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bpfilter, pare-feu Linux à la sauce eBPF

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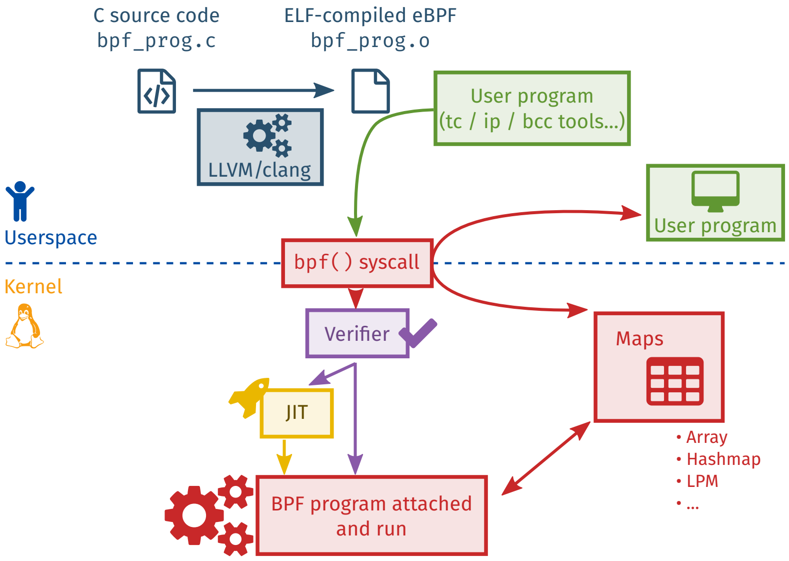
NETRONOME

A word about Netronome

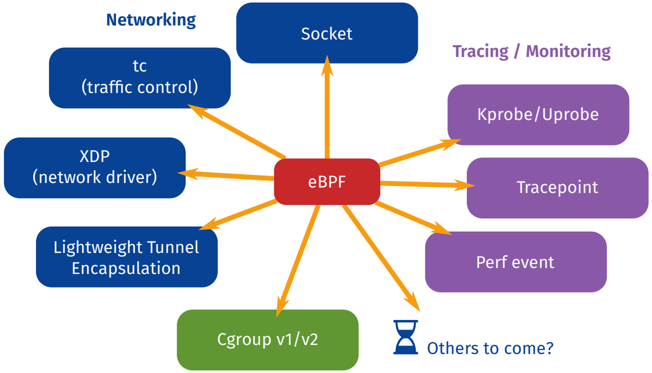
We make SmartNICs for data centers.

Features include vRouter, firewall, transparent HW offload for OvS… or **eBPF**!

eBPF: Programmability in the kernel



eBPF hooks


Networking
Socket
tc (traffic control)
XDP (network driver)
Lightweight Tunnel Encapsulation
Cgroup v1/v2
eBPF
Tracing / Monitoring
Kprobe/Uprobe
Tracepoint
Perf event
Others to come?

bpfilter

bpfilter, a new back-end for iptables in Linux, **based on eBPF**

- RFC posted to Linux network development (netdev) mailing list, mid-February 2018
- Code by David Miller (networking subsystem maintainer), Alexei Starovoitov and Daniel Borkmann (BPF tree maintainers)
- Not merged yet, everything that appears here is susceptible to change!

"BPF and firewalls? Reminds me of something."

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bpfilter not to be confused with...

- `xt_bpf` module (attach BPF program to Netfilter hook; rather an extension of xtables, and relies on classic BPF)

```
iptables -A INPUT \
    -p udp --dport 53 \
    -m bpf --bytecode "14,0 0 0 20,177 0 0 0,12 0 0 0,7 0 0 0, \
        64 0 0 0,21 0 7 124090465,64 0 0 4,21 0 5 1836084325, \
        64 0 0 8,21 0 3 56848237,80 0 0 12,21 0 1 0,6 0 0 1, \
        6 0 0 0," \
    -j DROP
```

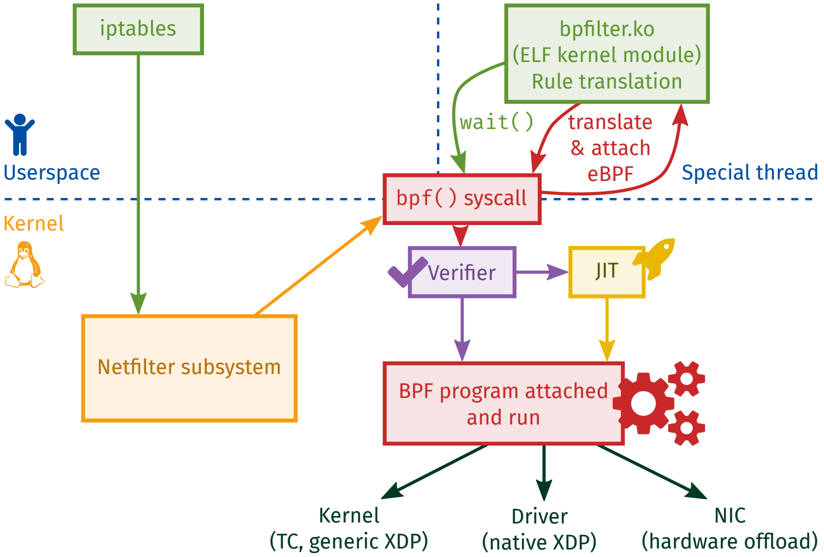
  (Matches a DNS query for "example.com", credit goes to Cloudflare)

- nftables, designed as iptables/xtables successor
- BPF in nftables (posted to netdev in reaction to bpfilter)
- NFP firewall on NetBSD with classic BPF (≠ eBPF) and JIT-compiling

bpfilter in details

- The `iptables` binary is left untouched
- Rules are translated into an eBPF program, attached to e.g. XDP
- bpfilter.ko: new kind of kernel module, here for rule translation
  - ELF file running in user space!
  - Based on user mode helpers (UMH)
  - But shipped and built from kernel tree
  - Should be compatible with `modprobe`, `modinfo`, etc.
  - Run in a special thread, full privileges and in root namespace
- Several objectives for this new kind of module
  - Easier to develop, to debug, to test
  - Reduce attack surface, cannot crash the kernel
  - Clear decoupling between data plane (kernel) and control planes (user space)
- bpfilter.ko module communicates with the kernel via `bpf()` syscall

bpfilter overview



The benefits of bpfilter

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- JIT compilation on x86_64, arm64, ppc64, sparc64, mips64, s390x, arm32
- Straightforward hardware offload on compatible NICs
- BPF verifier: security and safety
- User space ELF modules
- Existing BPF tooling; possibly writing rules in C?
- eBPF more and more used in the kernel, possibilities for integration with other subsystems?

Example usage, from the PoC

```
# ./bpfilter.ko              # Should eventually use modprobe


# iptables -t filter -A INPUT -i eth1 -d 10.0.0.4/32 -j DROP
# iptables -L
    Chain INPUT (policy ACCEPT)
    target     prot opt source               destination
    DROP       all  --  anywhere             10.0.0.4

    Chain FORWARD (policy ACCEPT)
    target     prot opt source               destination

    Chain OUTPUT (policy ACCEPT)
    target     prot opt source               destination
```

Rule translated to an eBPF program

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```
# bpftool prog dump xlated id 1337
 0: (bf) r9 = r1
 1: (79) r2 = (u64 )(r9 +0)
 2: (79) r3 = (u64 )(r9 +8)
 3: (bf) r1 = r2
 4: (07) r1 += 14
 5: (bd) if r1 <= r3 goto pc+2
 6: (b4) (u32) r0 = (u32) 2
 7: (95) exit
 8: (bf) r1 = r2
 9: (b4) (u32) r5 = (u32) 0
10: (69) r4 = (u16 )(r1 +12)
11: (55) if r4 != 0x8 goto pc+9
12: (07) r1 += 34
13: (2d) if r1 > r3 goto pc+7
14: (07) r1 += -20
15: (61) r4 = (u32 )(r1 +12)
16: (55) if r4 != 0x200000a goto pc+1
17: (04) (u32) r5 += (u32) 1
18: (61) r4 = (u32 )(r1 +16)
19: (55) if r4 != 0x400000a goto pc+1
20: (04) (u32) r5 += (u32) 1
21: (55) if r5 != 0x2 goto pc+2
22: (b4) (u32) r0 = (u32) 1
23: (95) exit
24: (b4) (u32) r0 = (u32) 2
25: (95) exit
```

E.g. instruction #19: check on `0x400000a`, which is "`ntohl(10.0.0.4)`"

Quick performance test

Comparison for simple packet drop between iptables, nftables, bpfilter

Setup:

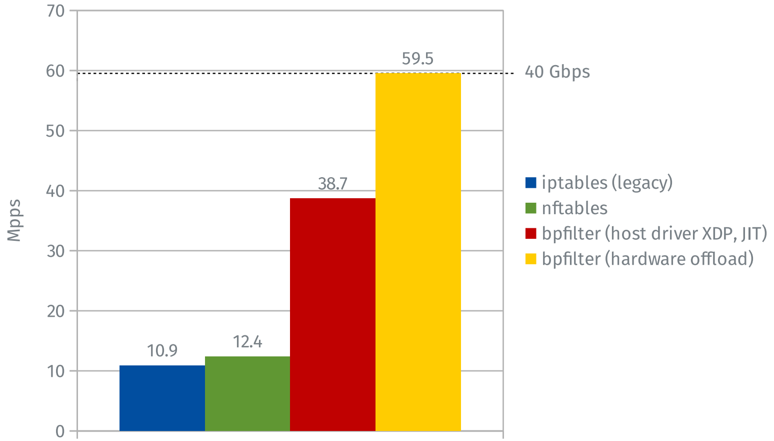
- One single iptables or nftables rule (as in previous example)
- Using one processor core
- 64 byte long packets

Hardware:

- Intel® Xeon® CPU E5-2630 v3 @ 2.40 GHz
  Single CPU, 8 cores 16 threads
- Netronome Agilio CX, 1 × 40 Gbps Ethernet

Many thanks to my colleague David Beckett for running the tests!

Performance test results



Reception from the community (1/2)

68 replies on the thread, many comments from Netfilter people

- Performance
  - Many speed improvements from nftables over iptables
  - JIT-compiling, XDP hook, hardware offload: way faster, whereas Netfilter in general was not good enough and failed to get a wide adoption
- Replication of iptables back-end
  - Users' assumptions regarding the behaviour of iptables, 100% perfect replication is impossible
  - Will make efforts to have the same, on as many use cases as possible
- Why iptables in the first place?
  - Maintainers trying to phase out the legacy interface, why not base bpfilter on nftables instead?
  - iptables widely spread and will remain for at least a decade, better improve performance and ease maintenance

Reception from the community (2/2)

- Security
  - Security concerns, mostly about the new ELF module mechanism
  - Safety and security through BPF verifier; ELF module no less secure than kernel modules.
- What about eBPF?
  - Not so much deployed as of today
  - Deployed in most major providers, used more and more in the kernel, for various taks
- … but, really, eBPF?
  - “BPF has many usability problems”
  - Simply not true

What happens next?

- PoC must be refined to get a more complete, optimised version
- The proposal needs to be accepted by the community
- bpfilter very likely to be accepted: backed by influent developers
- Early March: follow-up for nftables, with a common intermediate representation with iptables
- Early March, too: repost of the patch for the new ELF kernel modules
- Next:
  - bpfilter merge to the kernel?
  - nftables support?
  - User space tooling update?
  - More hardware offload?

Thank you!

Questions?

Additional resources:

RFC on netdev mailing list “*net: add bpfilter*”, sent by Daniel Borkmann
https://www.mail-archive.com/netdev@vger.kernel.org/msg217095.html
and following emails of this thread

LWN.net: *BPF comes to the firewalls*
https://lwn.net/Articles/747551/

LWN.net: *Designing ELF modules*
https://lwn.net/Articles/749108/

Resources on BPF — *Dive into BPF: a list of reading material*
https://qmonnet.github.io/whirl-offload/2016/09/01/dive-into-bpf/

Netronome website
https://www.netronome.com/

We’re hiring!