Operating System-Level Load Distribution for Network Telemetry Data Collection

Eduard Bachmakov

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Network telemetry and you

Traditional networks maintain distributed state across many devices and applications.

Observability requires joining relevant bits of state across devices and from different perspectives.

“perspectives”? control plane, forwarding plane, device topology

“relevant”? obtain via specialized network telemetry protocols

Obtaining network telemetry

Device configuration is hard, fragile, and comes with a long tail in actuation.
Preferred solution: globally consistent endpoint address.

Usable for load balancing!

1. Anycast for regional routing
2. ECMP for flow balancing
3. On-host balancing across processes

Background

Goal & setup

Setting: network with some number of routers configured to push network telemetry to a specific host.

Goal:

- combining control plane and forwarding plane information, per source device
    - IPFIX & BMP (and more)
- collector daemon: *pmacct*'s *nfacctd*
- (later steps: message broker $\rightarrow$ storage system $\rightarrow$ OLAP queries)

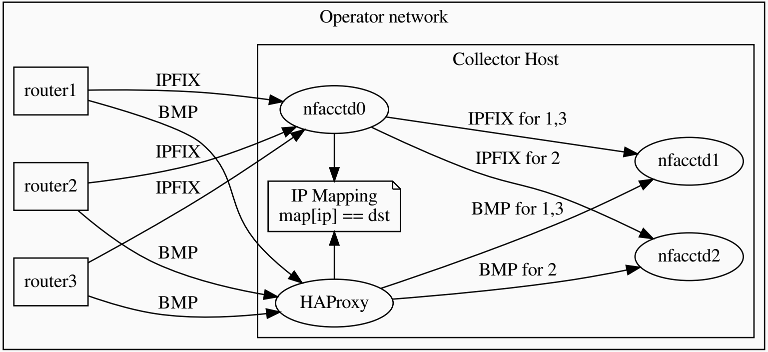
Data flow routing

To combine the data we need to ensure that both network telemetry data streams hit the same collector daemon.

Solution: proxies.

- *HAProxy* for TCP-based telemetry protocols (i.e. BMP)
- *nfacctd* for UDP-based ones (i.e. IPFIX)

Data flow routing: visualization



Data flow routing: issues

- Reliability
- Overhead
- Large configuration space

$$\overbrace{K}^{\text{devices}} \times \underbrace{L}_{\text{protocols}} \times \overbrace{M}^{\text{frontends}} \times \underbrace{N}_{\text{backends}}$$

Design

Refresher: SO_REUSEPORT

- Multiple processes bind to the same IP:port combination, forming a “reuseport group”.
- During local delivery of TCP/UDP packets, on socket lookup,
  - all *new* TCP connections and
  - all UDP datagrams are distributed among the reuseport group.
- socket assignment determined by hash of 5-tuple

Good start, however, uncontrolled assignment is not acceptable …

… but we can influence this using eBPF!

Refresher: eBPF

eBPF is a Linux kernel subsystem allowing users to attach custom logic at specific hooks at runtime.

Properties:

- virtual machine with restricted instruction set optimized for JIT-compilation
- limited functionality (not Turing-complete)
- on-load safety/security verification
- well defined interface to userspace (“eBPF maps”)
- not a kernel modification, not a kernel module
- public API/ABI $\rightarrow$ stability

One of the available hooks is right at the SO_REUSEPORT socket selection!

Core design

Now the pieces are in place. We can now

1. register all participating collector daemons in a lookup table (i.e. a special eBPF map),
2. create an algorithm to find the *appropriate* socket for a given, incoming packet,

$$\text{bucket} := h\left(\text{ip}_{\text{src}}, \cancelto{0}{\text{ip}_{\text{dst}}}, \cancelto{0}{\text{port}_{\text{src}}}, \cancelto{0}{\text{port}_{\text{dst}}}, \cancelto{0}{\text{proto}}\right)^{0} \mod N_{\cancelto{\text{intended}}{\text{now}}}$$

3. bundle that logic in a "SK_REUSEPORT" eBPF program, and
4. attach a SK_REUSEPORT eBPF program to the reuseport group.

Design Implications

We have now achieved balancing that is

- stateless,
- based on device identity only,
- stable across restarts,
- prevents cascading failures,
- requires virtually no configuration.

Conclusion

Summary

Network telemetry aggregation has additional, special requirements for load balancing.

We designed and implemented a system addressing these requirements using in-kernel loadbalancing via eBPF.

Balancing is device scoped and cross-protocol balancing across an arbitrary number of collection endpoints.

Enables reliable network monitoring by ensuring robust correlation of network telemetry data at the collection endpoint.

Requires less maintenance effort and much less configuration overhead than the previously existing architecture.

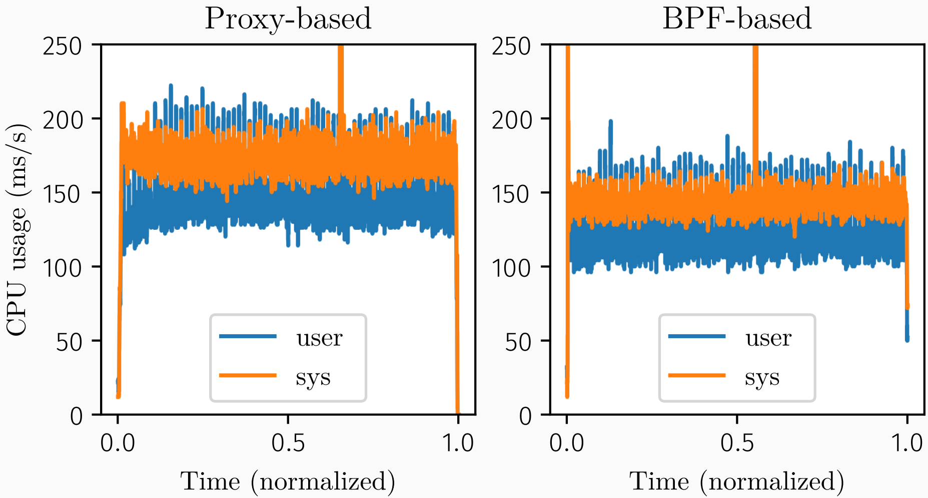
Evaluation shows more efficiently than the previously existing system.

Questions? Answers!

Same stuff—many, many more words: doi.org/10.3929/ethz-b-000507440

Backup

Resource usage: CPU



Resource usage: memory