Chaos Engineering in the Fast Lane: Accelerating Resilience with AI and eBPF

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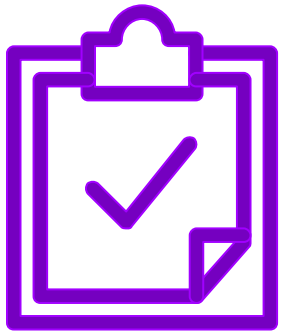
Agenda

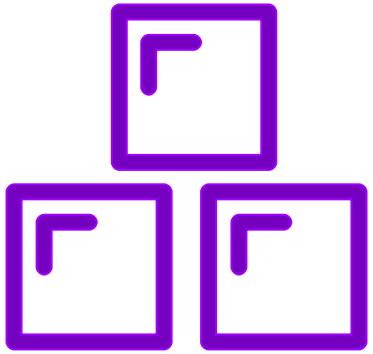
1. The current state of Chaos Engineering
2. Augmenting Chaos Engineering with eBPF
3. Augmenting Chaos Engineering with AI
4. Target Architecture & Live Demo
5. Conclusion & Takeaways

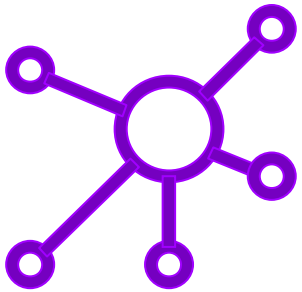
The Current State of Chaos Engineering

Lessons Learned – Key Benefits for SREs and Platform Engineers

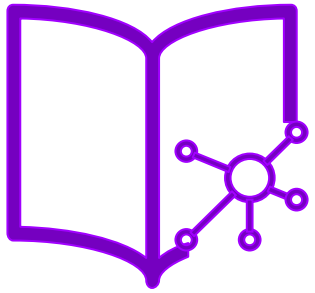


Bring up to speed new SRE resources

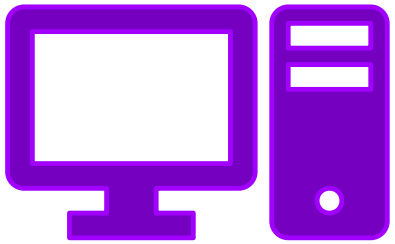




Improve communication inside the SRE team



Discover blind spots and reduce unknown behaviours



Improve MTTD/MTTR using new technologies

The Current State of Chaos Engineering

Lessons Learned – Key Challenges & Trends

CHALLENGES	HOW WE SOLVED IT
Complex connectivity troubleshooting of distributed Kubernetes clusters	?
Better visibility and control during chaos experimentation	?
Design enhanced security chaos experiments within Kubernetes	?
Getting started with the very first Chaos Engineering Experiment	?

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source: *https://pixabay.com/photos/honey-bees-insects-hive-bee-hive-401238/*

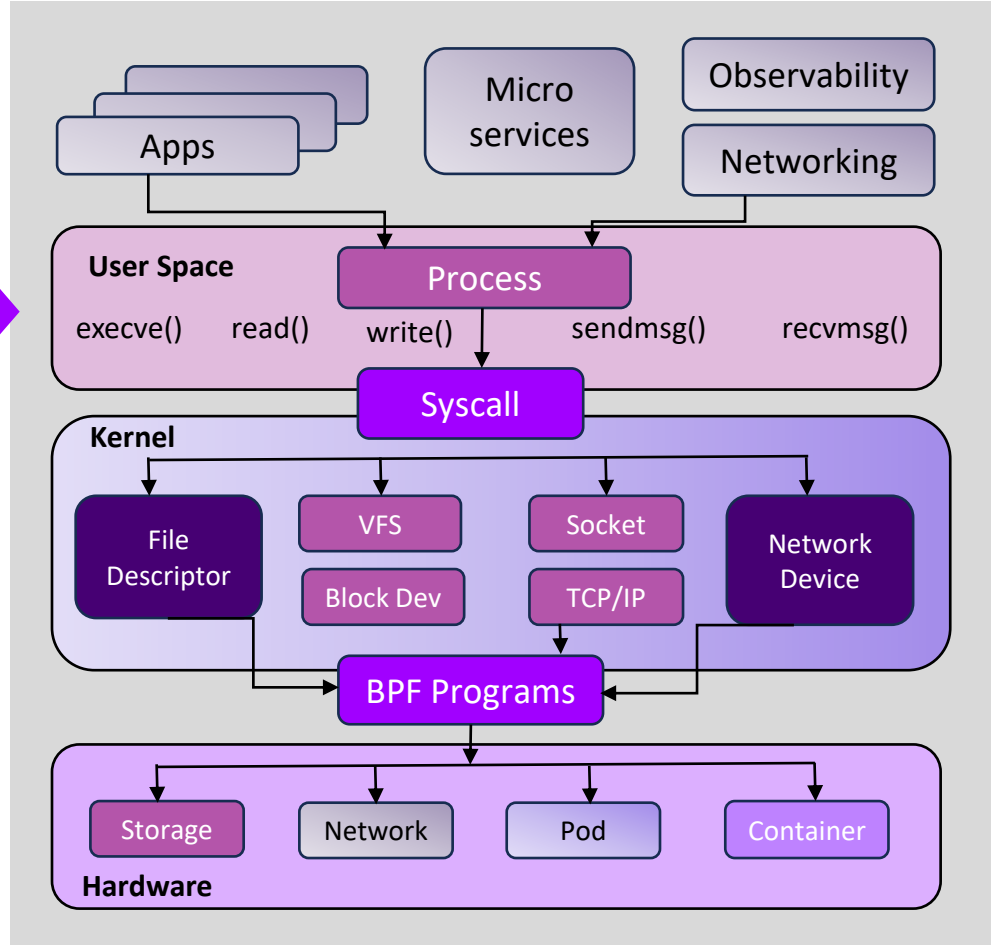
What is eBPF?

„eBPF, which stands for extended Berkeley Packet Filter, is an extraordinary technology with origins in the Linux Kernel, that can run sandboxed programs in a privileged context."

source: *https://ebpf.io/what-is-ebpf/*

How does eBPF work? (I)

eBPF makes the kernel programmable



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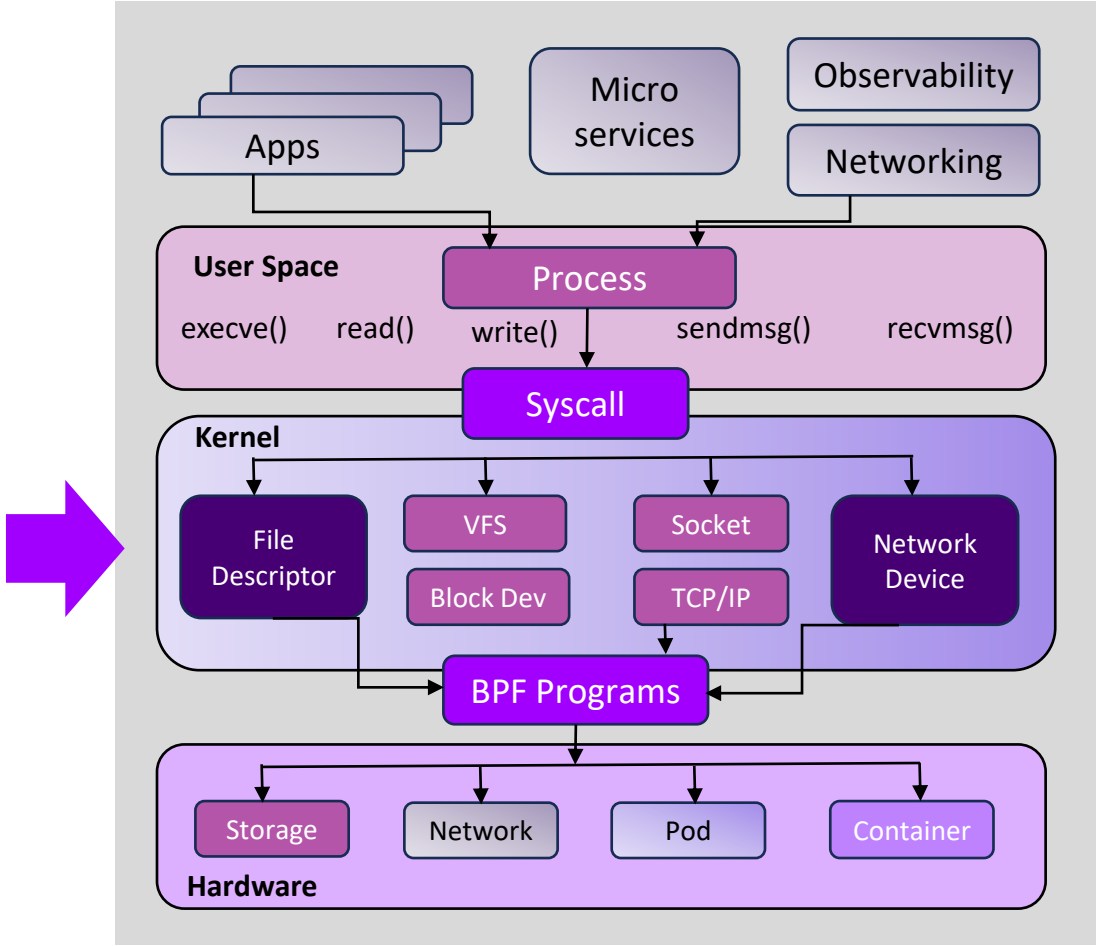

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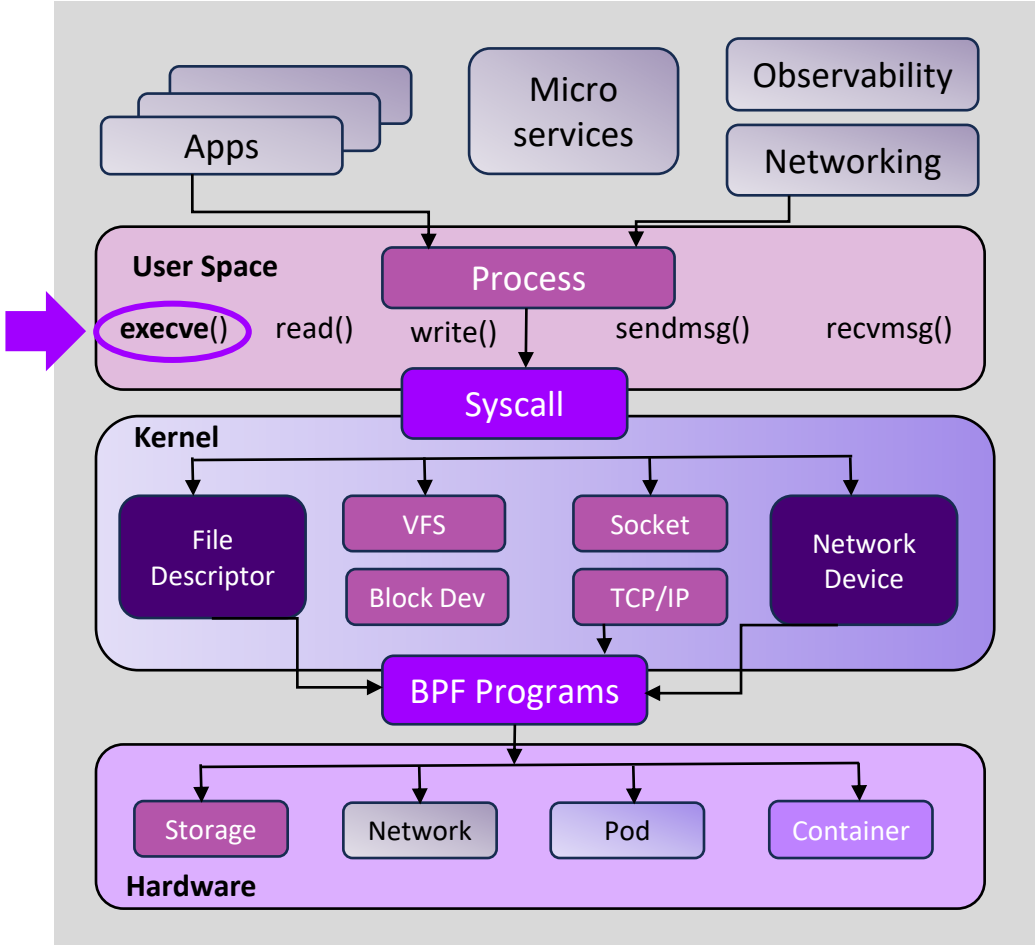

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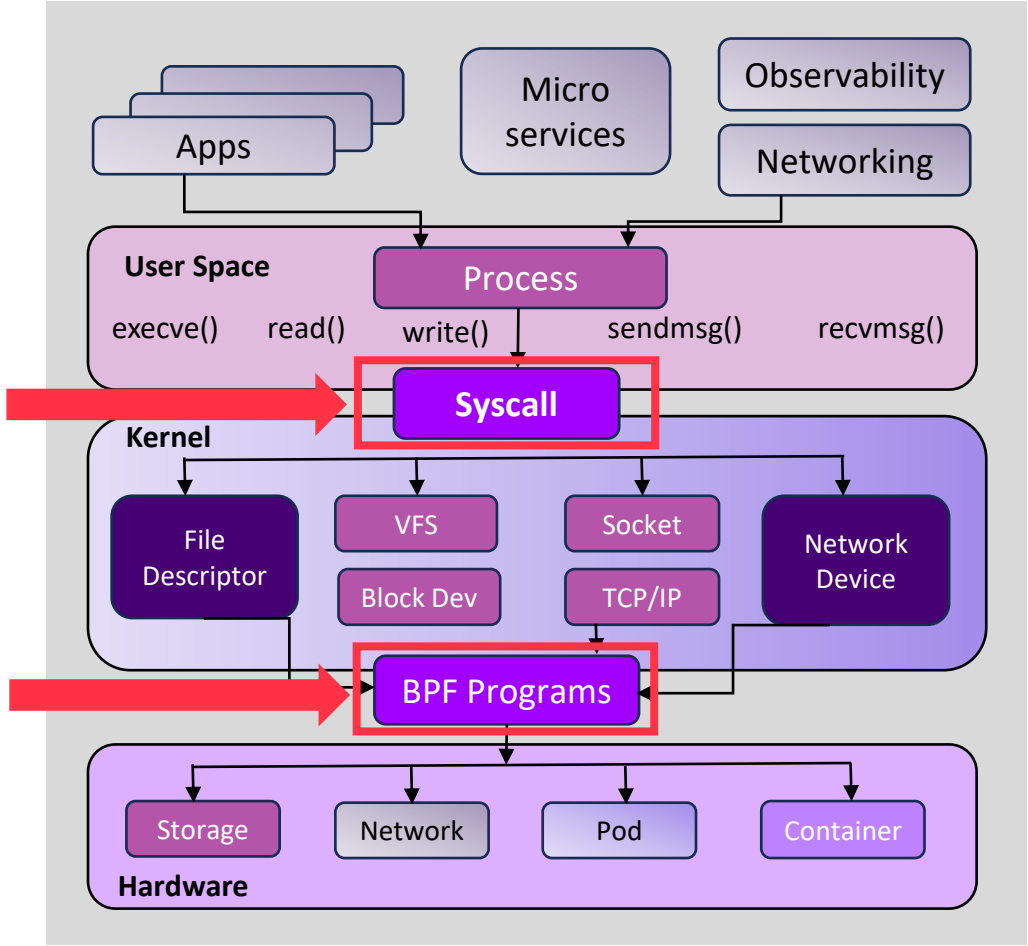

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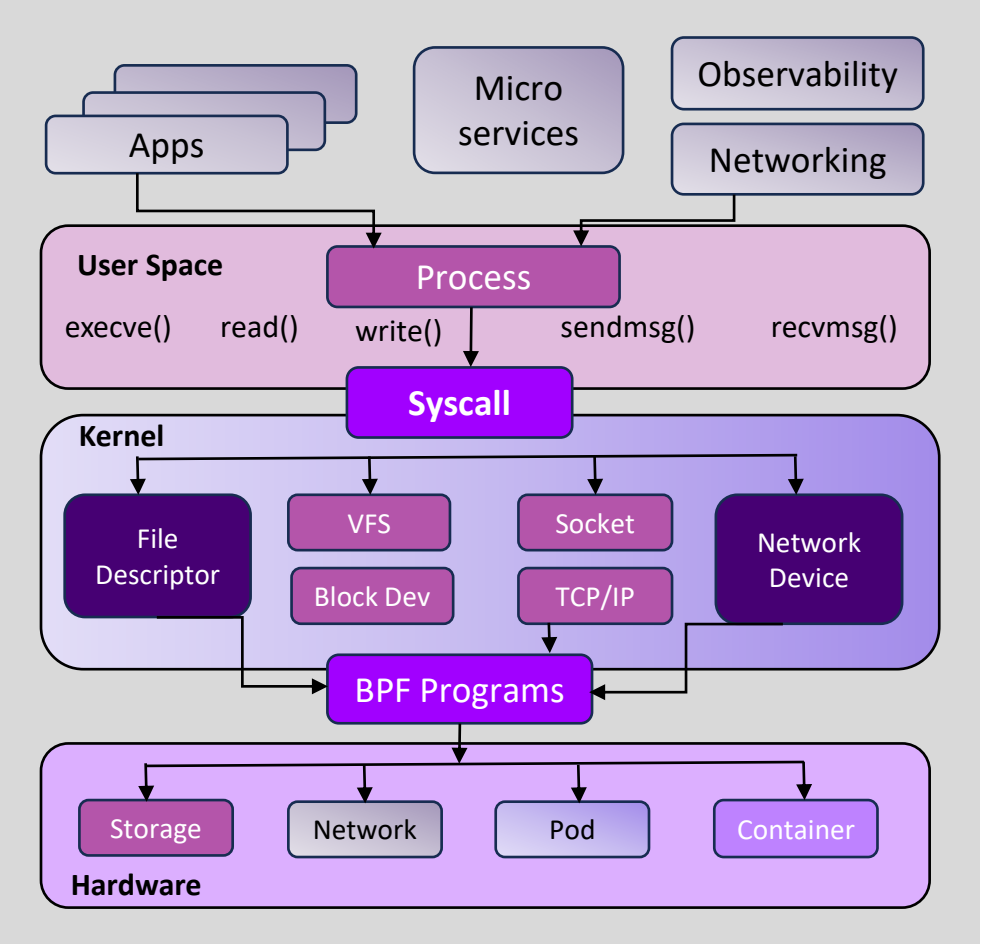
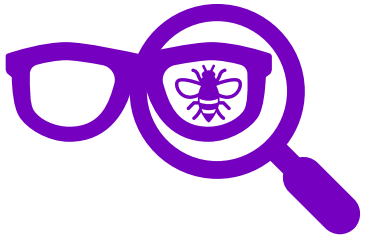


- **eBPF** tools instrument the system **without any app or config changes**
- The **kernel** is with eBPF like the **Big Brother** now. It sees everything!



How does eBPF work? (II)

How we technically load the eBPF program into the kernel?

Python code that compiles my eBPF program:

```
#!/usr/bin/python3
from bcc import BPF

program = eBPF_PROGRAM

b = BPF(text=program)
syscall = b.get_syscall_fnname("execve")
b.attach_kprobe(event=syscall, fn_name="hello")

b.trace_print()
```

source: *https://ebpf.io/what-is-ebpf/*

eBPF Hello World

```
int hello(void *ctx)
{
   bpf_printk("I'm alive!");
   return 0;
}
```

Info about process that called execvesyscall

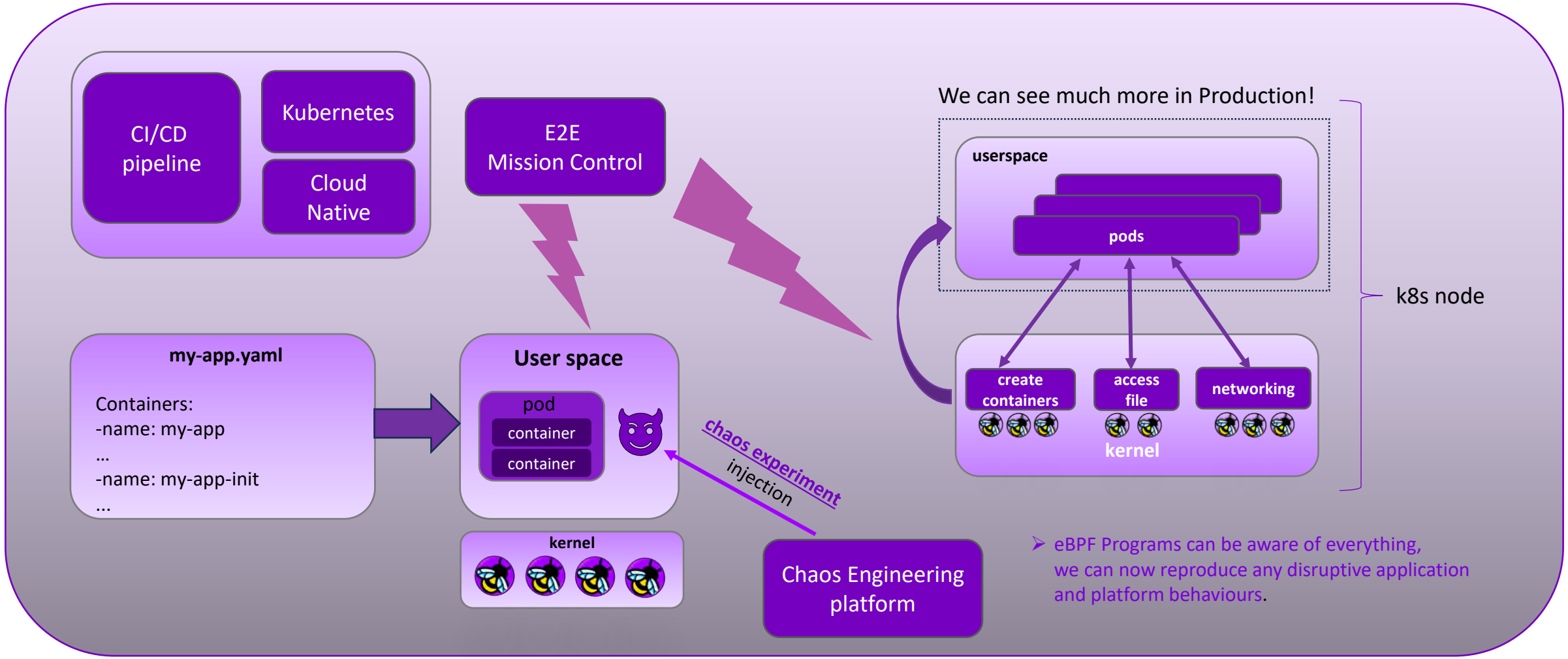
```
$ sudo ./hello
   bash-20241   [004] d... 84210.752785: 0: I'm alive!
   bash-20242   [004] d... 84216.321993: 0: I'm alive!
   bash-20243   [004] d... 84225.858880: 0: I'm alive!
```

source: *https://ebpf.io/what-is-ebpf/*

Every time a new program runs on this virtual machine, the `hello()`eBPF program will be triggered.

Augmenting Chaos Engineering with eBPF

Improved Chaos Experimentation observability: eBPF programs can be aware of everything



- eBPF Programs can be aware of everything, we can now reproduce any disruptive application and platform behaviours.

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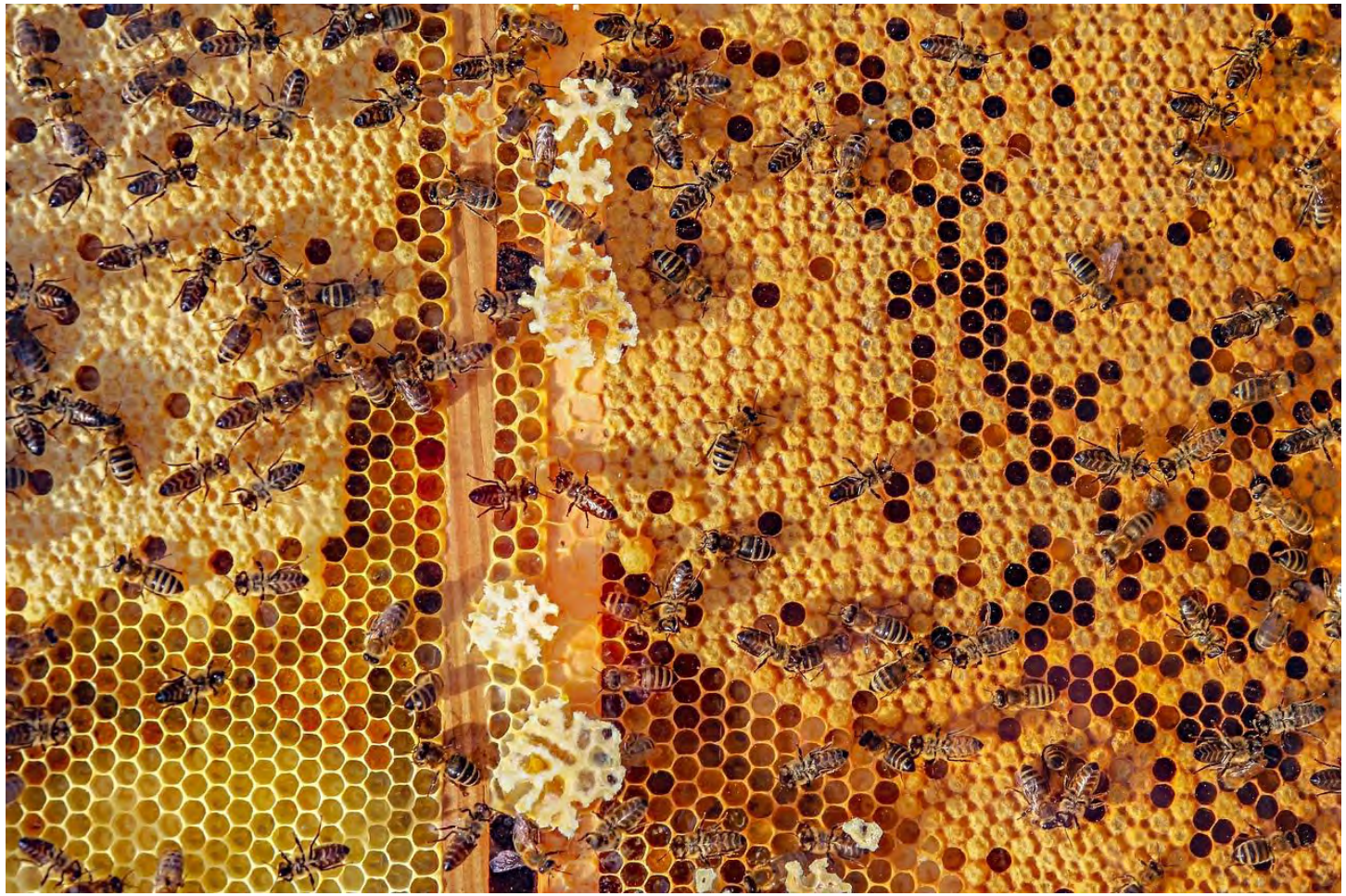
Augmenting Chaos Engineering with eBPF

Improved security context-awareness on a more Cloud-Native level

Benefits?

- eBPF does **not** need any **app changes**
- eBPF can **see all activities** on the node
- eBPF is applied to enable **security observability**
- eBPF data can be used to generate **metrics & events**, which are used as input for our **AI** prediction



source: *https://pixabay.com/photos/bees-insects-macro-honey-bees-4126065/*

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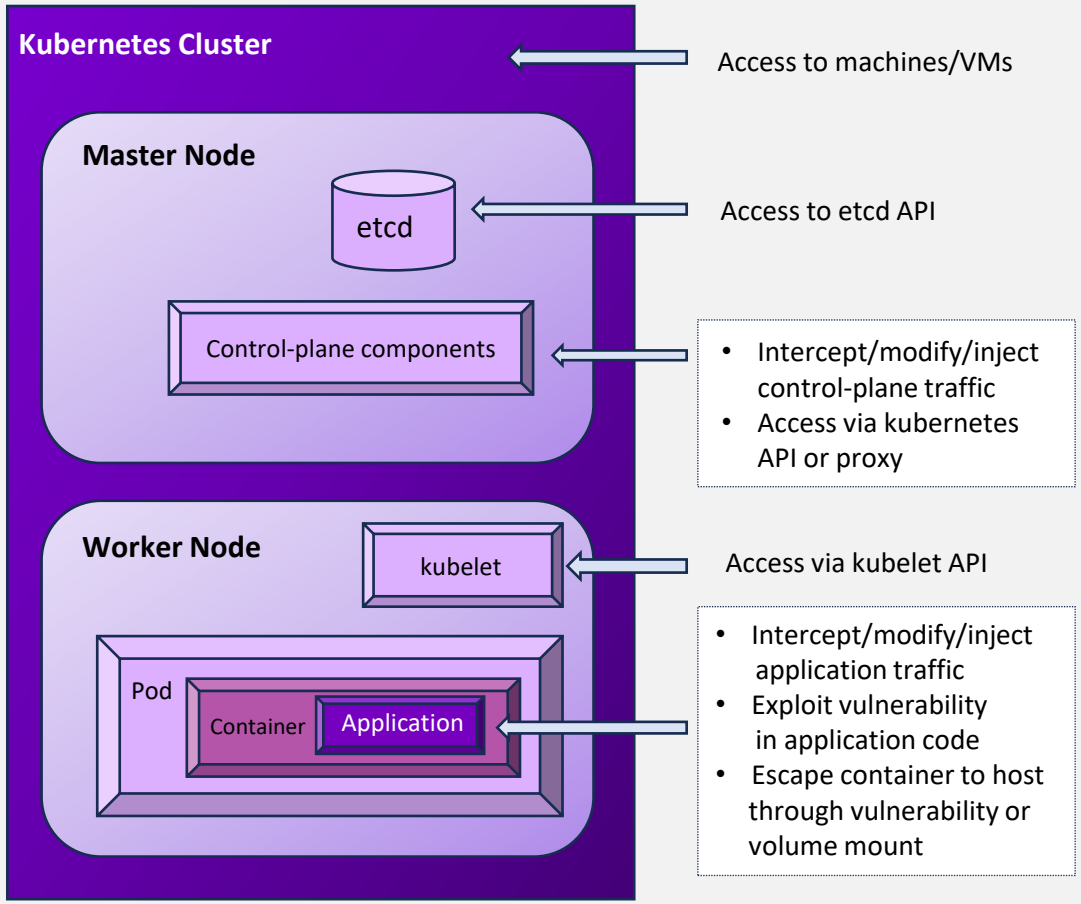
Potential security k8s vulnerabililties

Typical attacking surface



Access to machines/VMs

Access to etcd API

- Intercept/modify/inject control-plane traffic
- Access via kubernetes API or proxy

Access via kubelet API

- Intercept/modify/inject application traffic
- Exploit vulnerability in application code
- Escape container to host through vulnerability or volume mount

source: https://www.oreilly.com/library/view/kubernetes-security/9781492039075/ch01.html

What can we expect from a cyber attack ?

- Run another instance of kubelet on the same nodes
- Privileges pods
- Host network-enabled pod network direct attack
- Malicious webhook
- Pod network can be used for exploitation
- Using insecure root mounts
- Kubernetes cronjob/jobs
- Pod default tokens
- Kubernetes External-IPs

Top 3 vulnerabilities for **Kubernetes** attacks:

- Misconfigured Container
- **Unintentional Cluster Misconfiguration**
- Malicious Container Image

Advanced Chaos Experiments with eBPF

Leverage Cilium's Advanced Network Policy

Benefits

- Create better network Experiments
- Isolate pods
- Service Mesh Experiments
- Multi-Cluster Experiments

Future proof

- Node IO resource exhaustion
- Network resource exhaustion
- Pod resource exhaustion

Cilium EBPF

source: *https://cilium.io/use-cases/network-policy/*

eBPF removes the need to kill or delete the pod and to deploy any new tools.

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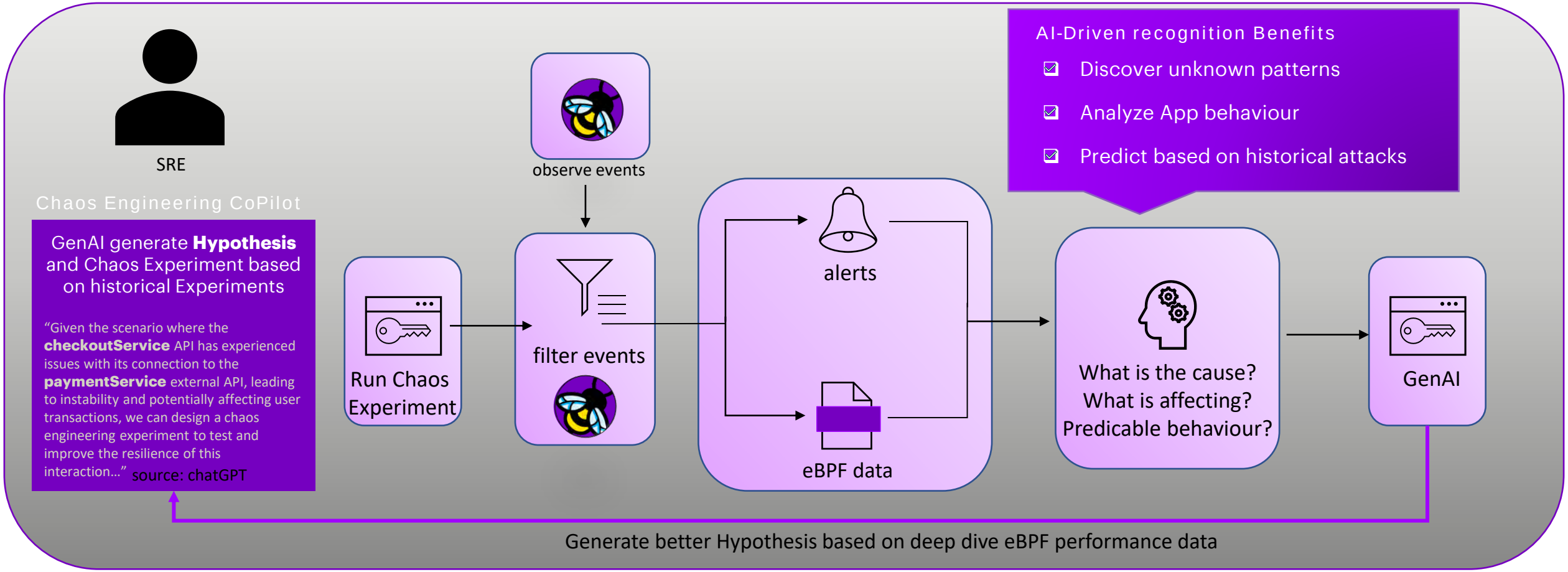
Augmenting Chaos Engineering with AI and GenAI

eBPF goes beyond traditional networking in enhancing the Chaos Engineering landscape



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Demo: AI-drive Chaos Engineering Platform

Enhanced Target Architecture

fsbaraglia Create chaos_experiment_ai.py 8d72815 · now History

Code Blame 36 lines (27 loc) · 2.18 KB Code 55% faster with GitHub Copilot Raw

```python
import os

from openai import OpenAI

client = OpenAI(
  organization=os.environ.get("ORG_ID")
  # This is the default and can be omitted
  api_key=os.environ.get("OPENAI_API_KEY")
)

#Prompt Engineering #system role
messages = [{"role": "system", "content": "
            Chaos Engineering Expert with Kubernetes and Cloud Background
description: |
  This role embodies an expert specialized in chaos engineering within Kubernetes environments and cloud infrastructure. The individual possesses a comprehensive understanding of des

expertise:
  - Chaos Engineering Principles: Profound knowledge in chaos engineering concepts, methodologies, and best practices to assess and enhance system resilience.
  - Kubernetes: Advanced experience in deploying, managing, and troubleshooting Kubernetes clusters, including familiarity with Kubernetes architecture, ecosystem, and orchestration.
  - Cloud Platforms: Extensive experience with major cloud service providers (e.g., AWS, Azure, Google Cloud) and their managed Kubernetes services like EKS, AKS, and GKE.
  - Automation and Tools: Proficiency in using chaos engineering tools and automation frameworks to conduct experiments in a controlled and automated manner.
  - Observability and Monitoring: Skilled in implementing observability and monitoring "}]

content = "Create an hypothesis and experiment (step-by-step) to improve the stability of the (checkoutservice) api, there were a lot of trouble in the past with the connection to th

messages.append({"role": "user", "content": content})

completion = client.chat.completions.create(
    messages=messages,
    model="gpt-3.5-turbo",
)

chat_response = completion.choices[0].message.content
print(f'SRE Pipeline: {content}')

print(f'Chaos Engineering CoPilot: {chat_response}')
```

System Role creation

Improve the result by adding Context based on historical data (observability and incident post-mortem reports).

Chaos Experiment YAML is ready for execution. Hypothesis saved into the Chaos Engineering backlog.

DEMO

Starting in 3.... 2.... 1....

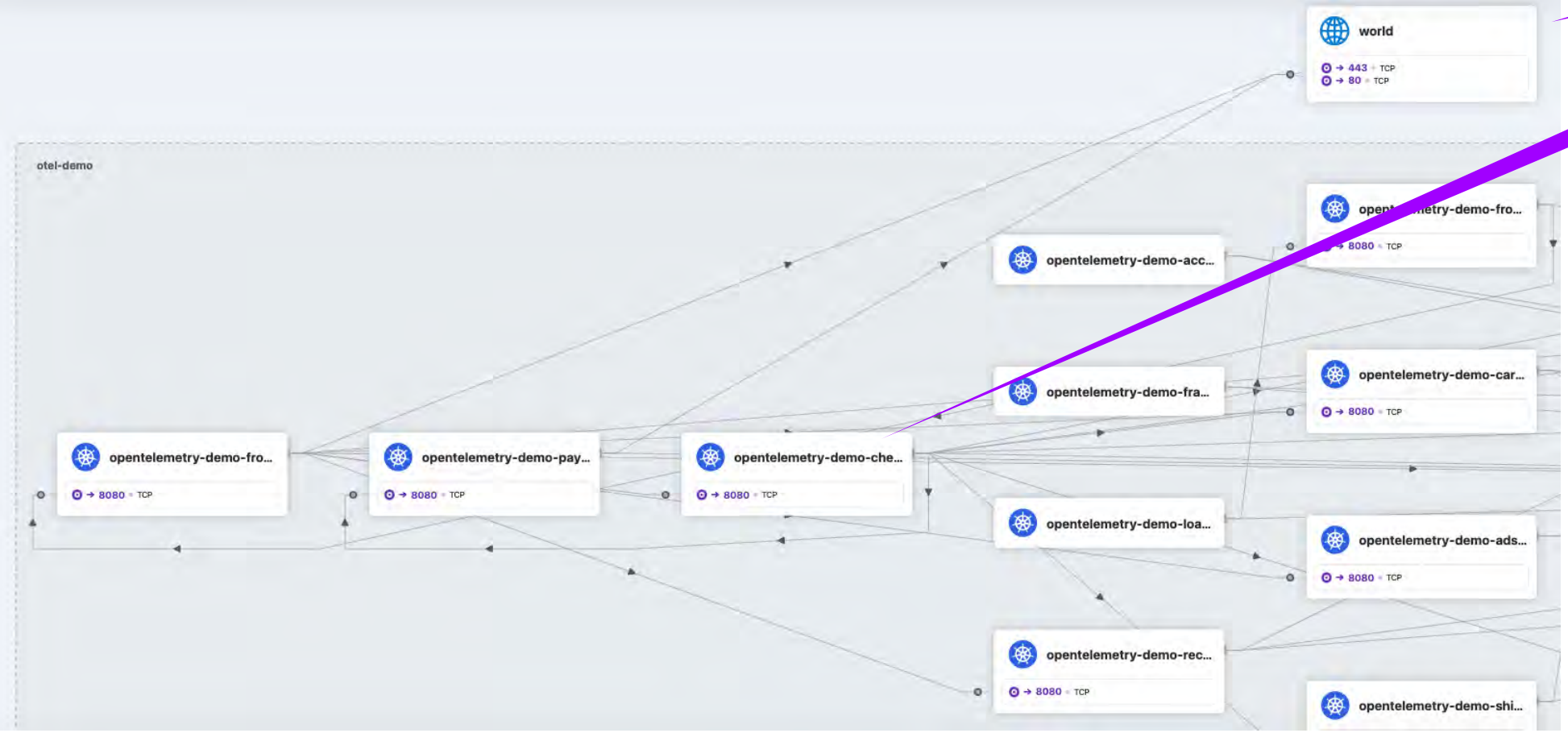
Photo by Alex Kondratiev on Unsplash

Demo: AI-drive Chaos Engineering Platform

Enhanced Target Architecture

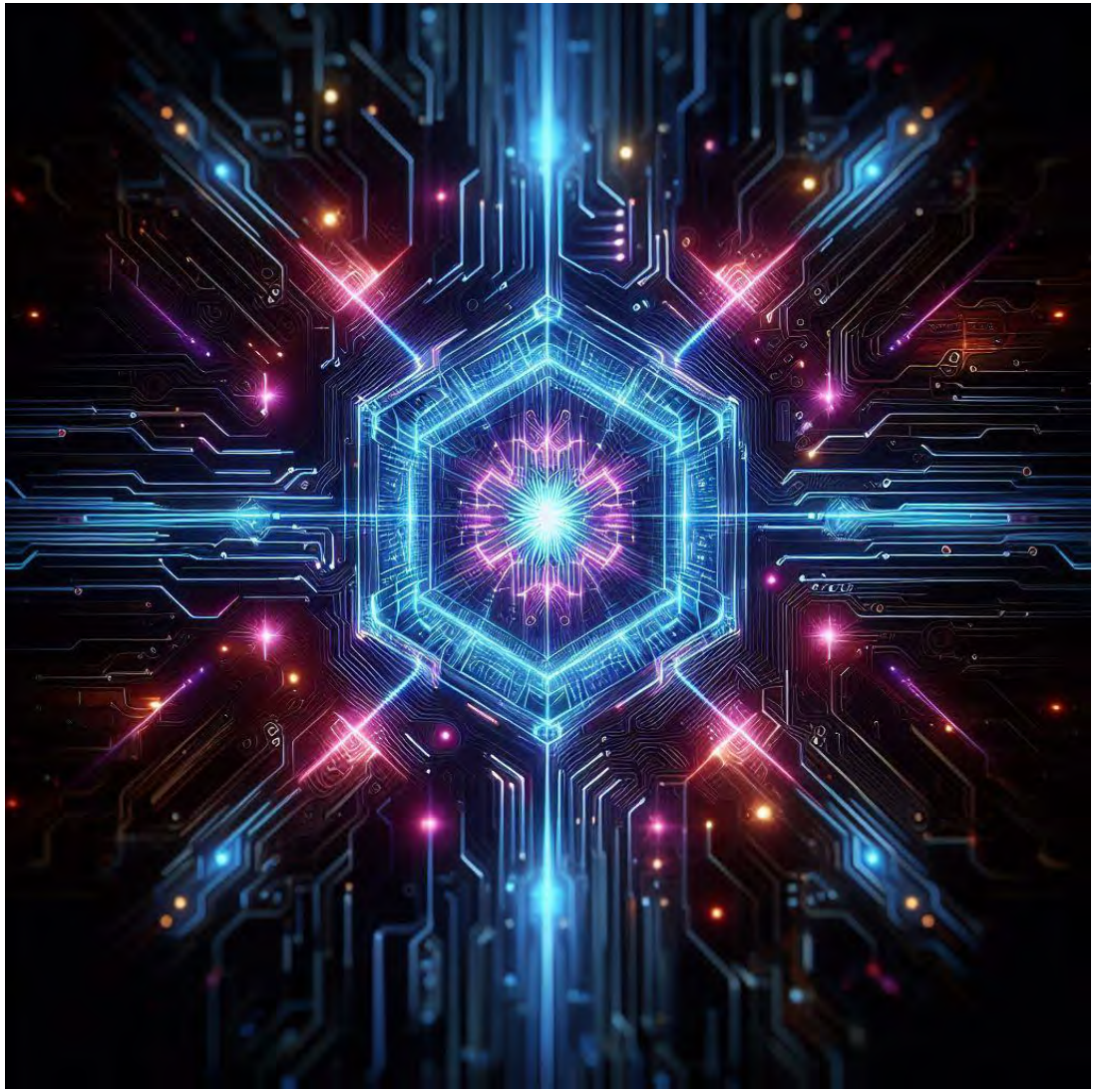
hubble-ui view

Target service



Conclusion & Takeaways

- **AI** , **GenAI** and **eBPF** can be leveraged to better detect **chaos experiments**
- **eBPF** goes beyond classical observability
- **AI** can significantly enhance threat detection capabilities by analyzing real-time data and identifying patterns indicative of security risks
- **Start small, scale fast**



Source: generated with GenAI on Bing.com

Thank You