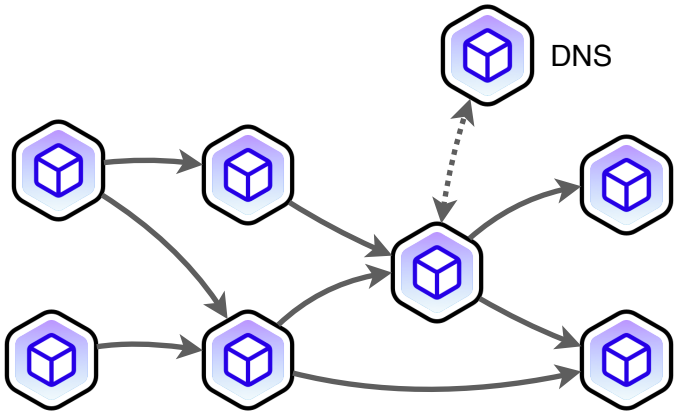
Is Your Kubernetes Cluster's DNS Working?

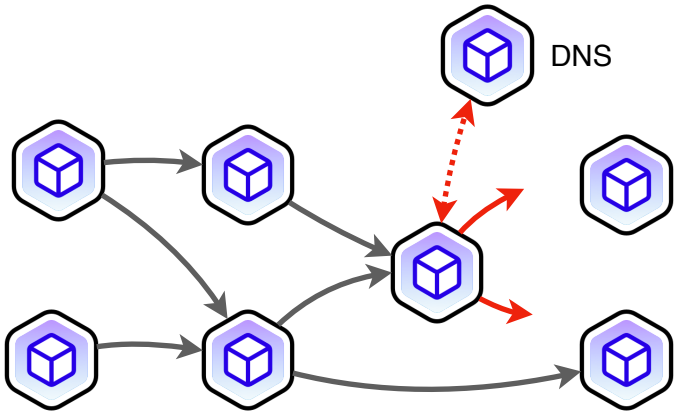
Jonathan Perry, Flowmill


DNS IS FINE.

Why care?



Why care?



How does it work?

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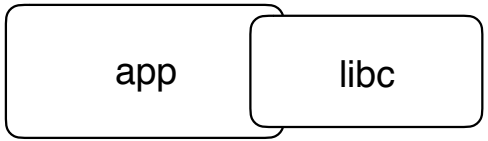

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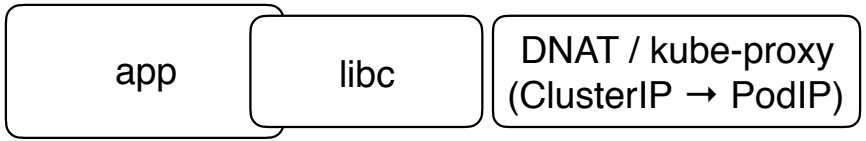

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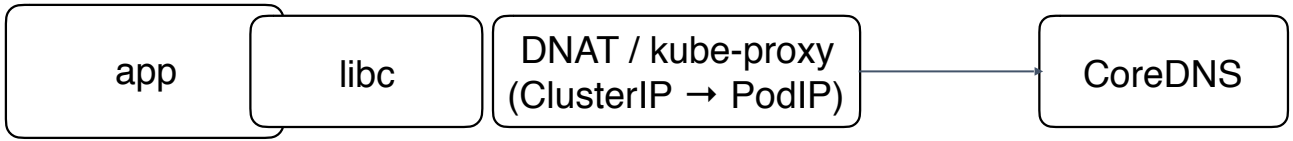

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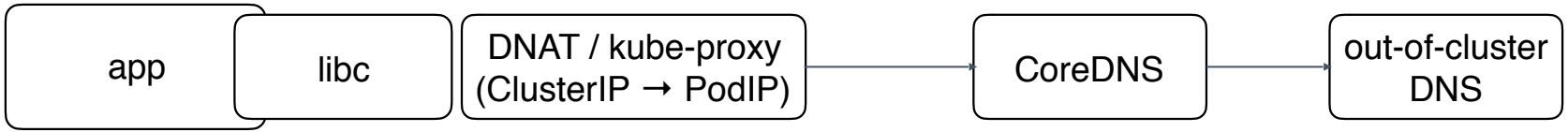

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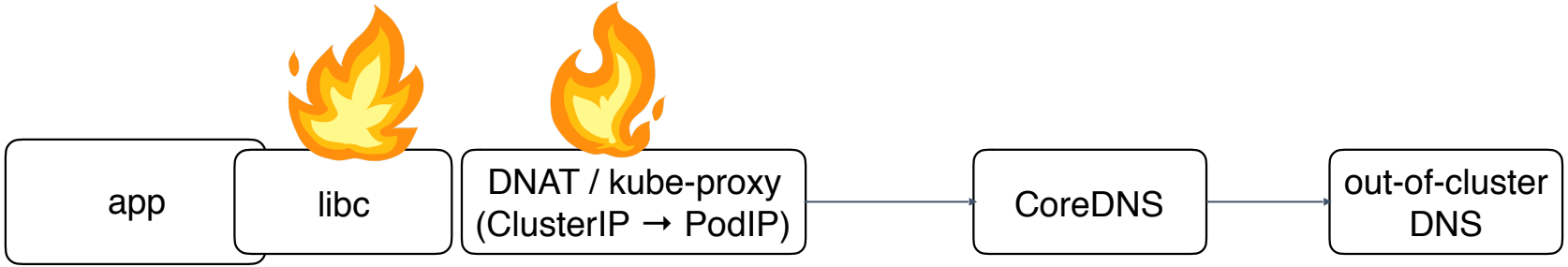
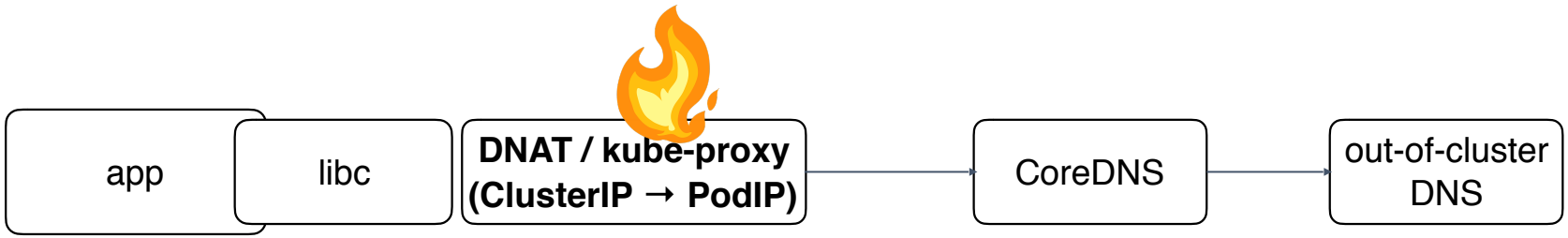
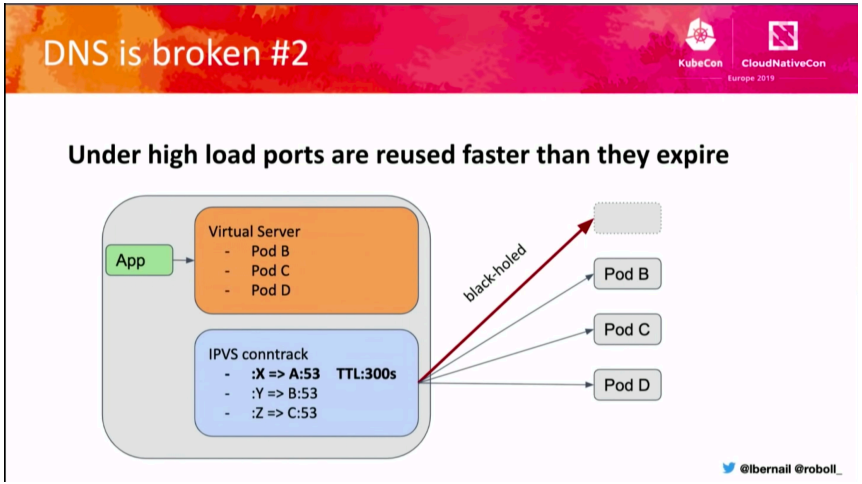
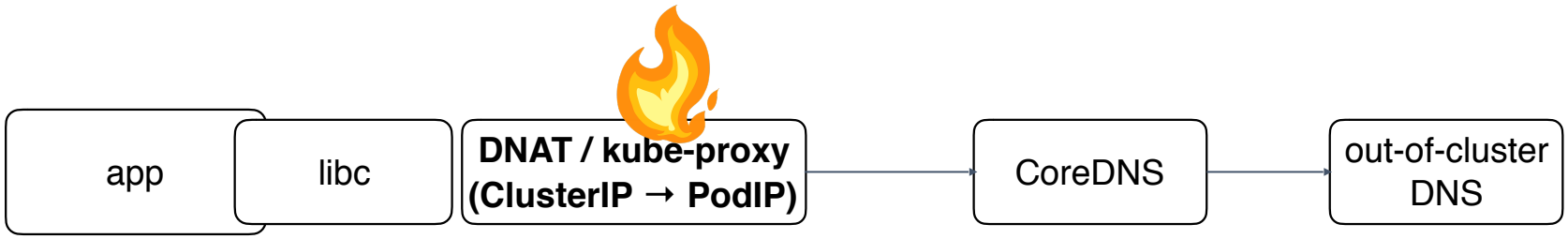




“High load” black hole (Datadog):



- Even if kube-proxy removed a dead pod, conntrack can still have mappings to it
- Under load, source port number is reused -> routed to dead pod



Kernel race: Parallel DNS packets

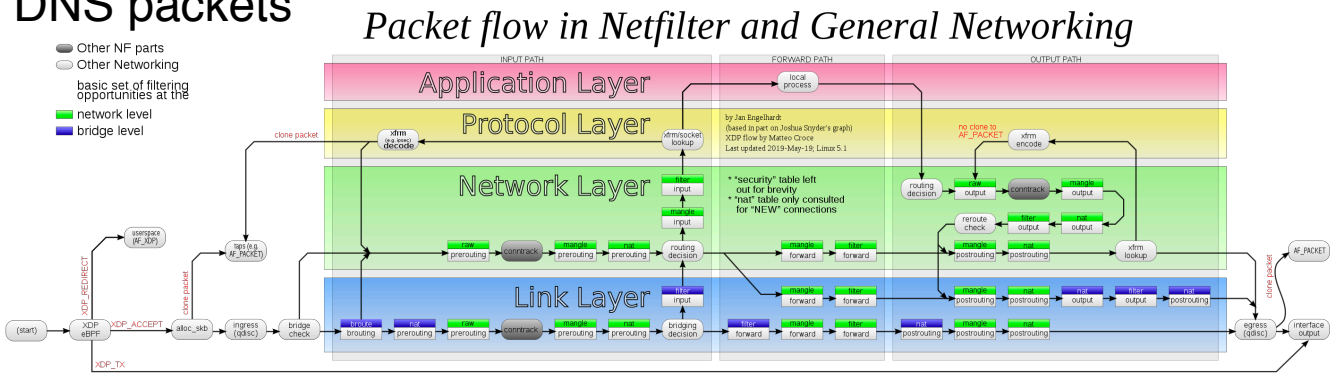


Diagram by Jan Engelhardt

[1] https://github.com/kubernetes/kubernetes/issues/56903
[2] https://tech.xing.com/a-reason-for-unexplained-connection-timeouts-on-kubernetes-docker-abd041cf7e02
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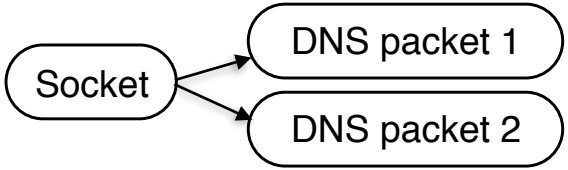
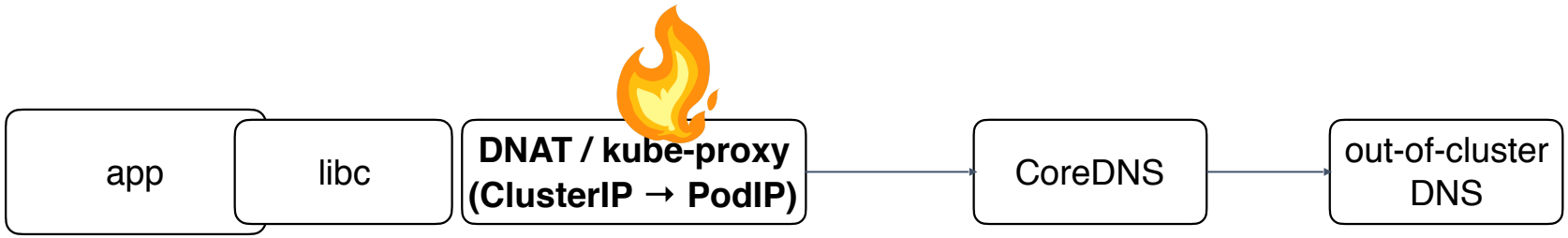
Conntrack-hooks NAT-hooks priority-consts



FLOWMILL



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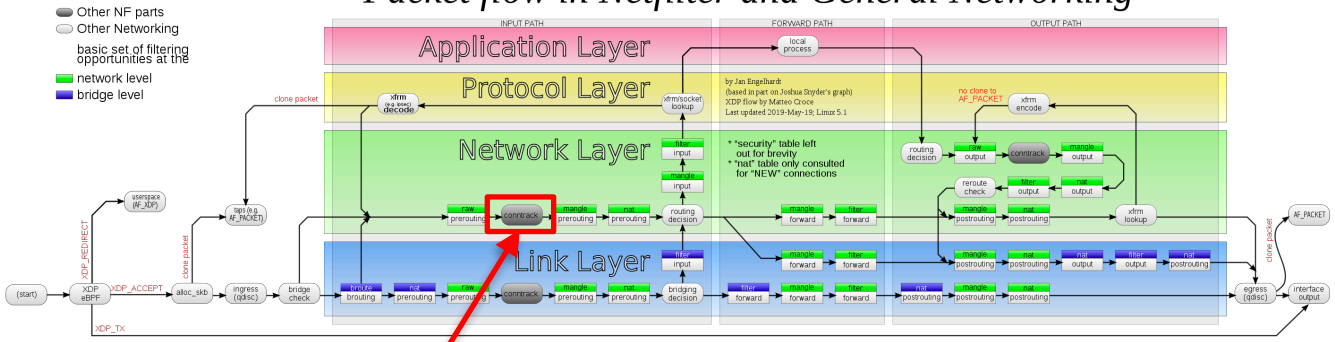
Packet flow in Netfilter and General Networking



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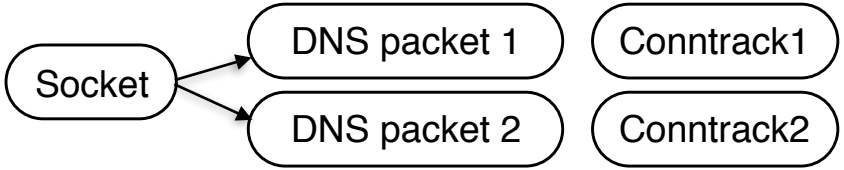
Allocate conntrack entry



FLOWMILL

app | libc | **DNAT / kube-proxy (ClusterIP → PodIP)** → CoreDNS → out-of-cluster DNS

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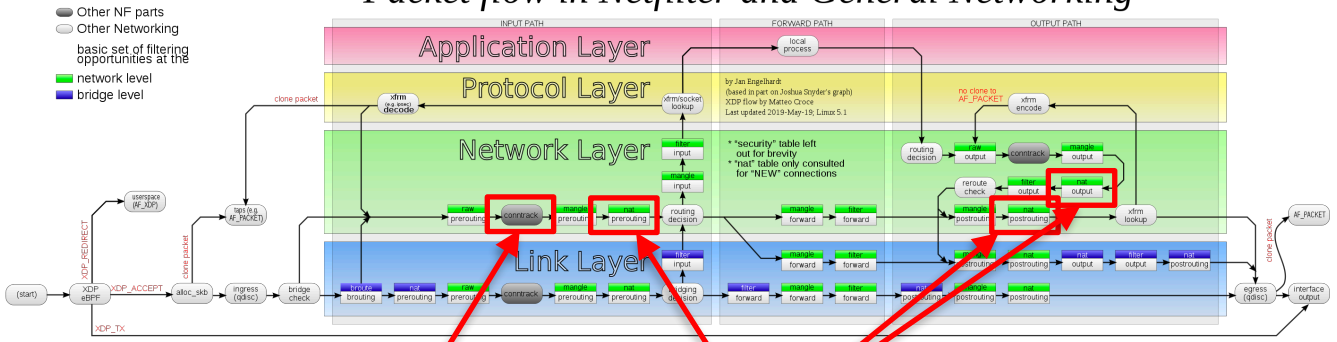

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Allocate conntrack entry

NAT

Socket → DNS packet 1 → Conntrack1 → DST: CoreDNS A

Socket → DNS packet 2 → Conntrack2 → DST: CoreDNS B

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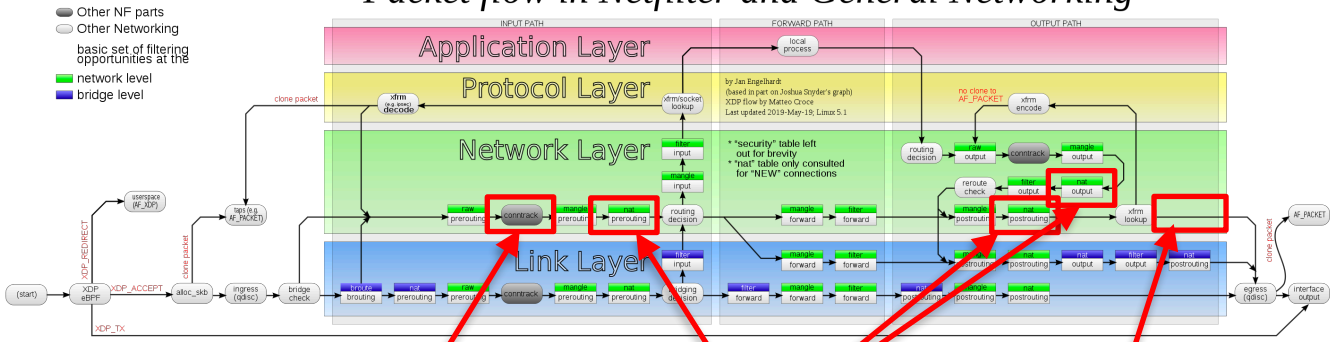

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"confirm" conntrack

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FLOWMILL

app

libc

DNAT / kube-proxy (ClusterIP → PodIP)

CoreDNS

out-of-cluster DNS

Kernel race: Parallel DNS packets

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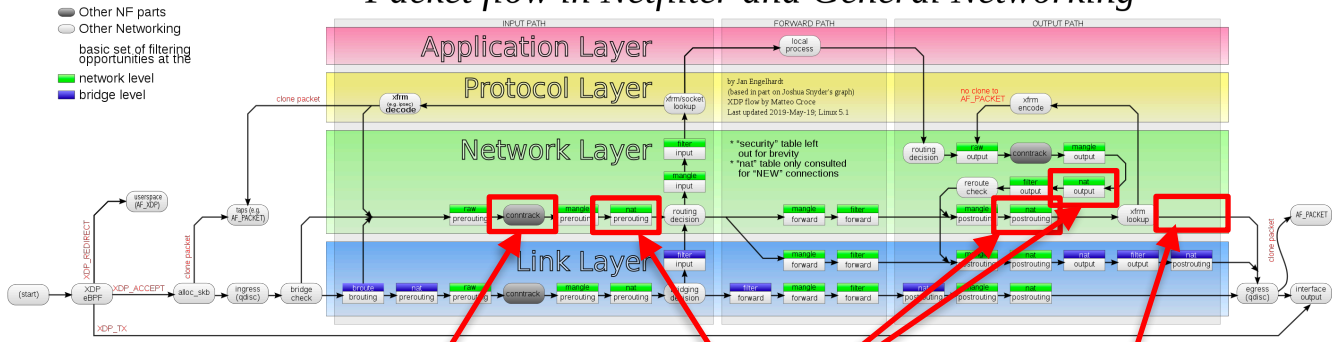

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Socket

DNS packet 1 — Conntrack1 — DST: CoreDNS A

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ACCEPT

FLOWMILL

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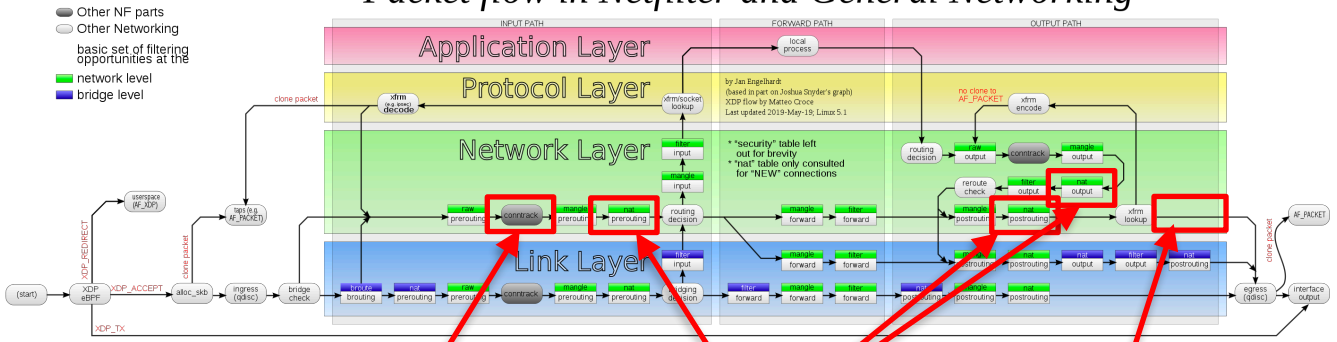

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Allocate conntrack entry

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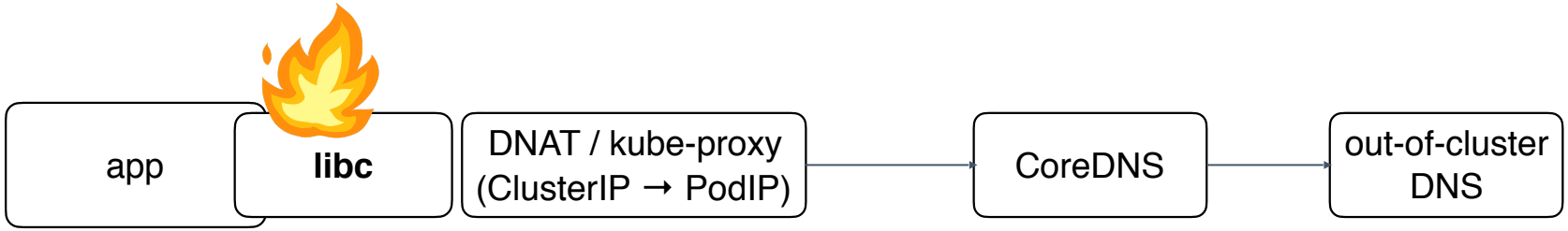
Socket → DNS packet 1 → Conntrack1 → DST: CoreDNS A → ACCEPT

Socket → DNS packet 2 → Conntrack2 → DST: CoreDNS B → DROP

FLOWMILL



Alpine/musl:

Queries are performed in parallel:

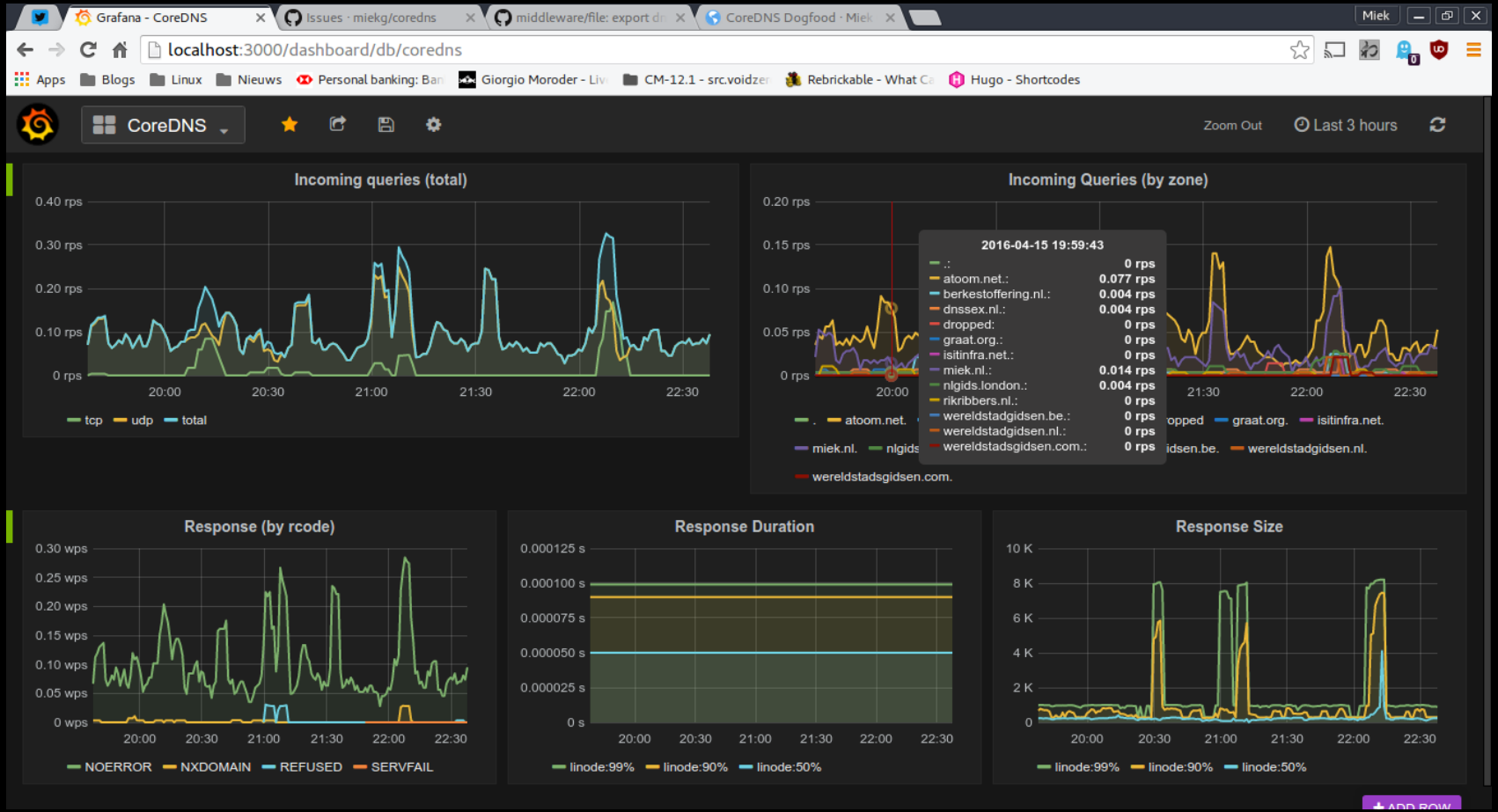
- Triggers the kernel race (no flag for sequential)

NODATA (success + no records):

- Stricter standard adherence than glibc
- Apparently broke k8s DNS for rancher-dns (since fixed), Cloudflare, github issue

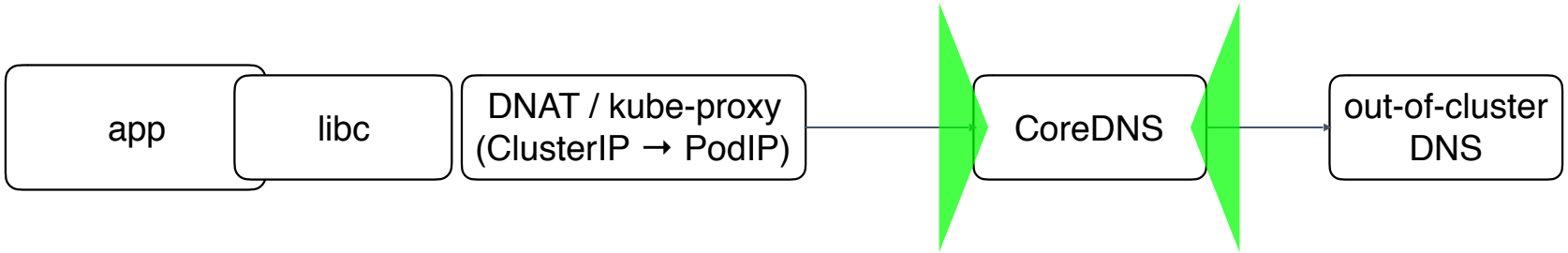
[1] Alpine caveats https://github.com/gliderlabs/docker-alpine/blob/master/docs/caveats.md

[2] Discussion https://github.com/gliderlabs/docker-alpine/issues/8



Credit: Miek Gieben (CoreDNS author) https://miek.nl/2016/april/15/coredns-dogfood-part-2/

CoreDNS metrics

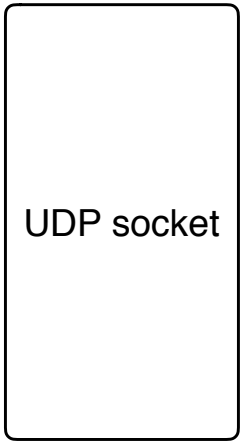


Great!

Caveats:

- needs to be available when DNS is down
- missing visibility around app

Can get visibility from the OS



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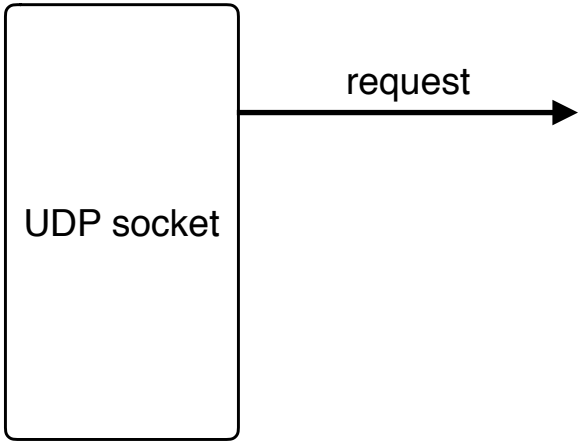

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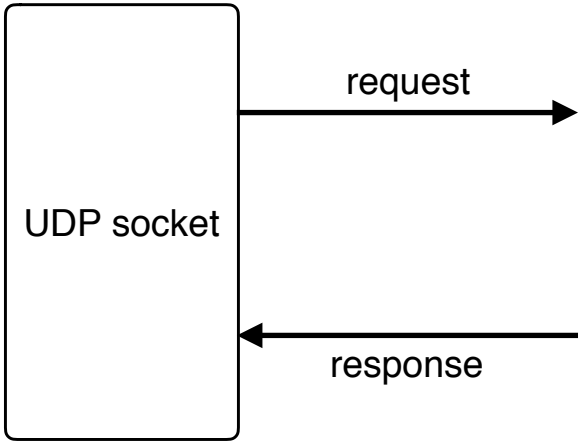

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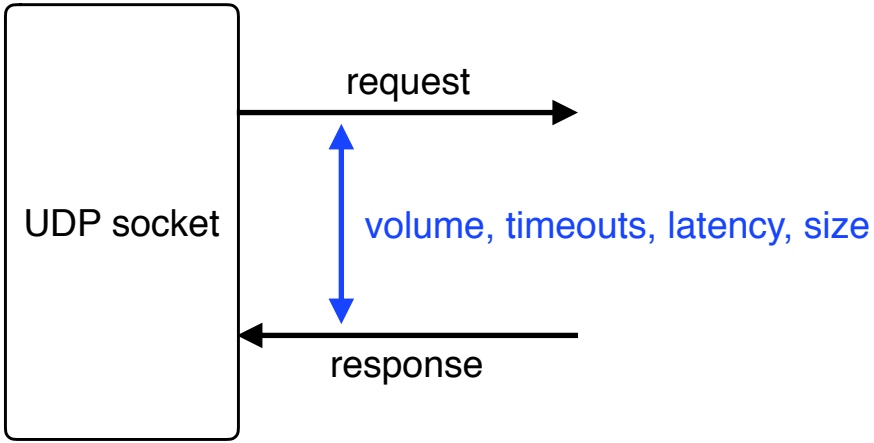

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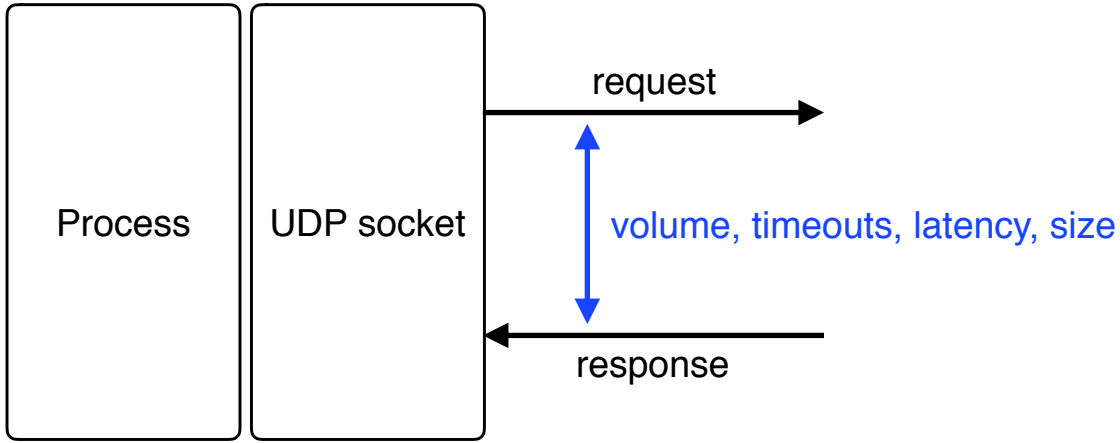

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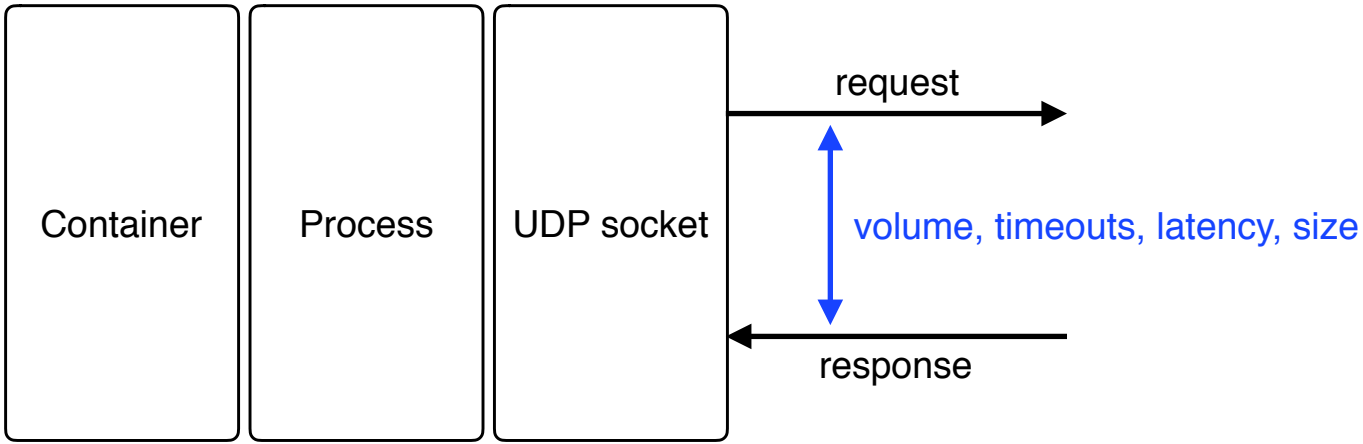

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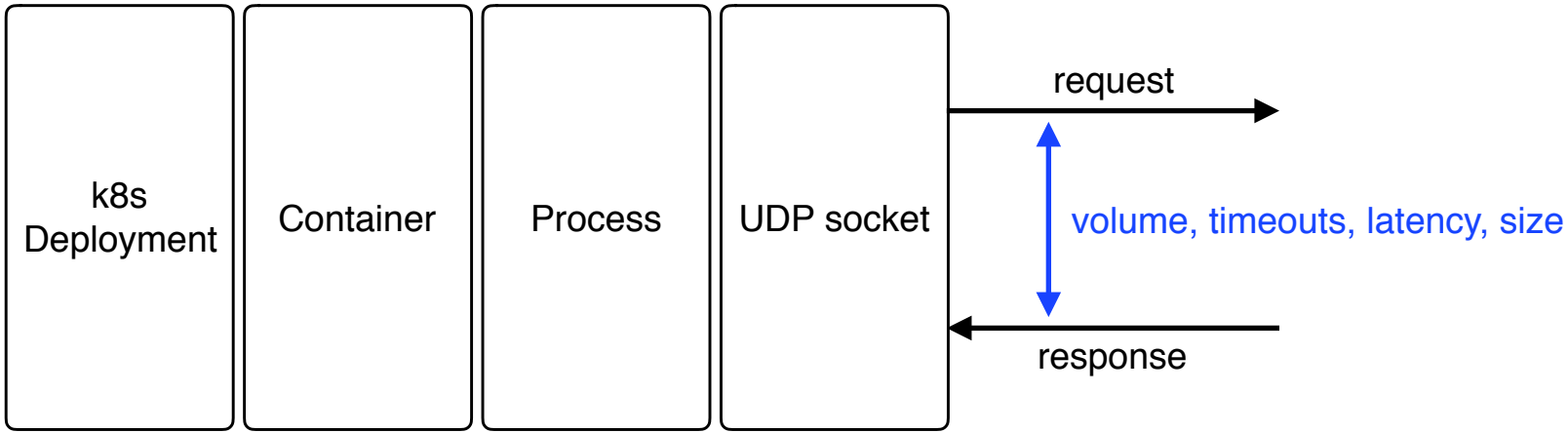
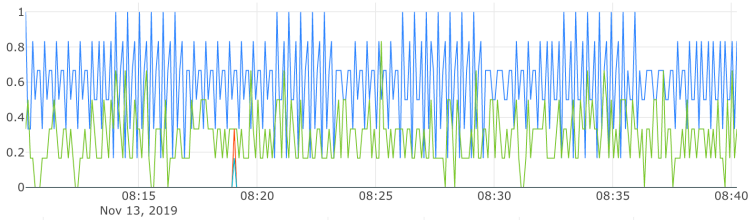
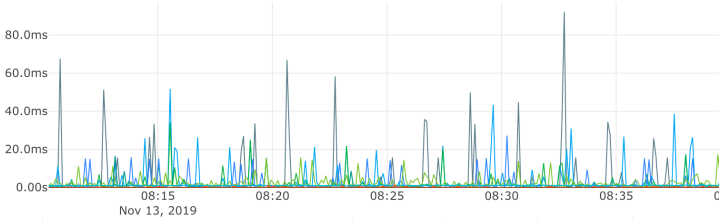


DNS Timeouts (DNS Timeouts)



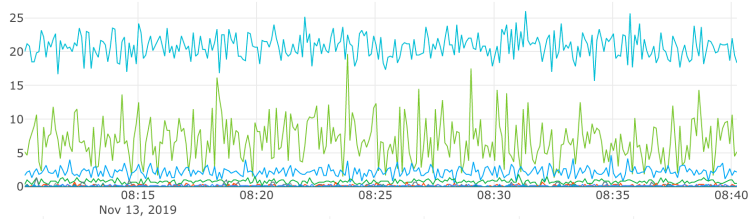
From Service	To Service	Max	Average	↓ Total
misconfiguredservice	DNS	1	0.6	1.1k
checkoutservice	DNS	0.8	0.3	520
kube-dns	DNS	0.3	0	2
loadgenerator	DNS	0.2	0	1
prometheus-to-sd	DNS	0	0	0
cartservice	DNS	0	0	0
coredns	DNS	0	0	0
ecs-agent	DNS	0	0	0
kernel-collector	DNS	0	0	0

DNS Latency (DNS Latency)



From Service	To Service	Min	Max	↓ Average
prometheus-to-sd	DNS	0s	92.1ms	3.32ms
coredns	DNS	151µs	51.8ms	3ms
checkoutservice	DNS	181µs	17.4ms	2.39ms
flowmill-k8s-collector	DNS	0s	33.9ms	1.77ms
misconfiguredservice	DNS	0s	27.2ms	1.36ms
loadgenerator	DNS	799µs	1.5ms	1.05ms
cartservice	DNS	0s	1.45ms	132µs
kernel-collector	DNS	0s	8.66ms	64.7µs
ecs-agent	DNS	0s	16.6ms	64.7µs

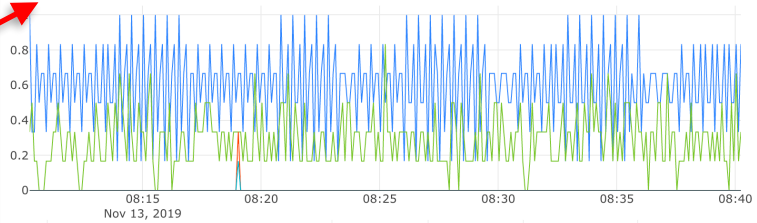
DNS Responses (DNS Responses)



From Service	To Service	Max	Average	↓ Total
loadgenerator	DNS	26	20.8	37.5k
checkoutservice	DNS	19.7	6.9	12.4k
coredns	DNS	4.7	2.2	4k
flowmill-k8s-collector	DNS	1.8	0.8	1.4k
cartservice	DNS	0.7	0.1	267
misconfiguredservice	DNS	0.3	0.1	236
prometheus-to-sd	DNS	1.3	0.1	148
ecs-agent	DNS	0.3	0	19
fluentd-gcp-v3.1.1	DNS	0.3	0	12

Timeouts

DNS Timeouts (DNS Timeouts)



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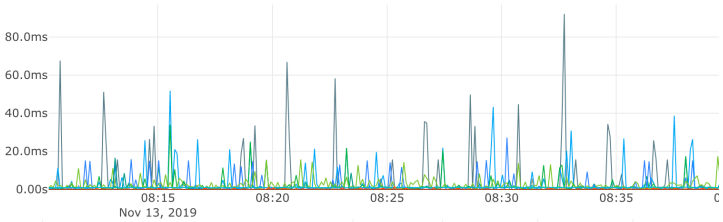
DNS Latency (DNS Latency)



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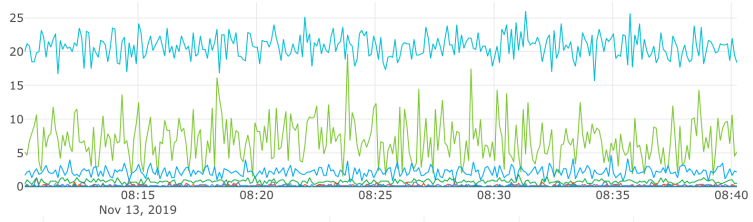

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Timeouts

Latency

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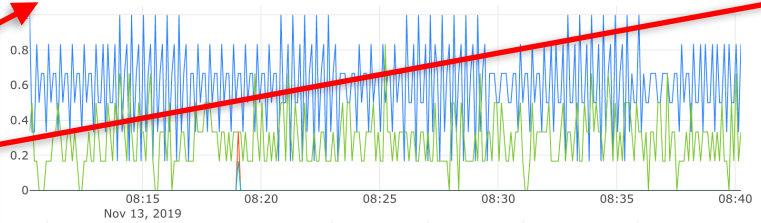

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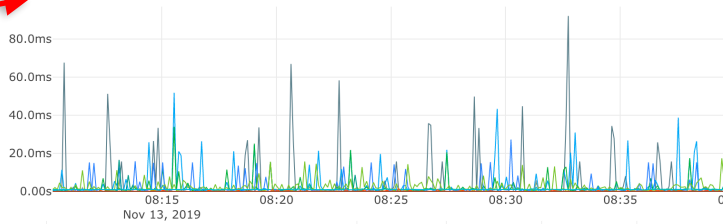

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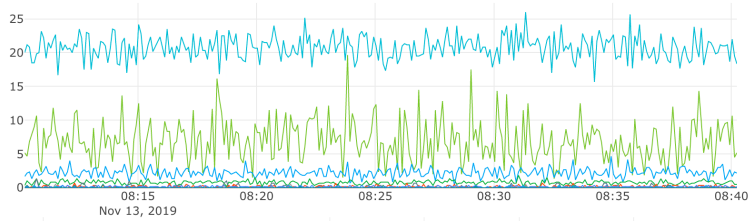
DNS Responses (DNS Responses)



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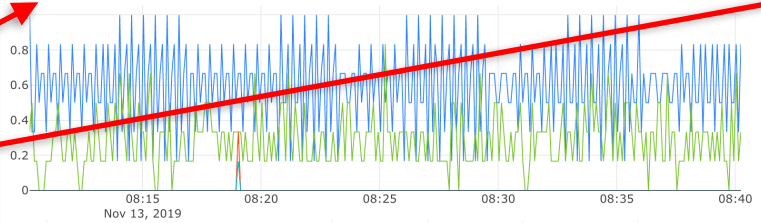
Timeouts

Latency

Volume

DNS Timeouts (DNS Timeouts)



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checkoutservice	DNS	0.8	0.3	520
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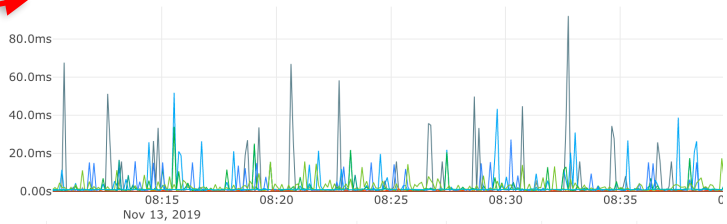

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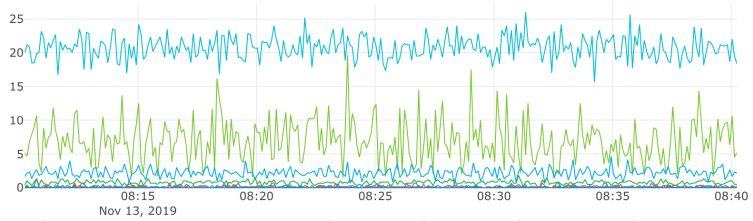

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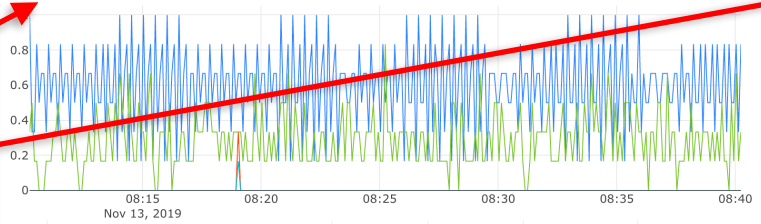

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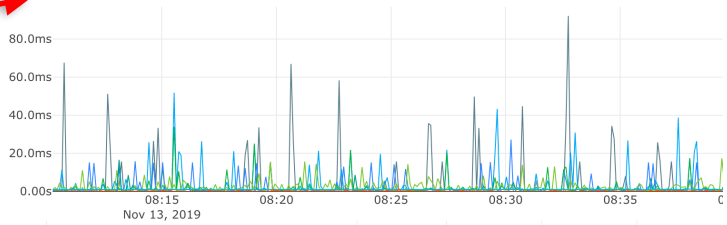
DNS Latency (DNS Latency)



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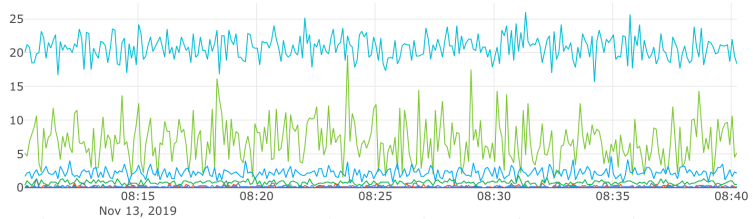

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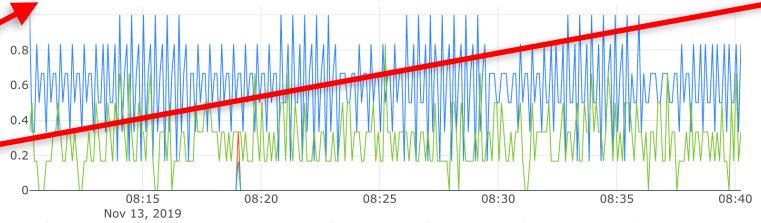

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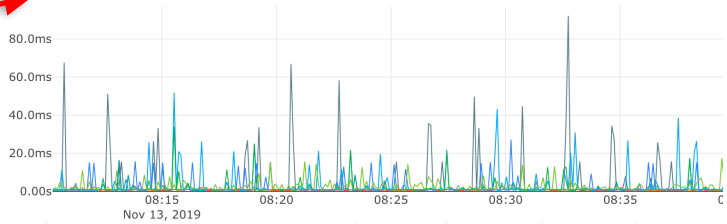

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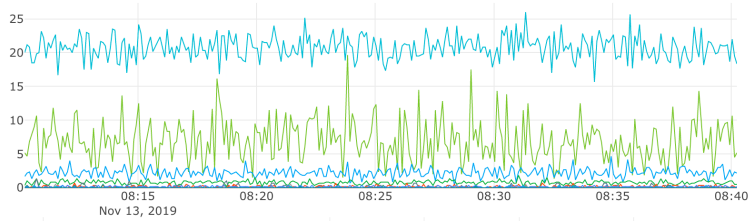

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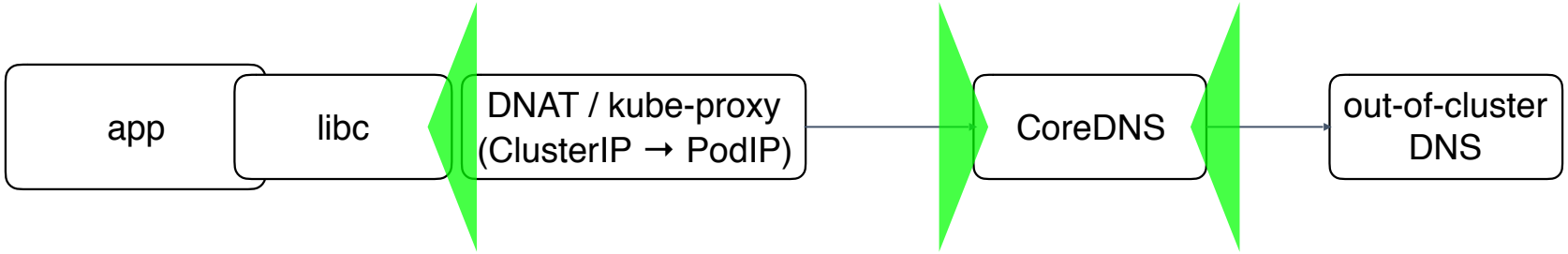
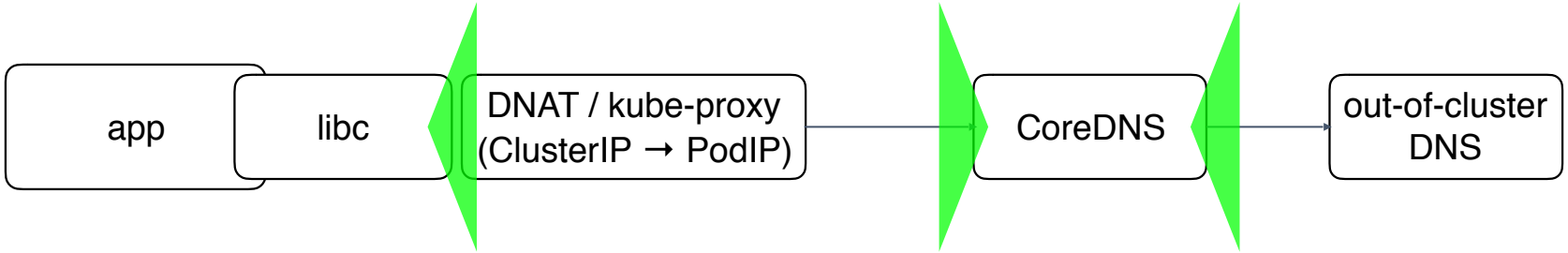

app
libc
DNAT / kube-proxy
(ClusterIP → PodIP)
CoreDNS
out-of-cluster
DNS



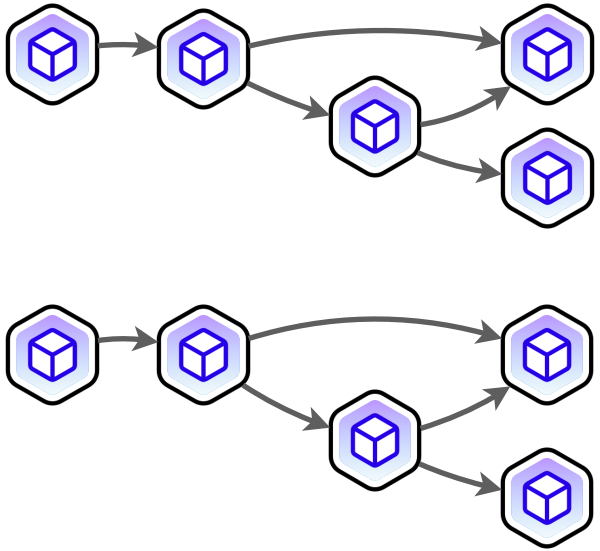
How? eBPF

- Linux bpf() system call, 3.18+, RHEL 7.6+
- Safe, High-Performance

Unofficial BPF mascot by Deirdré Straughan

OS+network can provide more visibility

- **Map application & HA architecture**



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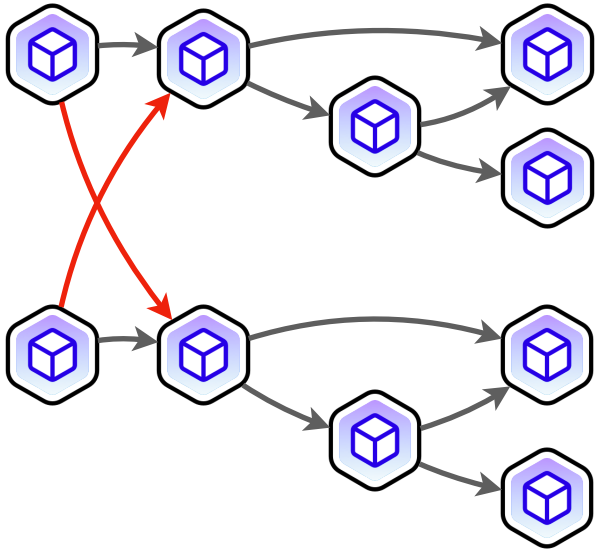

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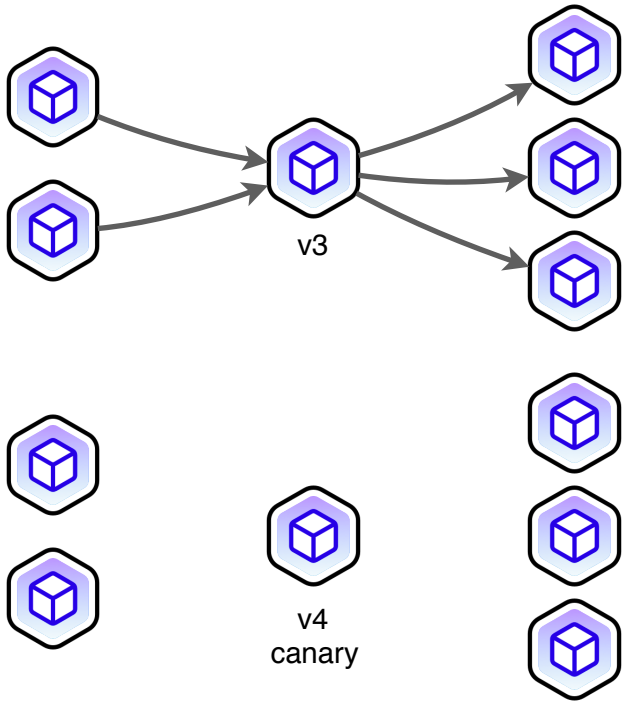

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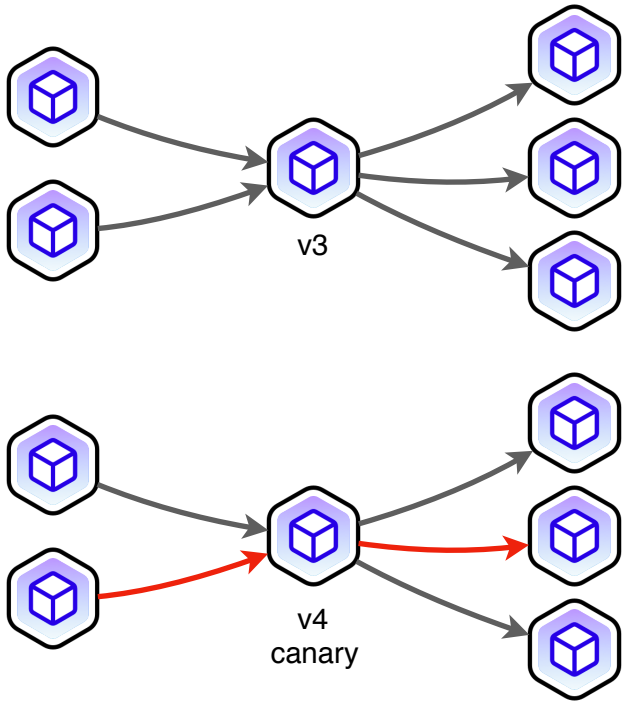

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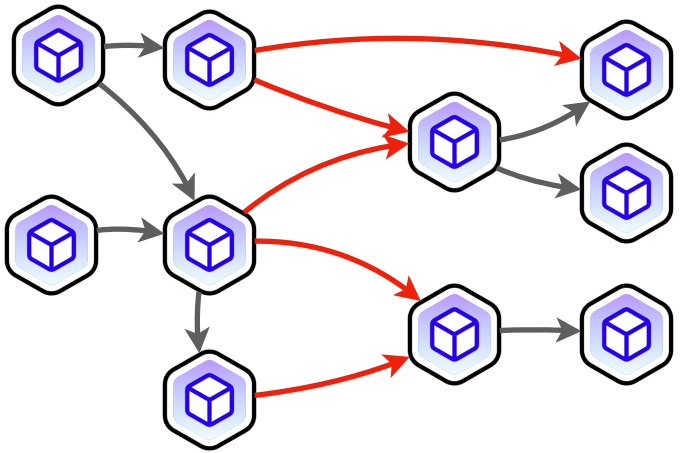

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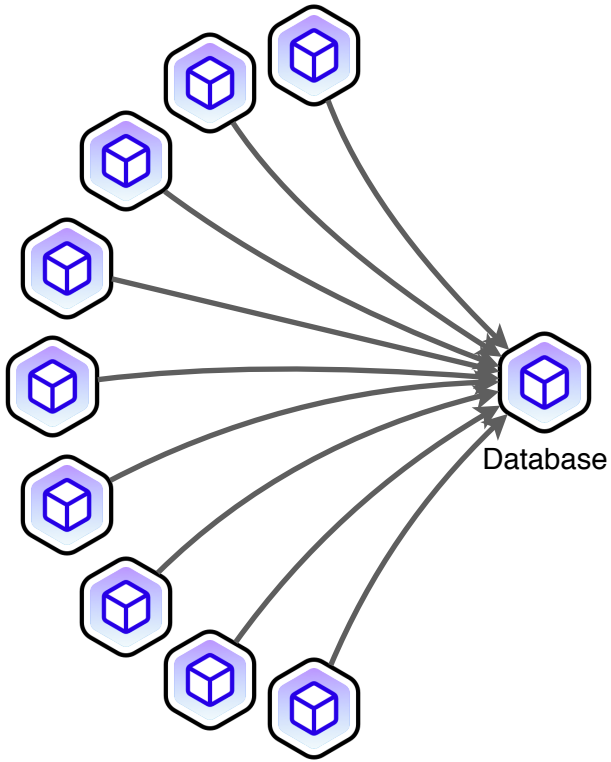

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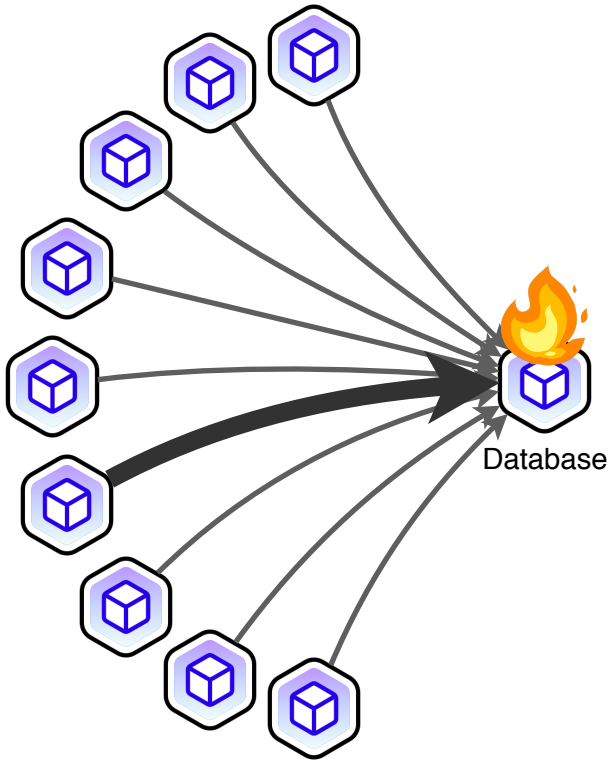
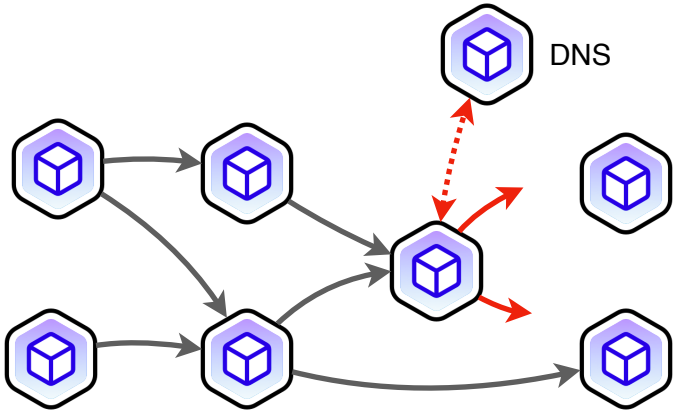


Take-aways:

- DNS can (and does) fail
- CoreDNS metrics are useful
- Can get per-service visibility with eBPF
- Network telemetry useful beyond DNS



Please
come say hi!