TECHNION
Israel Institute
of Technology

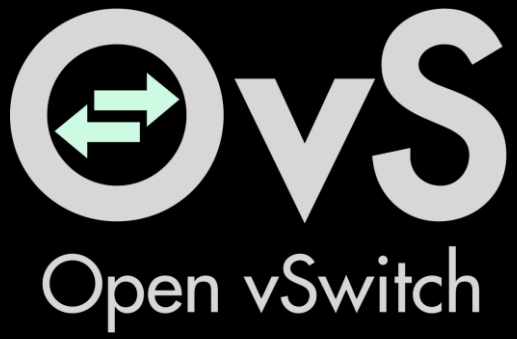
ACSL
Accelerated Computing
Systems Lab

Scaling Open vSwitch with a Computational Cache

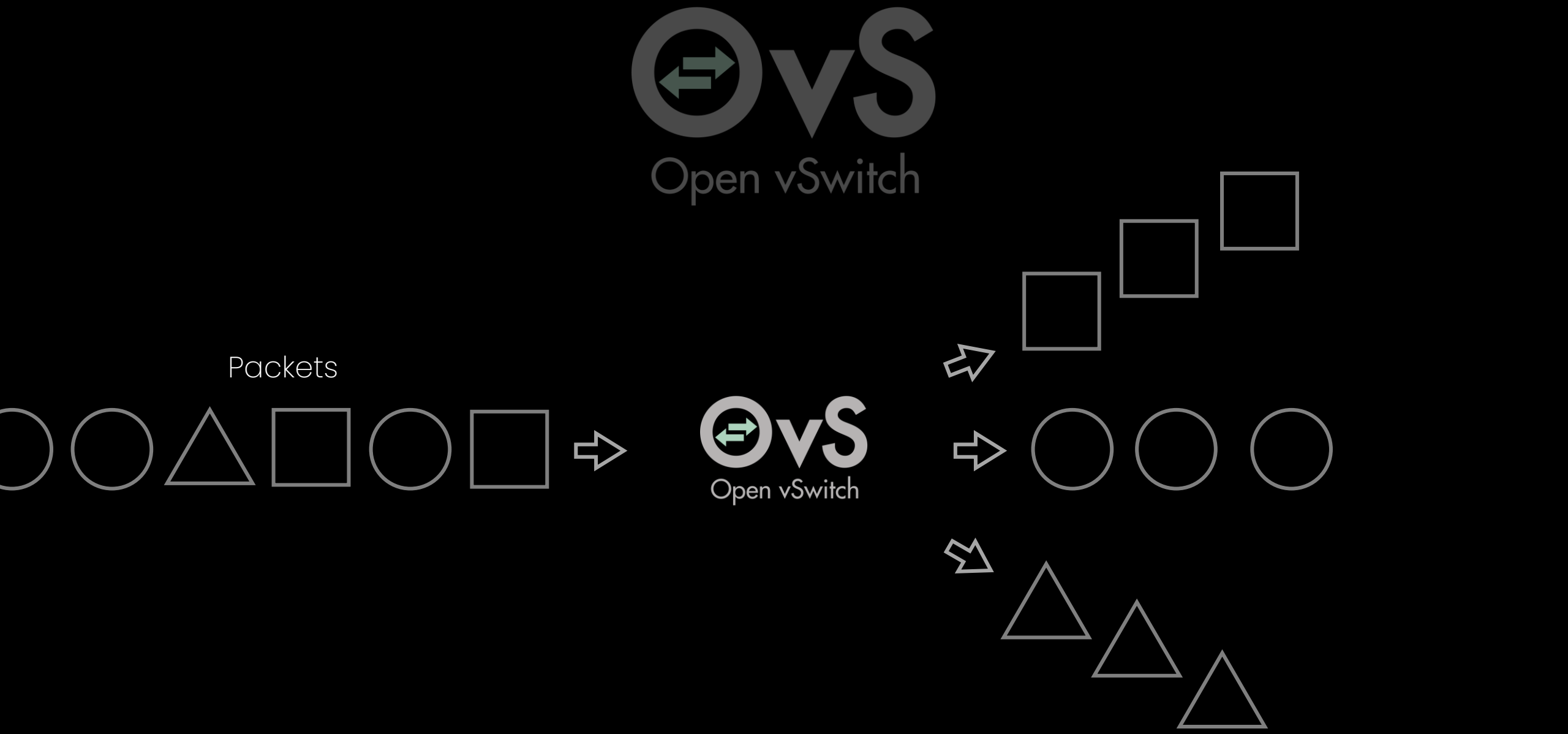
Alon Rashelbach Ori Rottenstreich Mark Silberstein

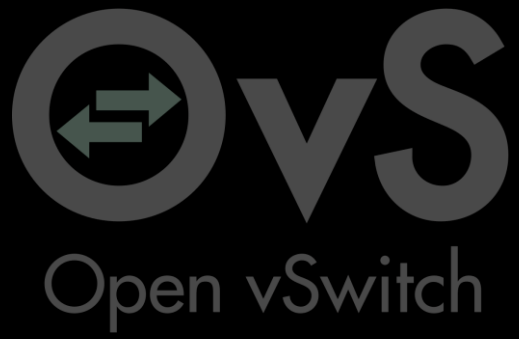
Technion, Israel

USENIX NSDI 2022

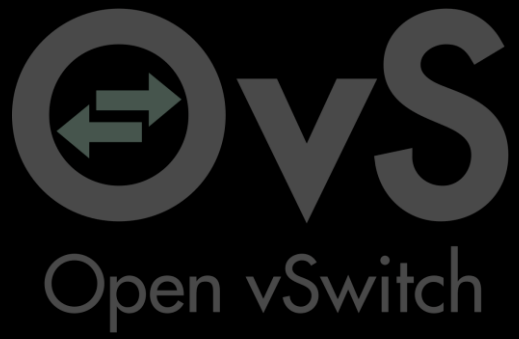


- Virtual Switch
- Open-source
- Data-centers


OvS
Open vSwitch
Packets
OvS
Open vSwitch



1K OpenFlow Rules ⇨ 500K OpenFlow Rules



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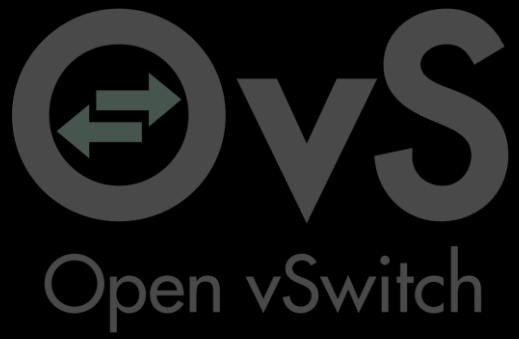
14x geomean throughput degradation

In some cases: throughput drops from a few Mpps to a few Kpps



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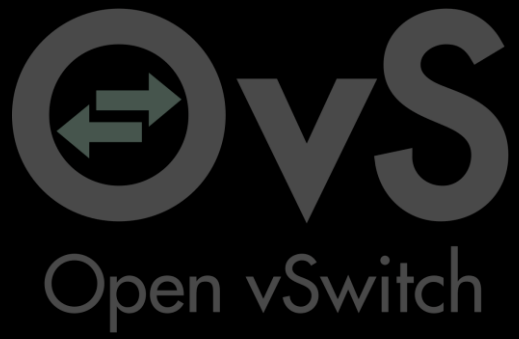
In this paper: a geomean speedup of 12x



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Neural-net inference per packet in OVS data-path

Background

Challenge

This paper

Integration with OVS

Evaluation

NuevoMatch algorithm for packet classification

(*) Rashelbach et al., "A Computational Approach to Packet Classification". *SIGCOMM 2020*.

NuevoMatch algorithm for packet classification

OpenFlow rules

Src IP	Dst IP	Action
`10.0.10.*`	`56.0.*.*`	`Port 1`
`10.0.*.*`	`56.22.7.1`	`Drop`

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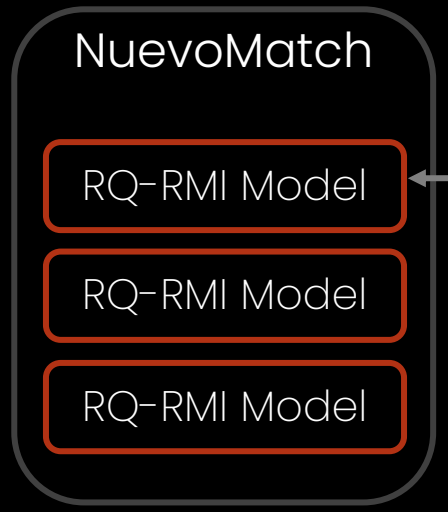

Unique model architecture
40ns NN inference on CPU

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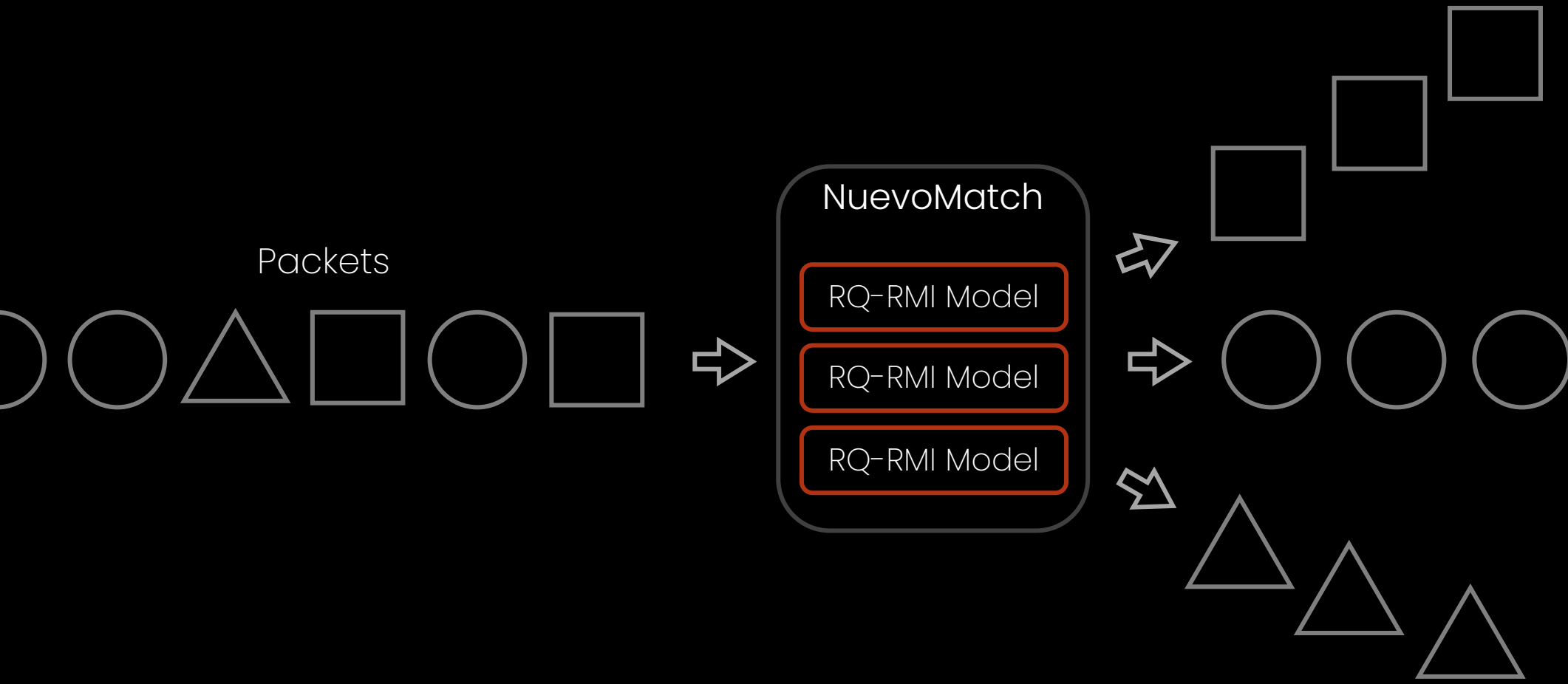
NuevoMatch algorithm for packet classification



Classifies packets on the CPU using Neural Network Inference

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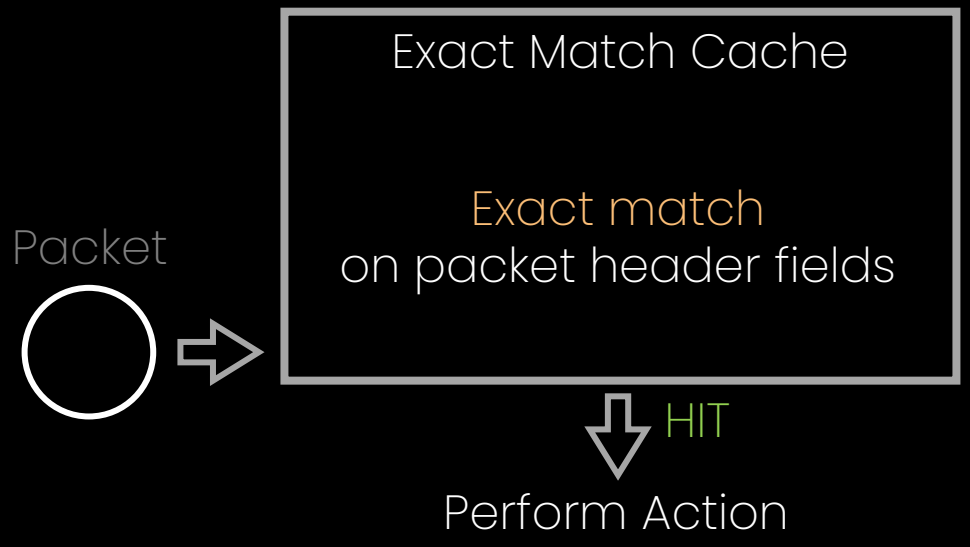
OVS Data-path

OVS Data-path



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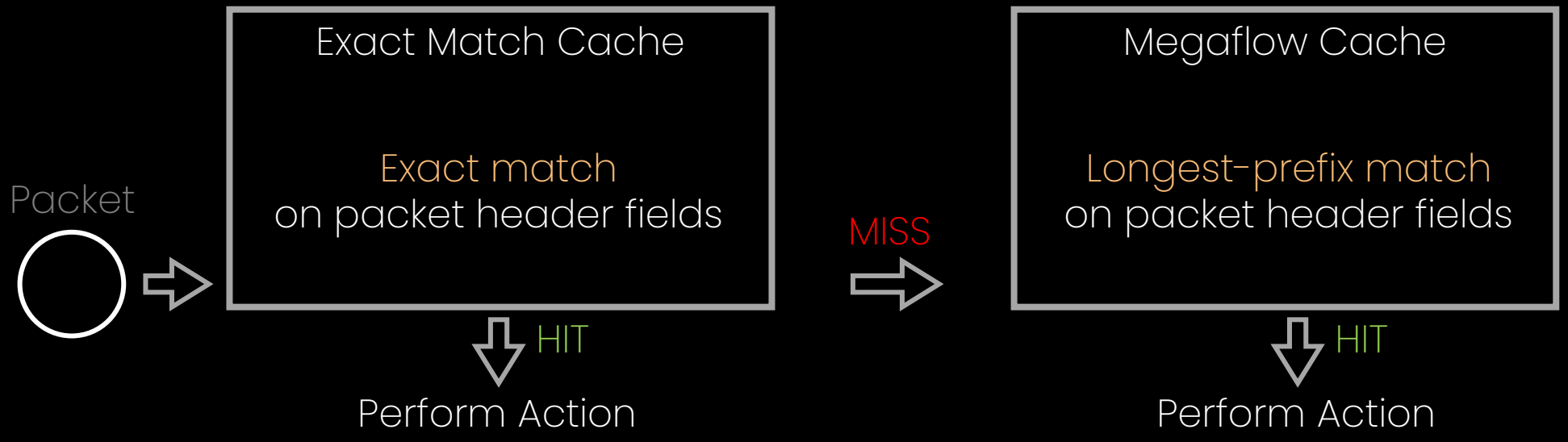

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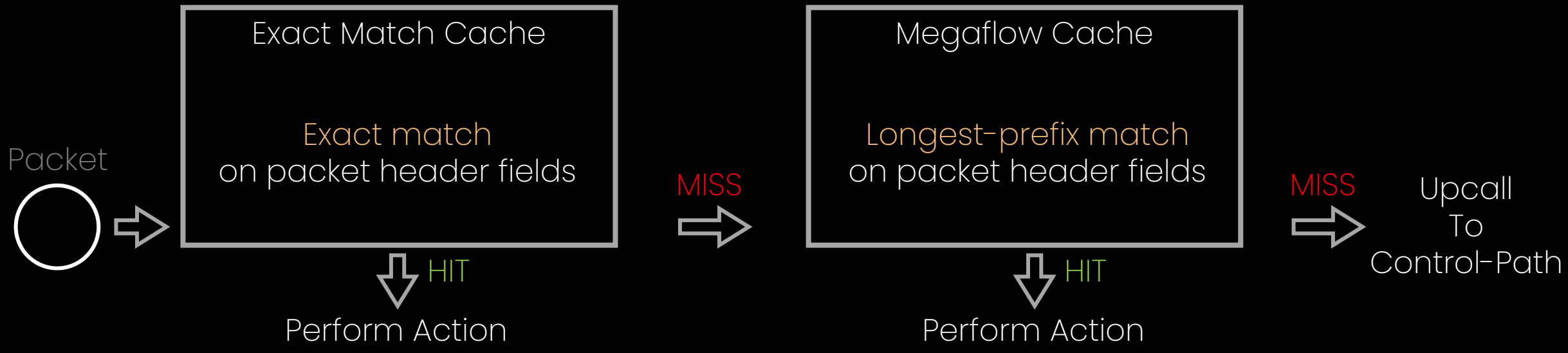
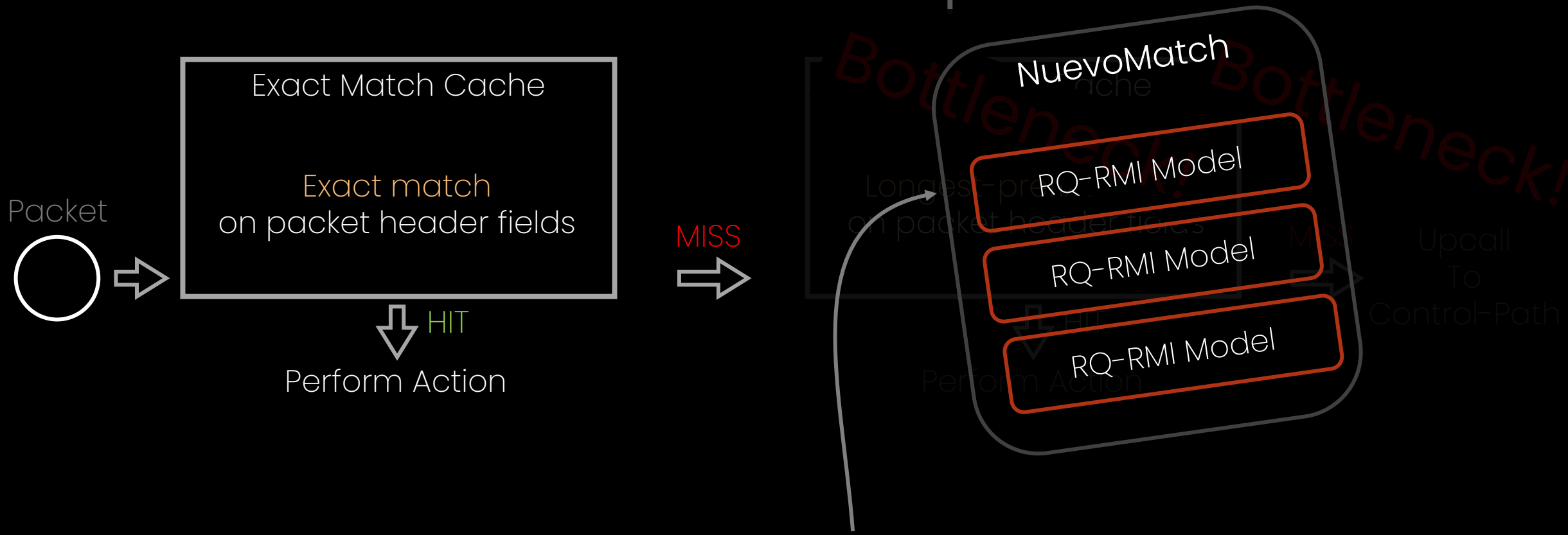


OVS Data-path

See paper for details

OVS Data-path



Can we use the **NuevoMatch** algorithm within the **OVS** data-path?

NO!

Can we use the **NuevoMatch** algorithm
within the **OVS** data-path?

Challenge: Slow Updates

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NuevoMatch uses neural-nets

to learn rules

Neural-nets must be trained

when rules change

The training time depends

on the total number of rules

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Train once

Challenge: Slow Updates

NuevoMatch uses neural-nets

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Neural-nets must be trained

when rules change

The training time depends

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Train fast

Must Support Frequent Updates

100K updates per second (on average)

(*) Katsikas et al. What you need to know about (smart) network interface cards. PAM, 2021.

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Training an RQ-RMI model with 100K+ rules
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Training an RQ-RMI model with 100K+ rules takes **5-20 minutes!**

NuevoMatch update rate is 1000x slower!

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Background: RQ-RMI models in NuevoMatch

Range: a single rule field

Row num	Range
1	0-100
2	130-700
3	800-803
4	807-890
5	970-990
6	991-991

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Sample the table for generating [range, #row] *tuples on the fly*

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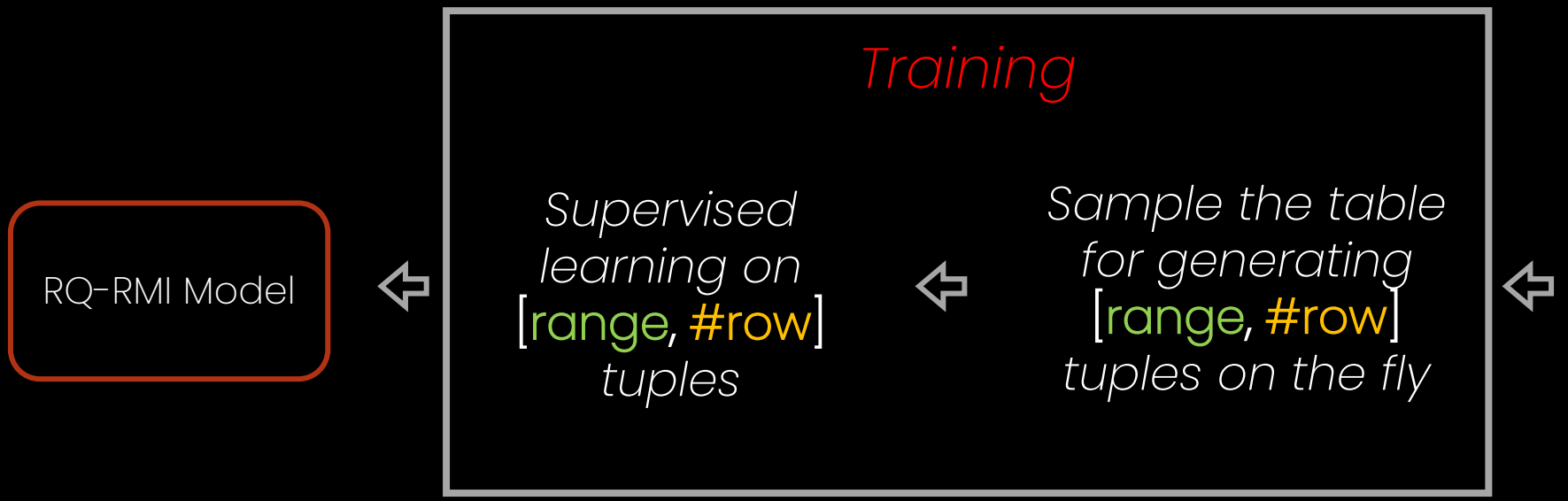
Sample the table for generating [range, #row] *tuples on the fly*

Supervised learning on [range, #row] *tuples*

RQ-RMI Model

Background: RQ-RMI models in NuevoMatch



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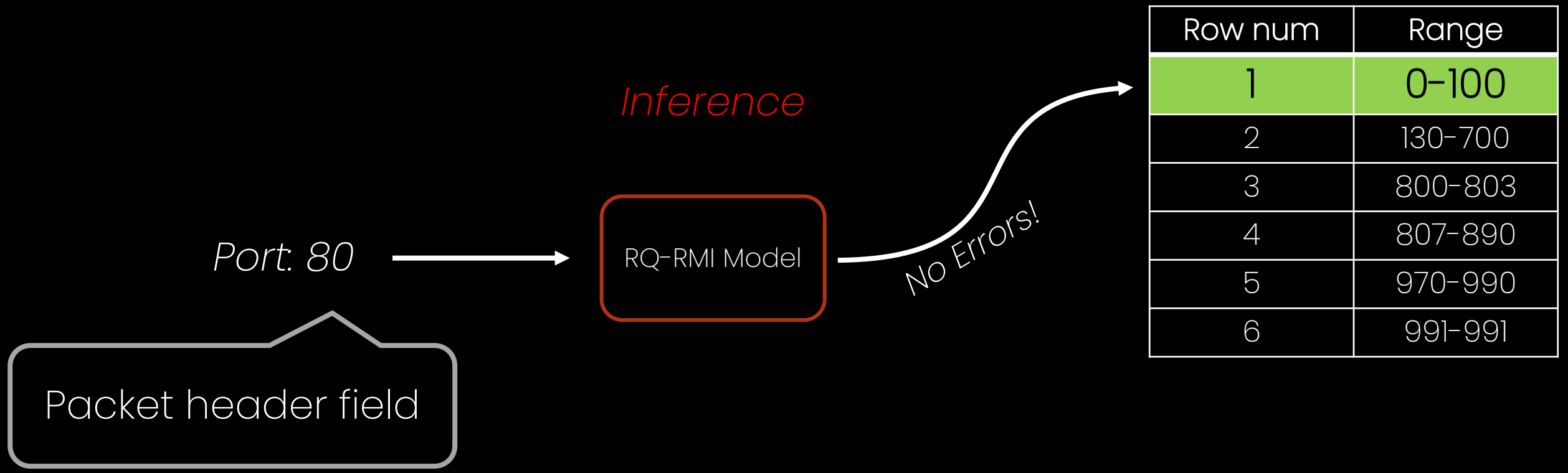

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introducing *NuevoMatch**UP***

speeding-up NuevoMatch updates

introducing *NuevoMatch**UP***

speeding-up NuevoMatch updates

Three orthogonal improvements:

Bucketizing Ranges

Efficient SIMD implementation

Optimized sampling (see paper)

introducing *NuevoMatch**UP***

speeding-up NuevoMatch updates

Bucketizing Ranges

Row num	Range
1	0–10
2	20–30
3	40–50
4	60–70
5	80–90
6	100–110

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Bucketizing Ranges

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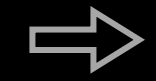

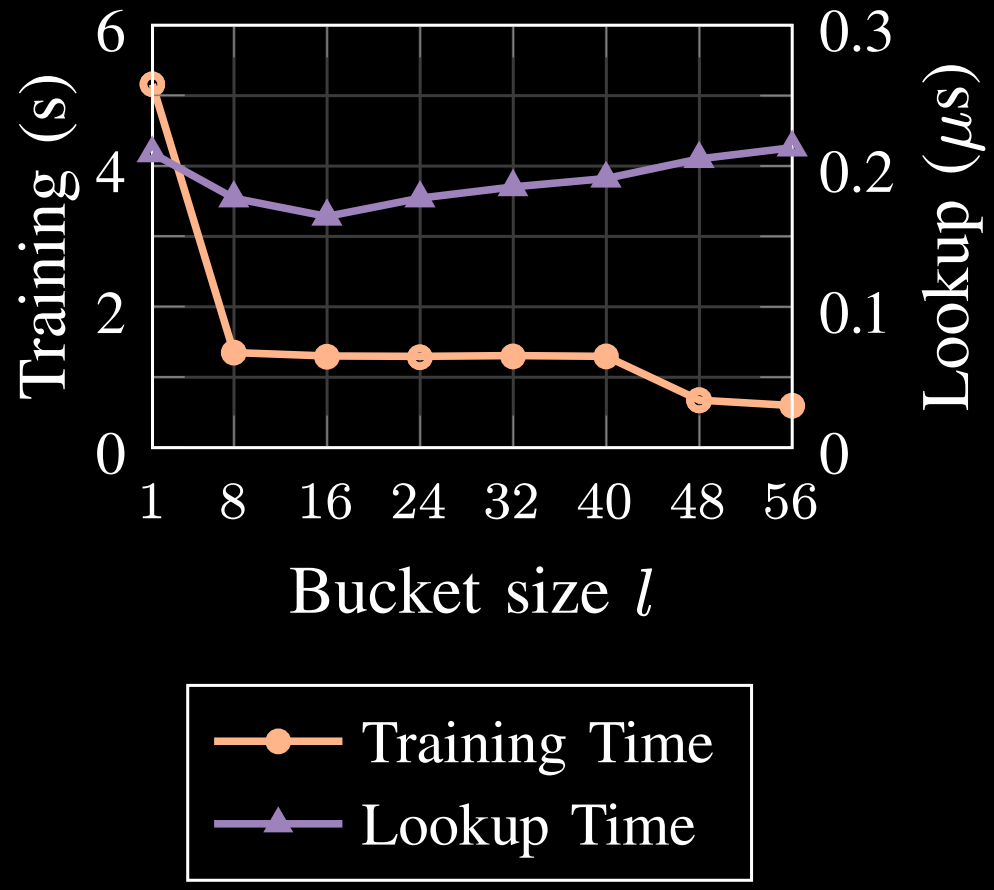

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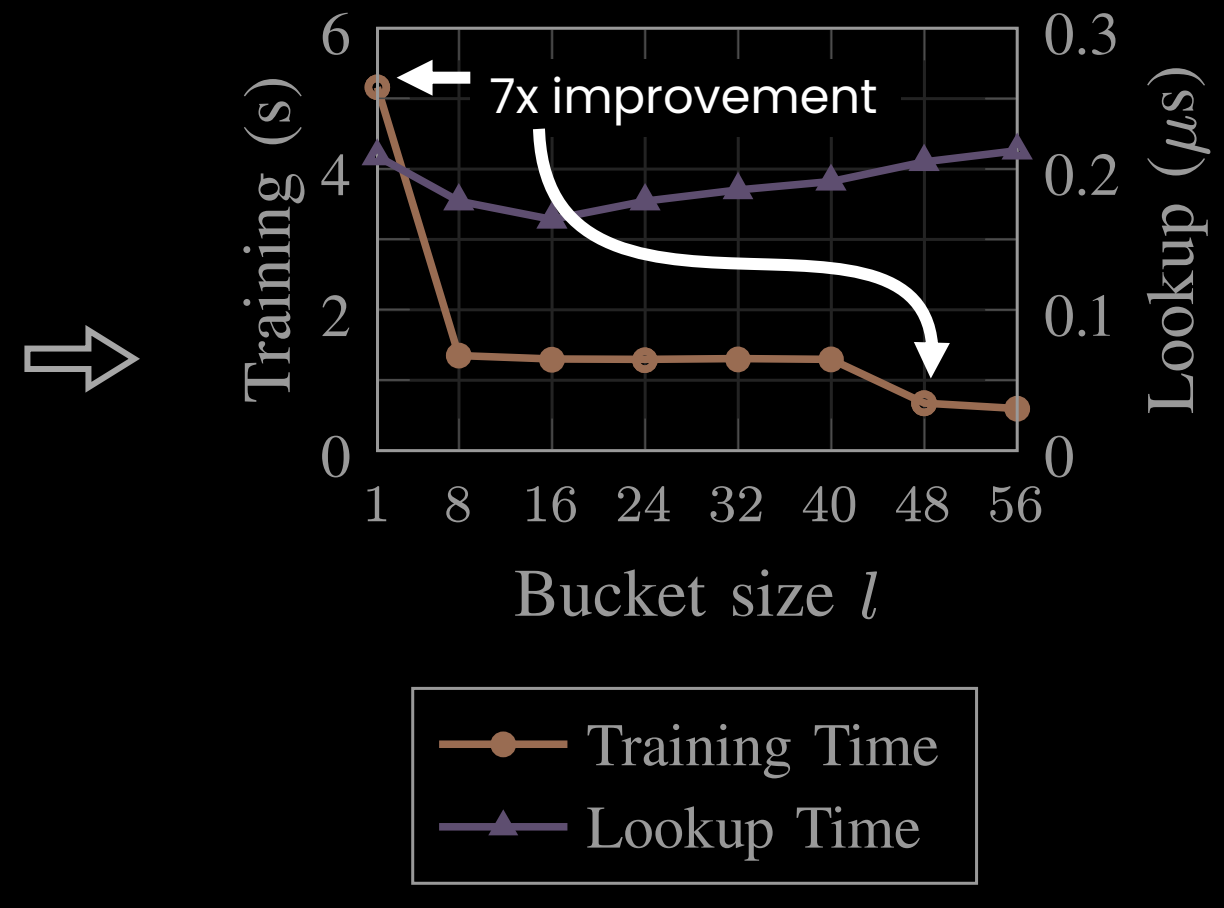

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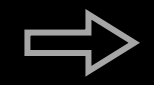

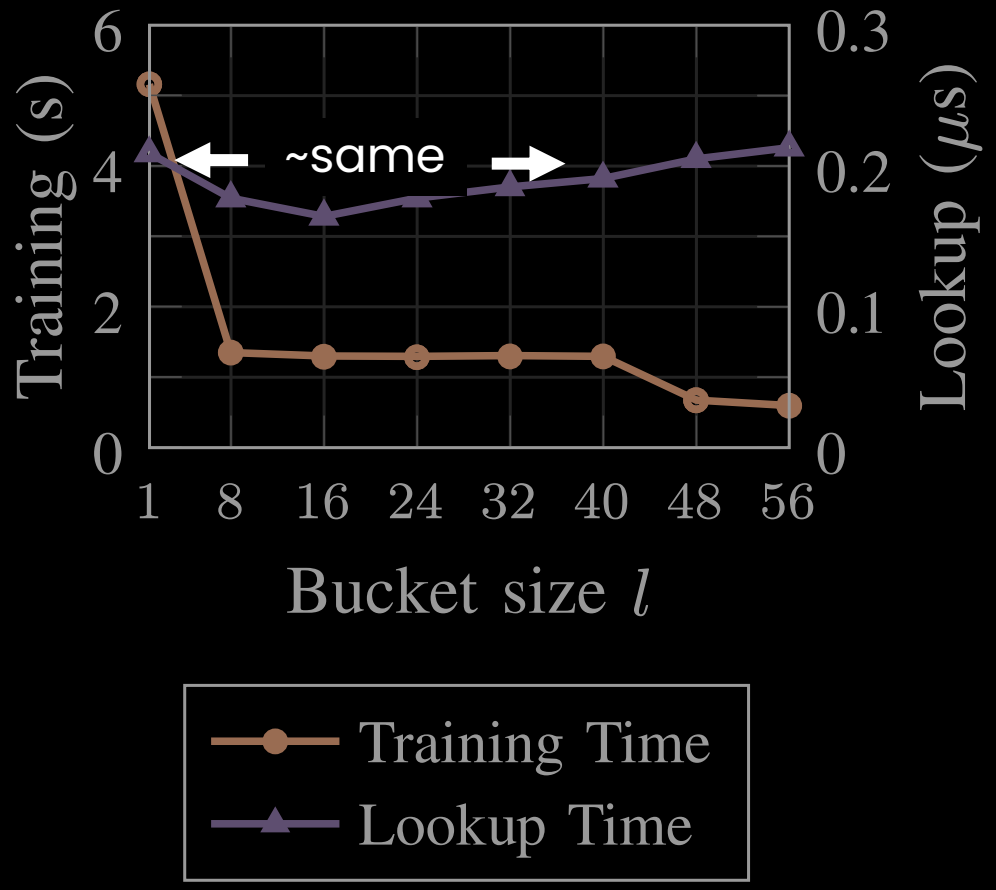

introducing *NuevoMatch**UP***

speeding-up NuevoMatch updates

Efficient SIMD Implementation

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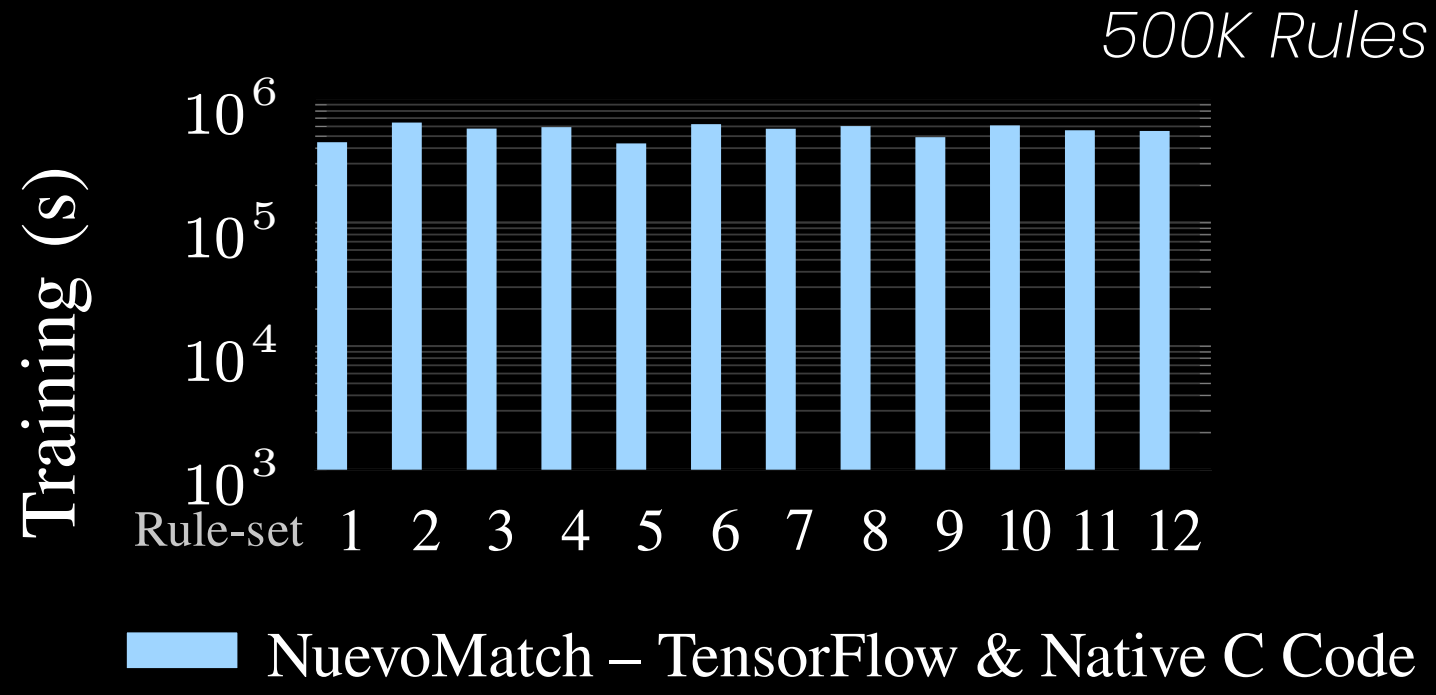

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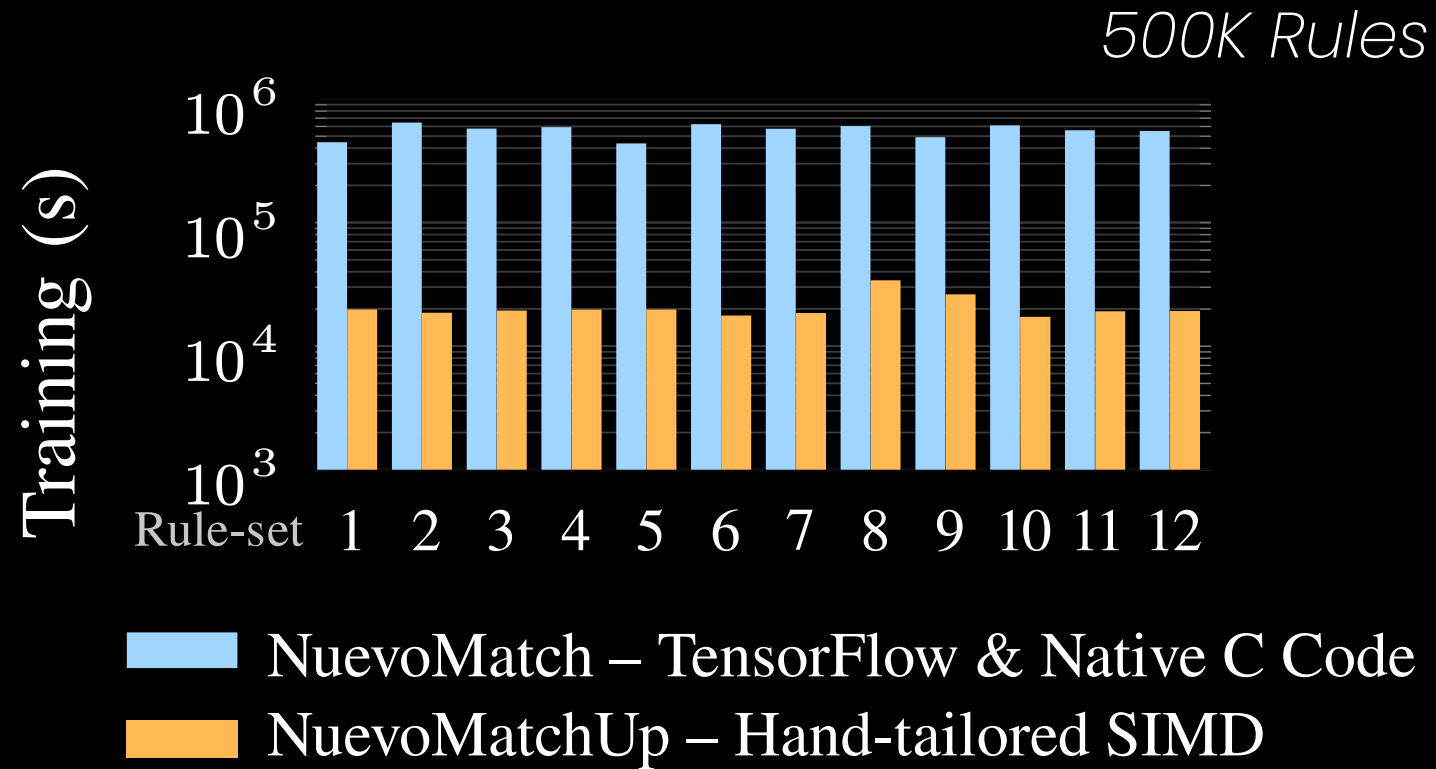
Efficient SIMD Implementation



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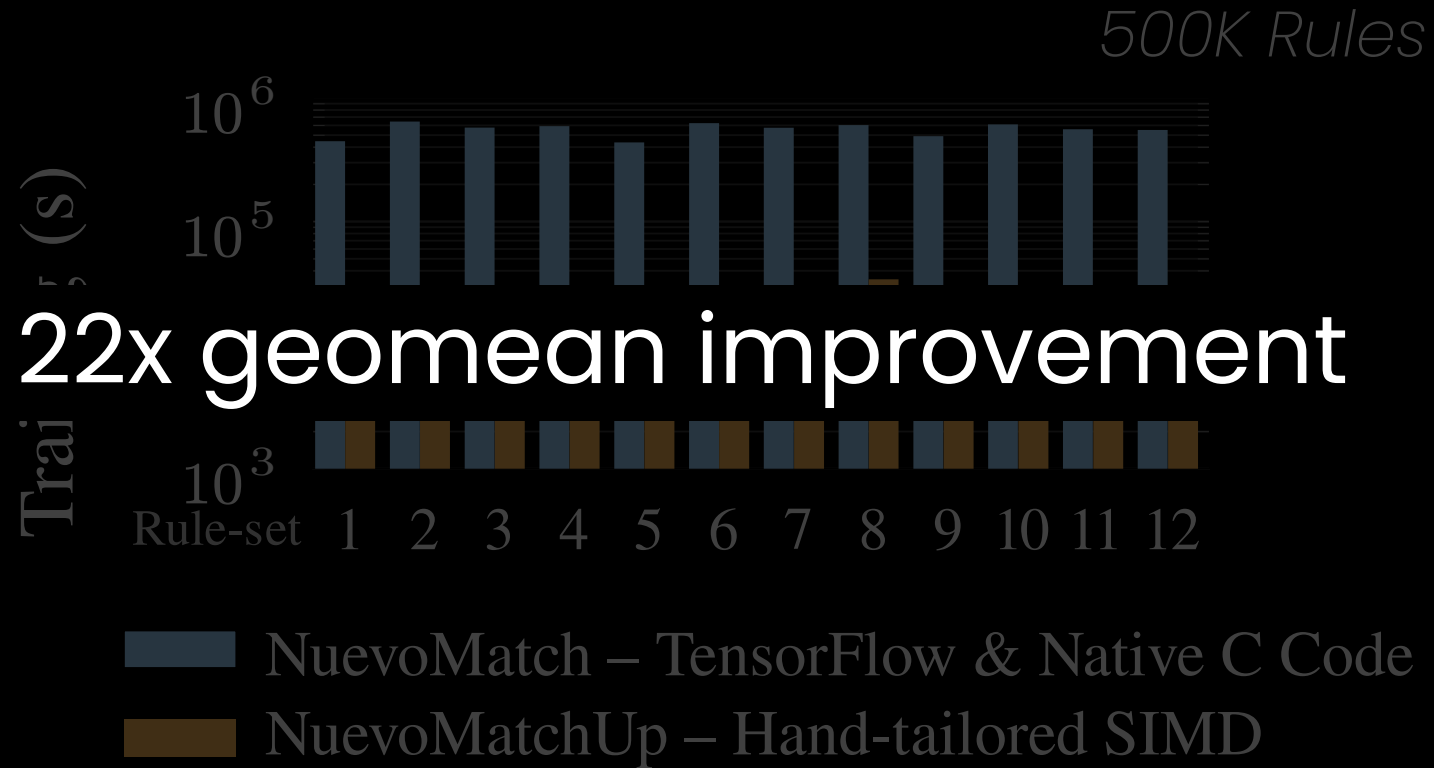
Efficient SIMD Implementation



22x geomean improvement

introducing *NuevoMatch**UP***

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Together:

Three orders of magnitude faster training

over NuevoMatch

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Together:

Three orders of magnitude faster training

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*NuevoMatch**UP*** can be integrated into OVS data-path!

Background

Challenge

This paper

Integration with OVS

Evaluation

*NuevoMatch**UP*** → OvS Open vSwitch

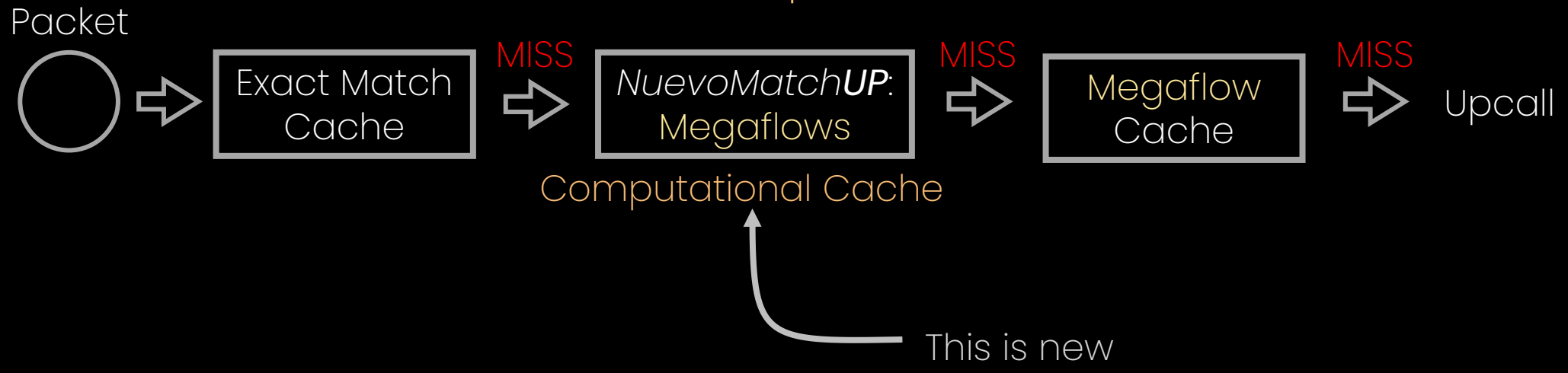
Two Design Options

for OVS data-path

*NuevoMatch**UP*** → OvS Open vSwitch

Two Design Options

(1) OVS with a Computational Cache



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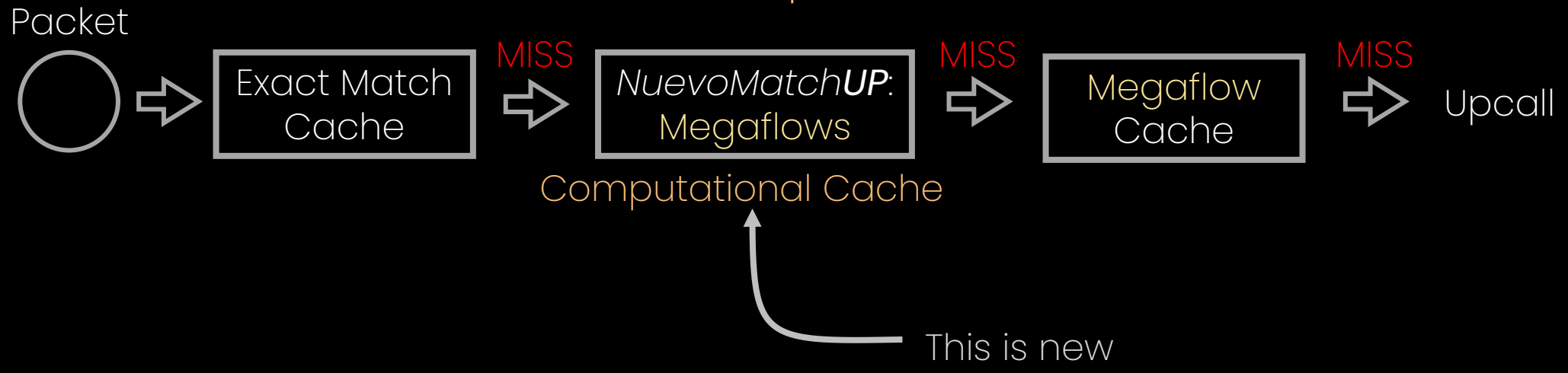

Works with Megaflows
Minor changes to OVS

*NuevoMatch**UP*** → OvS Open vSwitch

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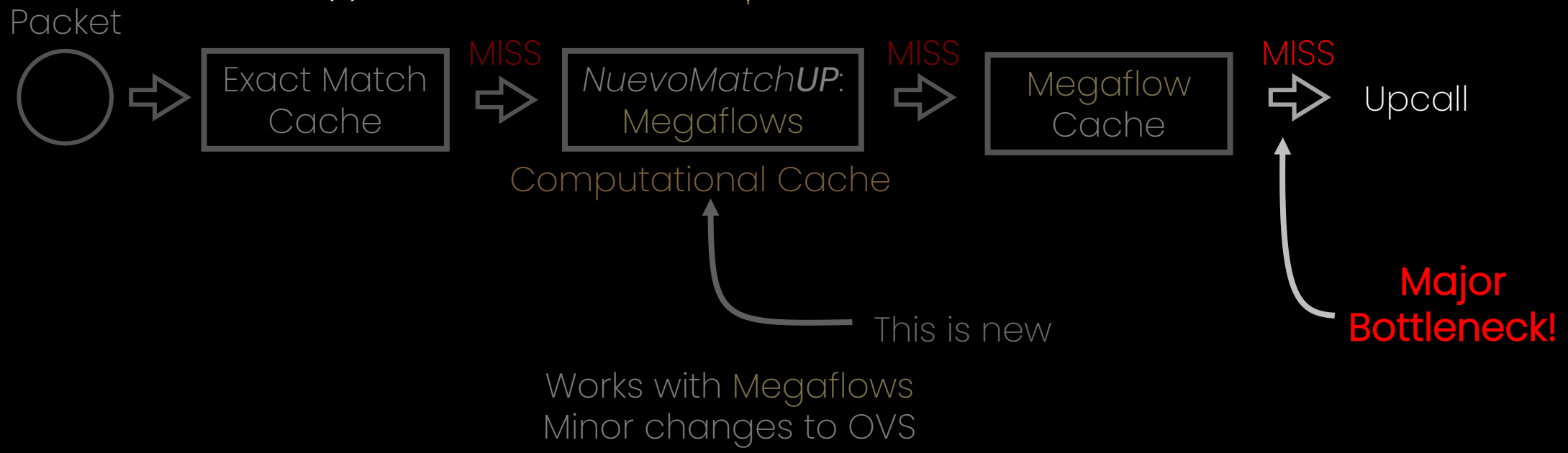

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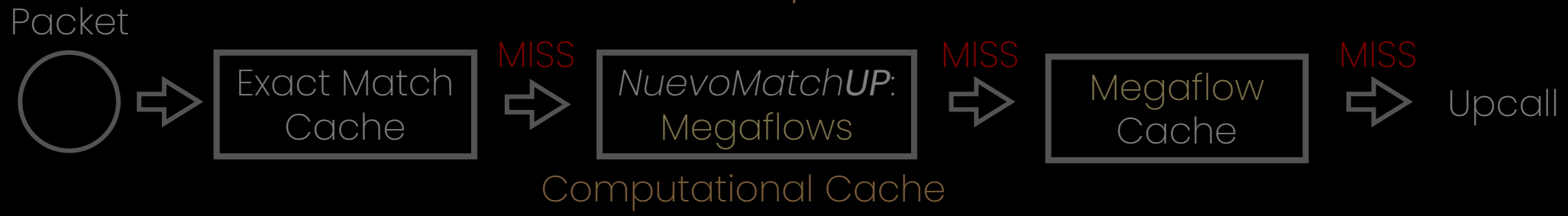

(2) OVS with Computational *Flows*

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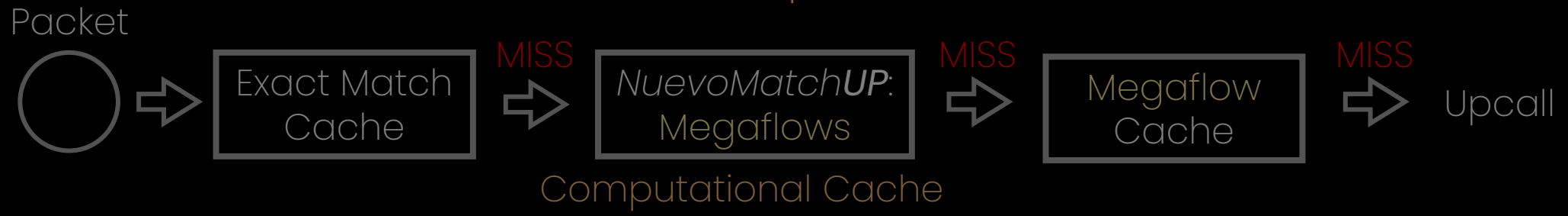

(2) OVS with Computational *Flows*

A paradigm shift: data-path matching on OpenFlow rules

No Upcalls!

*NuevoMatch**UP*** → OvS Open vSwitch

Two Design Options

(1) OVS with a Computational Cache

We design, implement, and integrate both into OVS DPDK data-path

(2) OVS with Computational Flows

A paradigm shift: data-path matching on OpenFlow rules

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End to End Results

10Gbps NICs

ClassBench

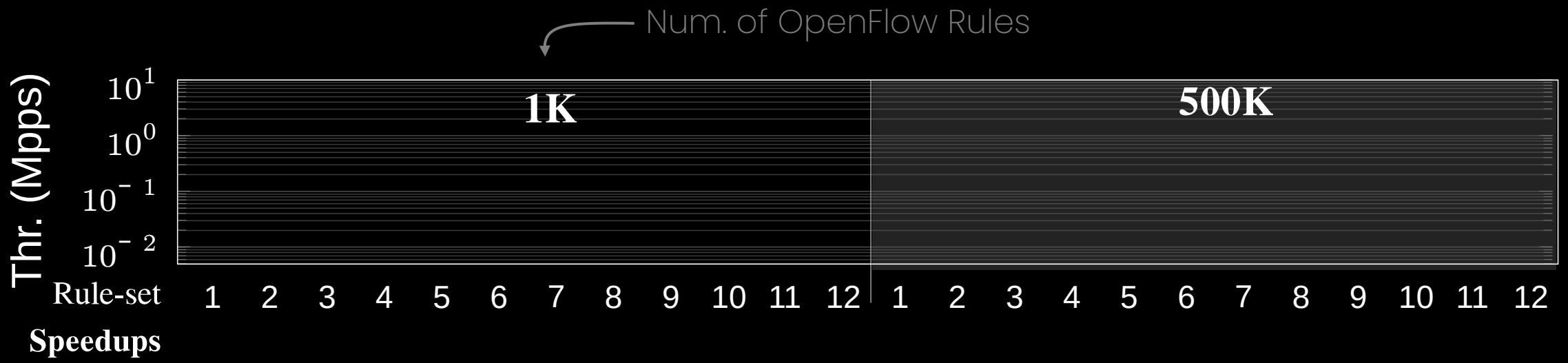
CAIDA

Max 1% Drops

NuevoMatchUP → OvS

Open vSwitch

End to End Results



NuevoMatchUP → OvS

Open vSwitch

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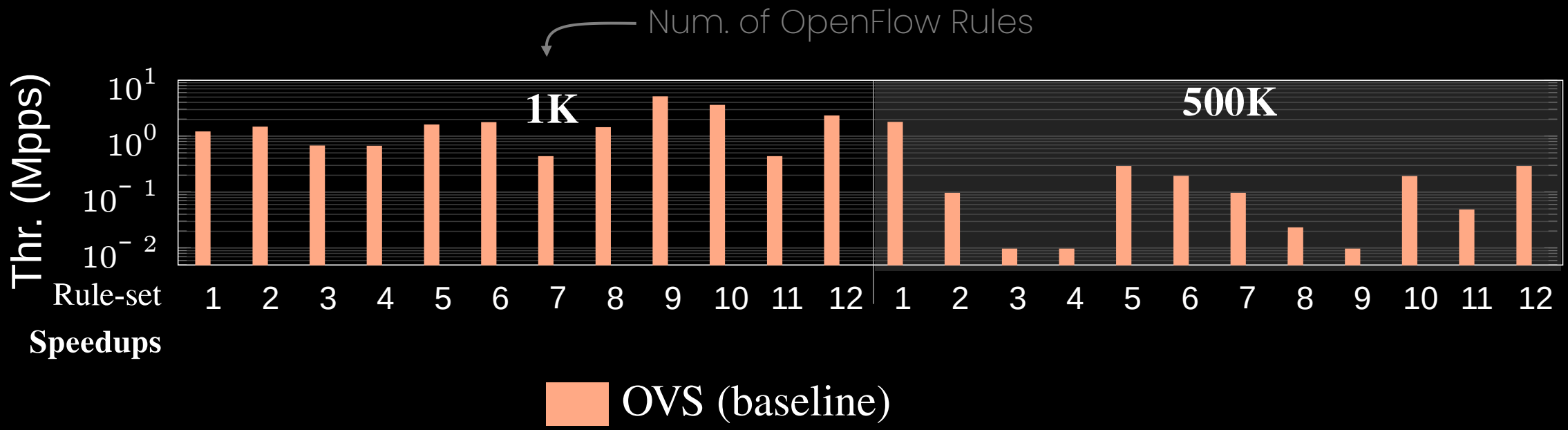

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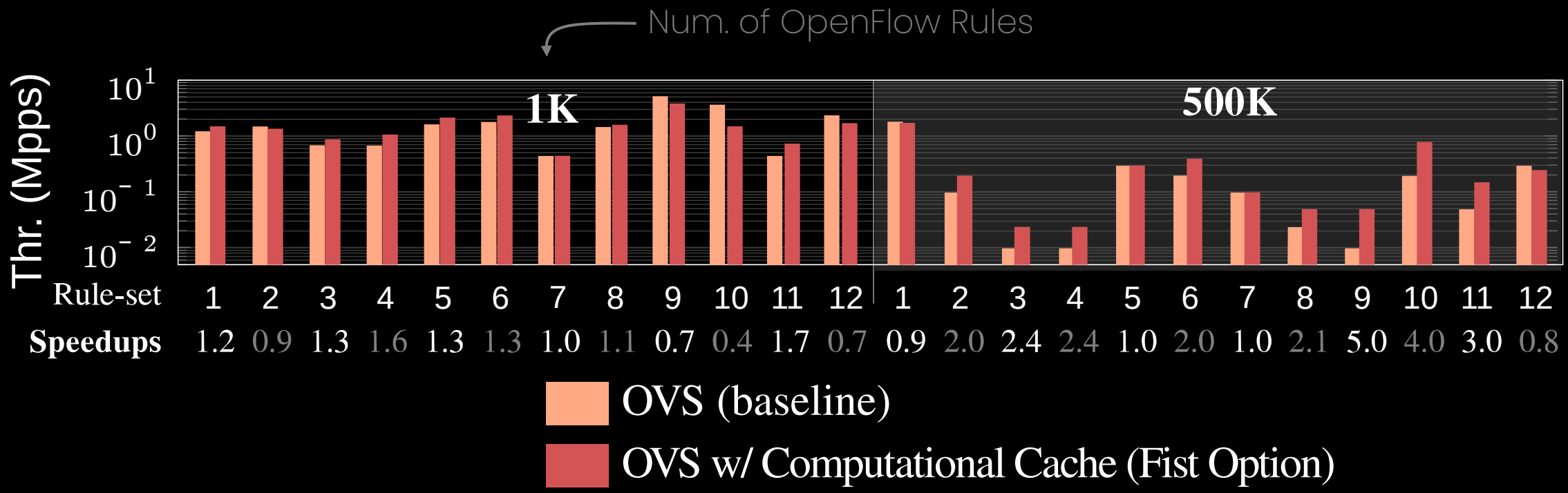

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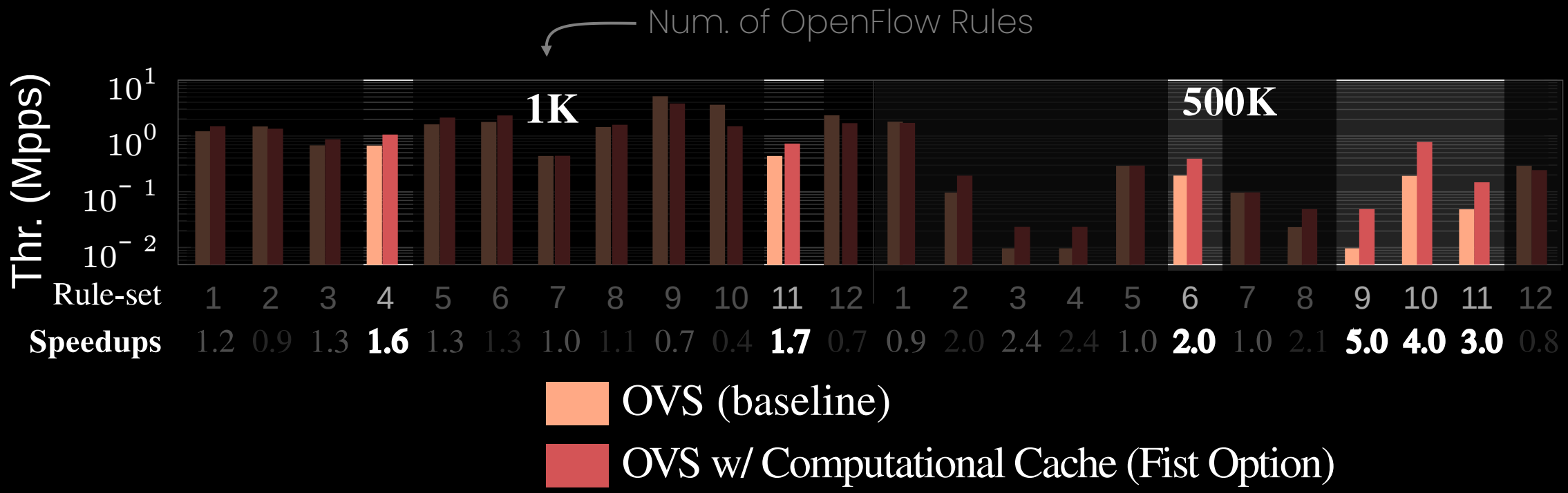

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Open vSwitch

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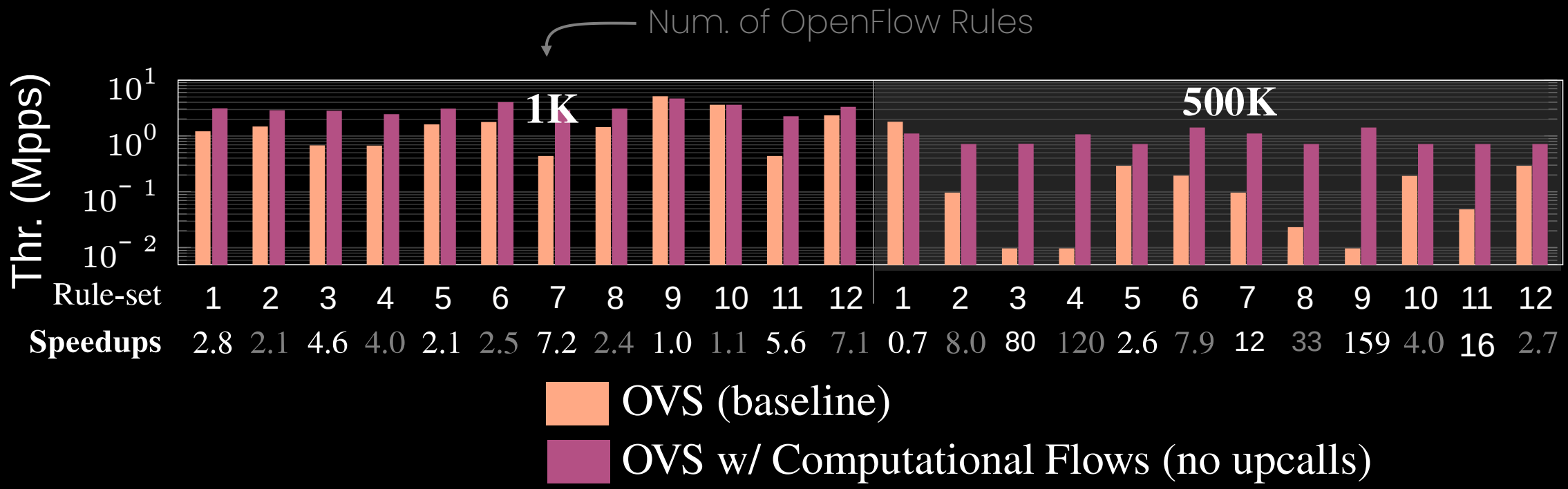

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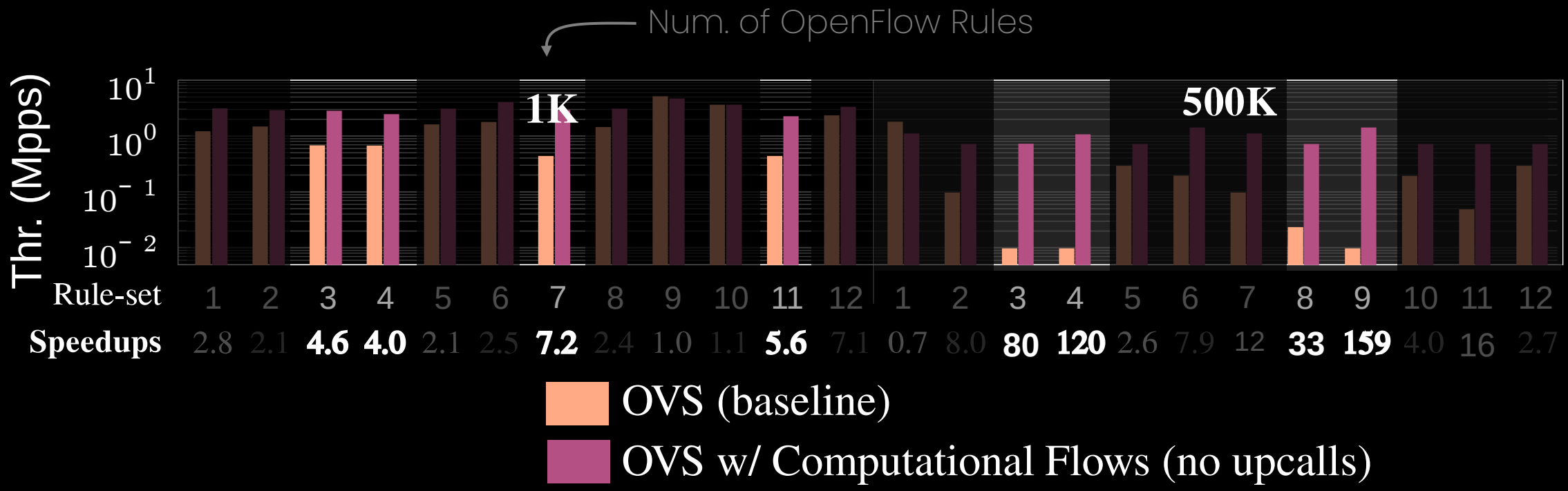

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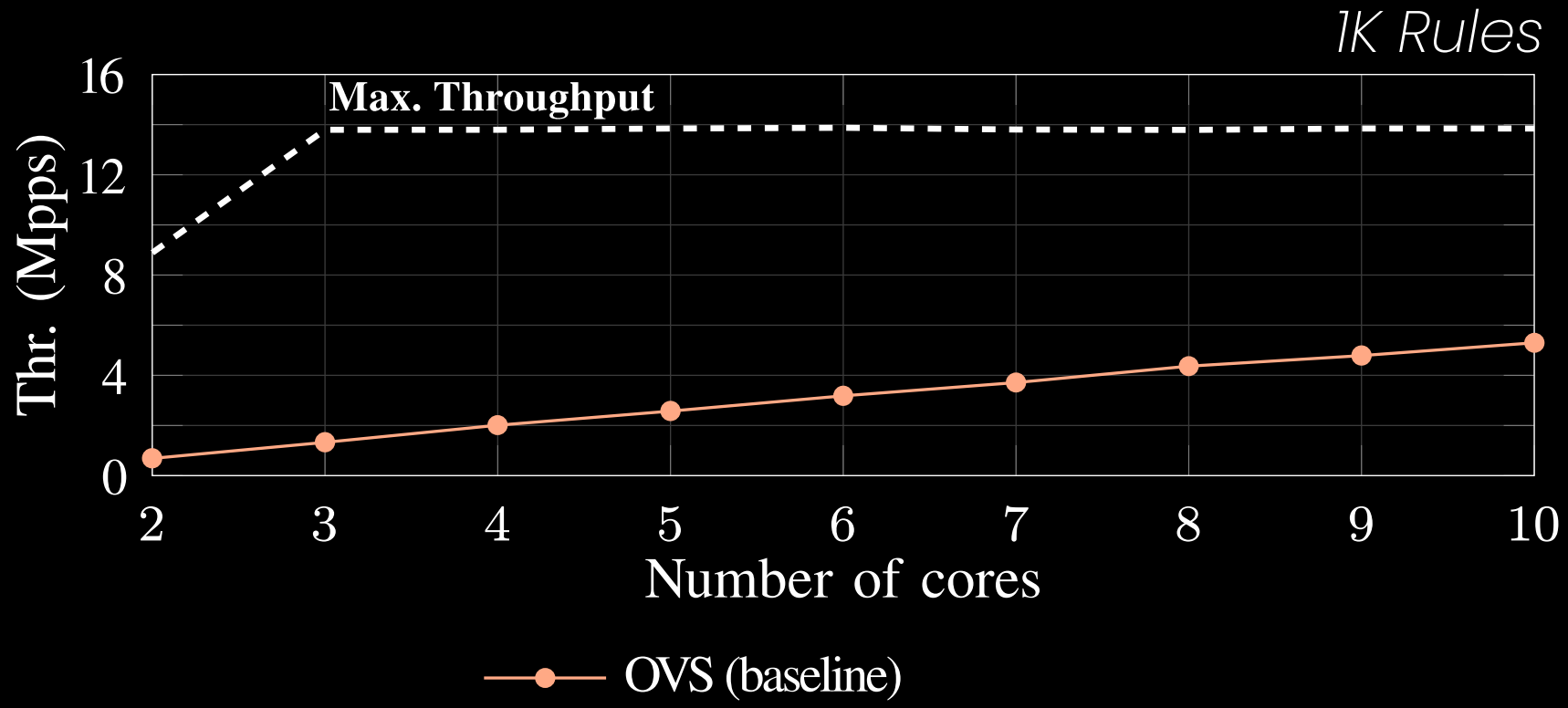
Open vSwitch

Scalable to #Cores



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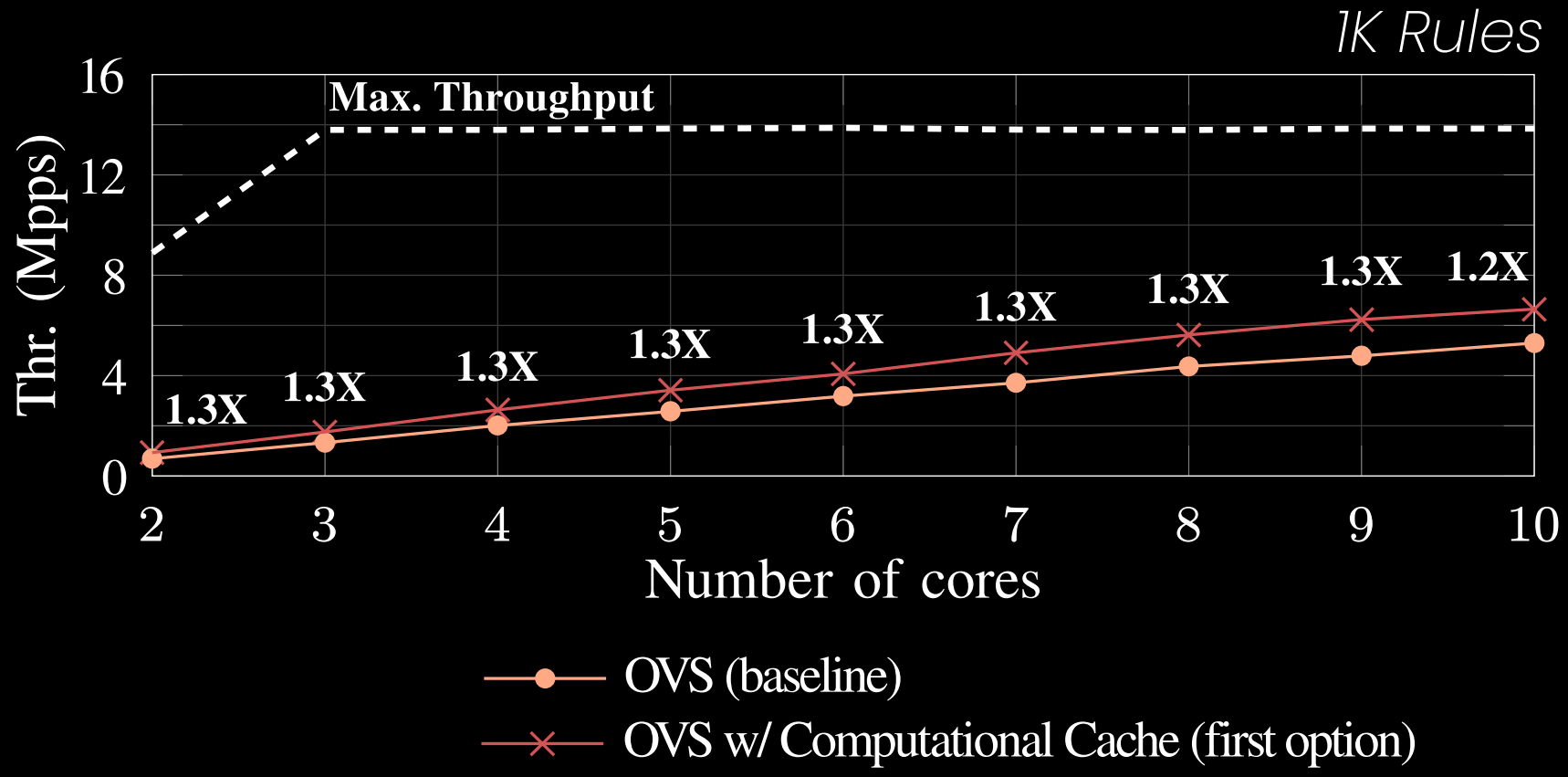
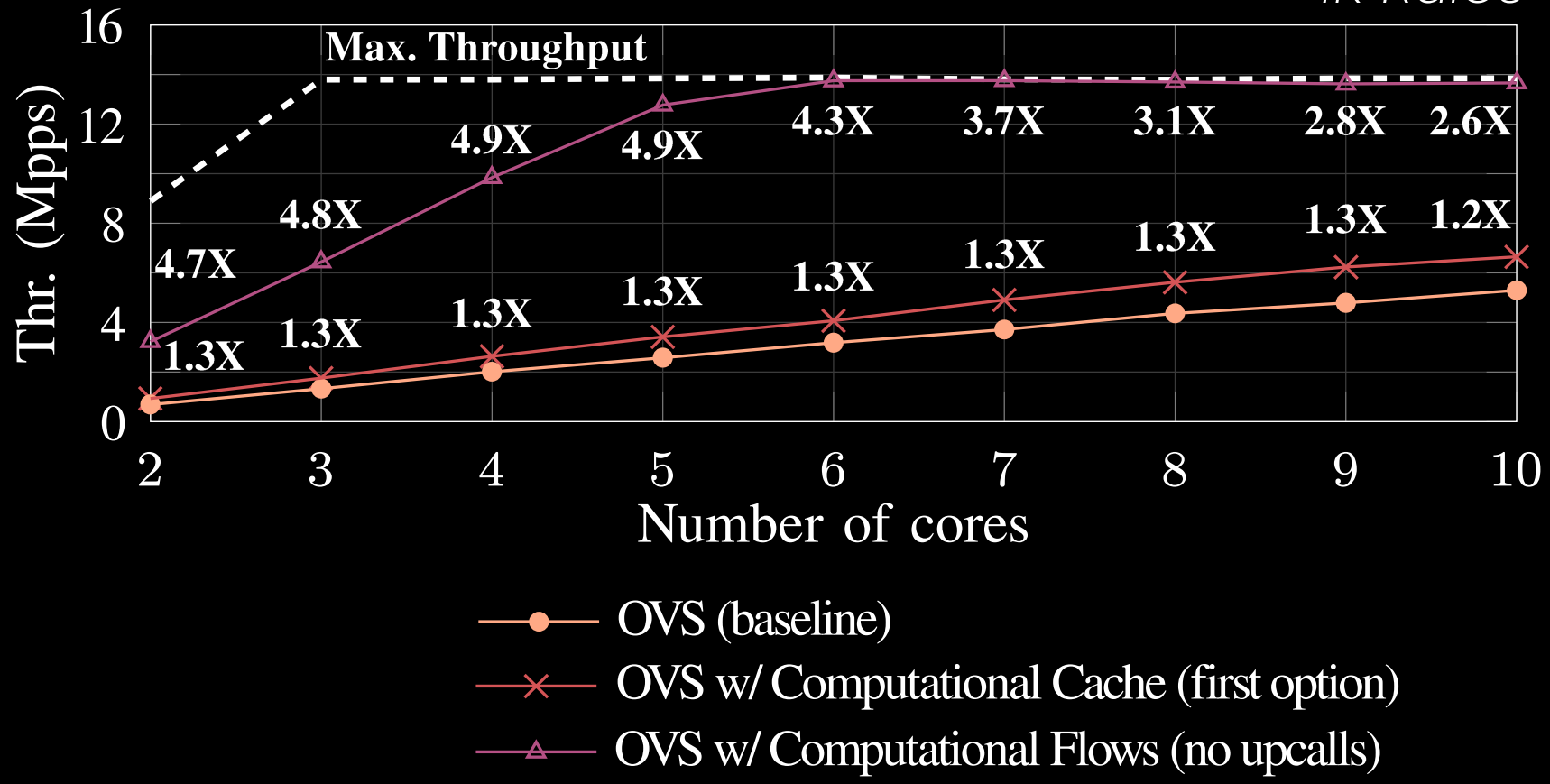


NuevoMatchUP → OvS

Open vSwitch

Scalable to #Cores

1K Rules



See Paper for

1. Throughput over time experiments
2. Throughput in the presence of updates
3. Microbenchmarks
4. And more...

Conclusions

1. Fast neural-net training for high update rates
2. New design of the OVS data-path
3. Readily deployable to commodity hardware

Future Work

1. NuevoMatchUP for P4
2. Reducing the need for training
3. Hardware acceleration

Future Work

1. NuevoMatchUP for P4
2. Reducing the need for training
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Thank You

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