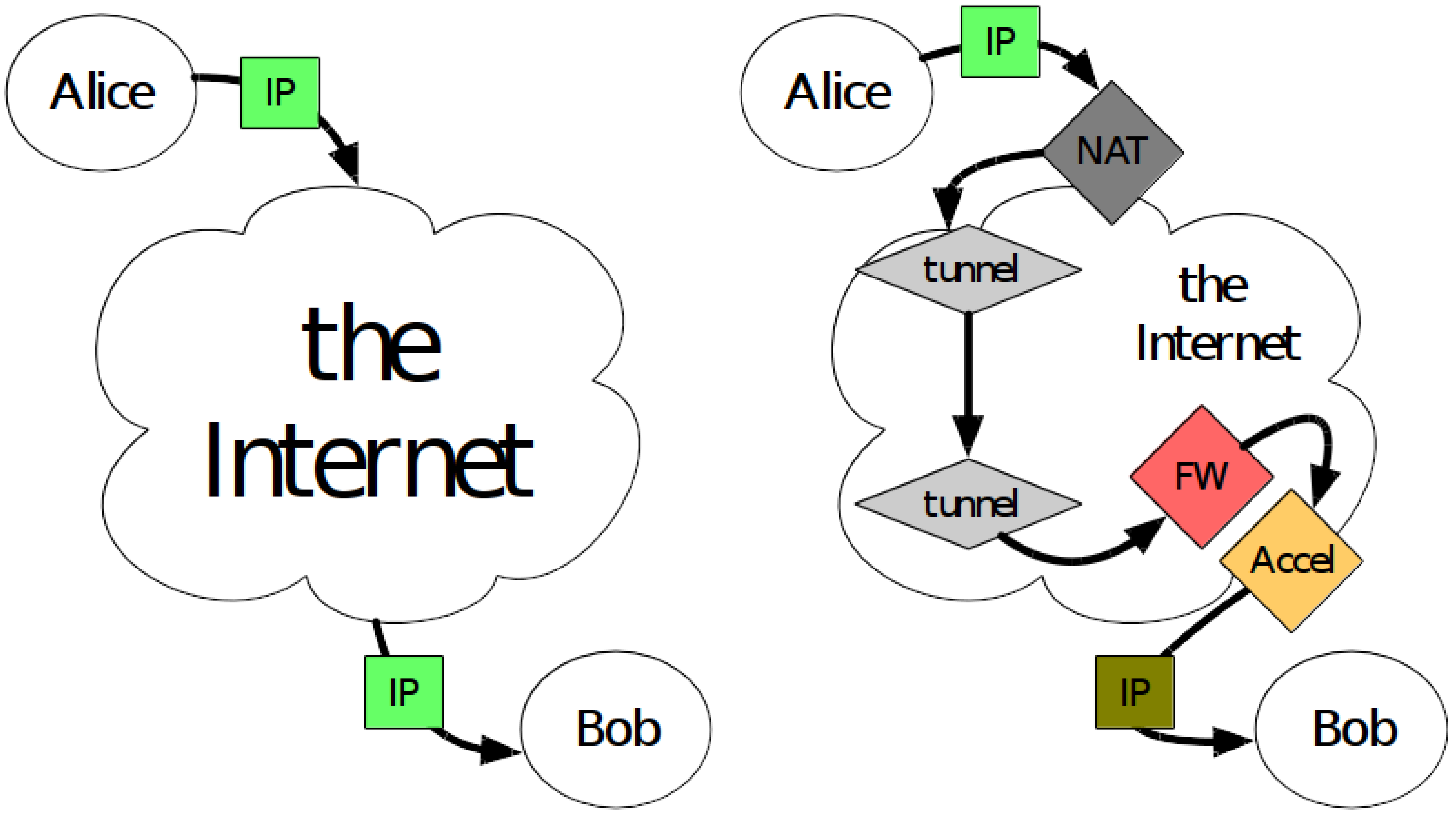
`mmb`: Flexible High-Speed Userspace Middleboxes

Korian Edeline, Justin Iurman, Cyril Soldani, Benoit Donnet
Montefiore Institute, University of Liège
Belgium

A middleboxed Internet



https://github.com/mami-project/roadshows

kernelspace vs userspace

Kernel:

Userspace:

kernelspace vs userspace

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✗ Too slow for high-speed forwarding

✗ Missing optimizations (batching, caching, etc)

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kernelspace vs userspace

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✔ DPDK (DMA, I/O batching)

kernelspace vs userspace

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Userspace:

- ✗ ~~No direct access to NIC (context switch, sk_buff)~~
- ✔ DPDK (DMA, I/O batching)
- ✔ Software optimizations
- ✔ Flexibility

Kernel-Bypass Frameworks

Framework	Modularity & Flexibility	Optimization Techniques	Commodity Hardware
Click	●	○	✓
PF_RING	◔	◔	✓
RouteBricks	●	◔	✓
mOS	◑	◔	✓
PacketShader	◔	◑	✗
DoubleClick	●	◑	✓
FastClick	●	◕	✓
MiddleClick	●	◕	✓
ClickNP	●	●	✗
VPP	●	●	✓

Vector Packet Processing (VPP)

- DPDK
- RSS queues, Zero-Copy and more
- Packet vectors
- Modular node-based processing
- Low-level optimizations (caching, pipelining)

VPP Dual-Loop

```
while (n_left_from >= 2) {
      /* prefetch next iteration */
      if (PREDICT_TRUE(n_left_from >= 4)){
            vlib_prefetch_buffer_header(b[2], STORE);
            vlib_prefetch_buffer_header(b[3], STORE);
      }

      process(b[0]);
      process(b[1]);

      b += 2;
      next += 2;
      n_left_from -= 2;
}

/* process remaining packets */
while(n_left_from > 0){
      process(b[0]);

      b += 1;
      next += 1;
      n_left_from -= 1;
}
```

mmb: A VPP middlebox

Goals:

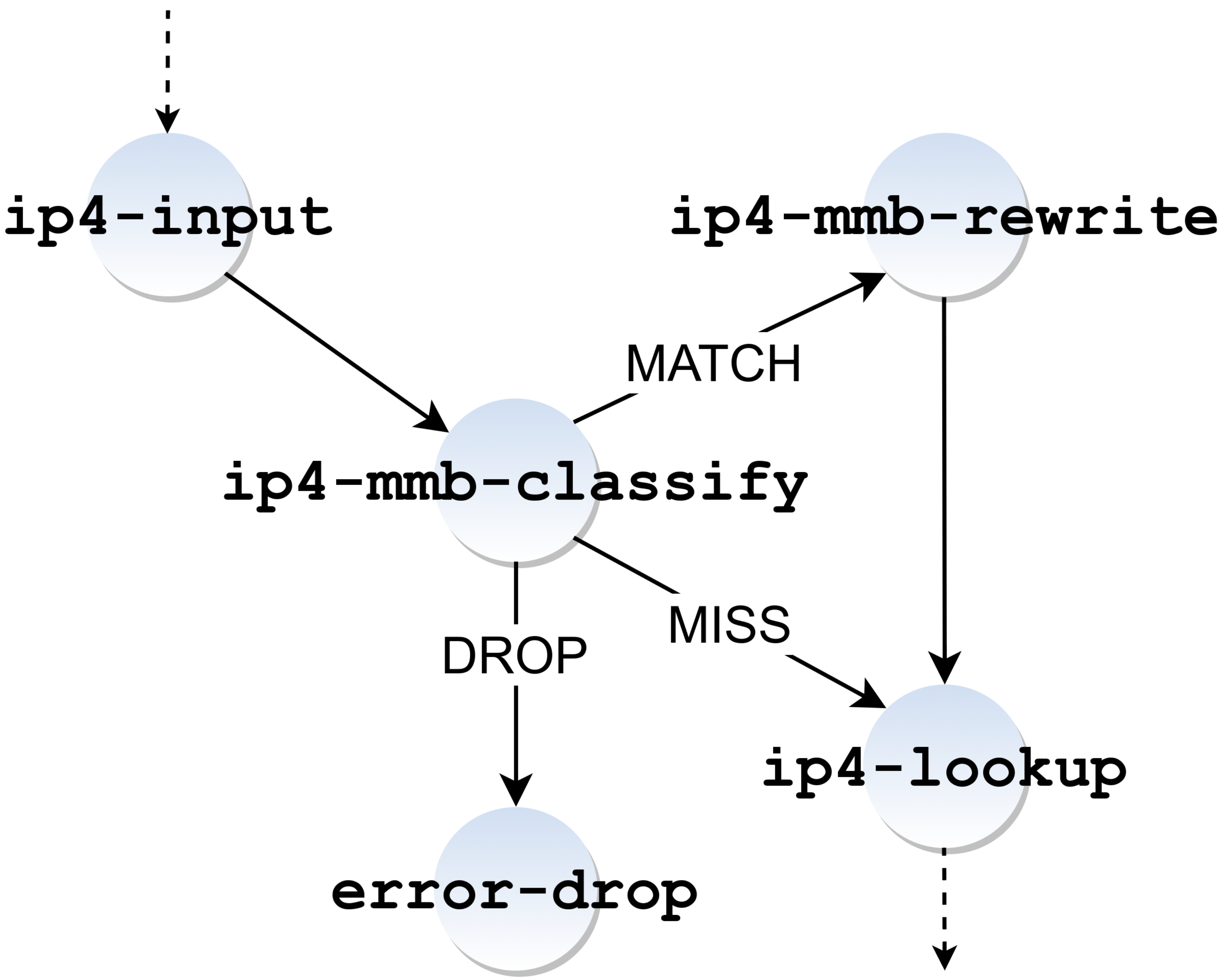
- Various middlebox policies (firewall, NAT, traffic engineering)
- Fast even with thousands rules
- Intuitive CLI

mmb: CLI grammar

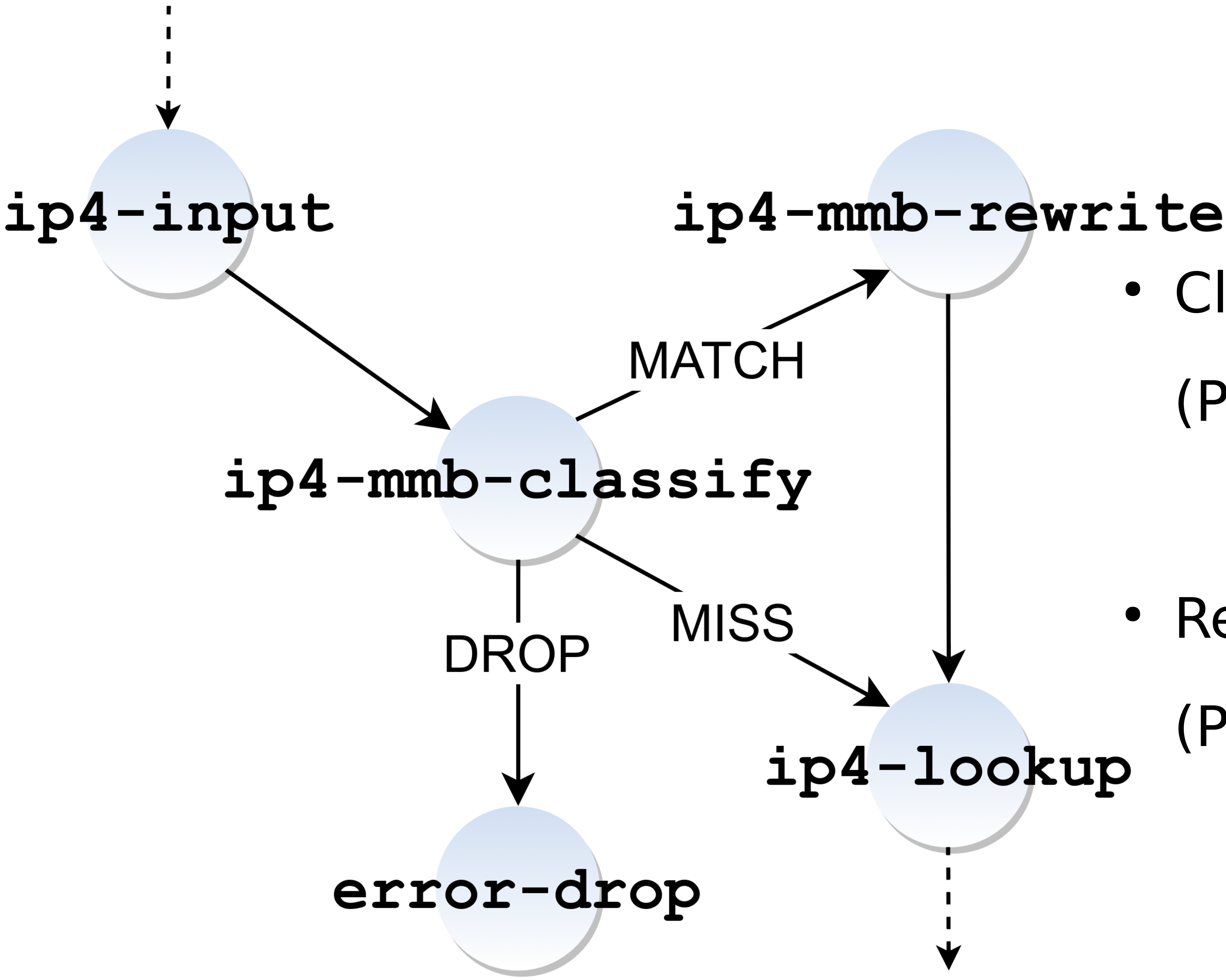
```
# mmb <add-keyword> <match>  [<match>  ...  <match>]
                    <target> [<target> ... <target>]

<add-keyword> : add-stateless | add-stateful
<match>       : <field> <condition> <value>
<target>      : mod <field> <value> | add <field> <value>
               | strip [!] <field>  | map <field> <value>
               | shuffle <field>    | drop
```

mmb: forwarding graph



mmb: forwarding graph



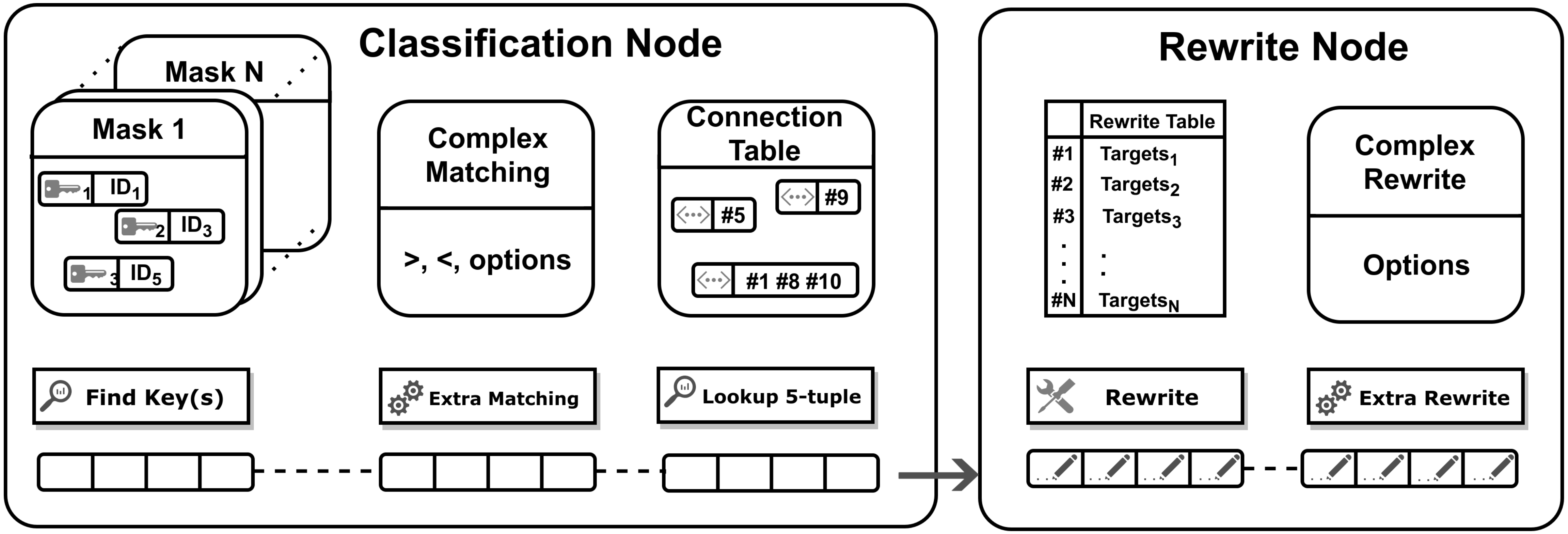
- Classification:

  (Packet & Mask) ⊕ Key

- Rewrite

  (Packet & Mask) | Key

mmb: processing path

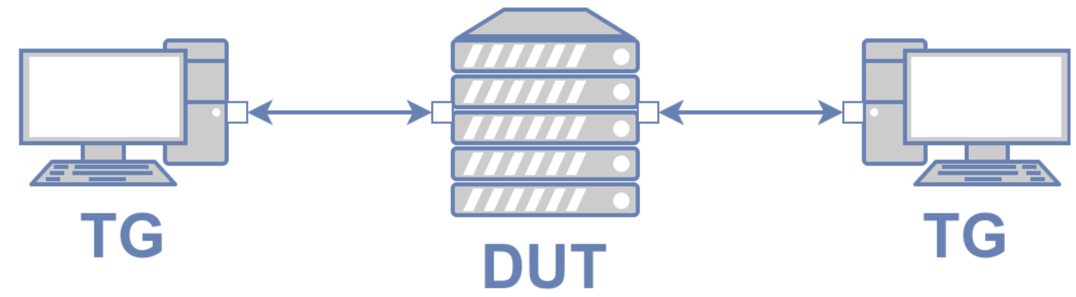


Performance Analysis

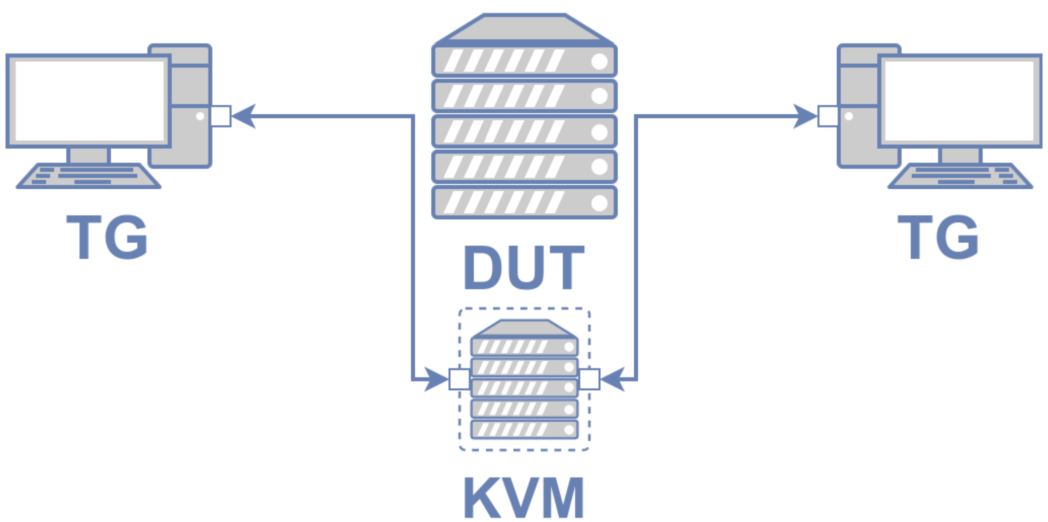
- FastClick:
  - Fast (multi-queue, ZC forwarding, batching, DPDK)
  - Click
- eXpress Data Path (XDP):
  - In-Kernel
  - eBPF
- iptables

Performance Analysis: Testbed

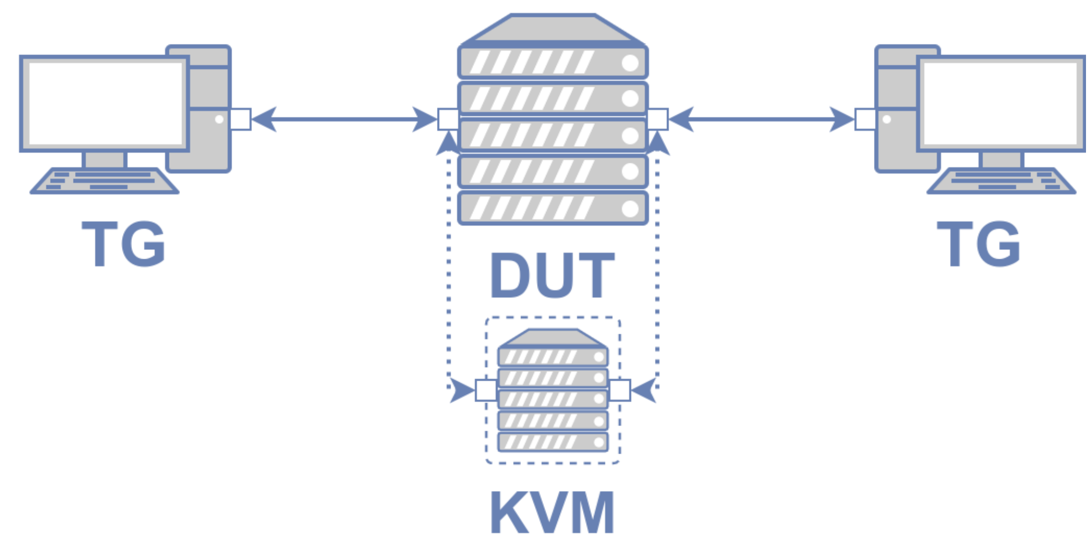
Direct



Indirect

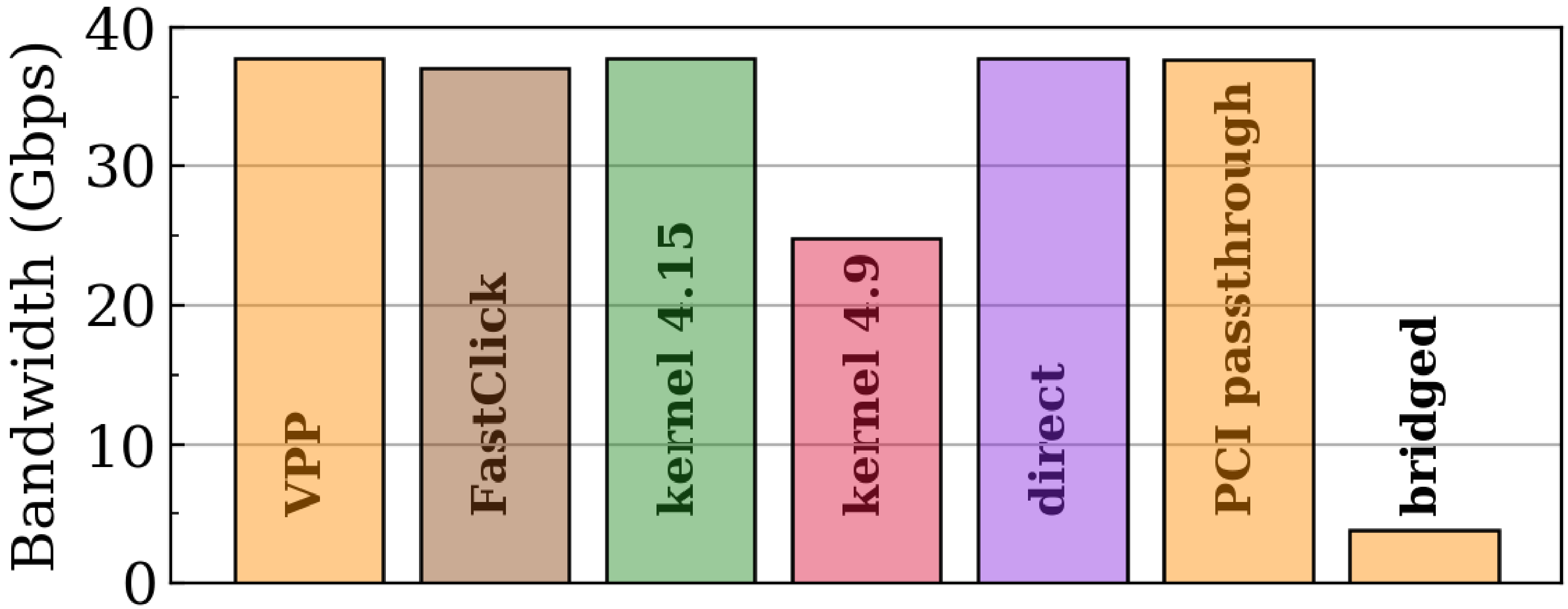


PCI Passthrough



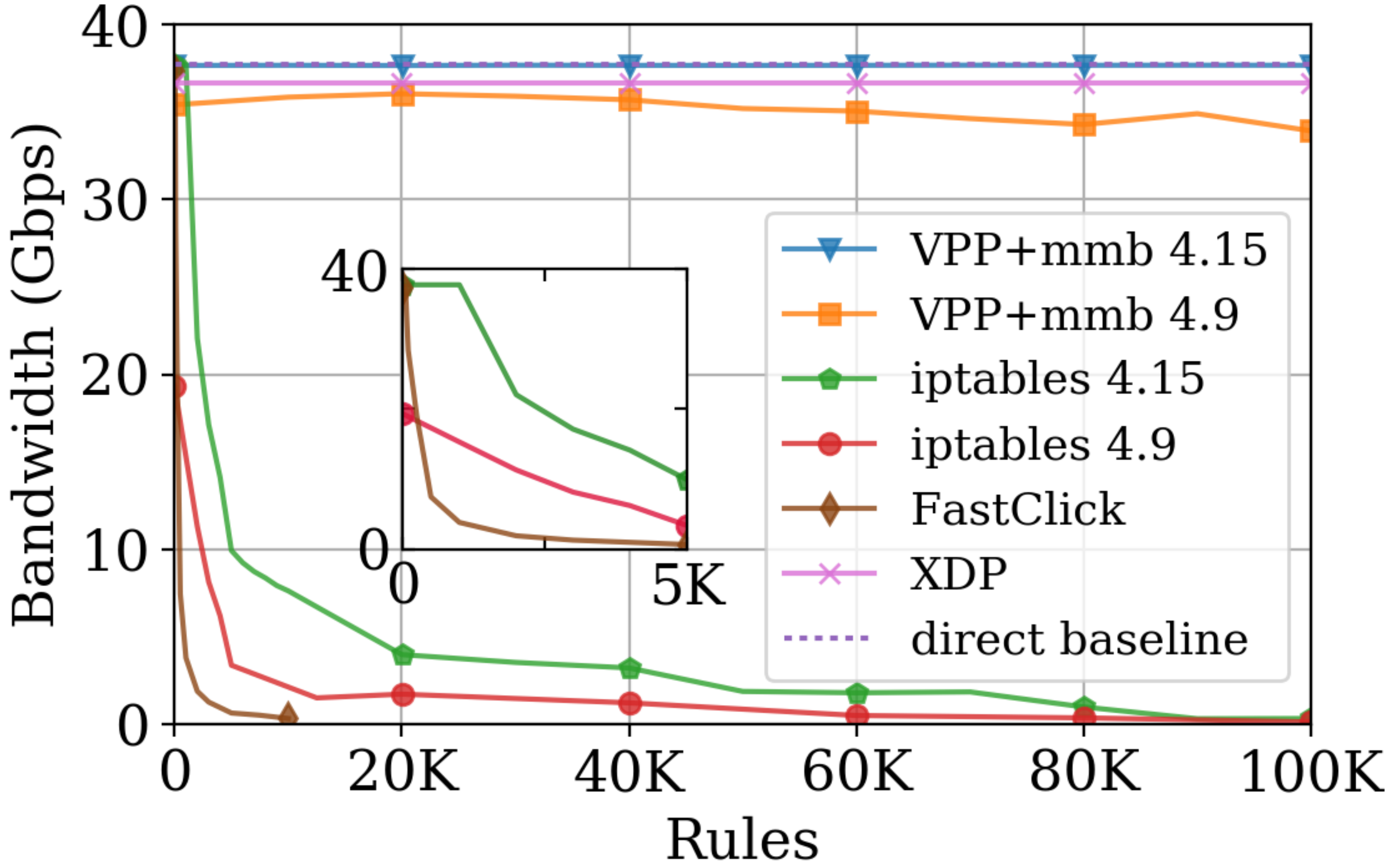
Bridged

Performance Analysis: Baselines



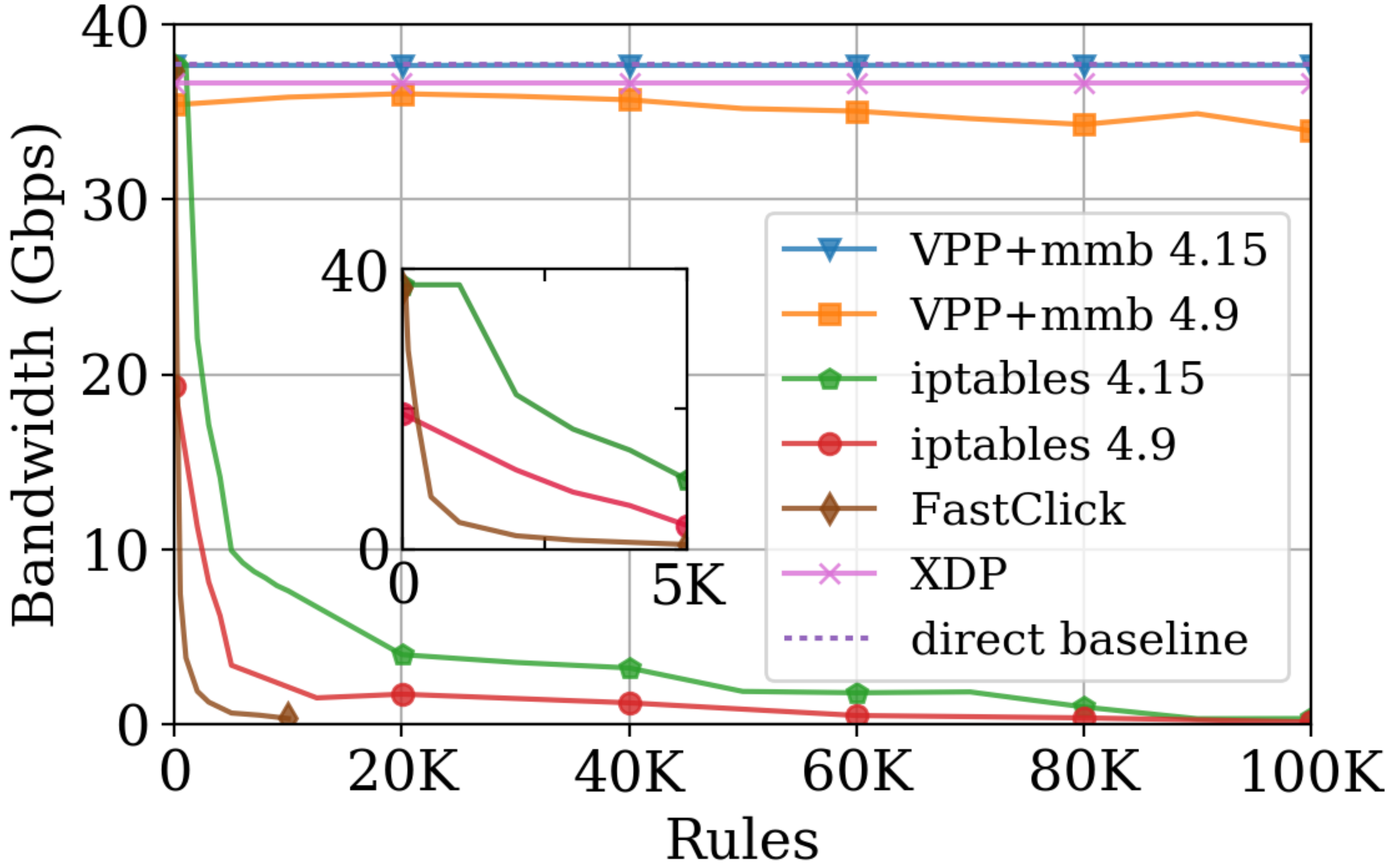
- VPP, FastClick, 4.15 > 99% of direct baseline

Performance Analysis: 5-tuples firewall



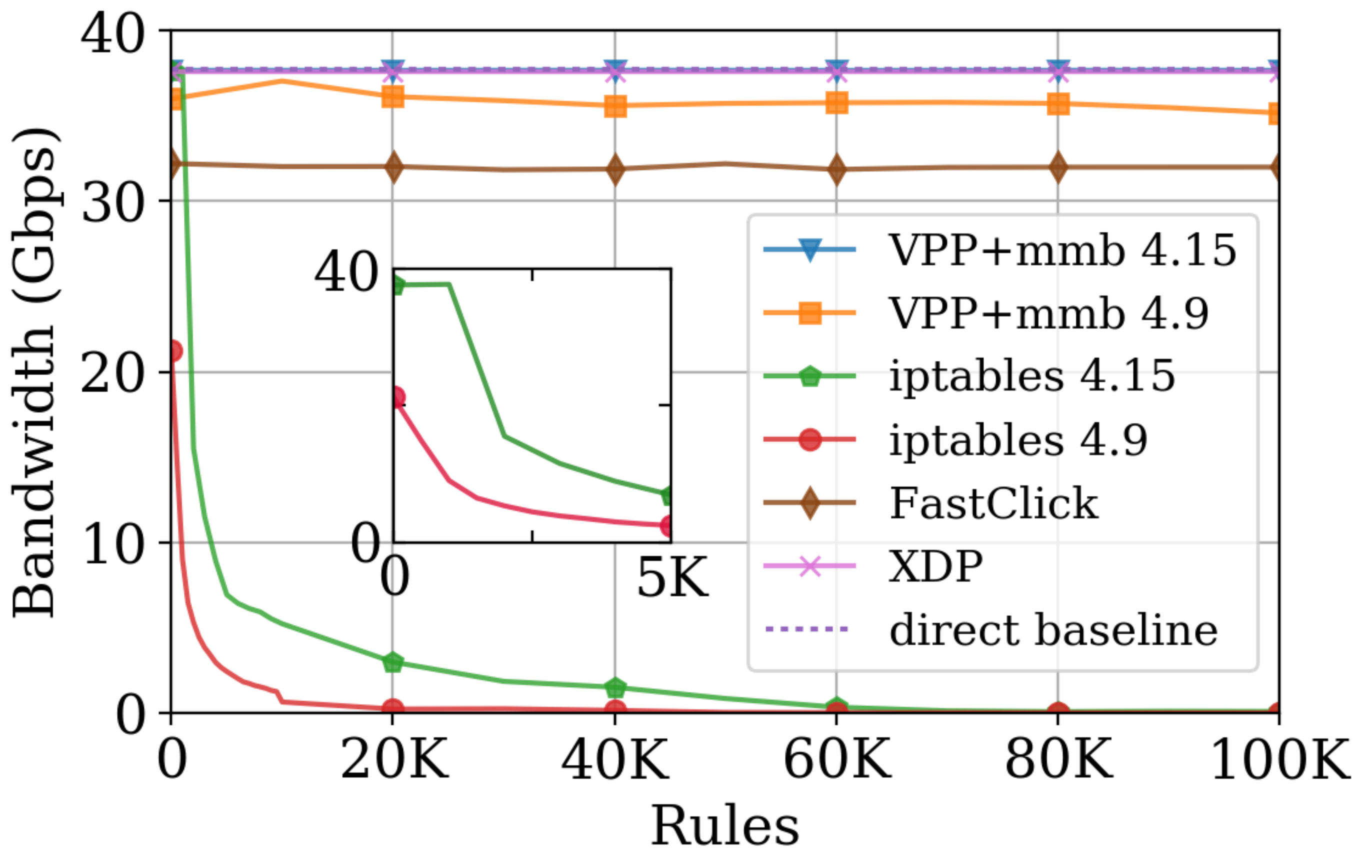
- Stateless matching on 5-tuples (saddr, daddr, sport, dport, proto)

Performance Analysis: 5-tuples firewall



- Stateless matching on 5-tuples (saddr, daddr, sport, dport, proto)
- mmb & XDP at direct baseline
- FastClick matching (IPFilter) has performance issues
- Iptables 4.15 sustains direct baseline with up to 1,000 rules

Performance Analysis: stateful flow matching



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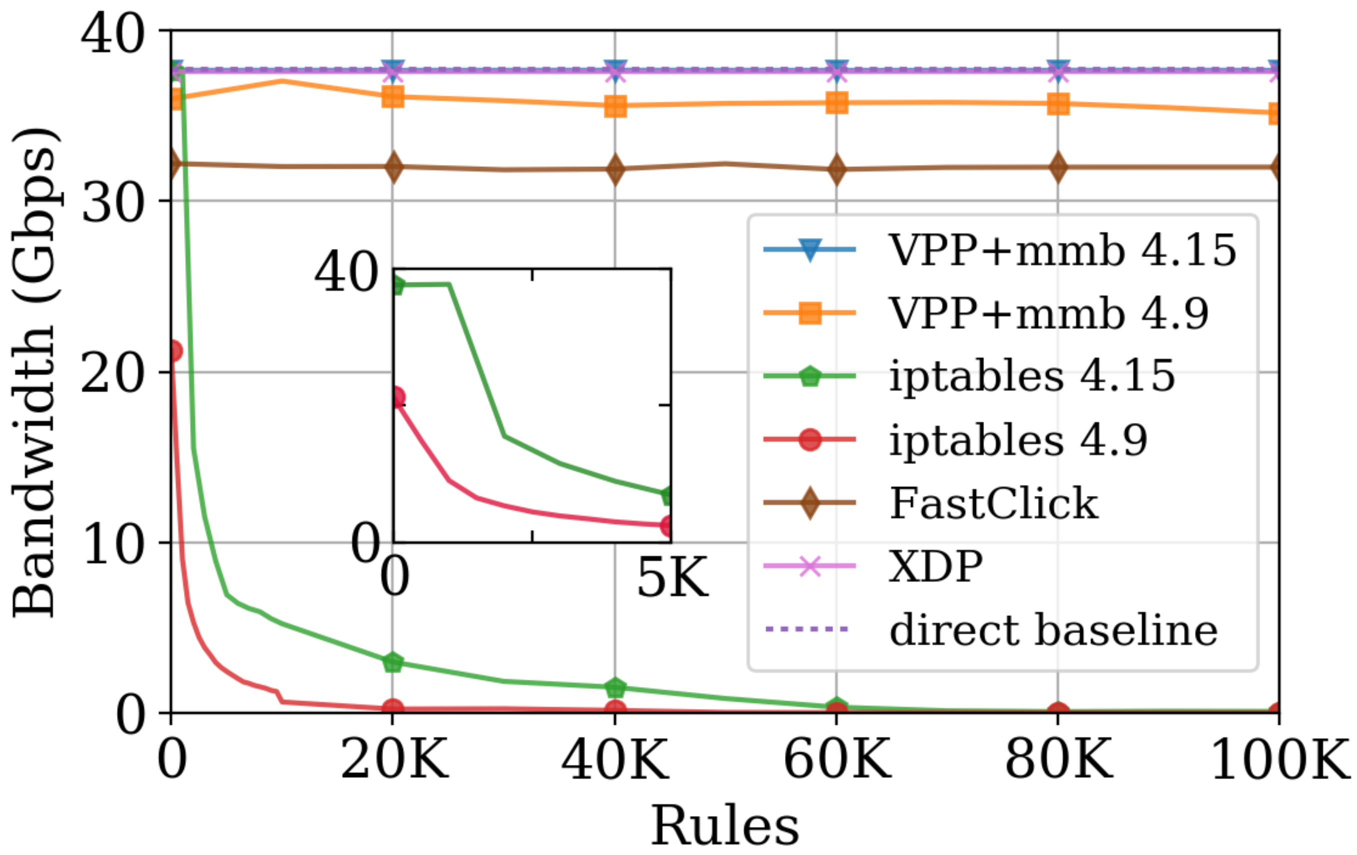
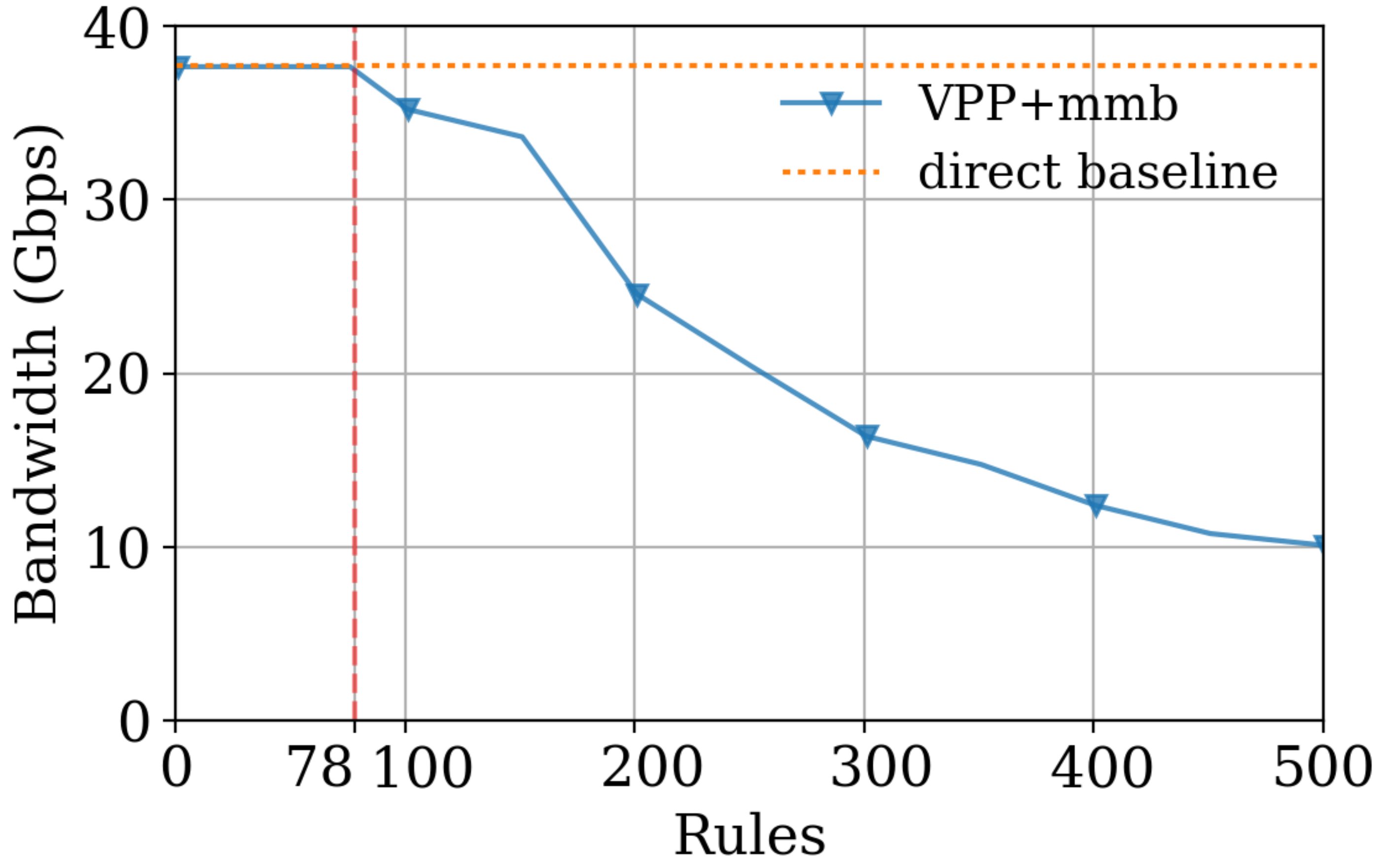
Performance Analysis: stateful flow matching



- Stateful matching on 5-tuples (saddr, daddr, sport, dport, proto)
- mmb & XDP at direct baseline
- FastClick at 85% direct baseline
- Iptables stateful is similar to stateless (with few rules).

Performance Analysis: TCP Options



- Matching on TCP Options
- Not applicable to iptables, FastClick & XDP
- Stable until 78 rules

Conclusion & Next steps

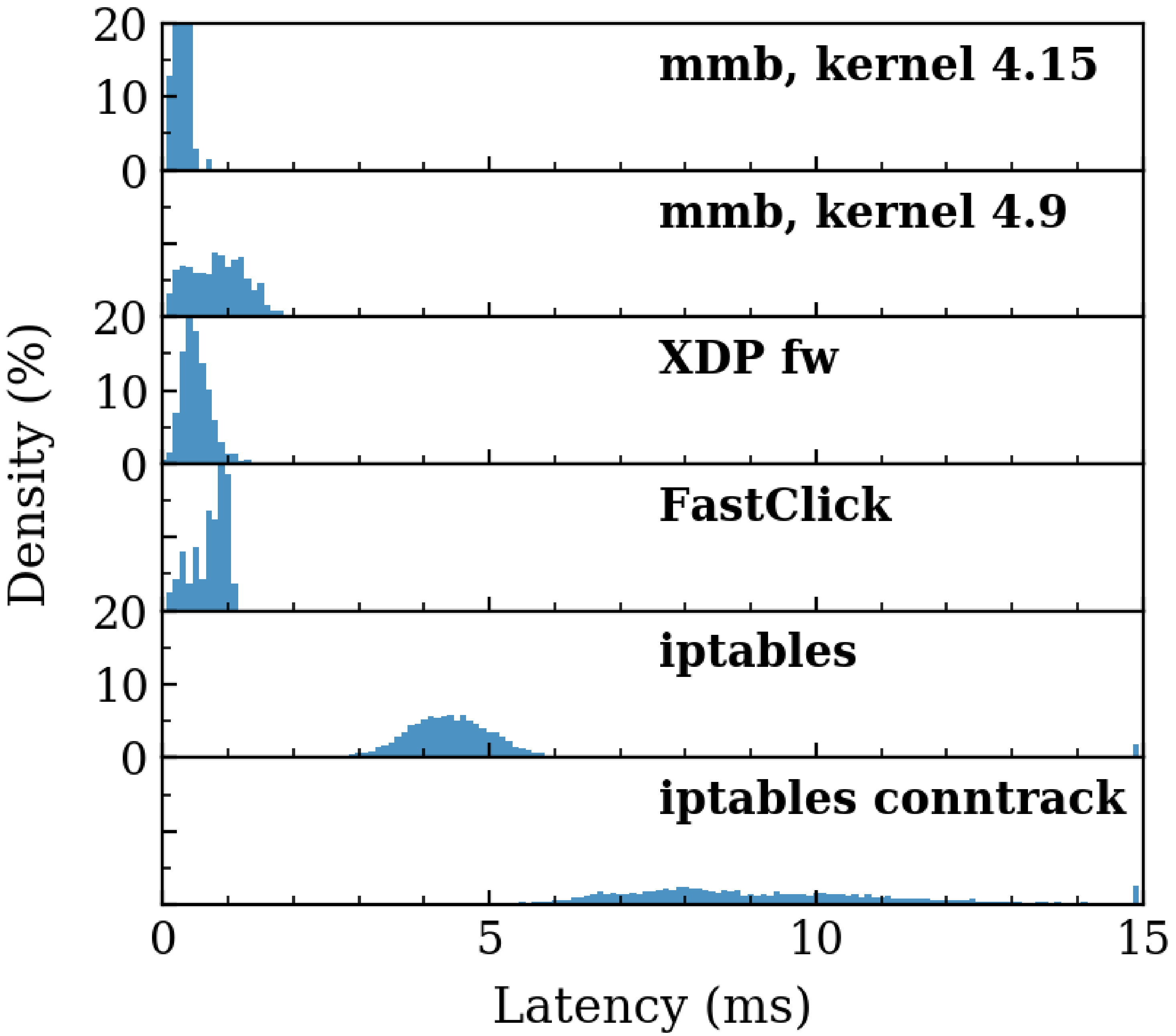
- mmb sustains line rate for different use cases
- Next Step: Payload reconstruction
- https://github.com/mami-project/vpp-mb

Thanks !

Performance Analysis: Testbed

- Intel Xeon E5-2620 2.1GHz, 16 Threads, 32GB RAM
- Intel XL710 2x40GB NICs
- Huawei CE6800 switch
- Debian 9

Performance Analysis: RTT



Performance Analysis: CPU time