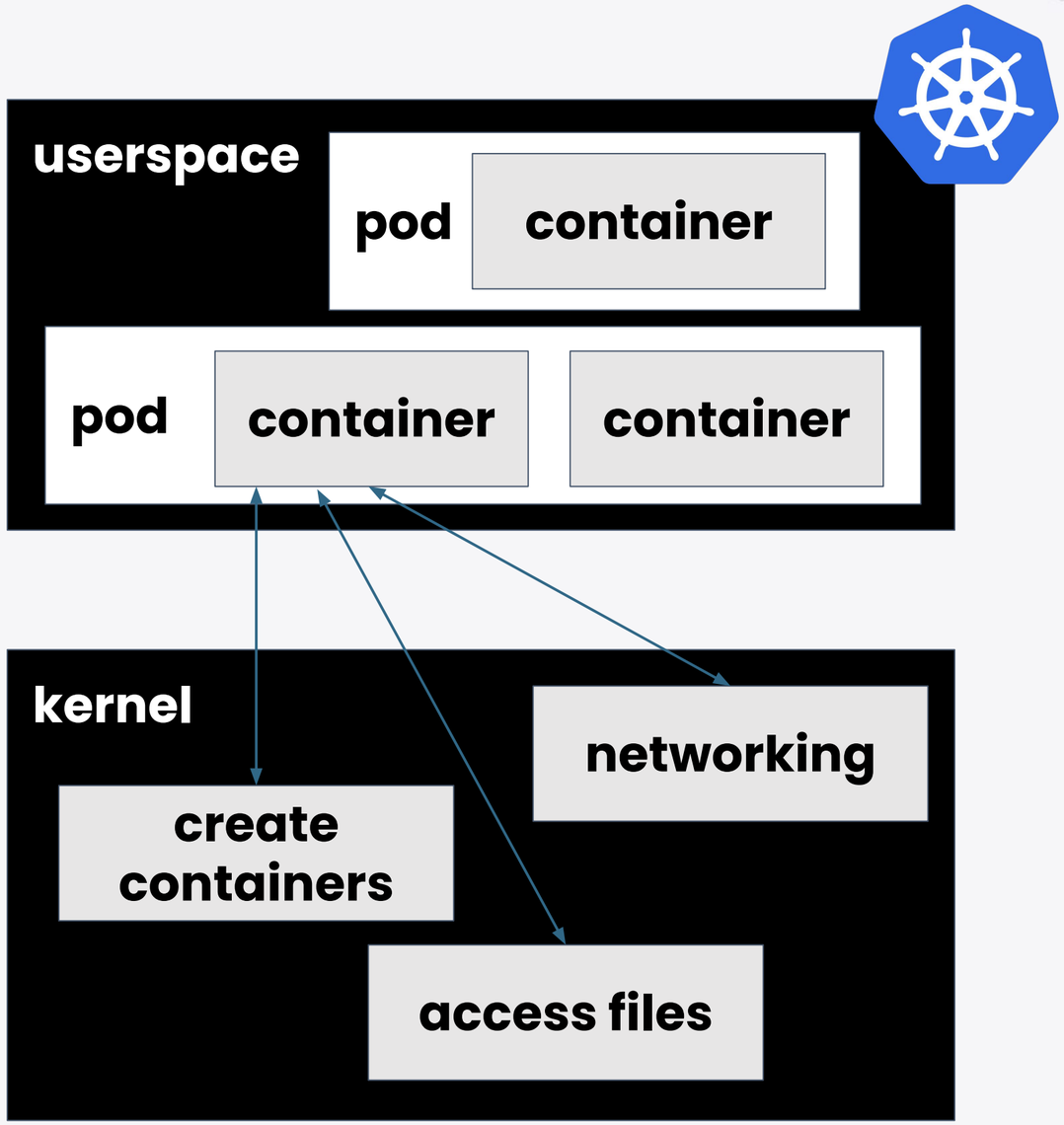

One kernel per host

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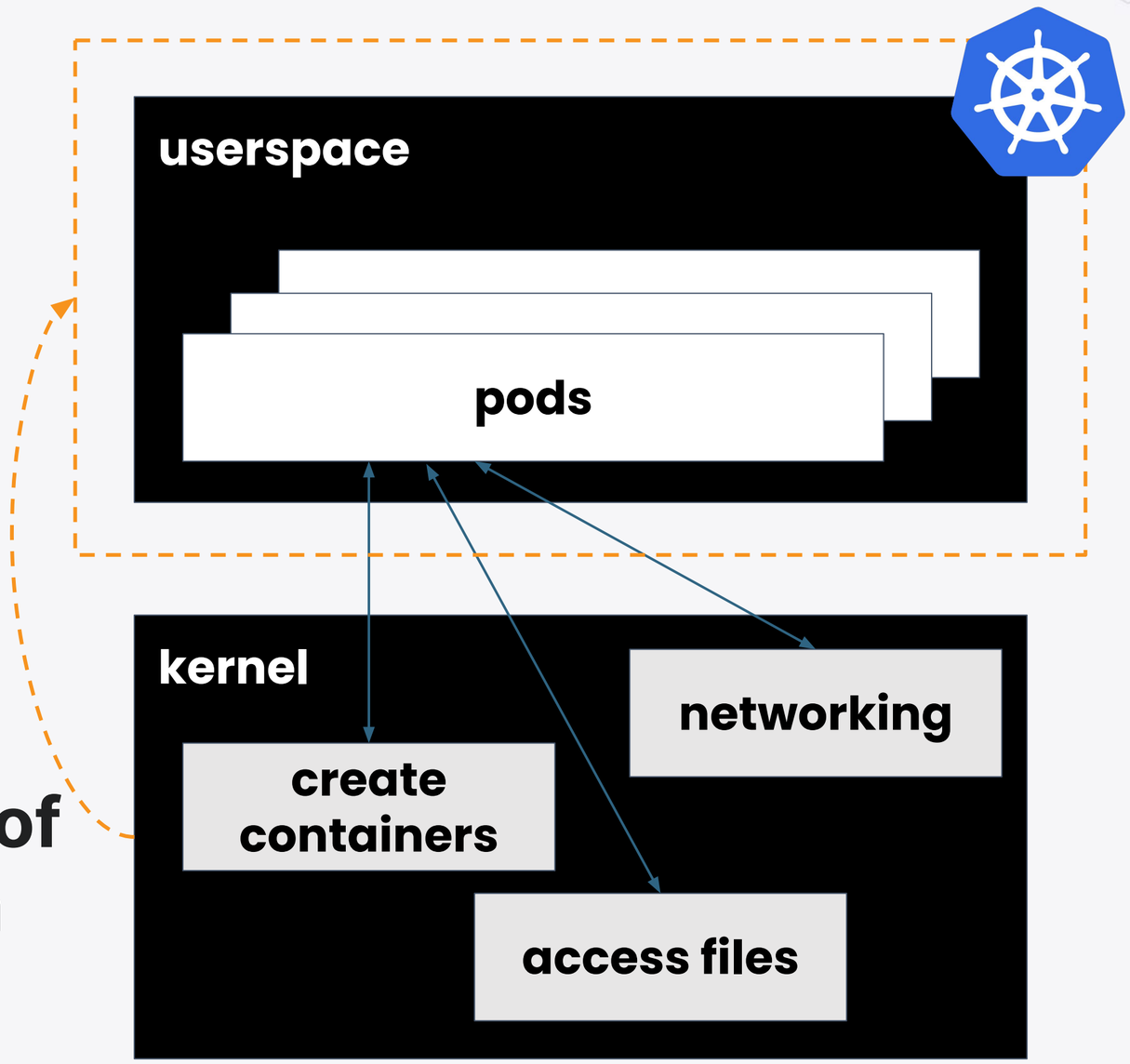

Kernel aware of everything on the host

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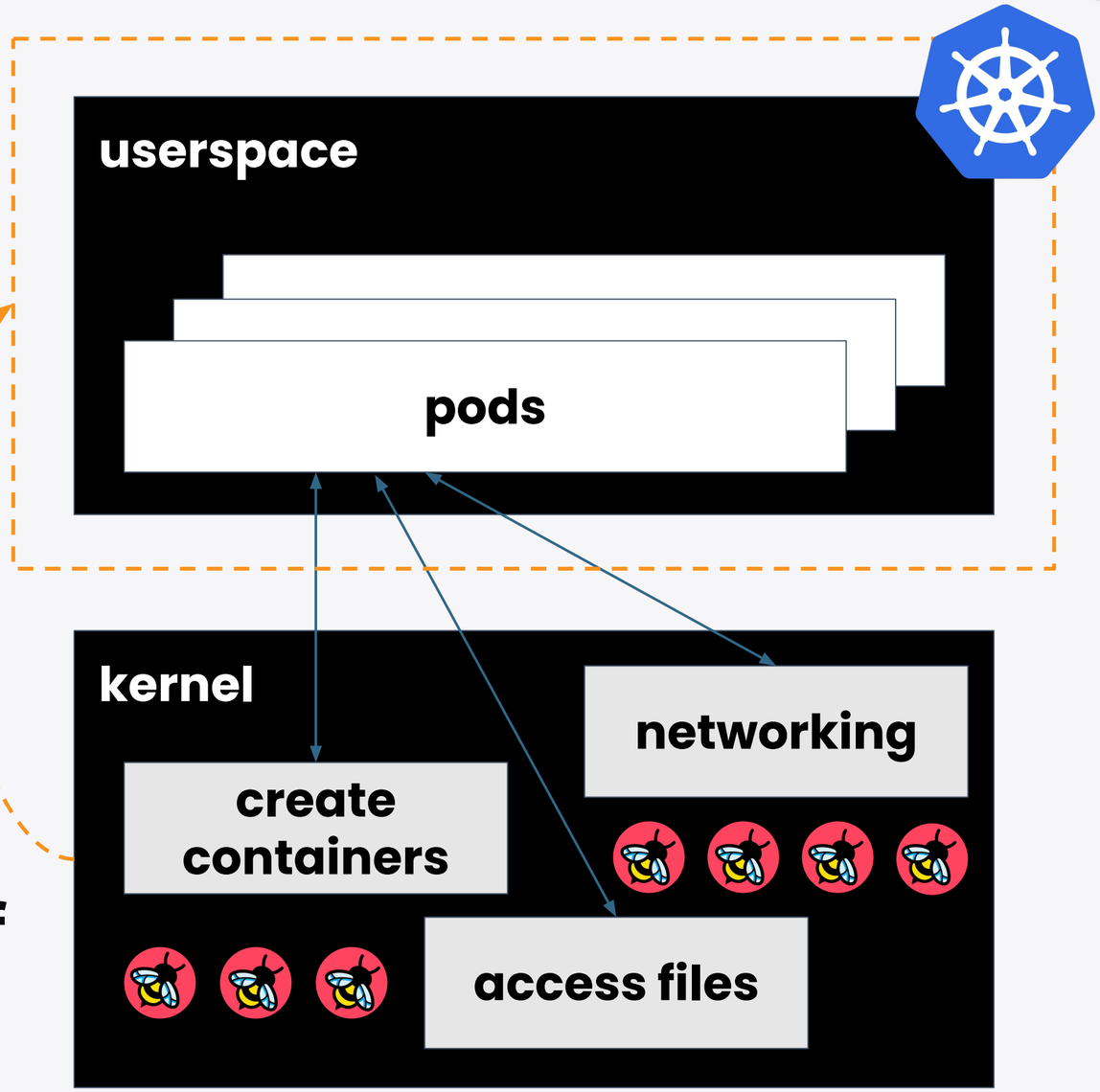

No changes to apps or config needed

eBPF programs can be aware of everything

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eBPF tracing on Kubernetes - Inspektor Gadget

```
$ kubectl gadget trace open
NODE                   NAMESPACE     POD      CONTAINER    PID     COMM    FD  ERR PATH
kind-2-control-plane   default       xwing    spaceship    361876 vi      3     0 /etc/passwd
```

Kubernetes info

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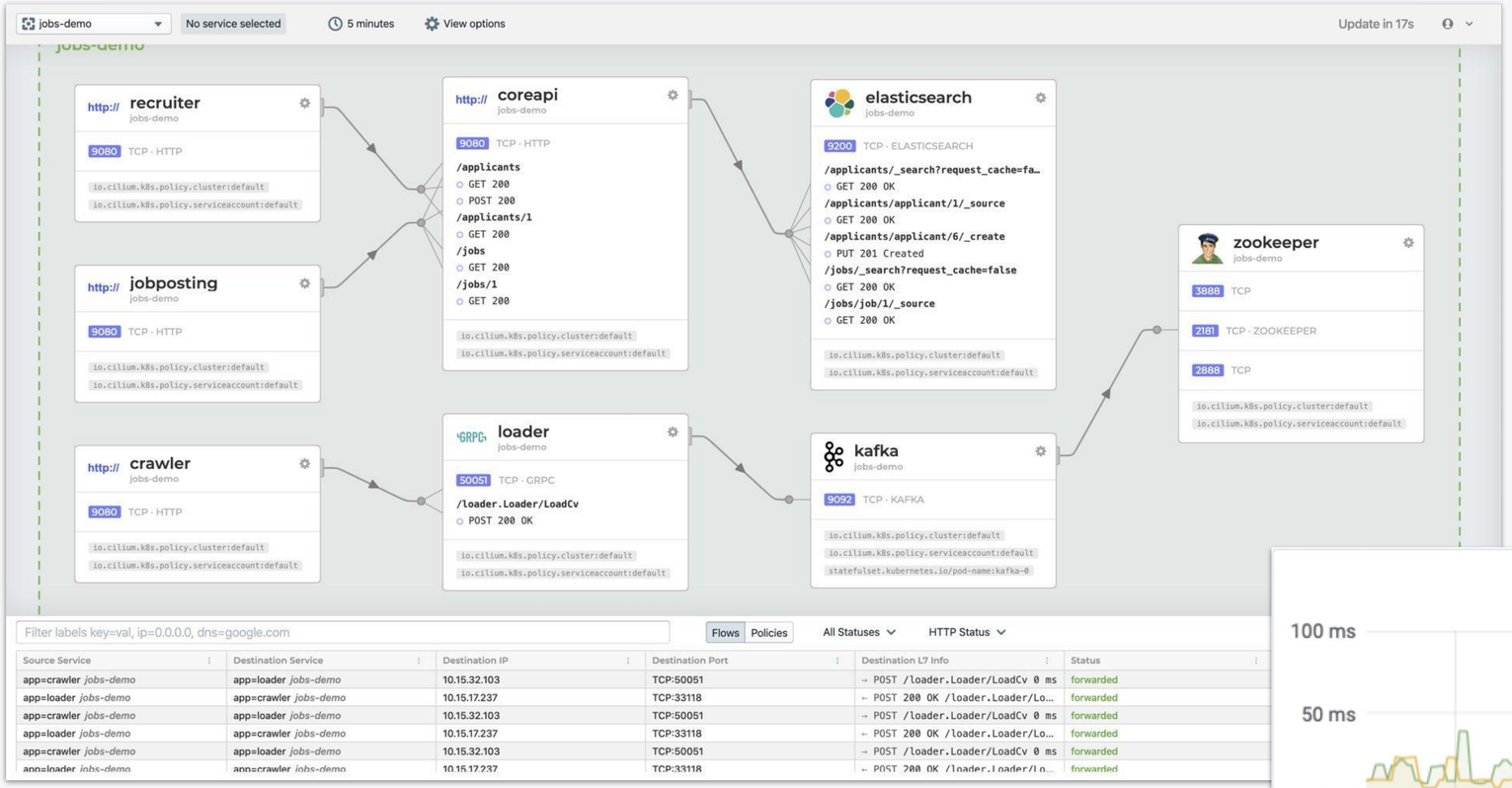
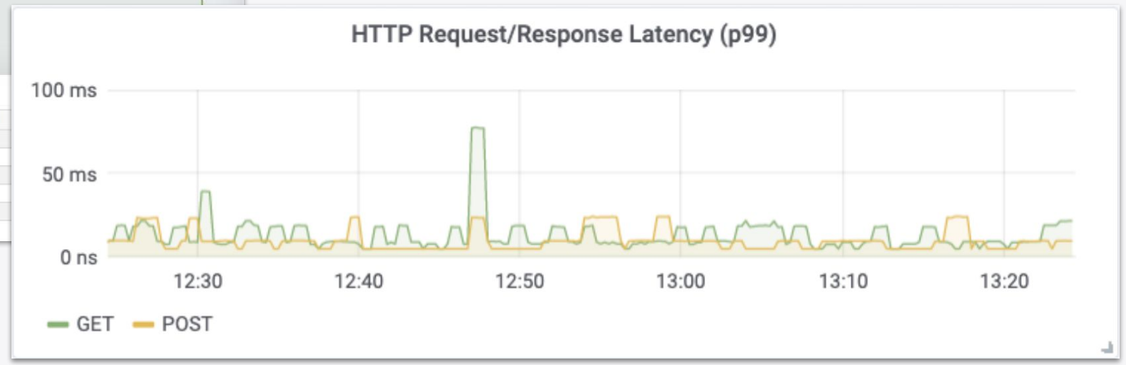
eBPF observability tools - Cilium Hubble





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eBPF security observability

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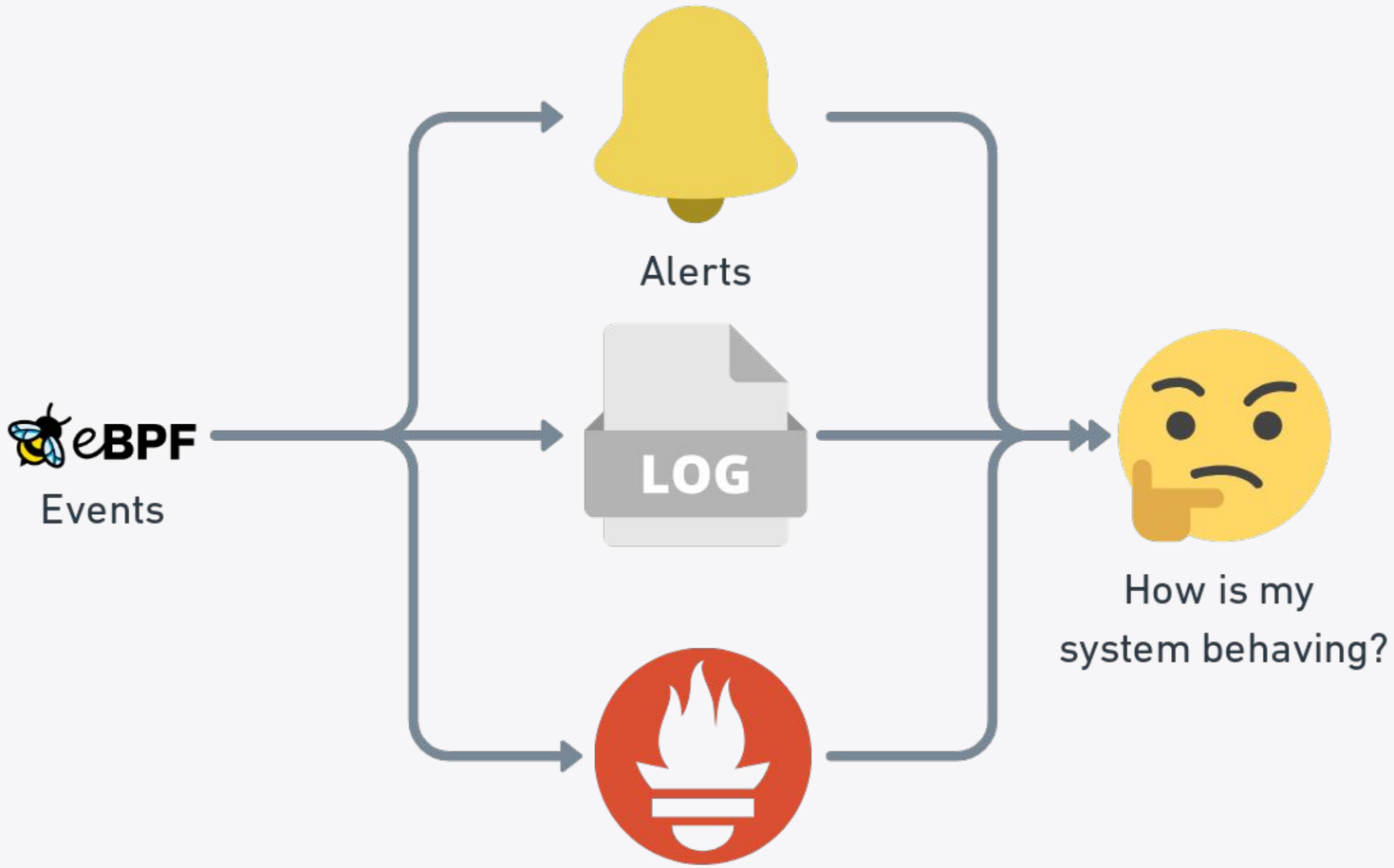
Observability



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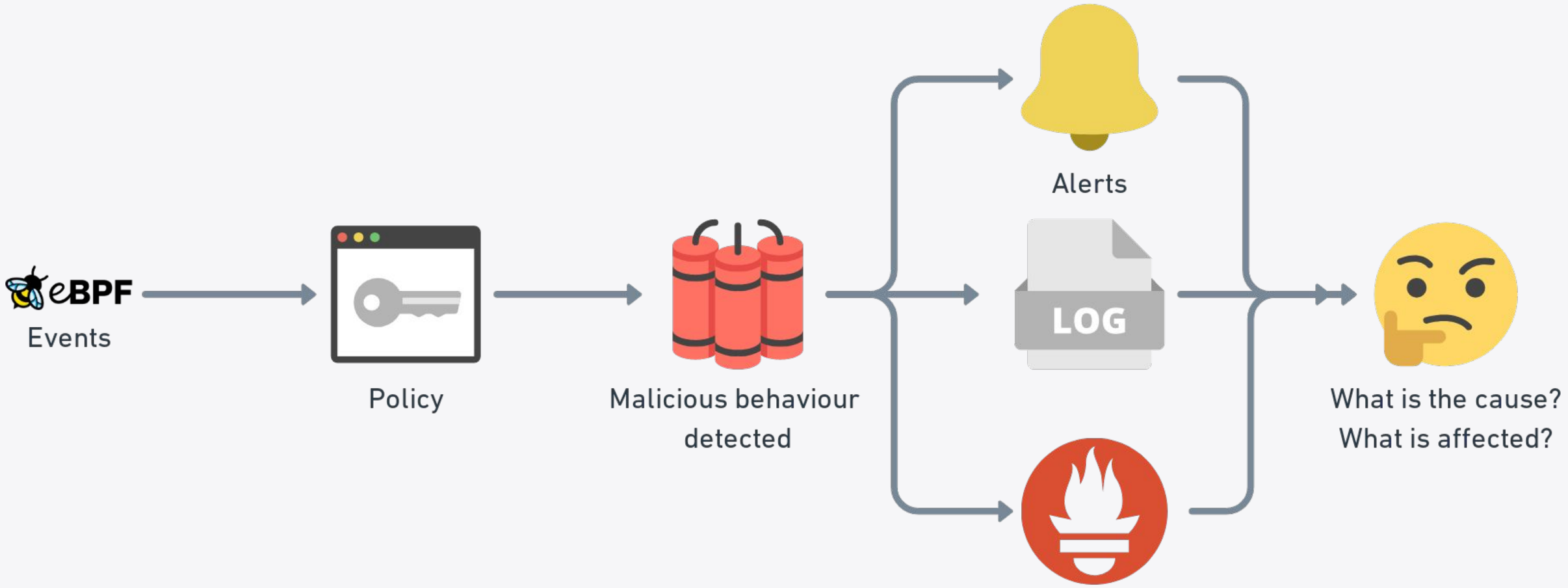
Security observability



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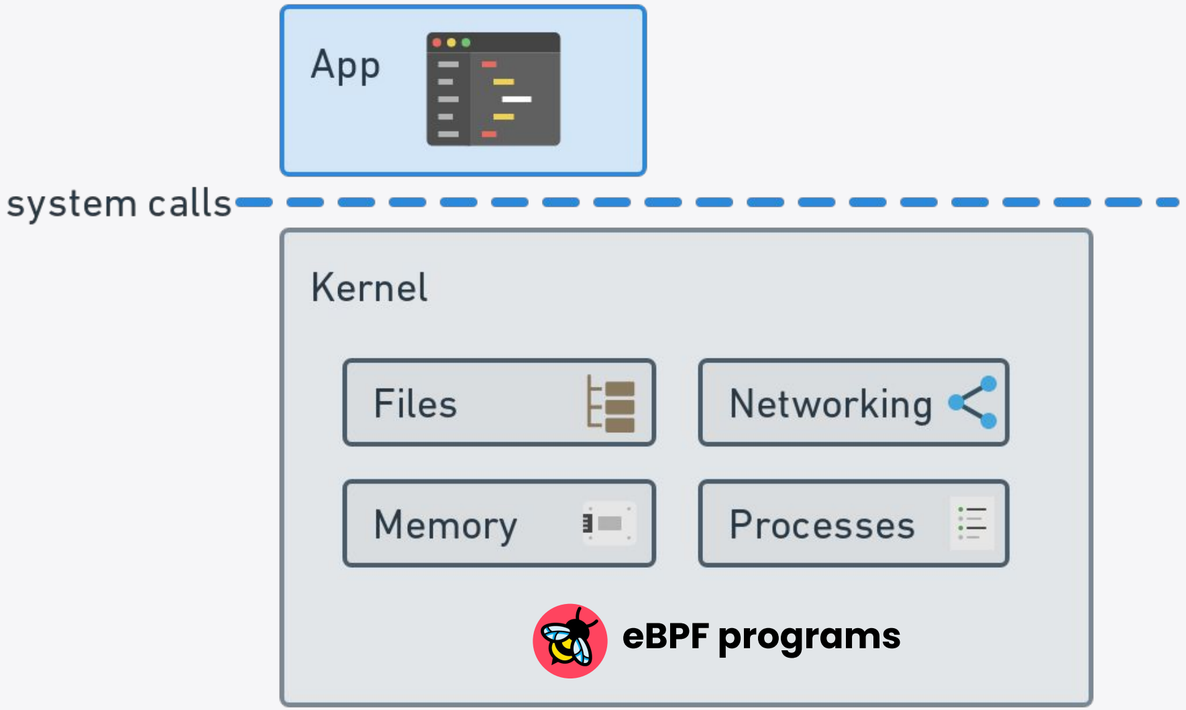
What activity do we care about for security?



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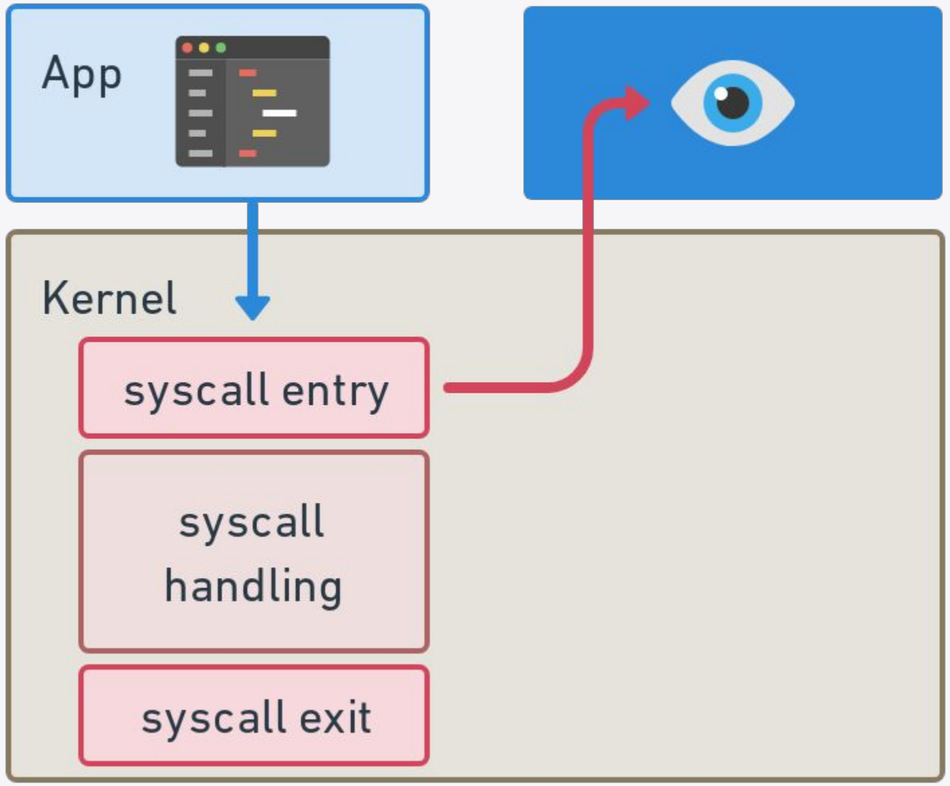
Syscall checks within the kernel



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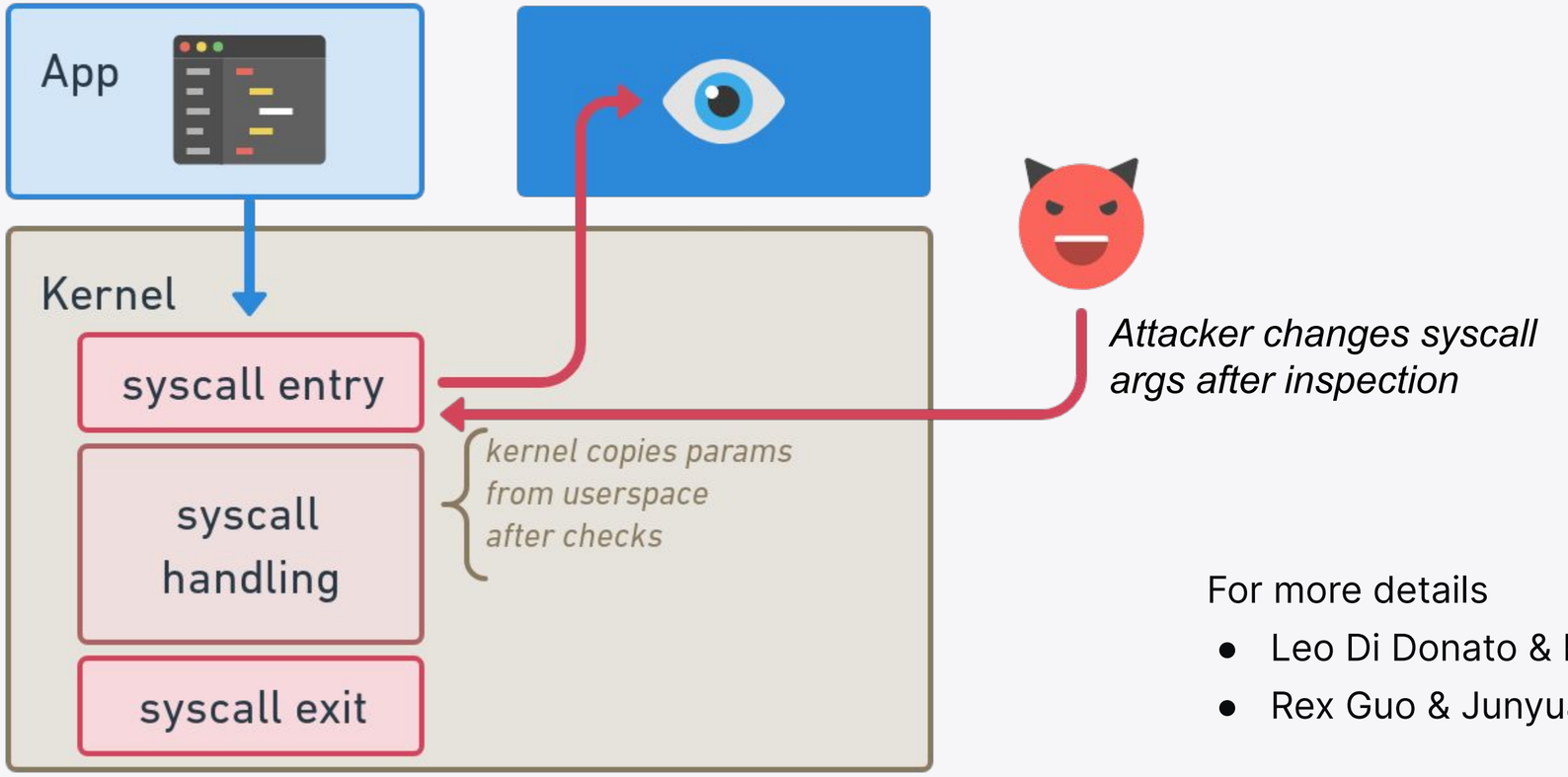
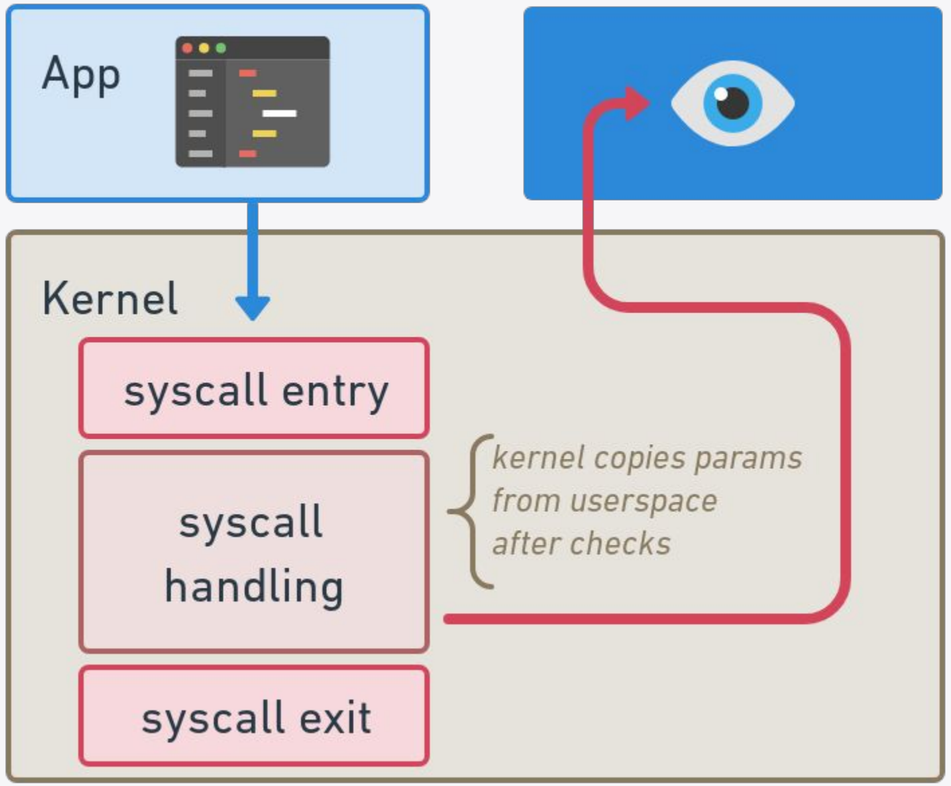
TOCTTOU vulnerabilities with syscalls



For more details

- Leo Di Donato & KP Singh at CN eBPF Day 2021
- Rex Guo & Junyuan Zeng at DEFCON 29 on Phantom attacks

Need to make the check at the right place



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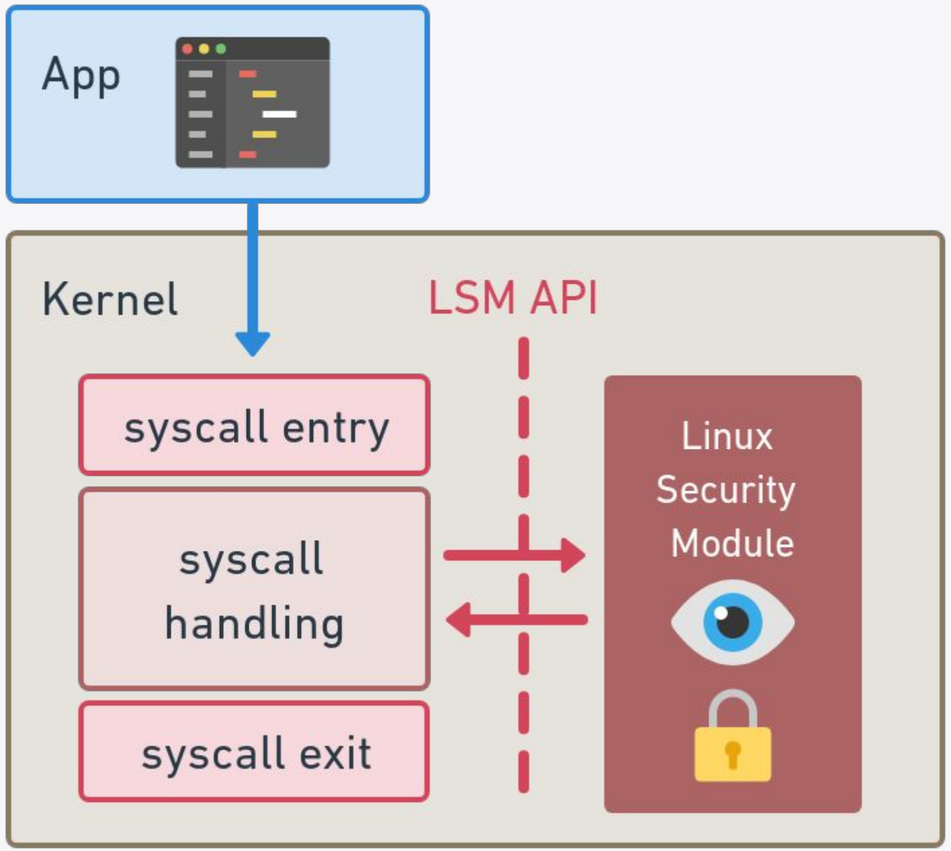
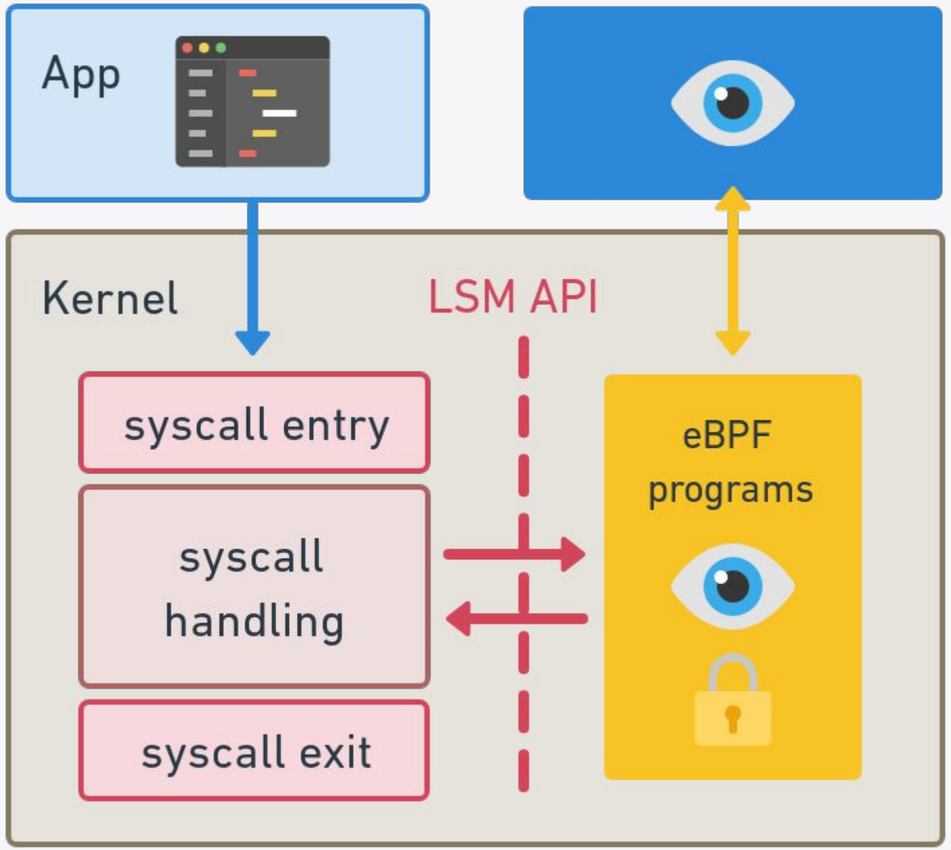
Linux Security Modules



- Stable interface
- Safe places to make checks

BPF LSM



- Stable interface
- Safe places to make checks

+ **eBPF benefits**
- Dynamic
- Protect pre-existing processes

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BPF LSM hook has kernel info populated

```
SEC("lsm/path_chmod")
int BPF_PROG(path_chmod, const struct path *path, umode_t mode)
{
    bpf_printk("lsm path_chmod %s\n", path->dentry->d_iname);
    return 0;
}
```

```
$ sudo ./chmoddemo &
[1] 7631
$ sudo cat /sys/kernel/debug/tracing/trace_pipe
           chmod-7776    [001] d... 38197.342160: bpf_trace_printk: lsm path_chmod liz
```

Filename known to kernel

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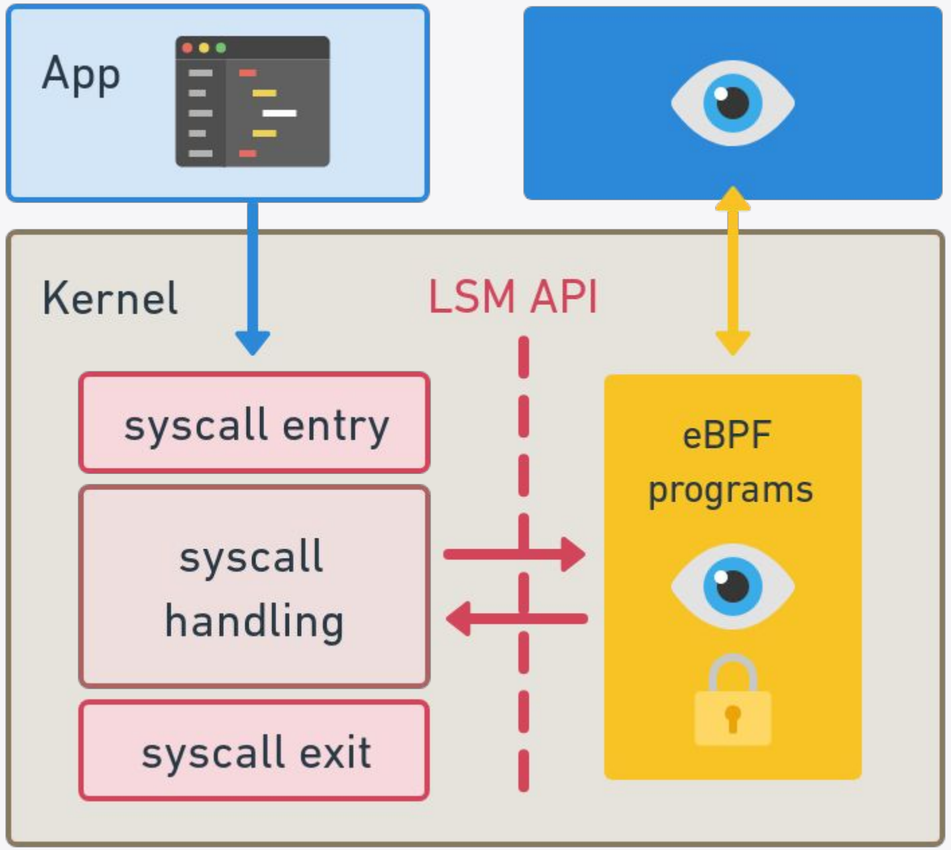
BPF LSM



- Stable interface
- Safe places to make checks

\+ **eBPF benefits**

- Dynamic
- Protect pre-existing processes

But needs **kernel 5.7+**

& Kubernetes context?

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How stable is the Linux kernel?

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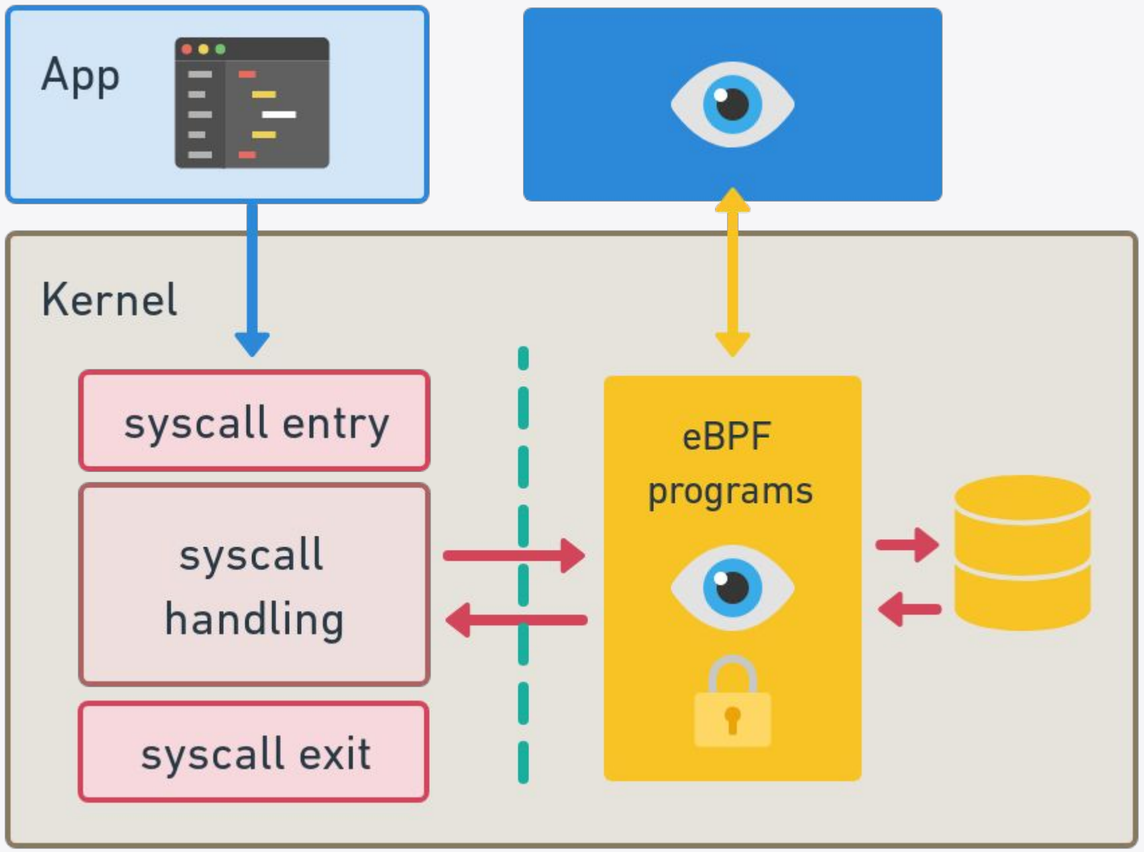
Cilium Tetragon



- Safe places to make checks

+ **eBPF benefits**
- Dynamic
- Protect pre-existing processes

Uses **kernel knowledge** to hook into sufficiently stable functions

Adds Kubernetes context

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A Tetragonisca angustula bee guarding the nest-entrance

Photo credit: Bibafu

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Cilium Tetragon tracing policy

```
apiVersion: cilium.io/v1alpha1
kind: TracingPolicy
metadata:
 name: "etc-files"
spec:
 kprobes:
 - call: "fd_install"
…
      matchArgs:
      - index: 1
        operator: "Prefix"
        values:
        - "/etc/"
…
```

+ Policy “follows” file descriptor through read, write & close events

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Cilium Tetragon observe security events

```
$ kubectl logs ds/tetragon -c export-stdout -f | tetra getevents -o compact
🚀 process default/xwing /usr/bin/vi /etc/passwd
📬 open    default/xwing /usr/bin/vi /etc/passwd
📪 close   default/xwing /usr/bin/vi
📬 open    default/xwing /usr/bin/vi /etc/passwd
📝 write   default/xwing /usr/bin/vi /etc/passwd 1275 bytes
📪 close   default/xwing /usr/bin/vi
💥 exit    default/xwing /usr/bin/vi /etc/passwd 0
```

Kubernetes info

Policy events

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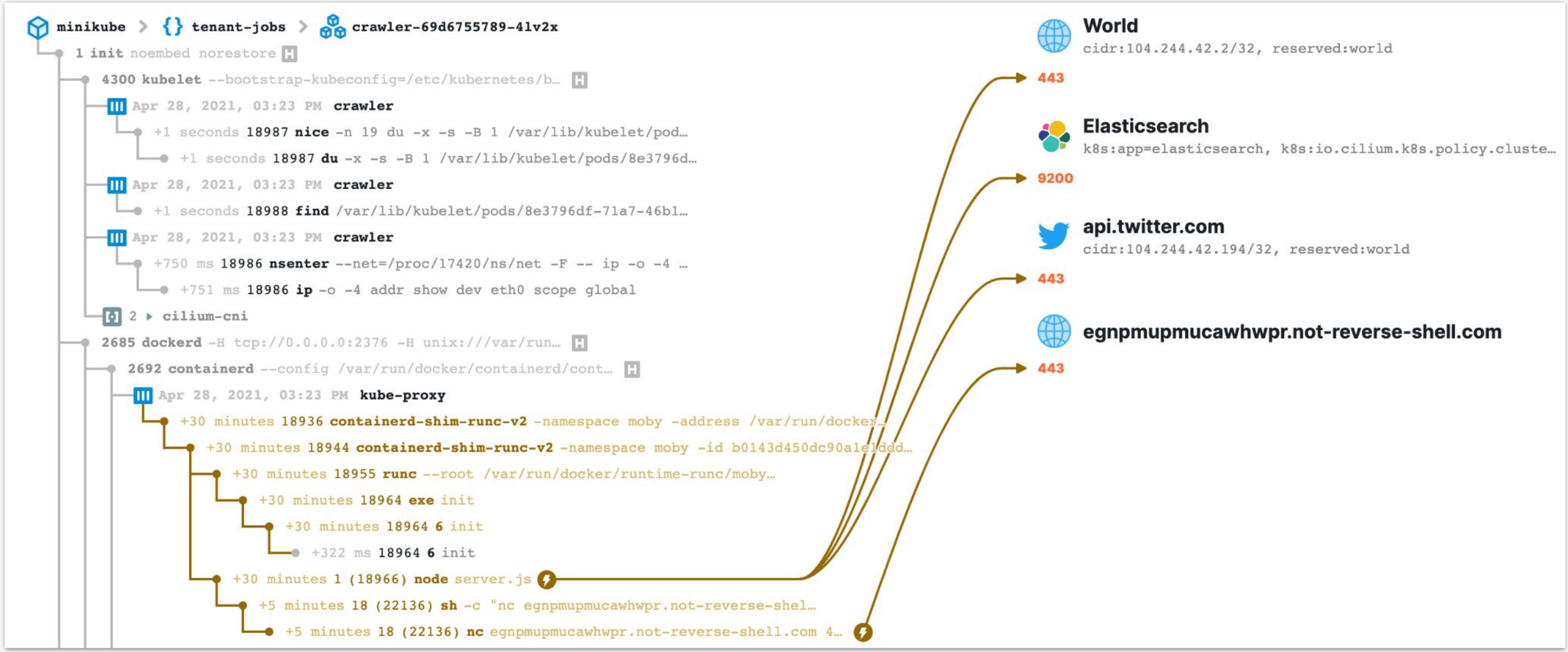
Combined network and runtime visibility



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eBPF preventative runtime security

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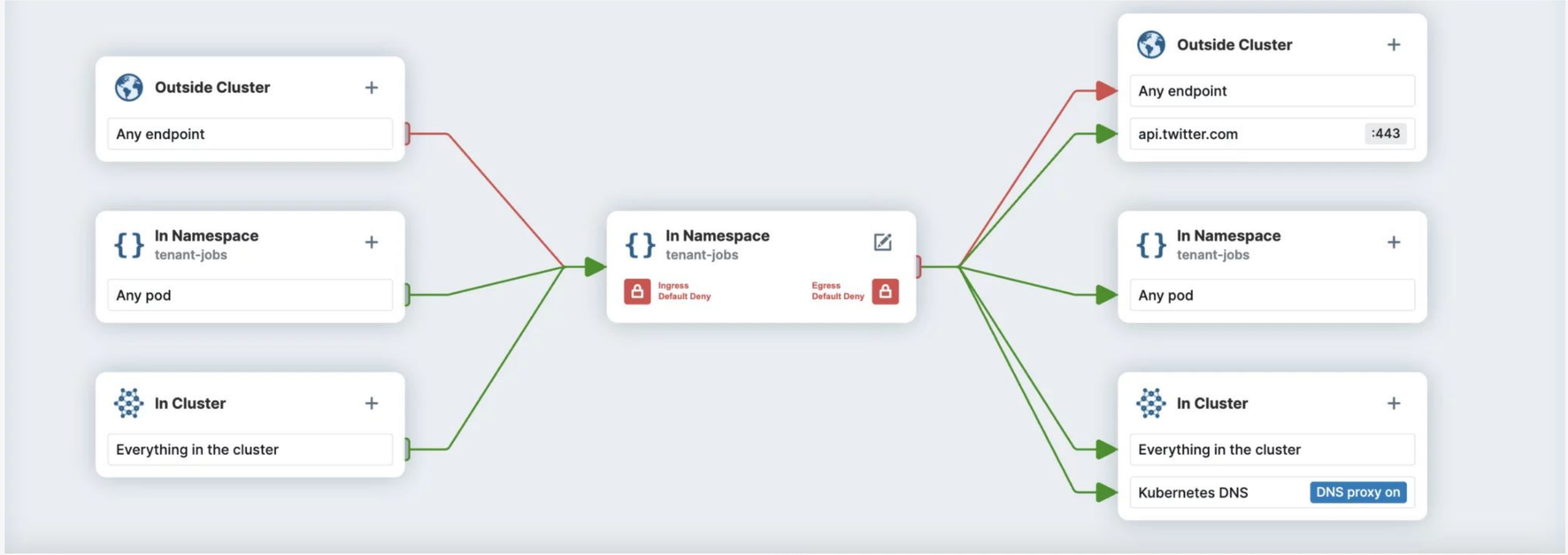
Cilium network policy → eBPF programs drop packets



Kubernetes | Cilium | Download

```
21        - ports:
22            - port: "53"
23              protocol: ANY
24          rules:
25            dns:
26              - matchPattern: "*"
27    - toFQDNs:
28        - matchName: api.twitter.com
29      toPorts:
30        - ports:
31            - port: "443"
```

Source Identity	Destination Identity	Verdict
crawler *tenant-jobs*	api.twitter.com	forwarded
crawler *tenant-jobs*	elasticsearch *tenant-jobs*	forwarded
crawler *tenant-jobs*	elasticsearch *tenant-jobs*	forwarded
crawler *tenant-jobs*	api.twitter.com	forwarded
loader *tenant-jobs*	kafka *tenant-jobs*	forwarded
coreapi *tenant-jobs*	elasticsearch *tenant-jobs*	forwarded
jobposting *tenant-jobs*	coreapi *tenant-jobs*	forwarded
jobposting *tenant-jobs*	coreapi *tenant-jobs*	forwarded
coreapi *tenant-jobs*	elasticsearch *tenant-jobs*	forwarded
kafka *tenant-jobs*	zookeeper *tenant-jobs*	forwarded
coreapi *tenant-jobs*	elasticsearch *tenant-jobs*	forwarded
recruiter *tenant-jobs*	coreapi *tenant-jobs*	forwarded
recruiter *tenant-jobs*	coreapi *tenant-jobs*	forwarded
loader *tenant-jobs*	kafka *tenant-jobs*	forwarded

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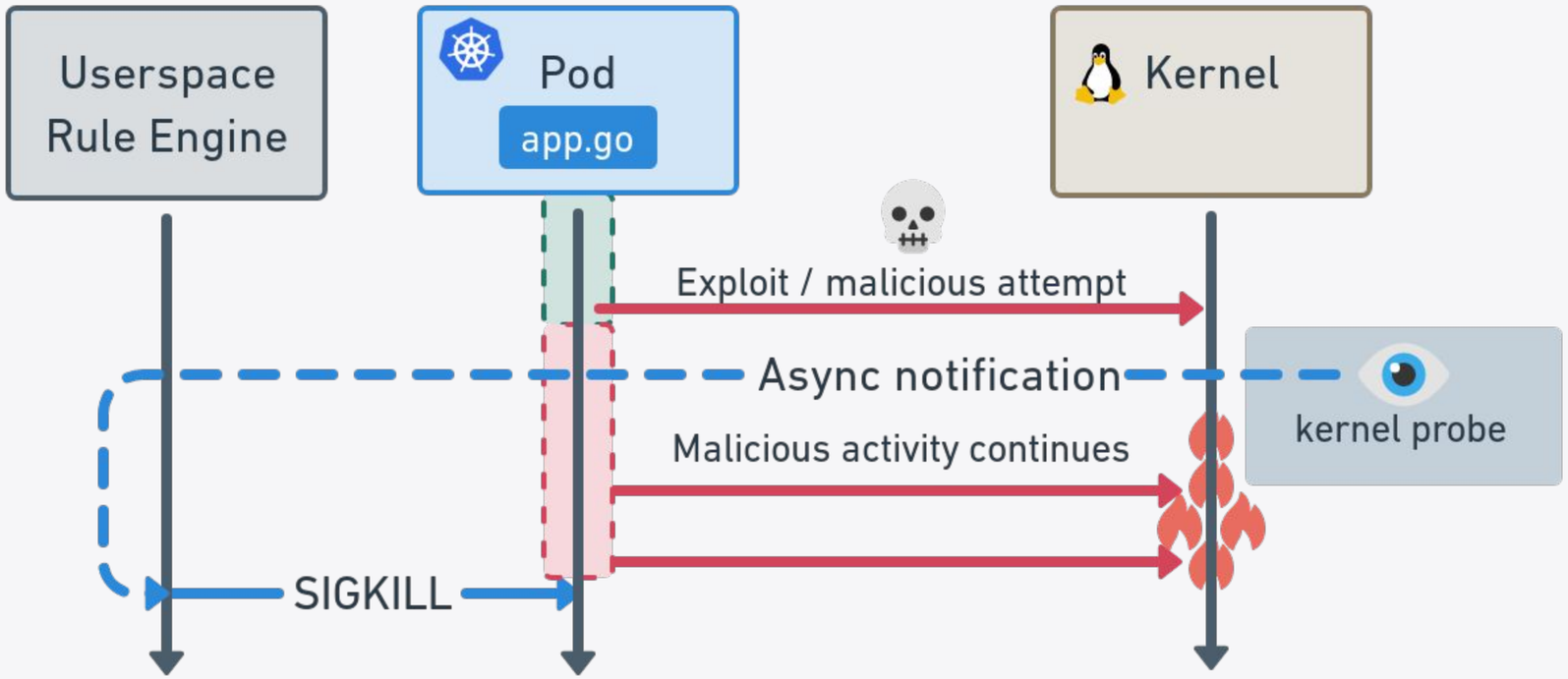
Preventative actions from user space



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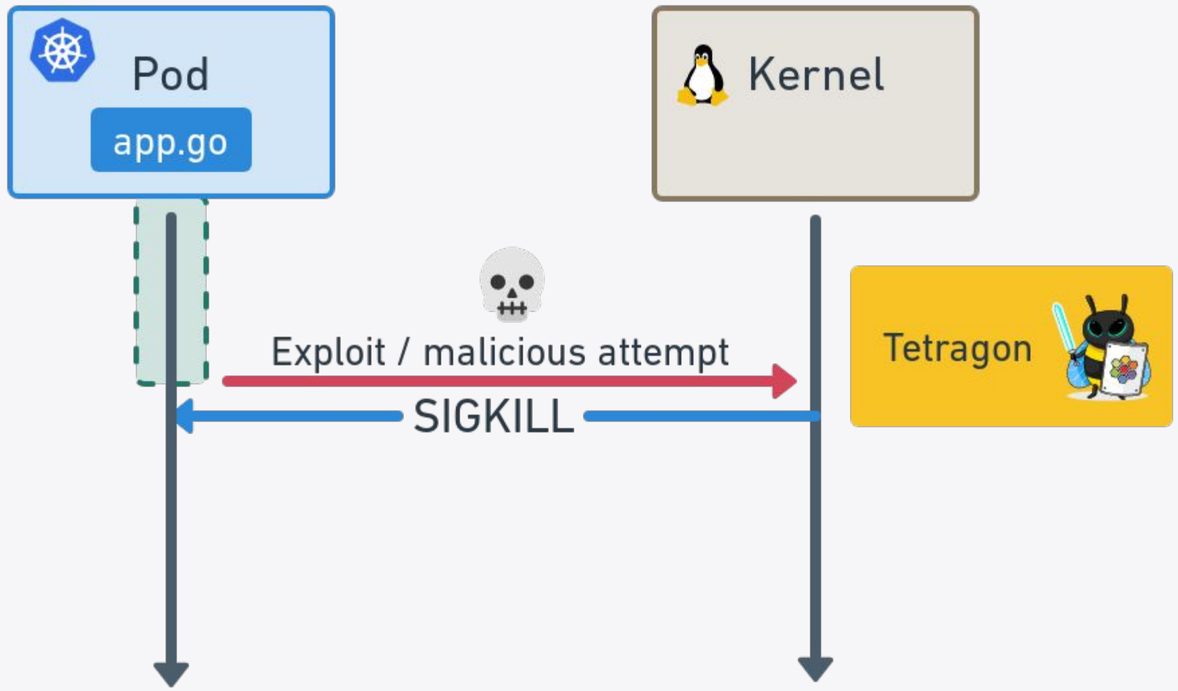
Preventative actions from kernel



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Cilium Tetragon observe

```
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🚀 process default/xwing /usr/bin/vi /etc/passwd
📬 open    default/xwing /usr/bin/vi /etc/passwd
📪 close   default/xwing /usr/bin/vi
📬 open    default/xwing /usr/bin/vi /etc/passwd
📝 write   default/xwing /usr/bin/vi /etc/passwd 1269 bytes
💥 exit    default/xwing /usr/bin/vi /etc/passwd SIGKILL
```

Killed before write

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eBPF security

- Dynamic instrumentation
- Zero app modifications
- Contextual information, Kubernetes identity-aware

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Isovalent Security Summer School 2023!

Summer is here! And it is a great time to relax, enjoy the sun, recharge - and learn something new! Team Isovalent invites you to our virtual Security Summer School where you can level up your skills with hands-on labs. Learn how Cilium, Tetragon, and Hubble help improve Kubernetes security.

Earn a swag box by completing all 3 sessions!

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ebpf.io/summit-2023

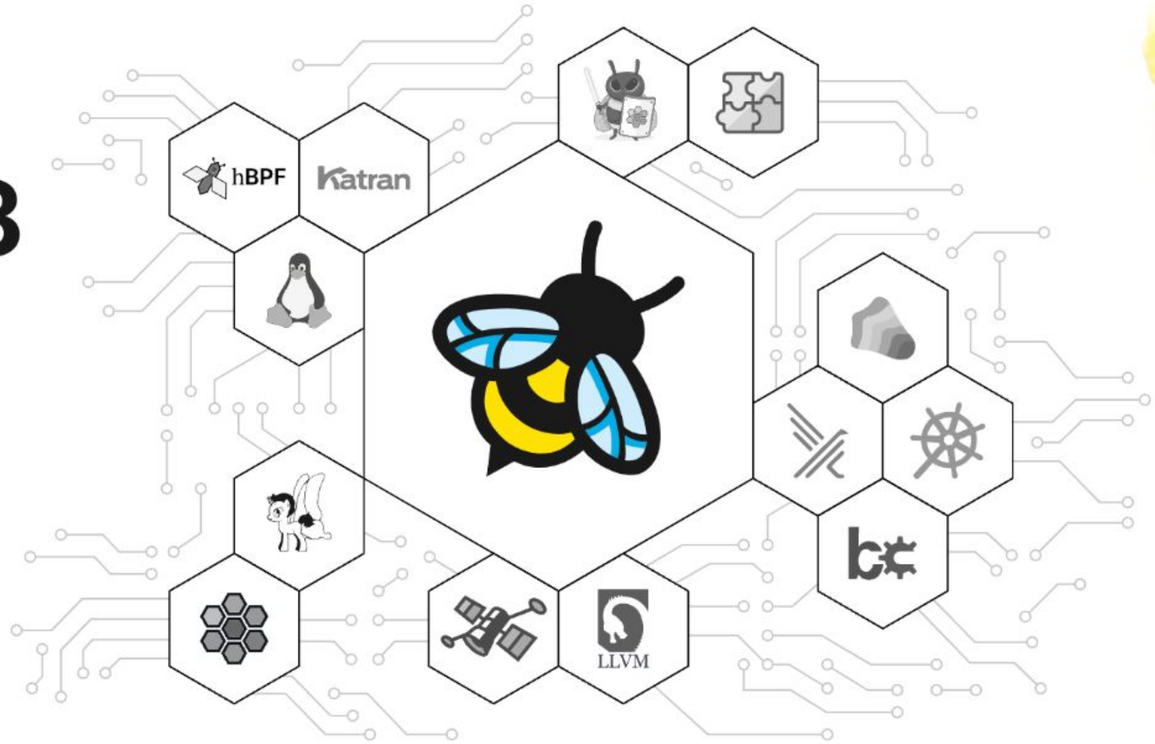
SEPTEMBER 13, 2023

eBPF Summit 2023

Welcome to the eBPF Summit, a virtual event for all things within the Open Source eBPF ecosystem. This event for the eBPF community is aimed at new and existing members wishing to learn and grow and includes hands-on technologists building, using or interested in eBPF as a platform.

Register here

Join Summit Slack



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Thank you

cilium/tetragon

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