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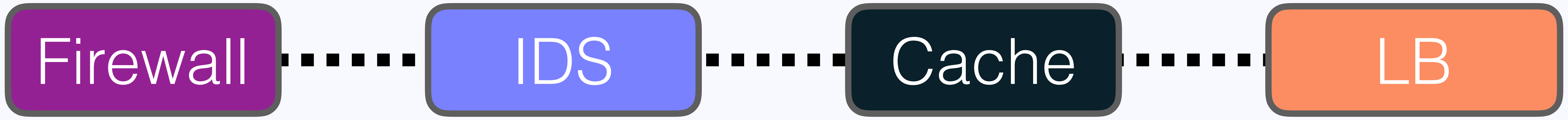
- **NF Chaining**: Packets go through sequence of NFs



Challenges for NFV

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  - **Isolation** and **Performance**

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- **Running NFs**
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Running NFs

Isolation

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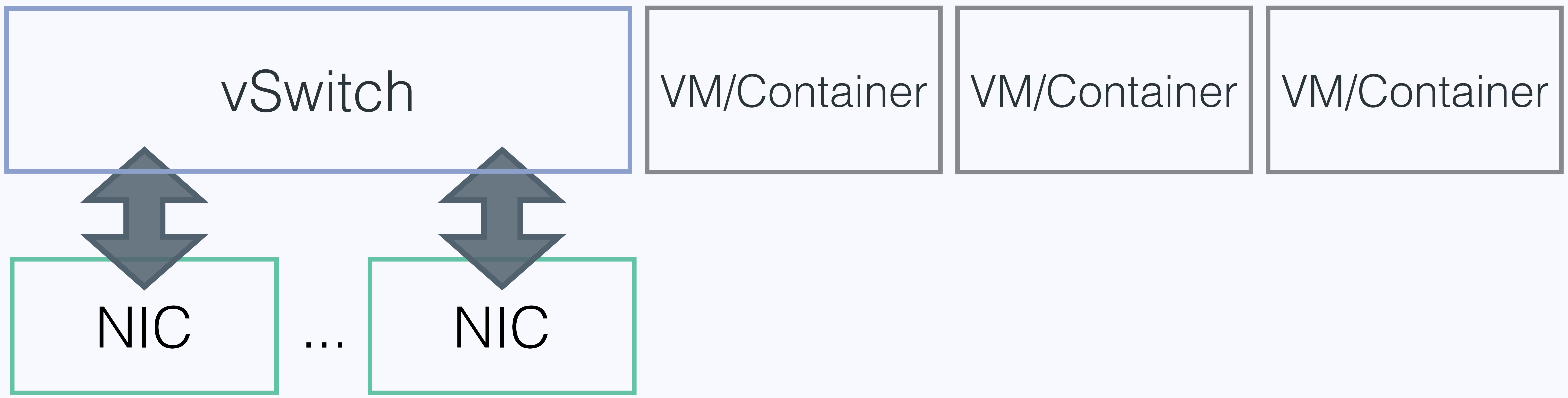
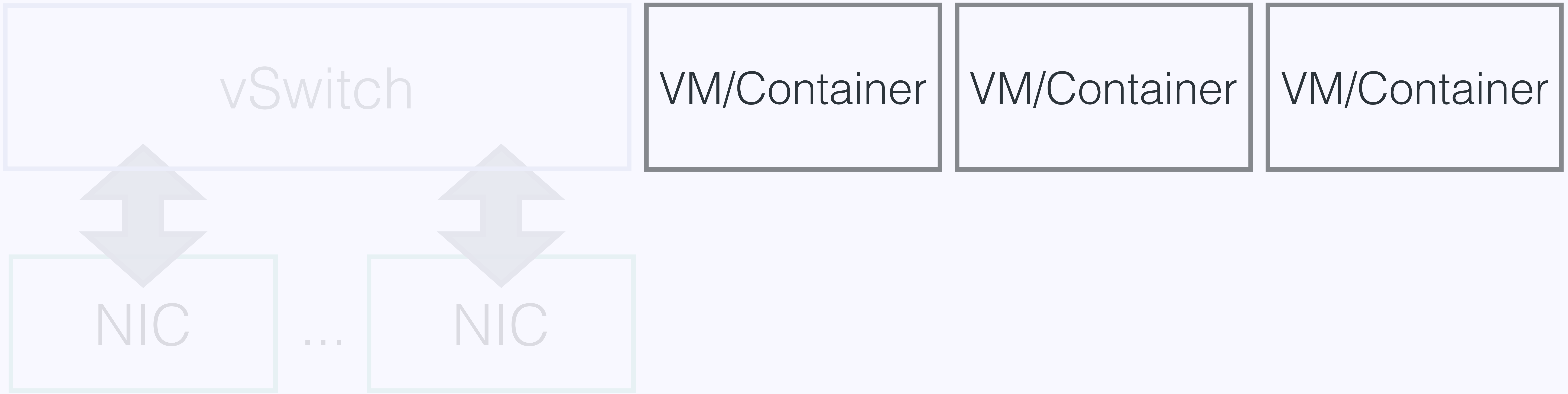


Memory Isolation

Packet Isolation

Performance

Current Solution



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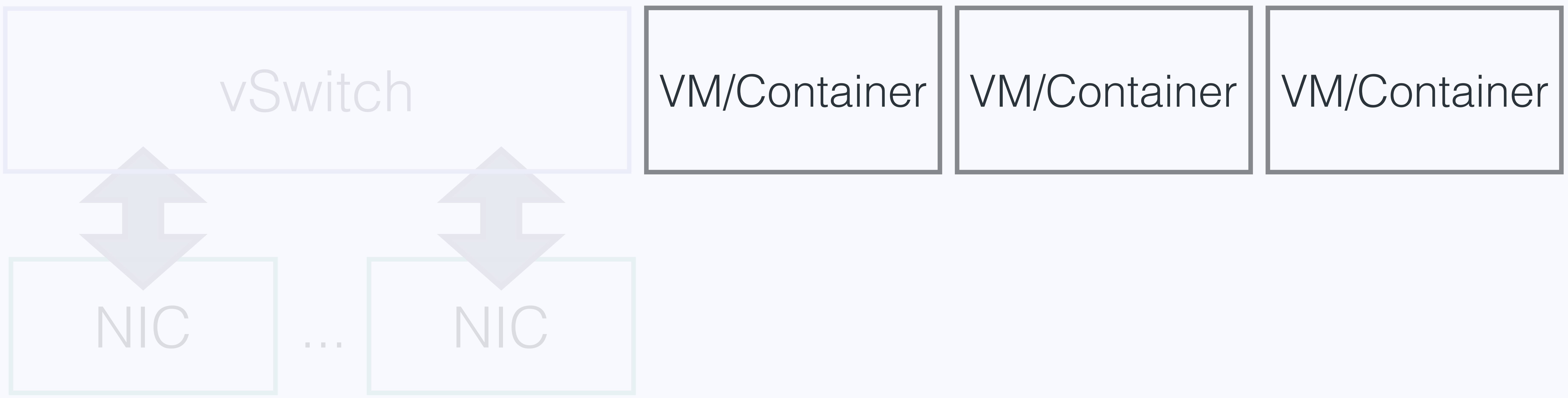

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Packet Isolation

Performance

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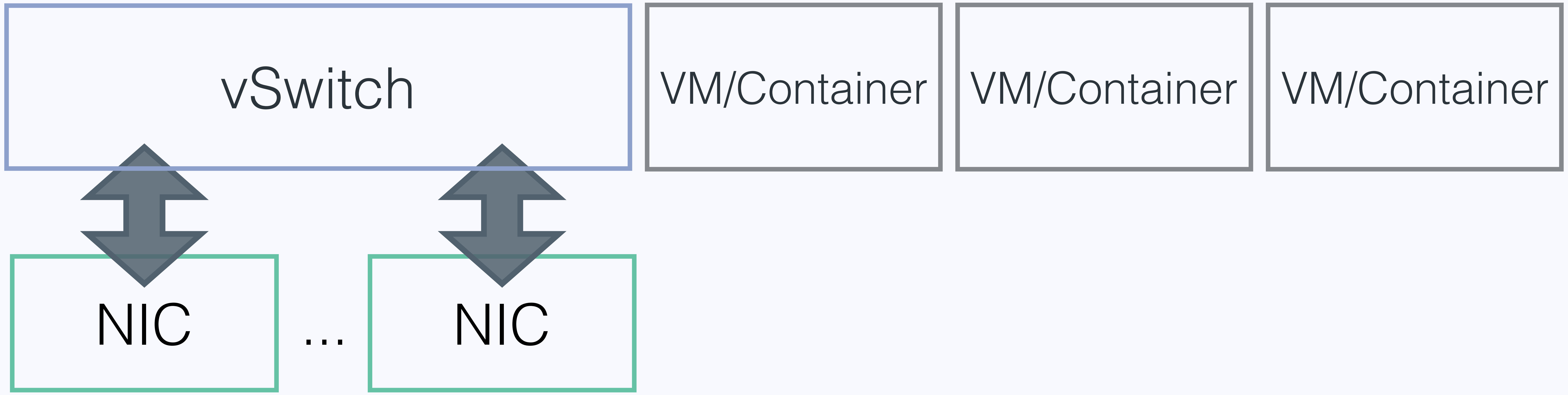

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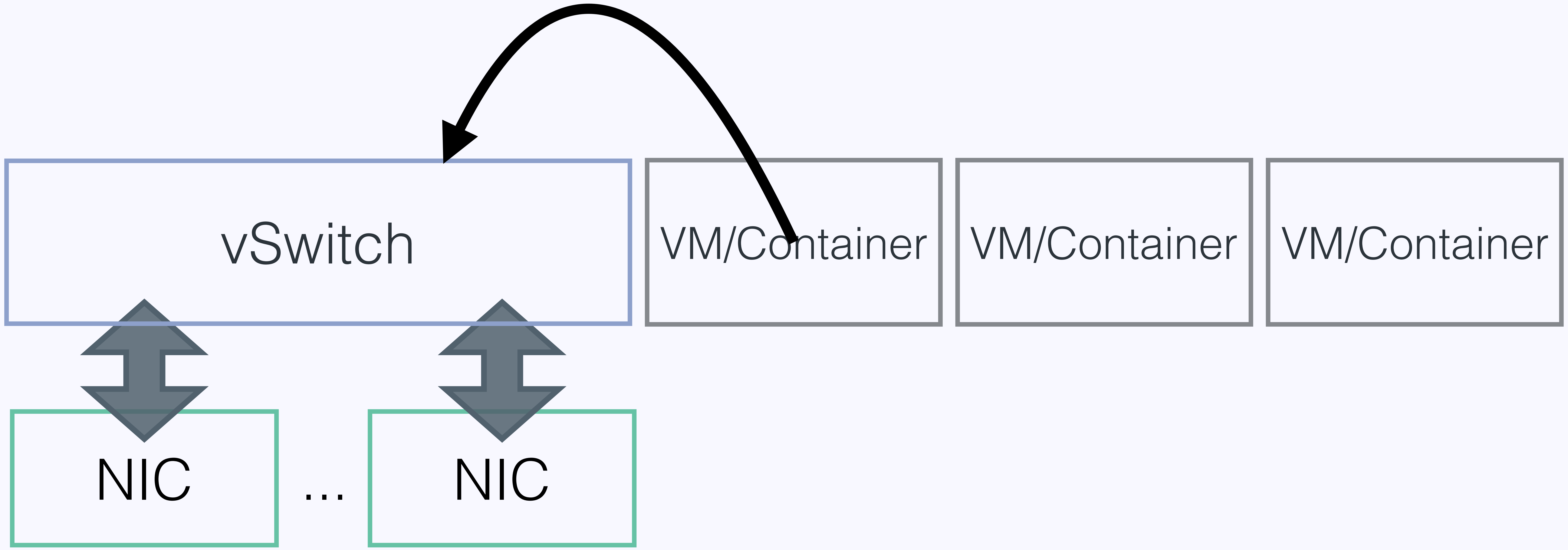

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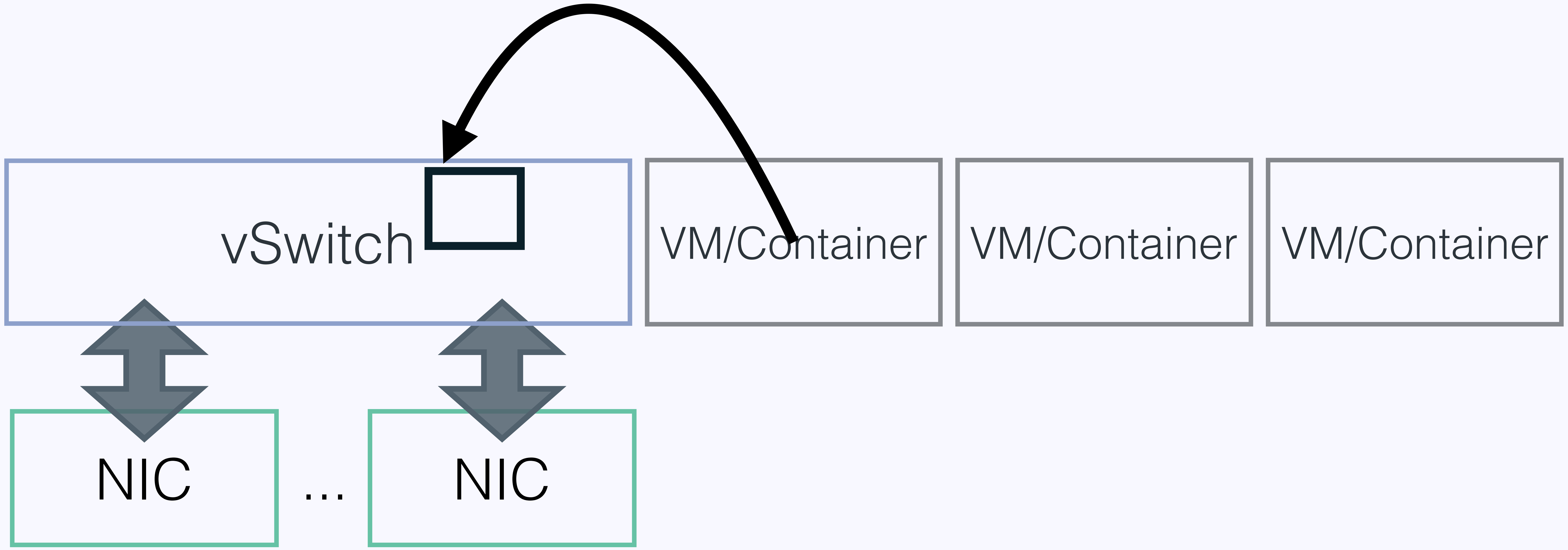

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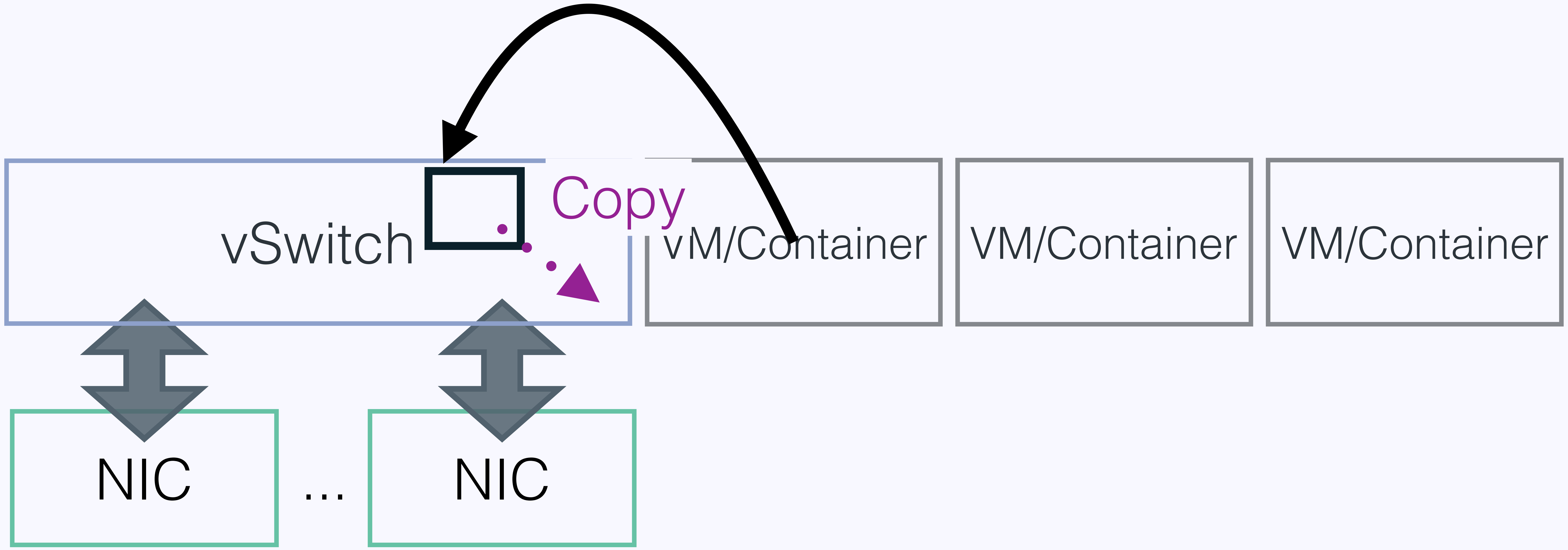

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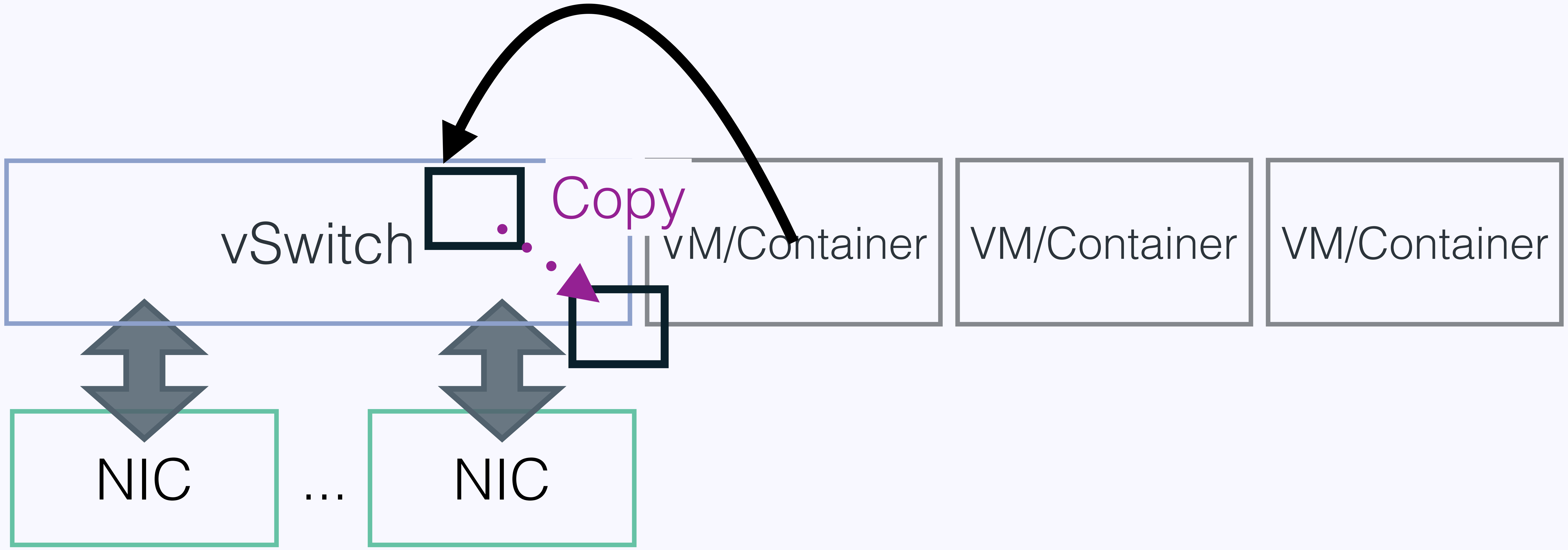

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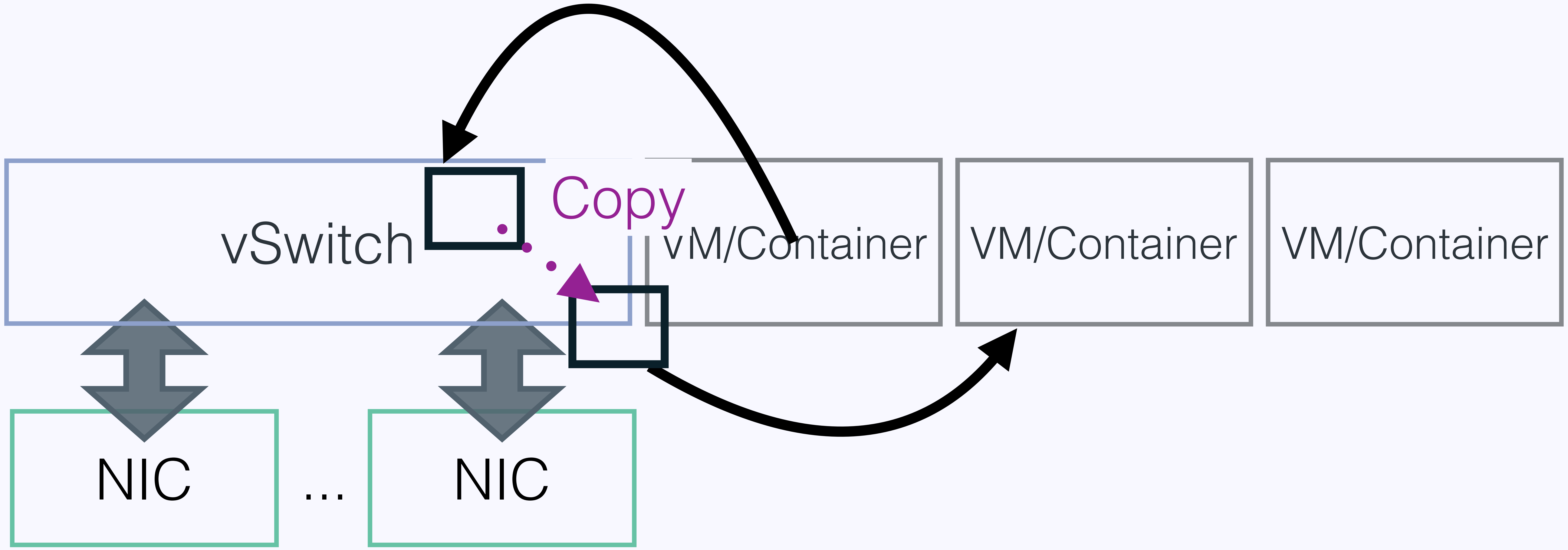

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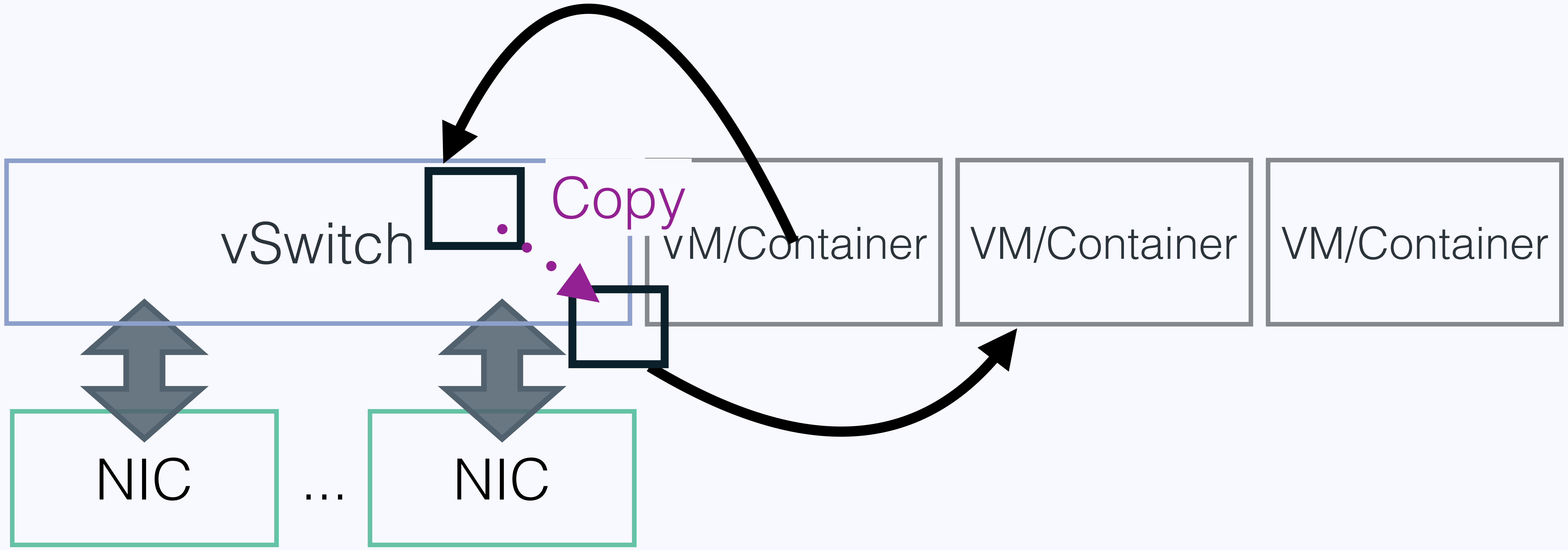

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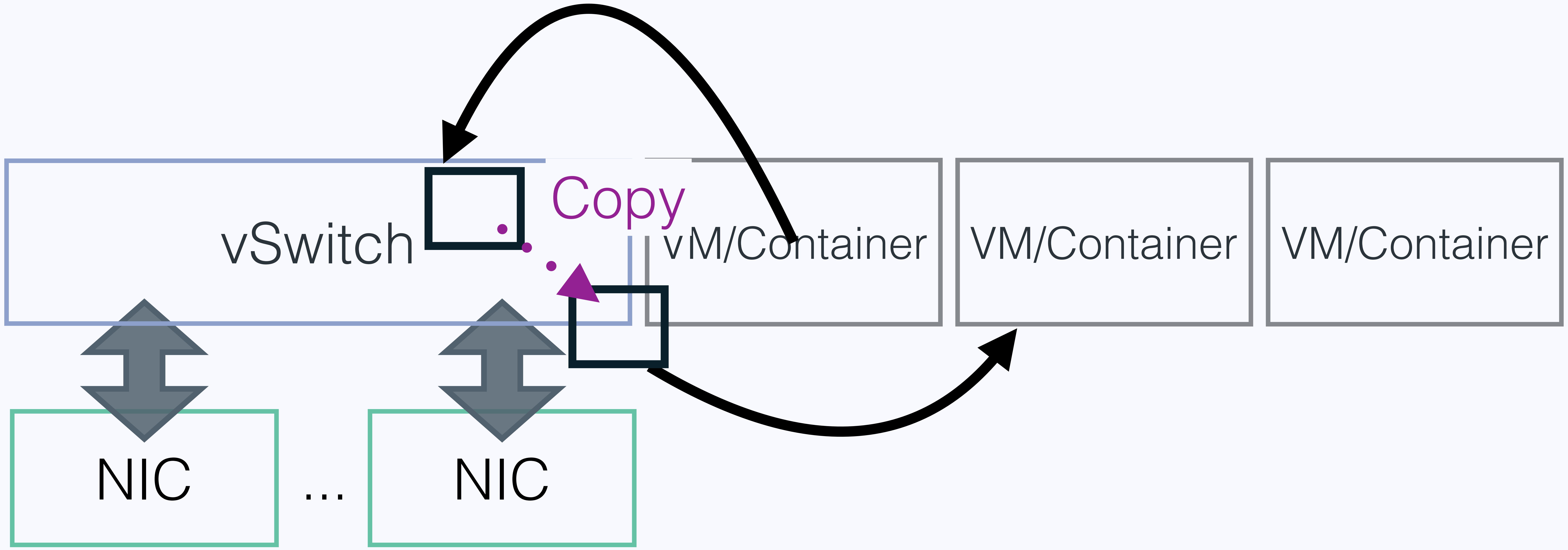

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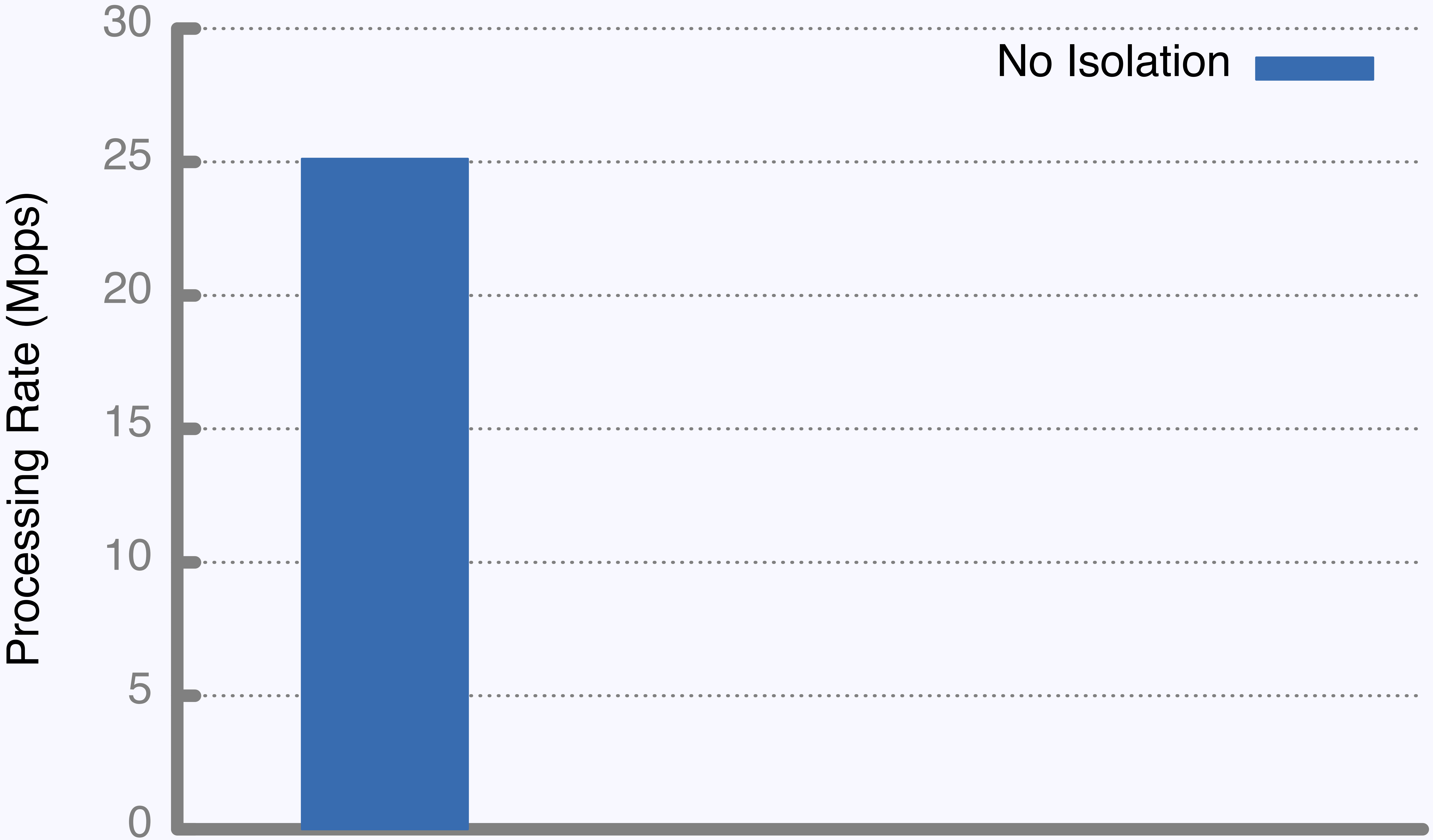
Isolation Costs Performance



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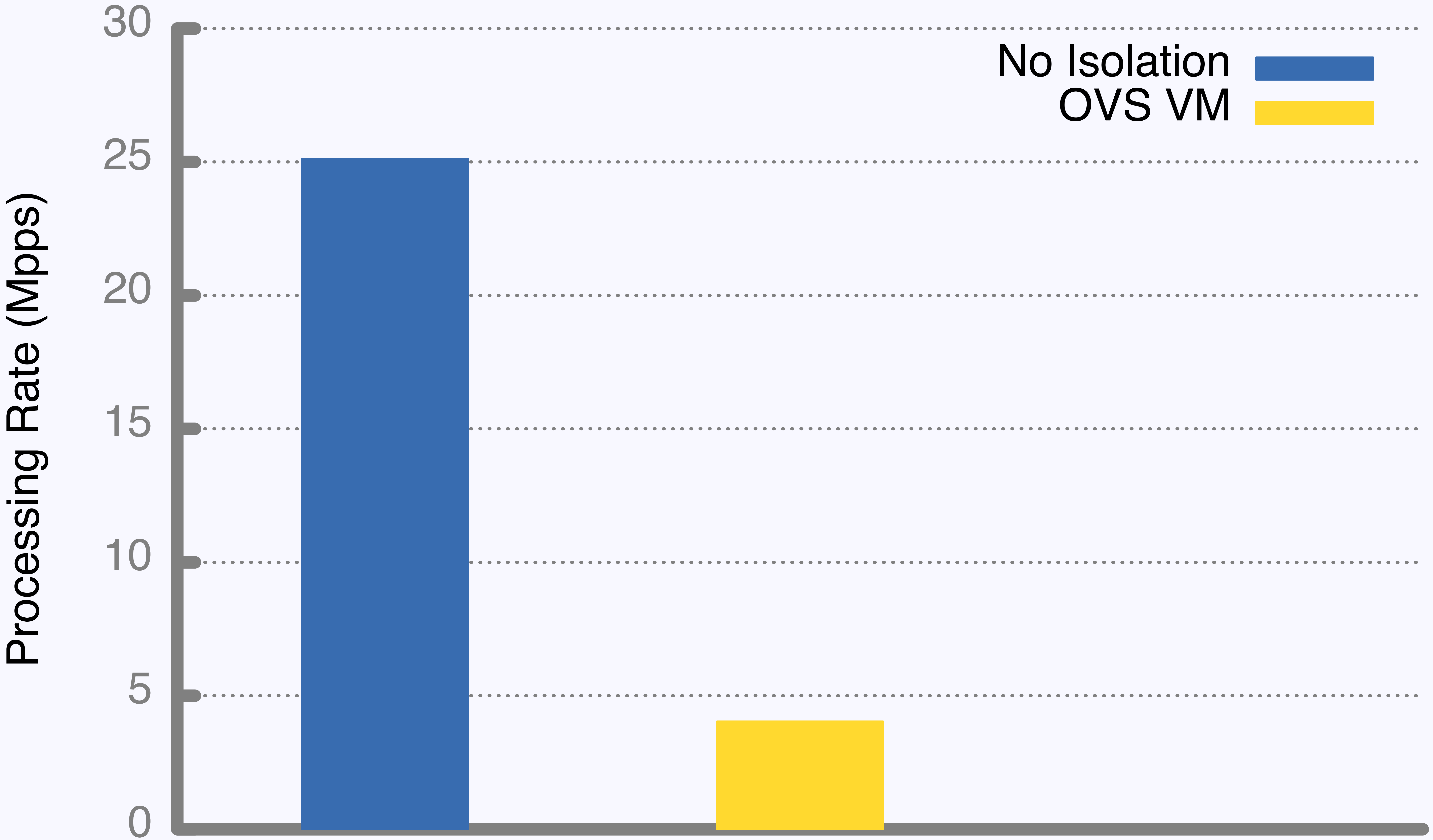

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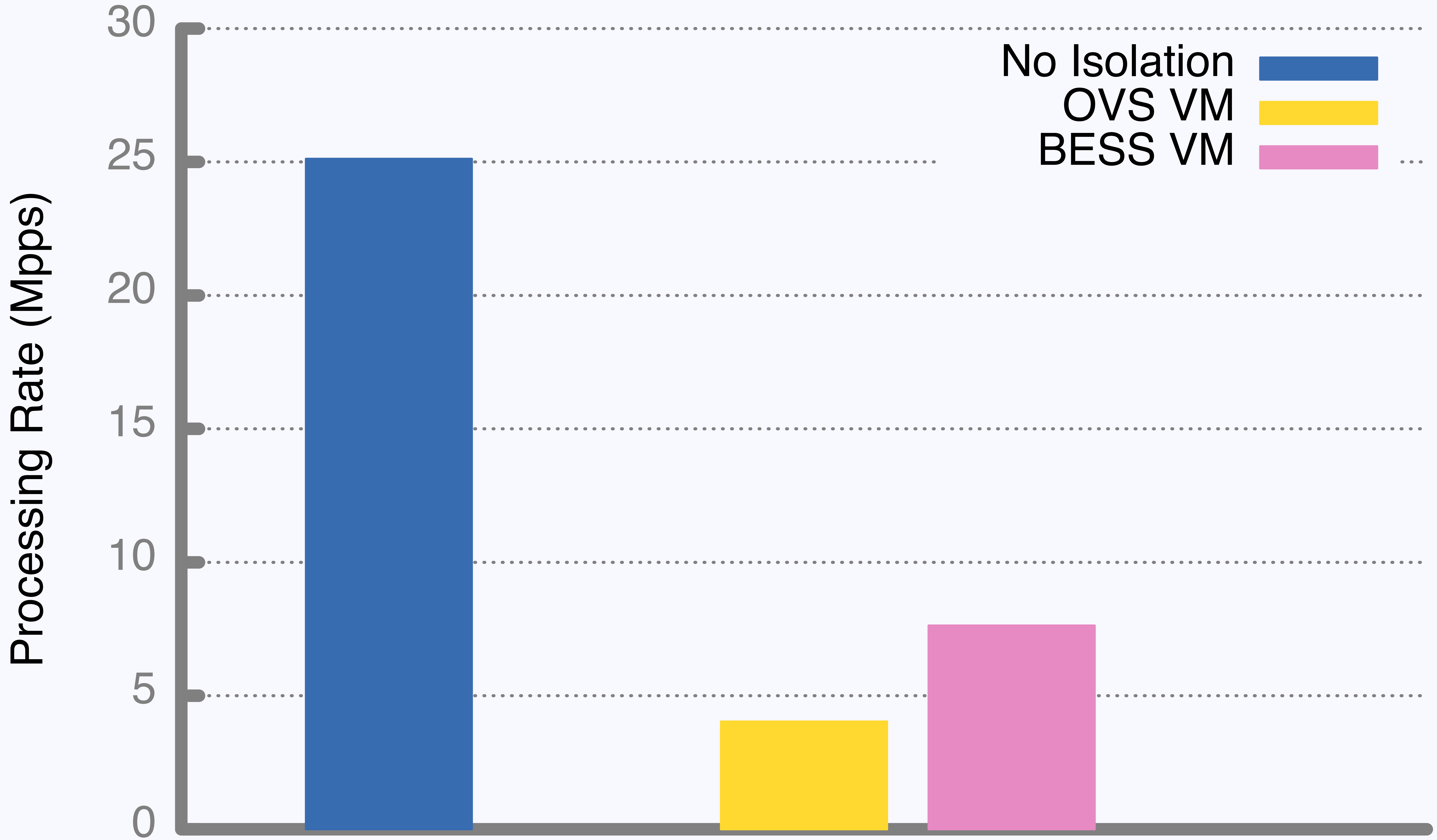

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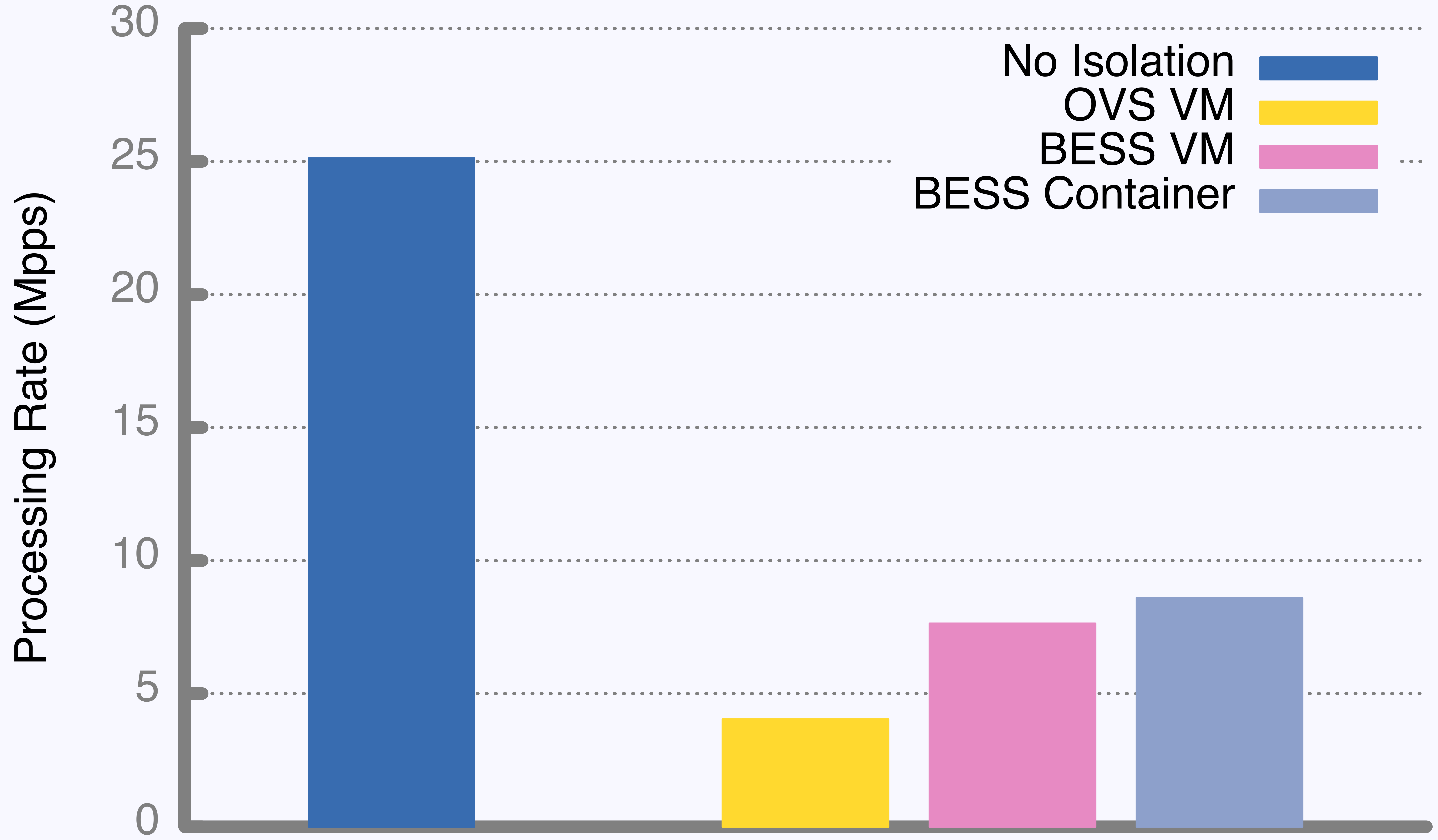

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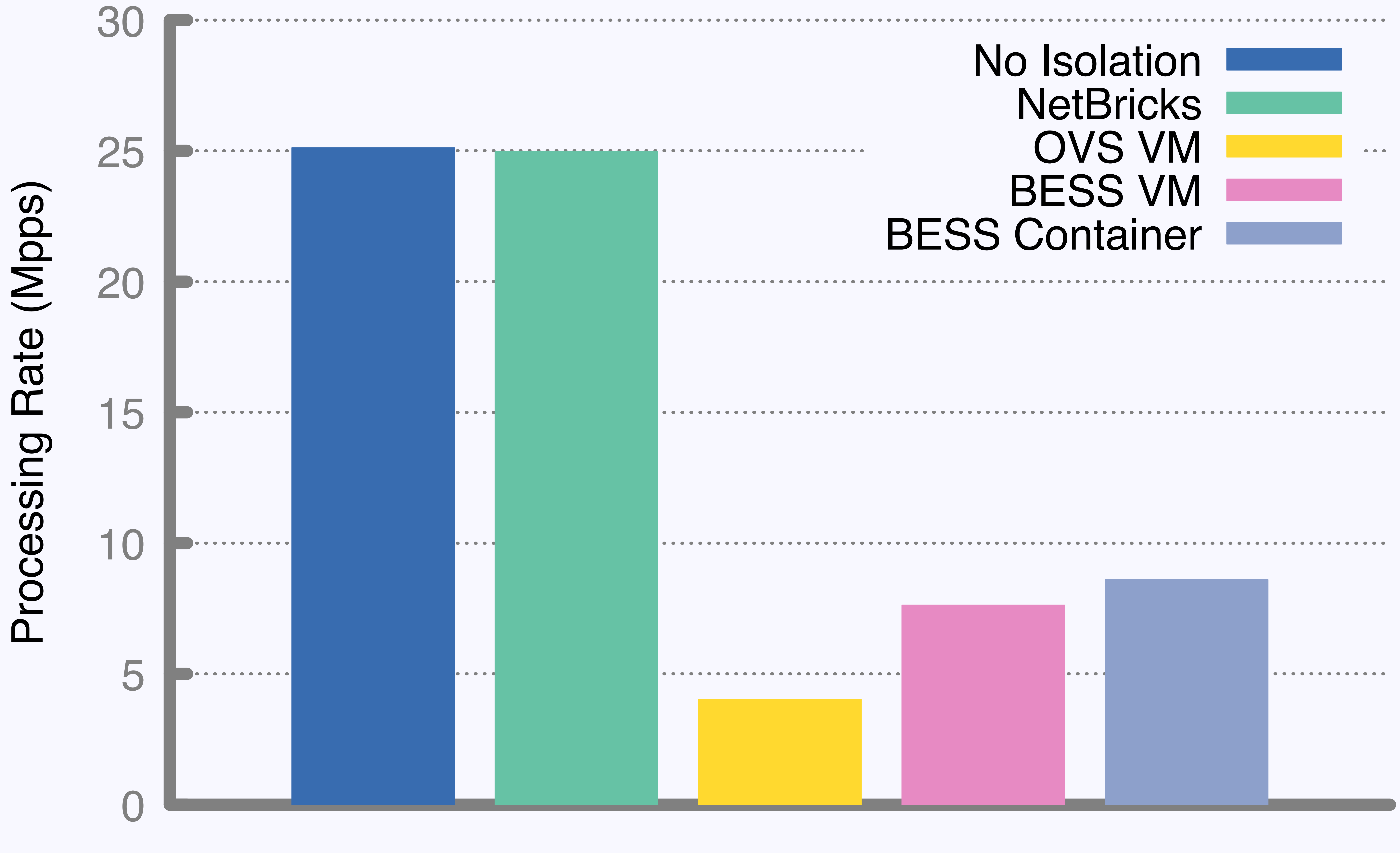
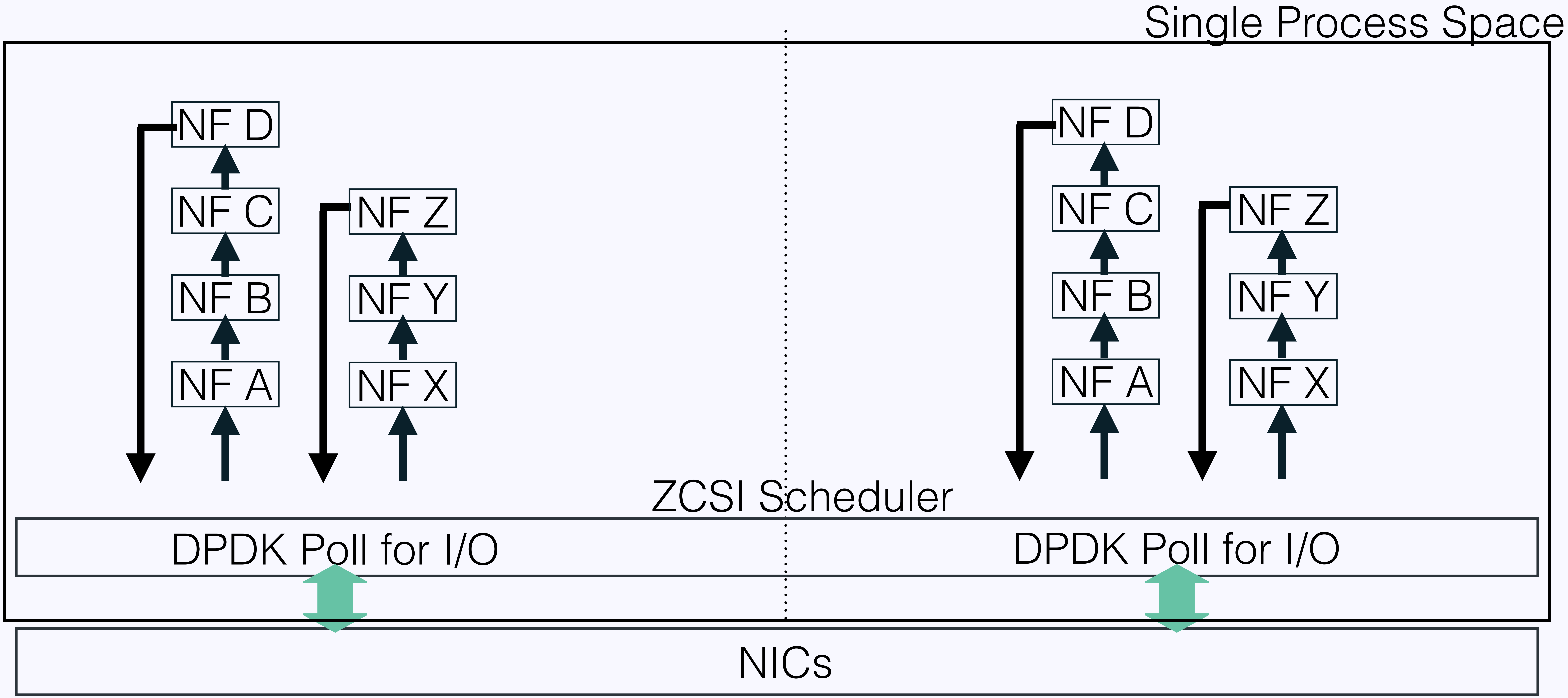


NetBricks Runtime Architecture



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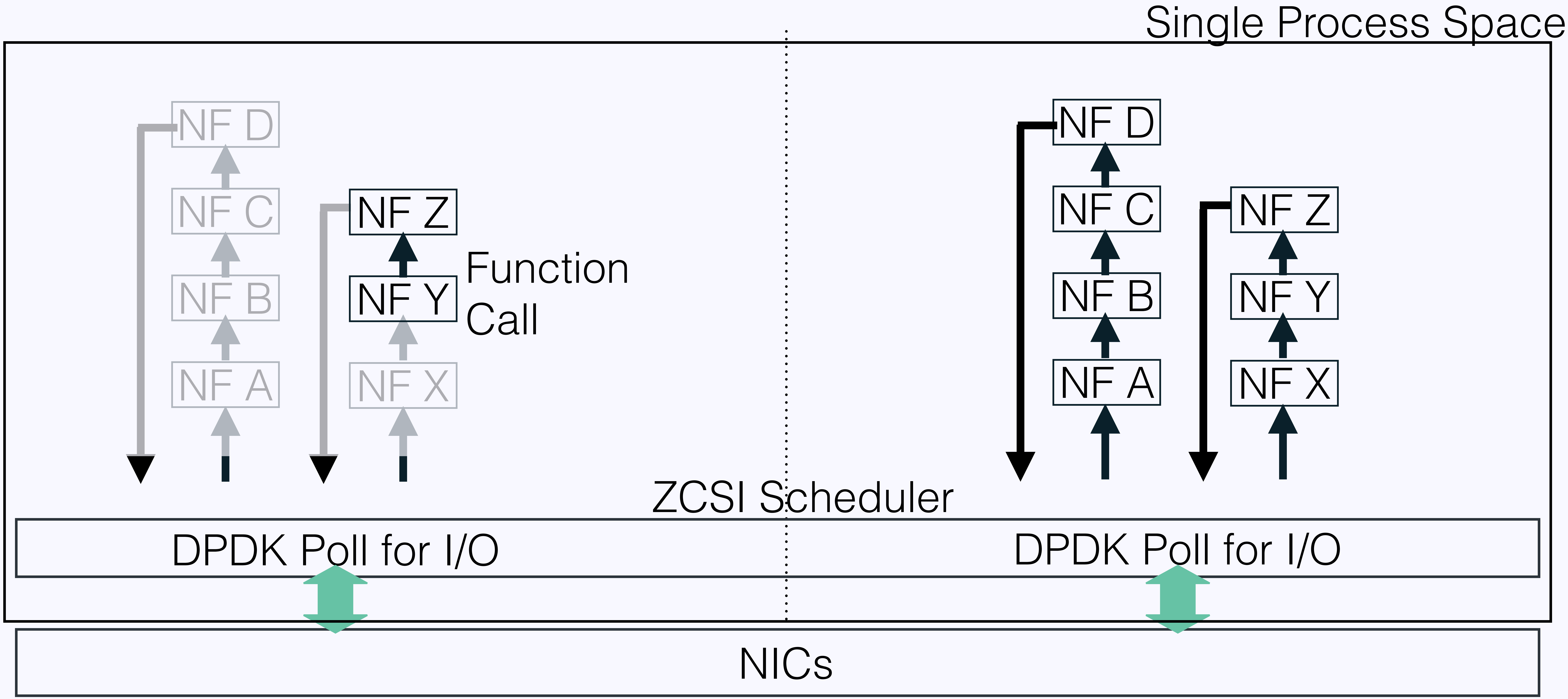

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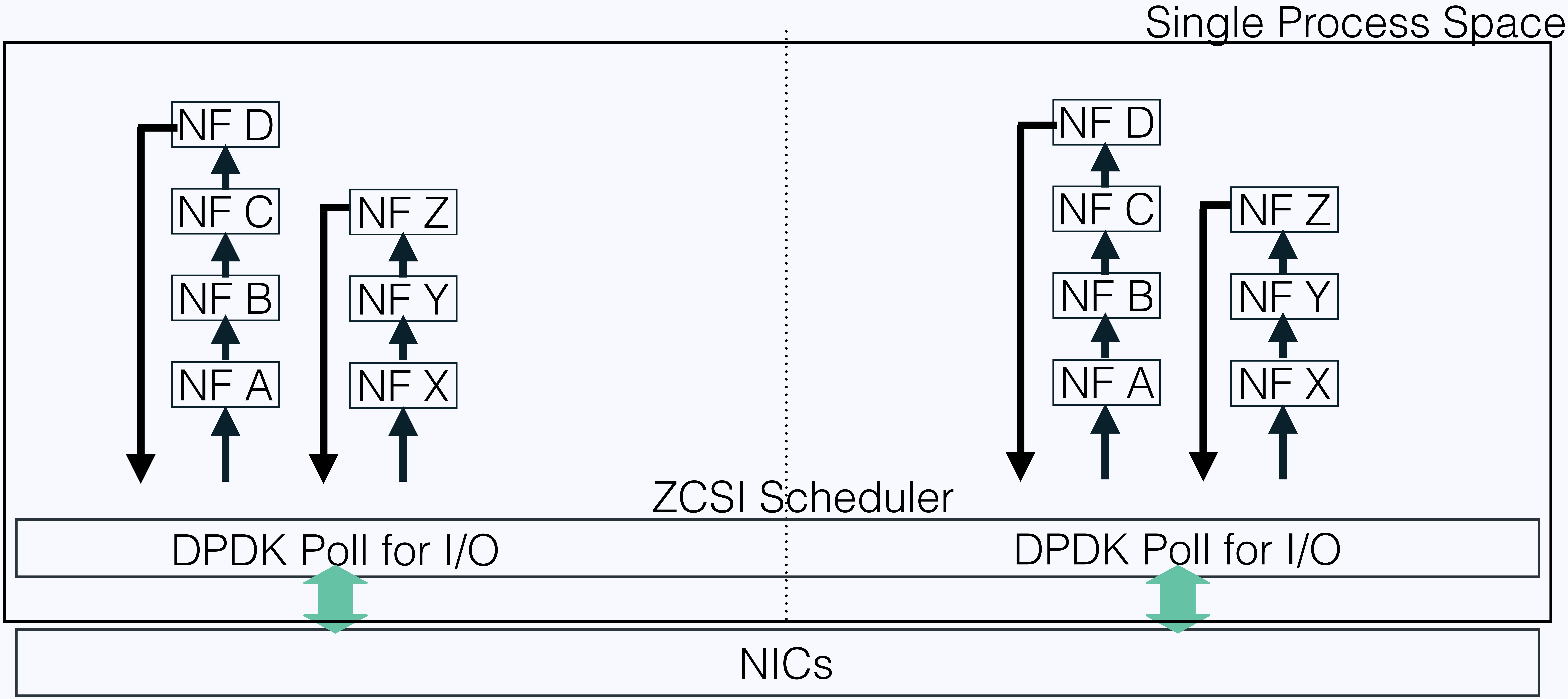

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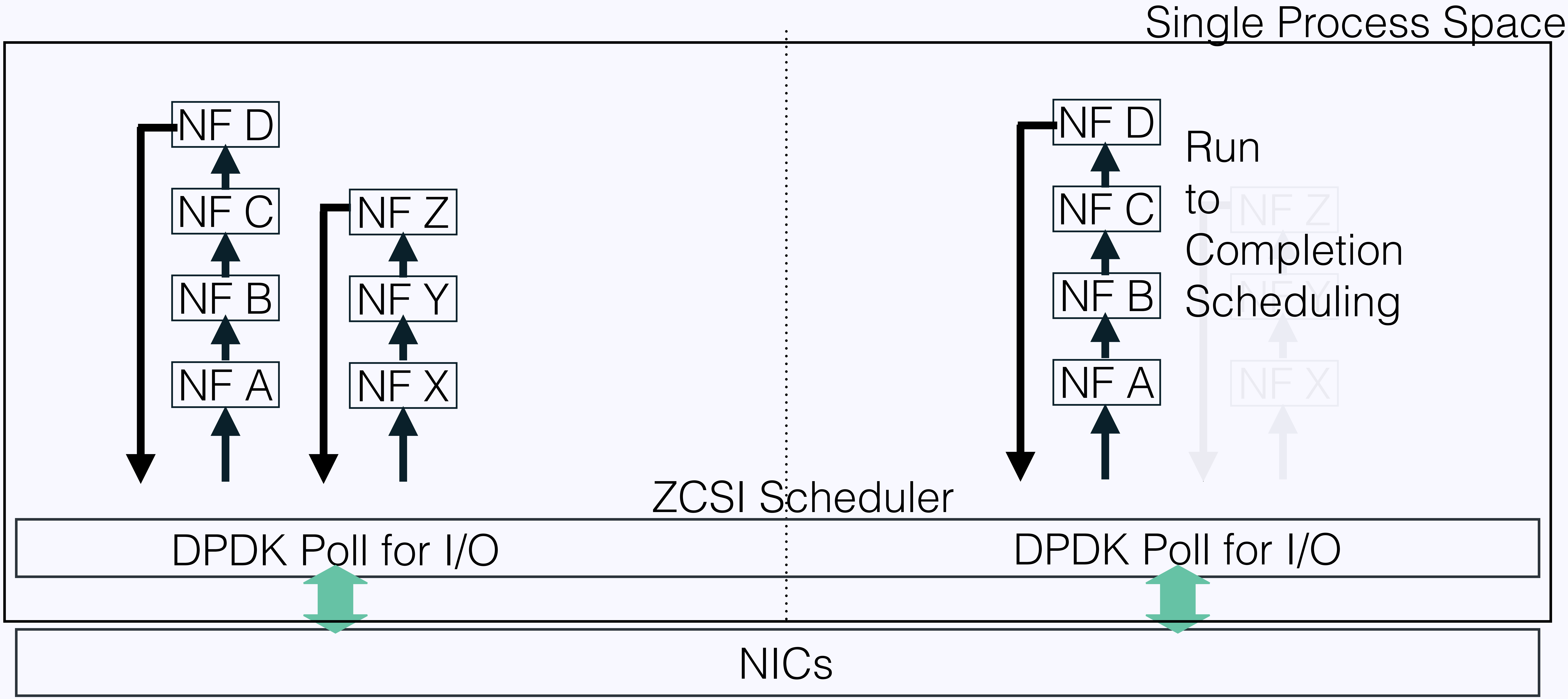

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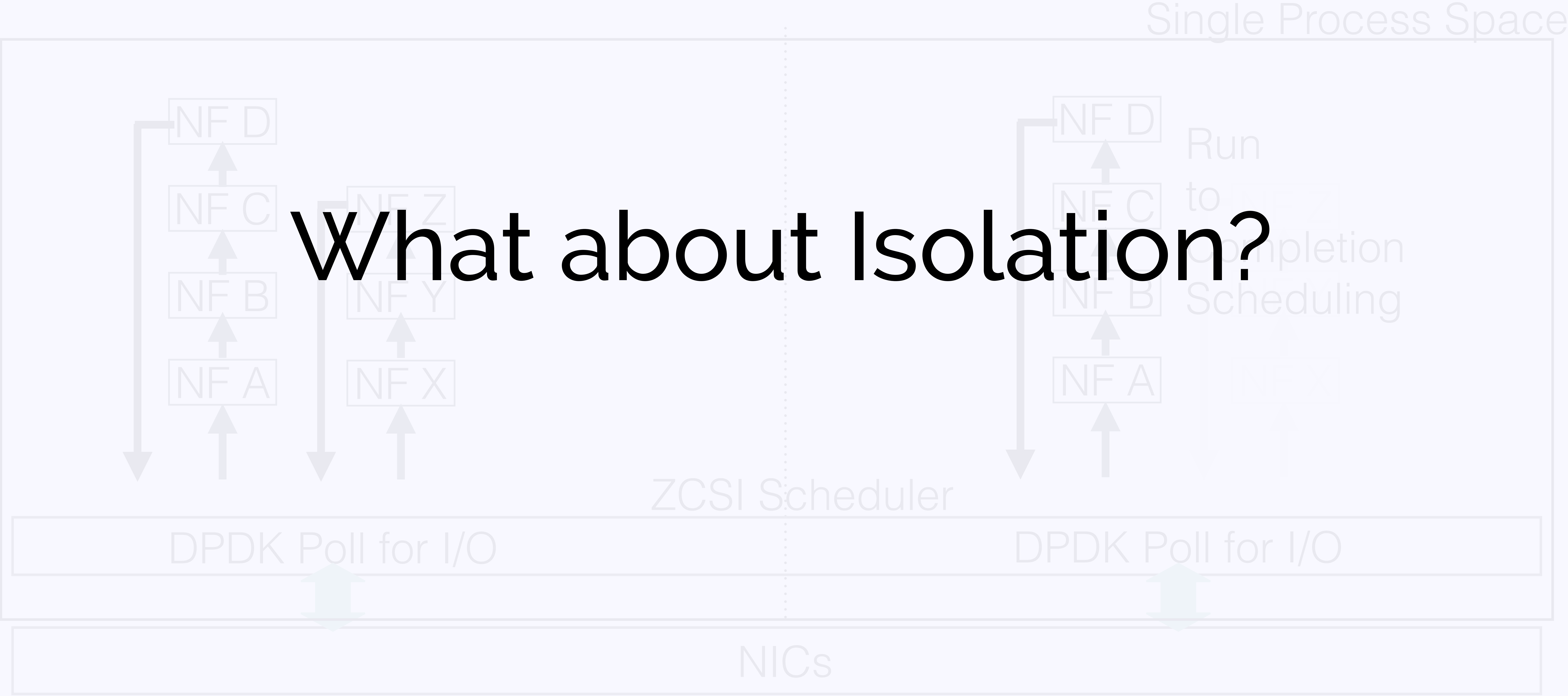

What about Isolation?

ZCSI: Zero Copy Soft Isolation

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- VMs and containers impose cost on packets crossing isolation boundaries.
- **Insight**: Use type checking (compile time) and runtime checks for isolation.
    - Isolation costs largely paid at compile time (small runtime costs).

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    - Enables zero copy packet I/O.
- All of these features implemented on top of **Rust**.

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- Reduce **memory** and **cache pressure**.
  - Zero copy I/O => do not need to copy packets around.

Challenges for NFV

- **Running NFs**
  - **Isolation** and **Performance**

- **Building NFs**
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- What happened in other areas
    - MPI to Map Reduce, etc.

Abstractions

Packet Processing

- Parse/Deparse
- Transform
- Filter

Control Flow

- Group By
- Shuffle
- Merge

Byte Stream

- Window
- Packetize

State

- Bounded
- Consistency

Abstractions

Packet Processing

- Parse/Deparse — Header
- Transform — UDF
- Filter — UDF

Control Flow

- Group By — UDF
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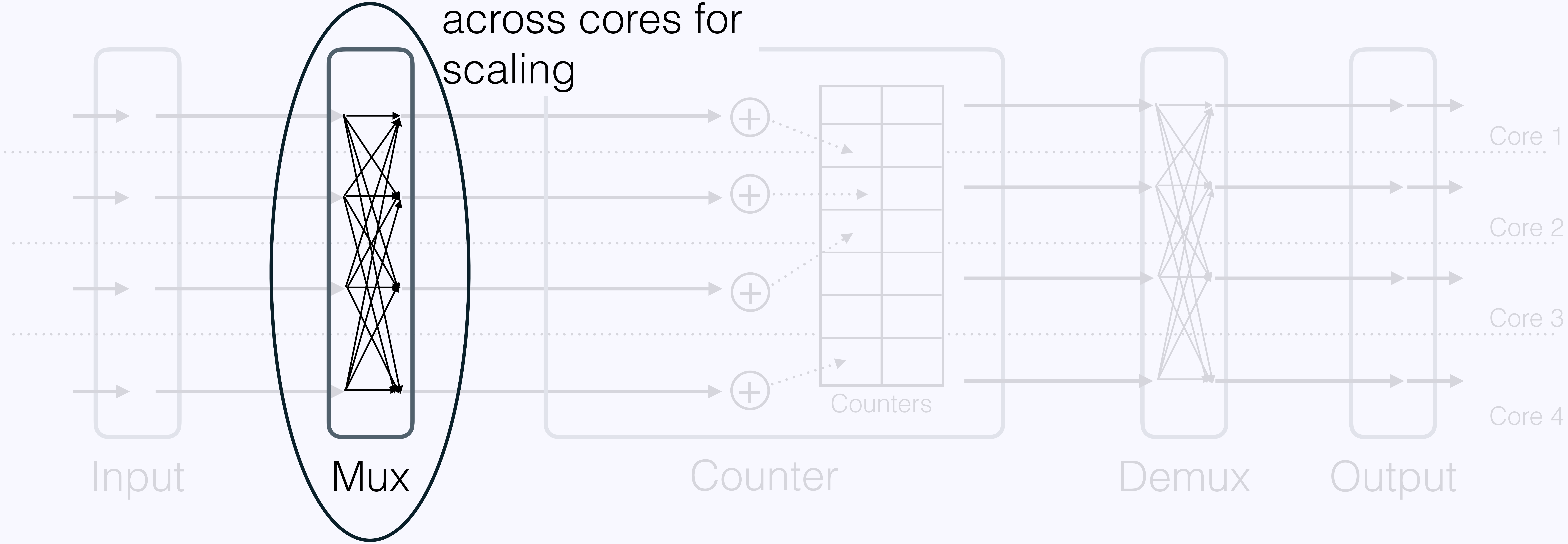
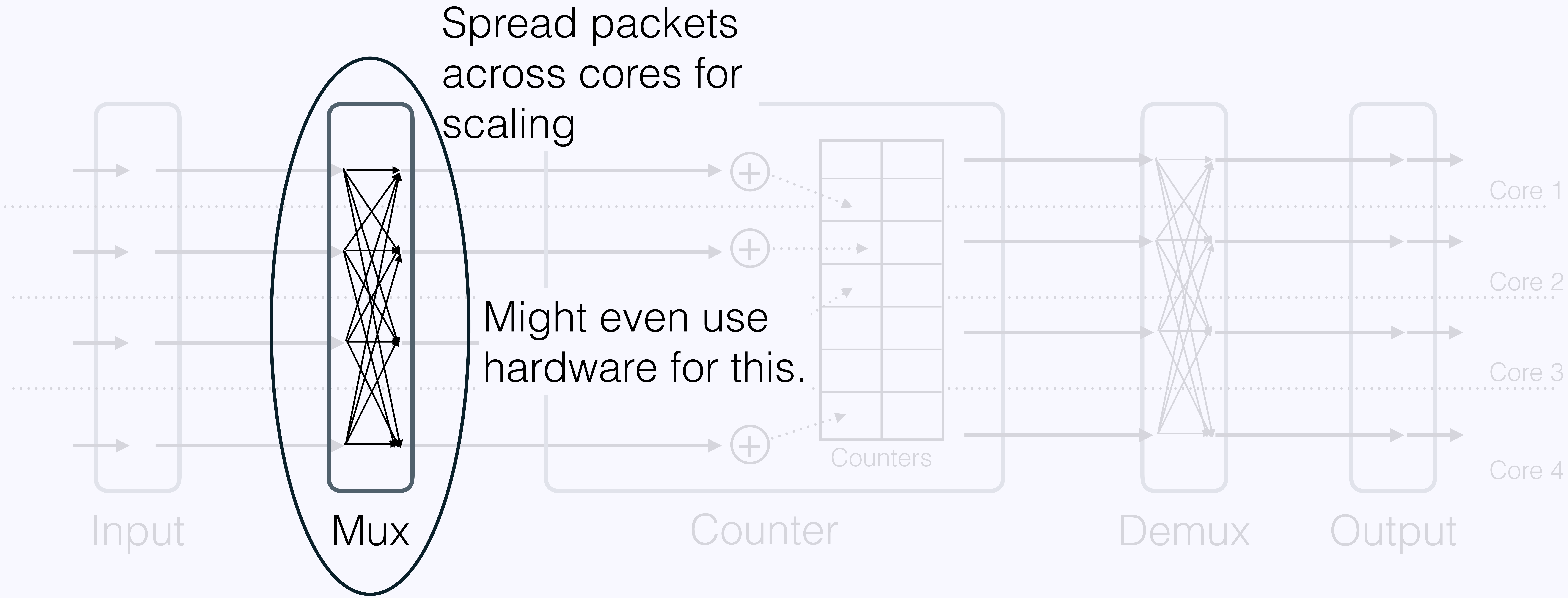
Shuffle Abstraction

Spread packets across cores for scaling



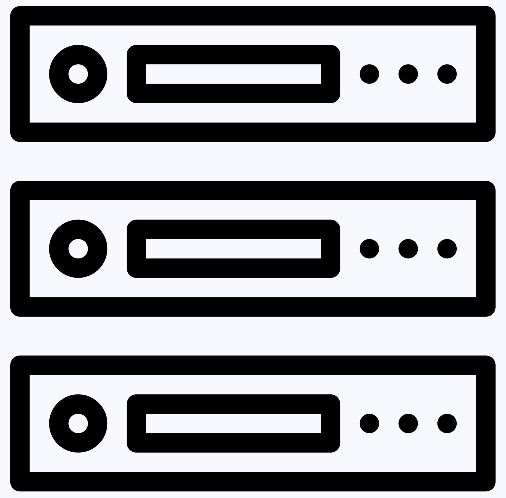
Shuffle Abstraction



Example NF: Maglev

- **Maglev**: Load balancer from Google (NSDI'16).
- Main contribution: a **novel consistent hashing algorithm.**
    - Most of the work in common optimization: batching, scaling cross core.
- NetBricks implementation: **105 lines, 2 hours of time**.
- Comparable performance to optimized code

Managing NFs



E2 (SOSP'15)

Stratos

FTMB (SIGCOMM '15)

FlowTags (NSDI '14)

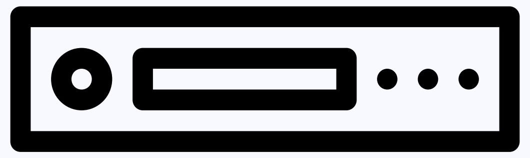
Building and Running NFs

No Isolation

CoMB (NSDI'12)
xOMB (ANCS'12)

VM Isolation

ClickOS (NSDI'14)
NetVM (IEEE TNSM)
HyperSwitch (ATC'13)
mSwitch (SOSR'15)



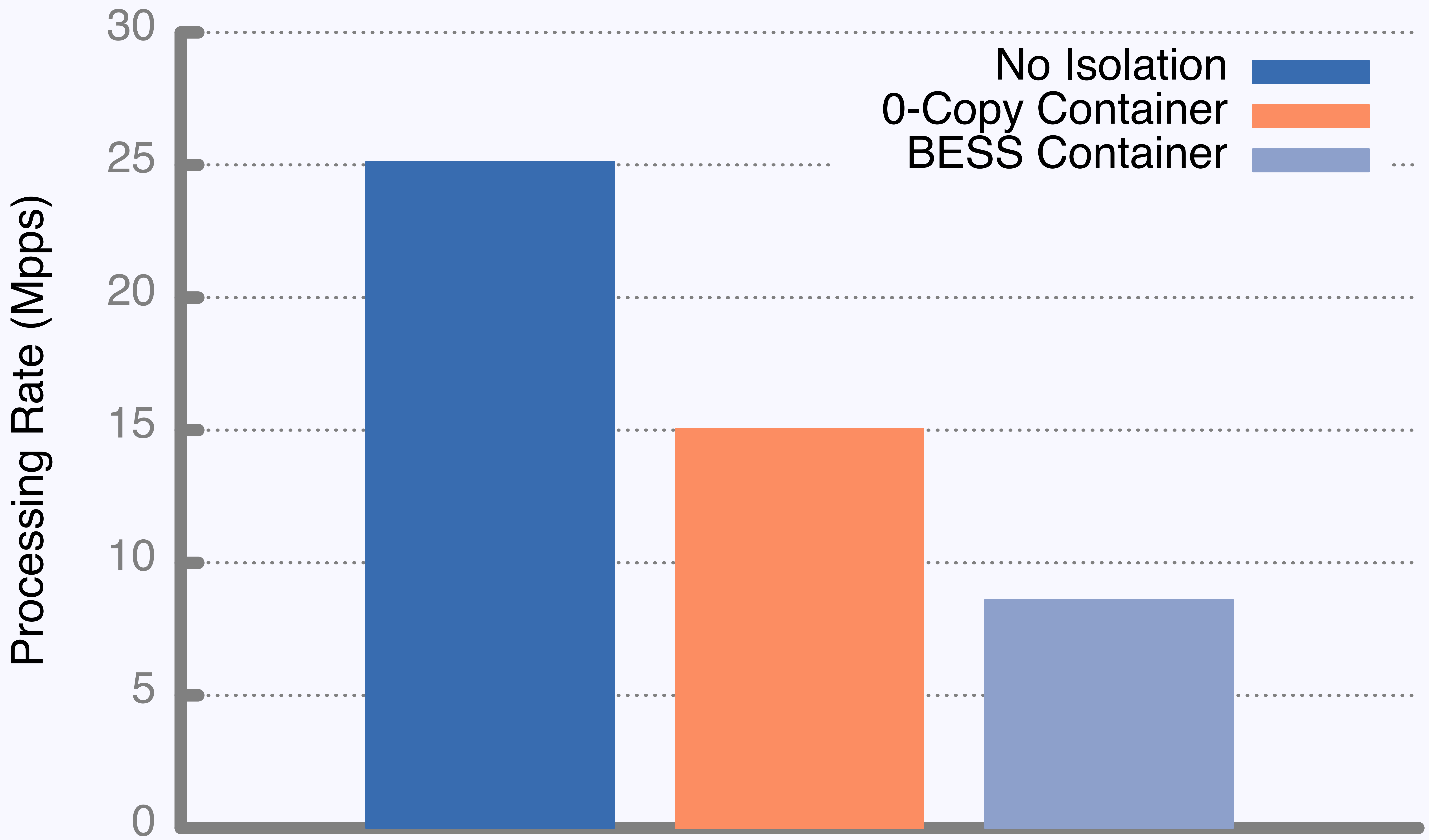
Conclusion

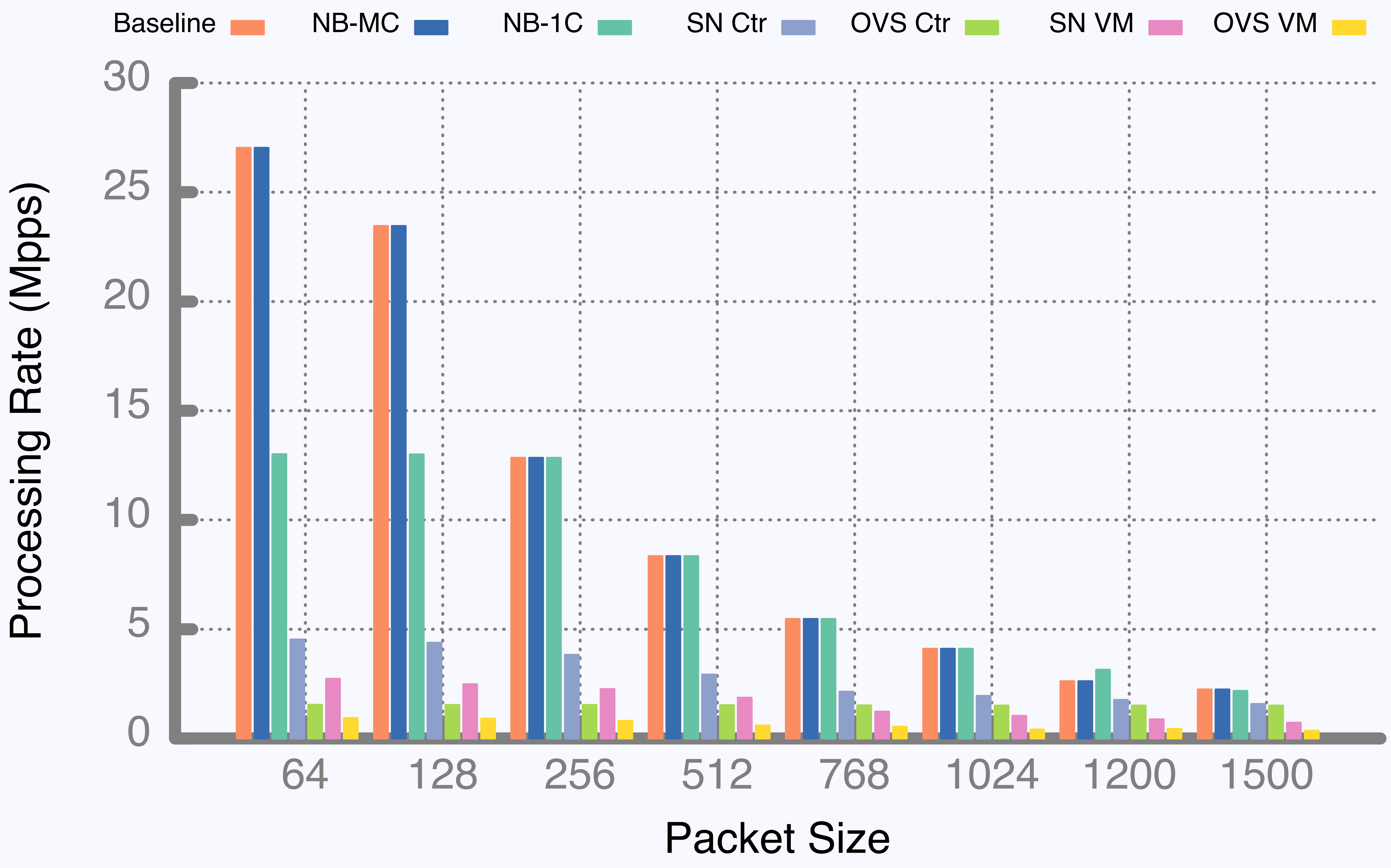
- Software isolation is necessary for high performance NFV.
  - Type checking + bound checking + unique types.
- Performance is not anathema to high-level programming
  - Abstract operators + UDF simplify development.

Code available at **http://netbricks.io/**

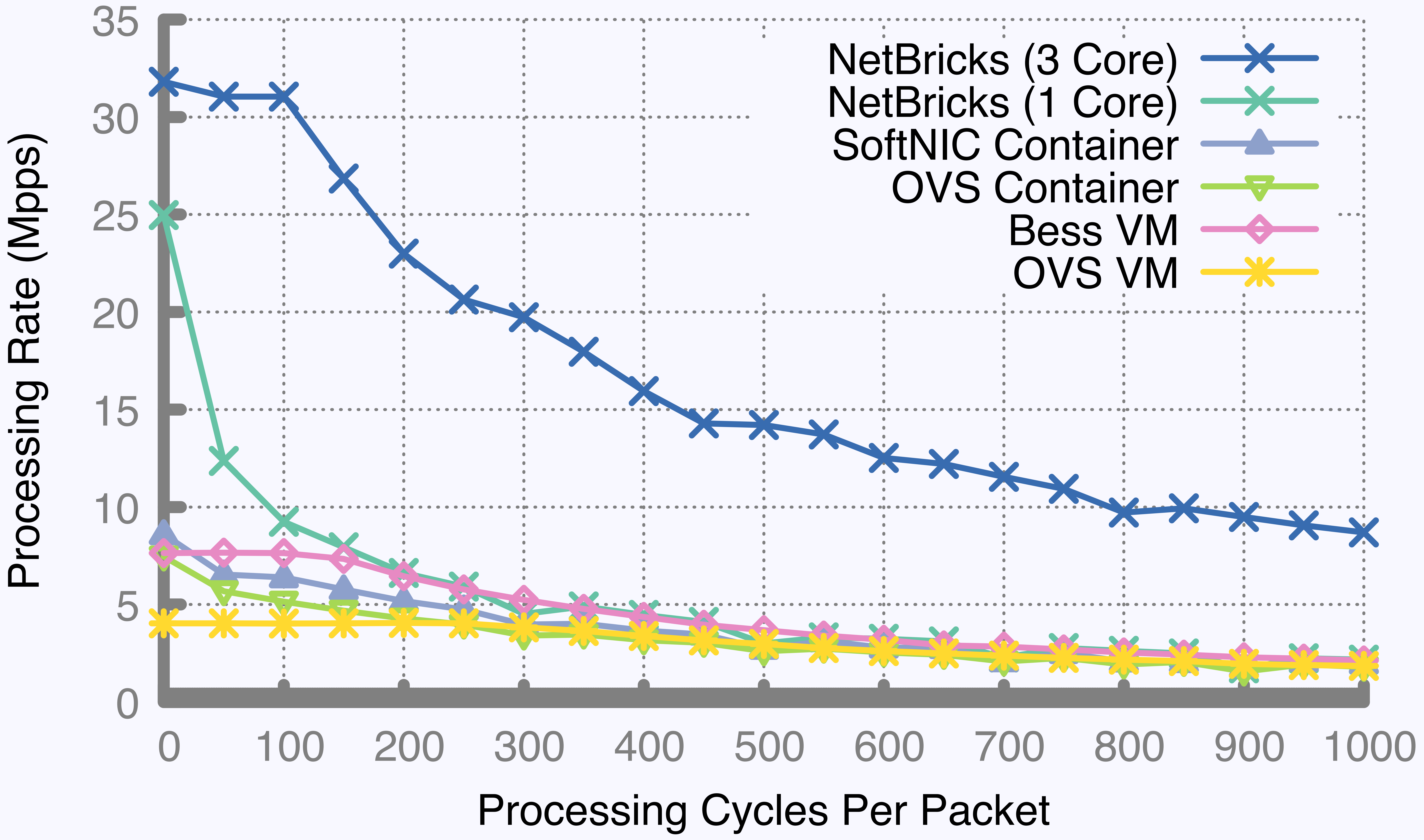
Backup

Both Memory Isolation and I/O Induce Overheads

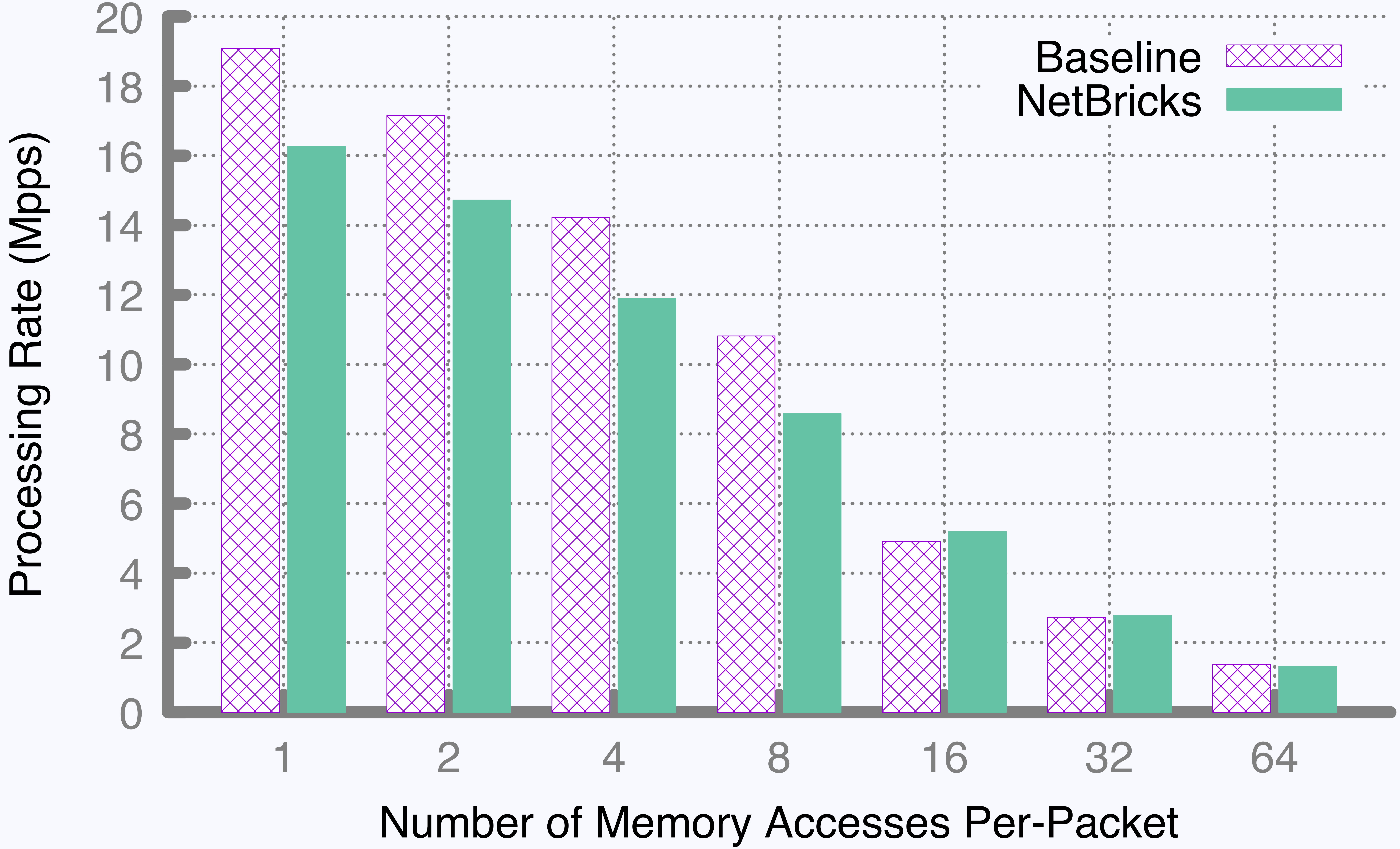




Baseline
NB-MC
NB-1C
SN Ctr
OVS Ctr
SN VM
OVS VM
Processing Rate (Mpps)
30
25
20
15
10
5
0
64
128
256
512
768
1024
1200
1500
Packet Size



NetBricks (3 Core)
NetBricks (1 Core)
SoftNIC Container
OVS Container
Bess VM
OVS VM
Processing Rate (Mpps)
0
5
10
15
20
25
30
35
0
100
200
300
400
500
600
700
800
900
1000
Processing Cycles Per Packet



Baseline
NetBricks
Processing Rate (Mpps)
0
2
4
6
8
10
12
14
16
18
20
1
2
4
8
16
32
64
Number of Memory Accesses Per-Packet