Optimizing Data Plane Programs for the Network

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Data Plane Programs

- **Shift from fixed to programmable data planes**
  - P4 on e.g., Barefoot Tofino
  - eBPF on NPUs, e.g., Netronome NFP-6000
  - eBPF with XDP e.g., Intel Core-i7
- **Programs are executed for each packet**
- **Limited per-packet time budget**
  - e.g., 67.2 ns at 10GbE
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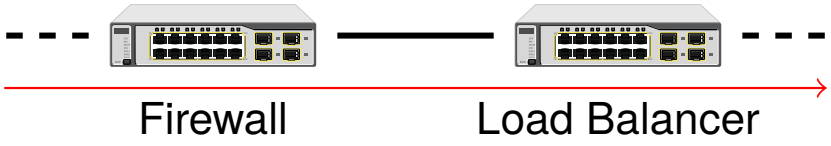
Our proposal

- Integrating the network topology into program optimization

Optimizing for the Network



Firewall

- Drops non IPv6 TCP
- Inserts fixed sized IPv6 options
  - e.g., Authentication Header

cilium.io Load Balancer

1. Parse Ethernet header
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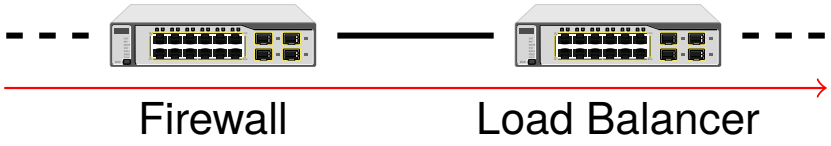

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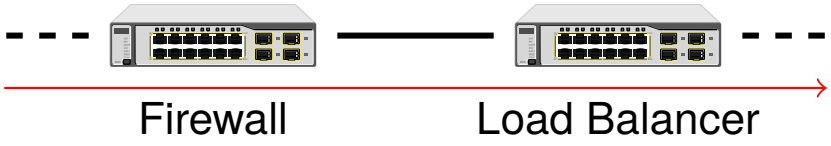

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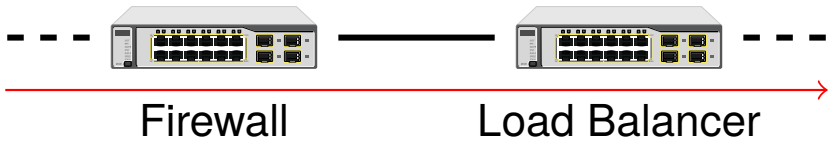

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Parts of a data plane program are redundant if equivalent functionality was already applied to packets before reaching this program.

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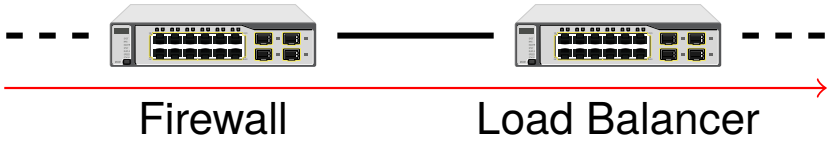

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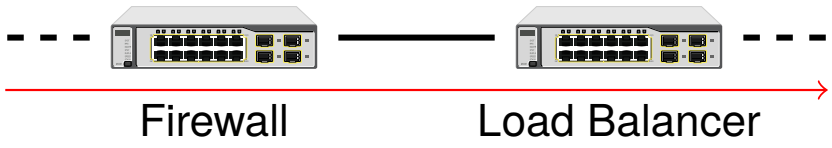

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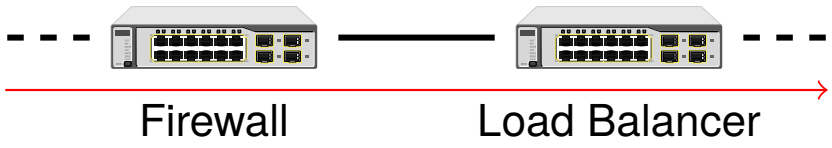

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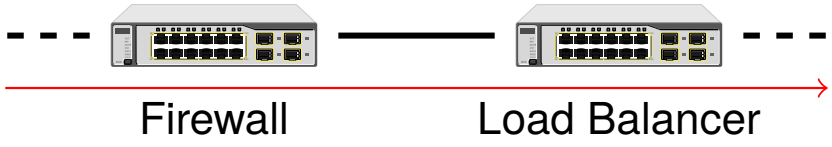

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This example, XDP BPF Core i7-870

⇒ **2.3**× packet rate (2.5→5.8 M pkt/s)

⇒ **12%** program size(7.6→0.9 KiB)

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Problem: Conventional tools (e.g., llvm) only output the combined optimized program

Solution: Instead use exhaustive symbolic execution

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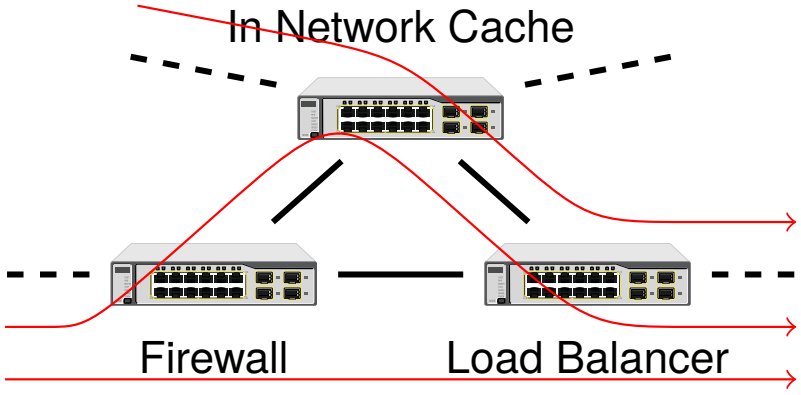
Runtime to optimize the cilium.io Load Balancer in our example

- **30 s** for all steps including **25 s** of symbolic execution

Challenge: Program Chain Selection

A program may be part of multiple network paths.



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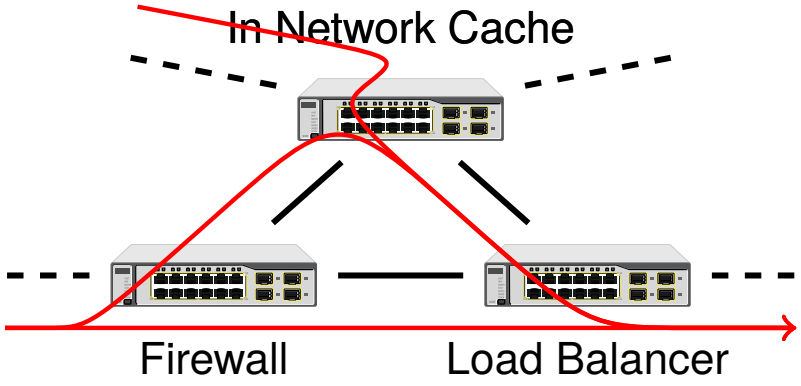

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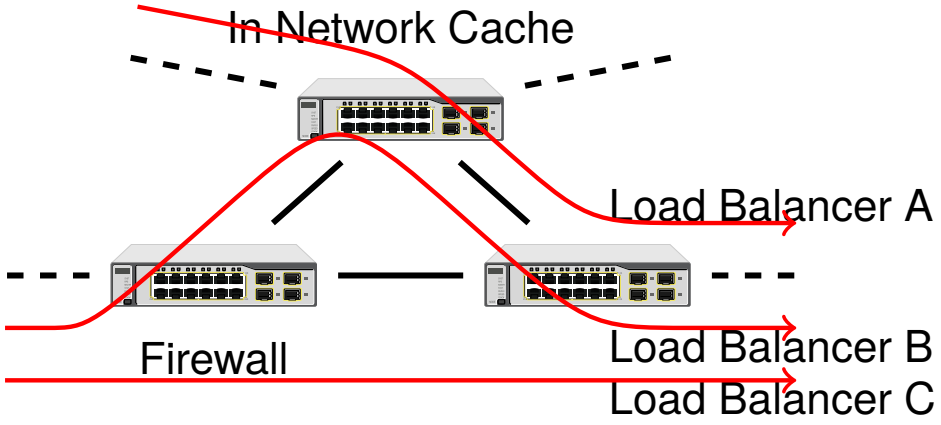

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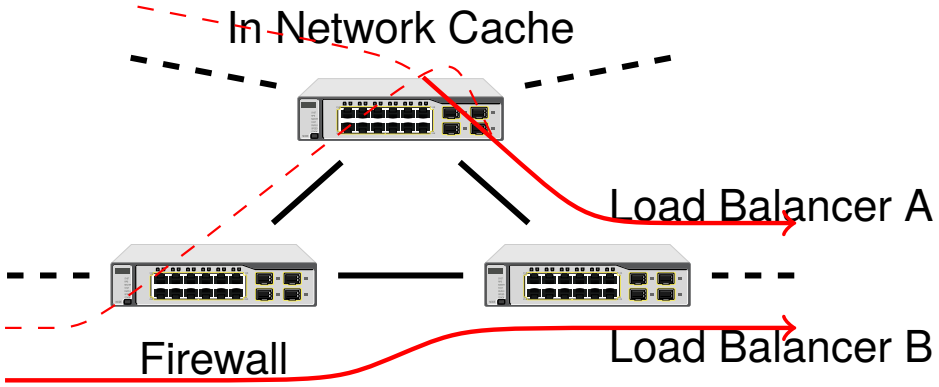

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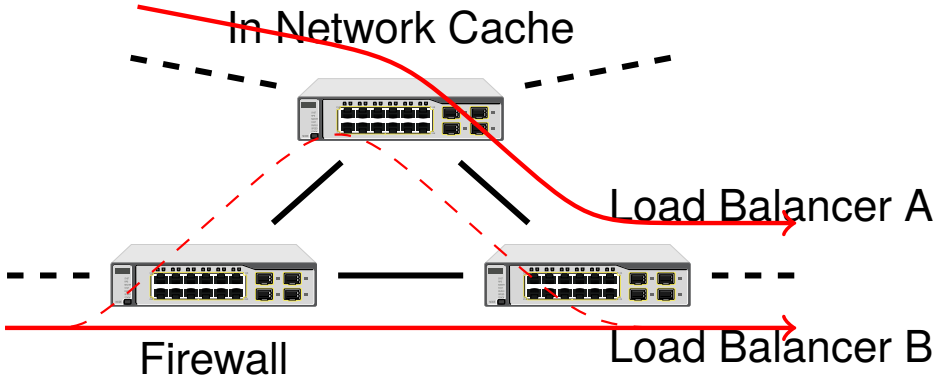

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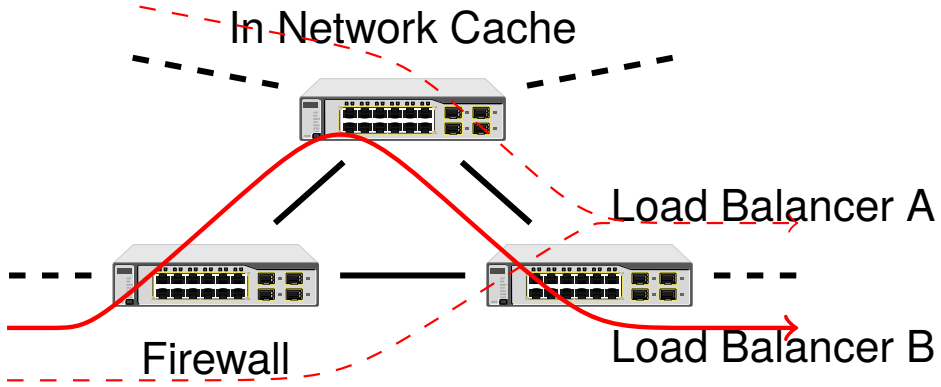

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- **Selectively applying optimizations**
  - Optimize slow hotspots
  - Identify program chains with high optimization potential
  - Run some optimization whenever controller is idle

Summary

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- **High optimization potential on example with real-world program**
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- **Still much to do**
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