RedHat OpenShift Container Platform on Z Networking Performance

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Linux on IBM z Performance

ibm.biz/perfradar – the Performance Radar Blog

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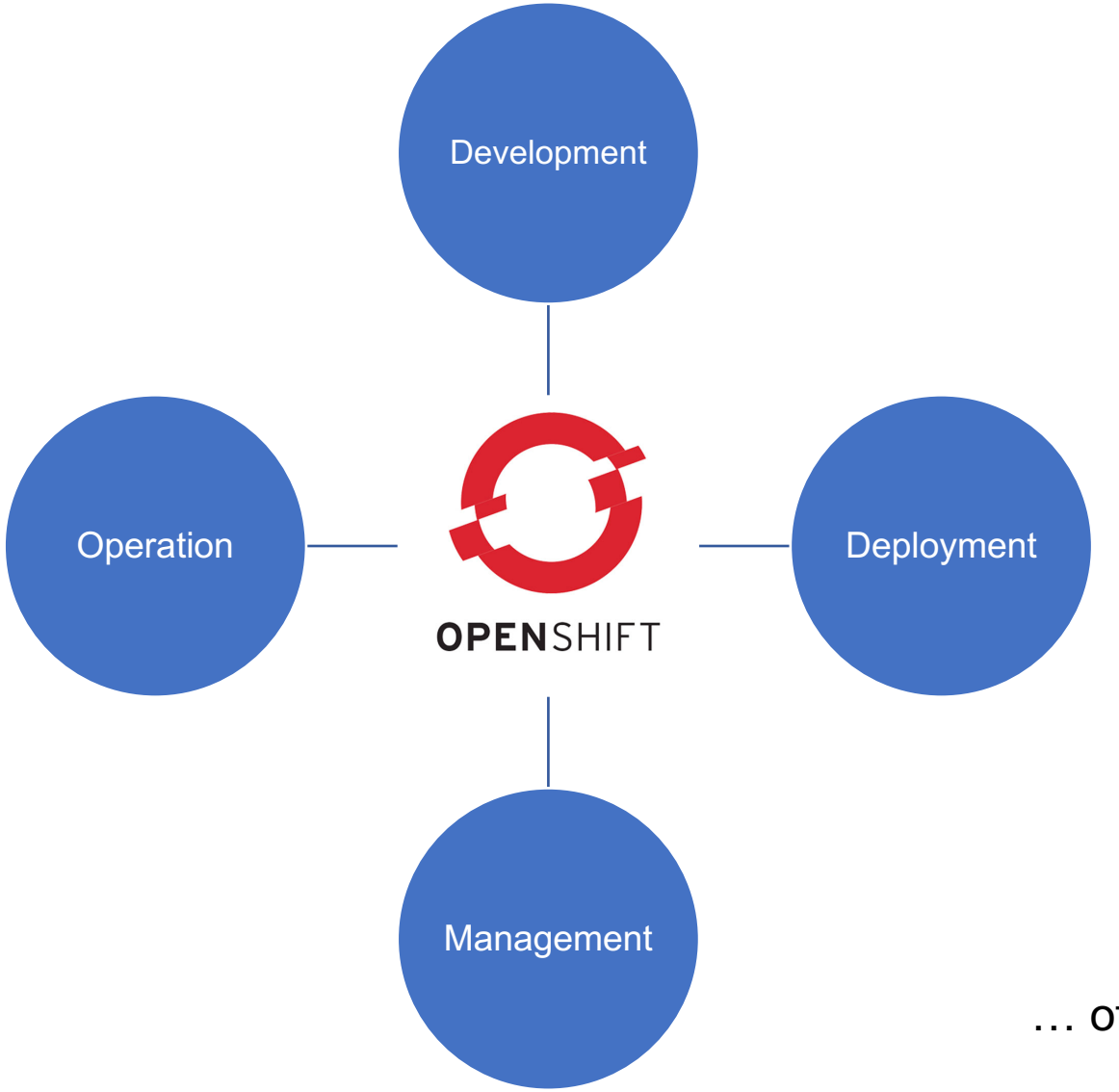
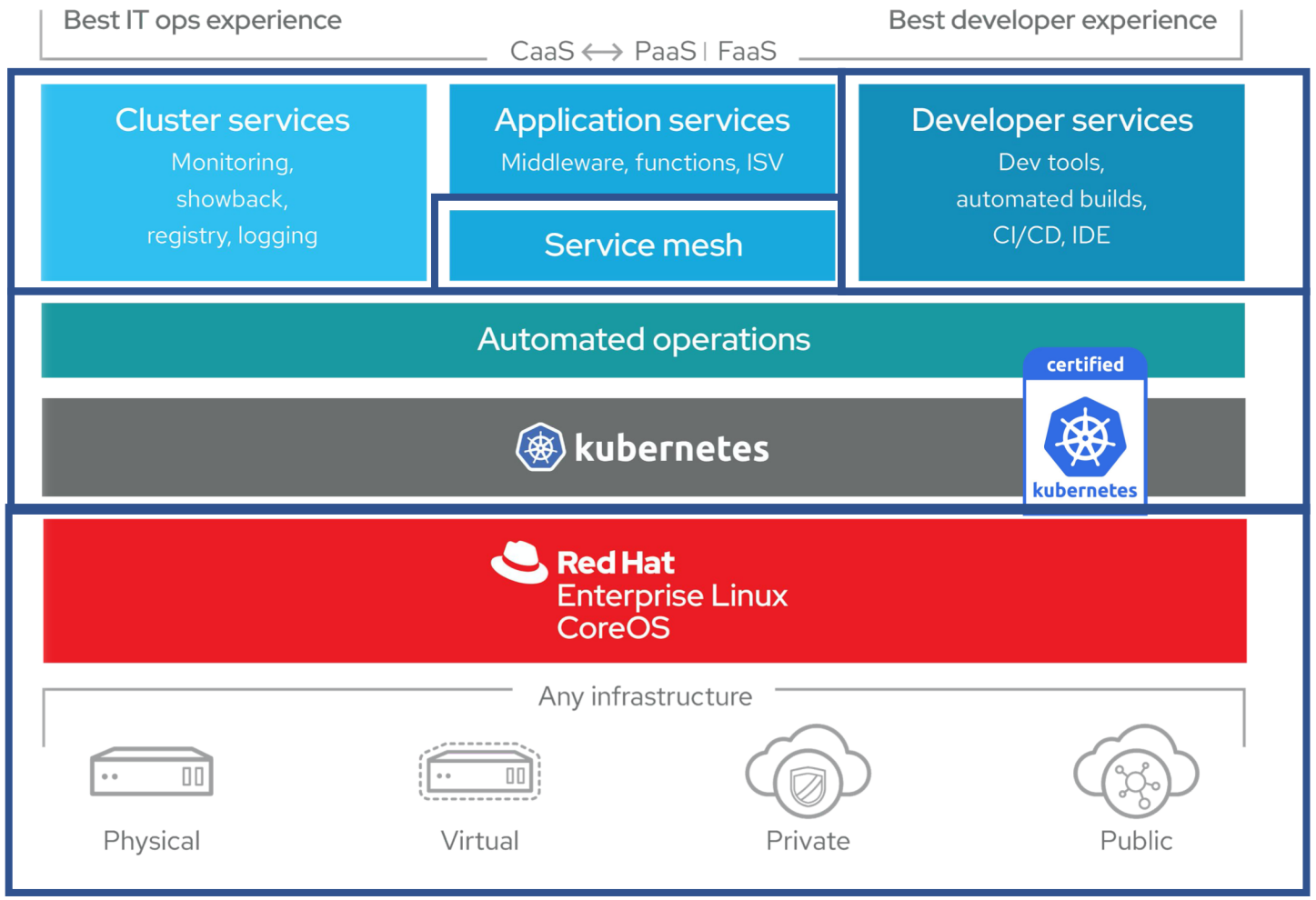
OpenShift Container Platform in a Nutshell



… of cloud applications & infrastructure (automatically)

OpenShift Container Platform in a Nutshell



- Manage
  - resources, .e.g. public/private cloud
  - infrastructure, e.g. network
  - operating system, e.g. Linux performance settings
- Development
  - of applications using CI/CD pipeline
  - … in different programming languages
  - … and code repositories
- Deployment
  - of applications in containers
  - … to be scaled
  - … and made reliable
- Operation
  - Monitoring, logging
  - Middleware, operators
  - Network topology

Why considering OCP Networking Performance?

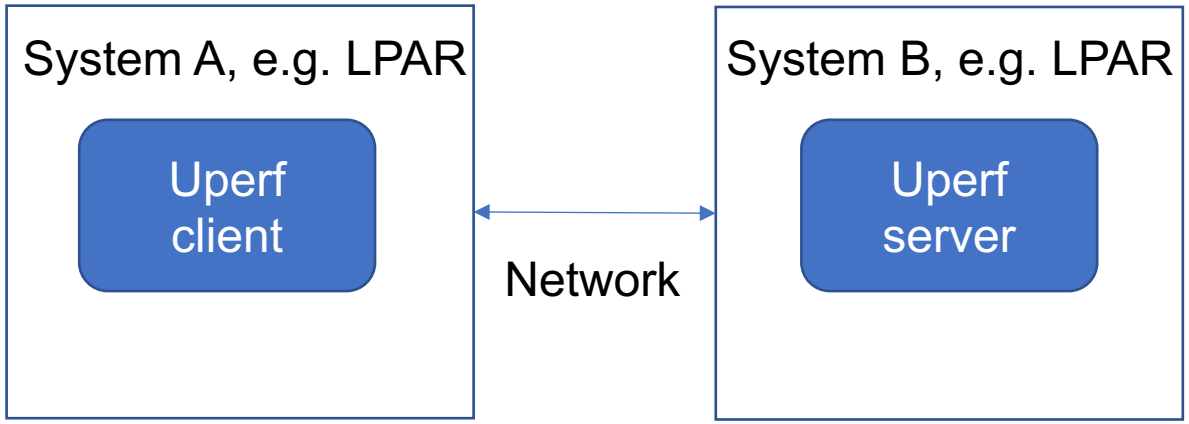
- Business perspective
  - Networking performance, i.e. latency, throughput **business critical** quality attribute
  - Network Performance **critical** in microservice architectures through interdependencies
- Technical perspective
  - OCP networking architecture **complex system**
  - Several **new technologies**
  - **Not much documentation** publicly available
  - **Limited experience** with intertwinement of technologies

Container technology **more difficult** to analyse compared to LPAR
- More layers, e.g. software-defined network (SDN)
- Limited insights and monitoring capabilities (“grey box“)

What‘s the **influence** of the OCP architecture such as SDN on networking performance?

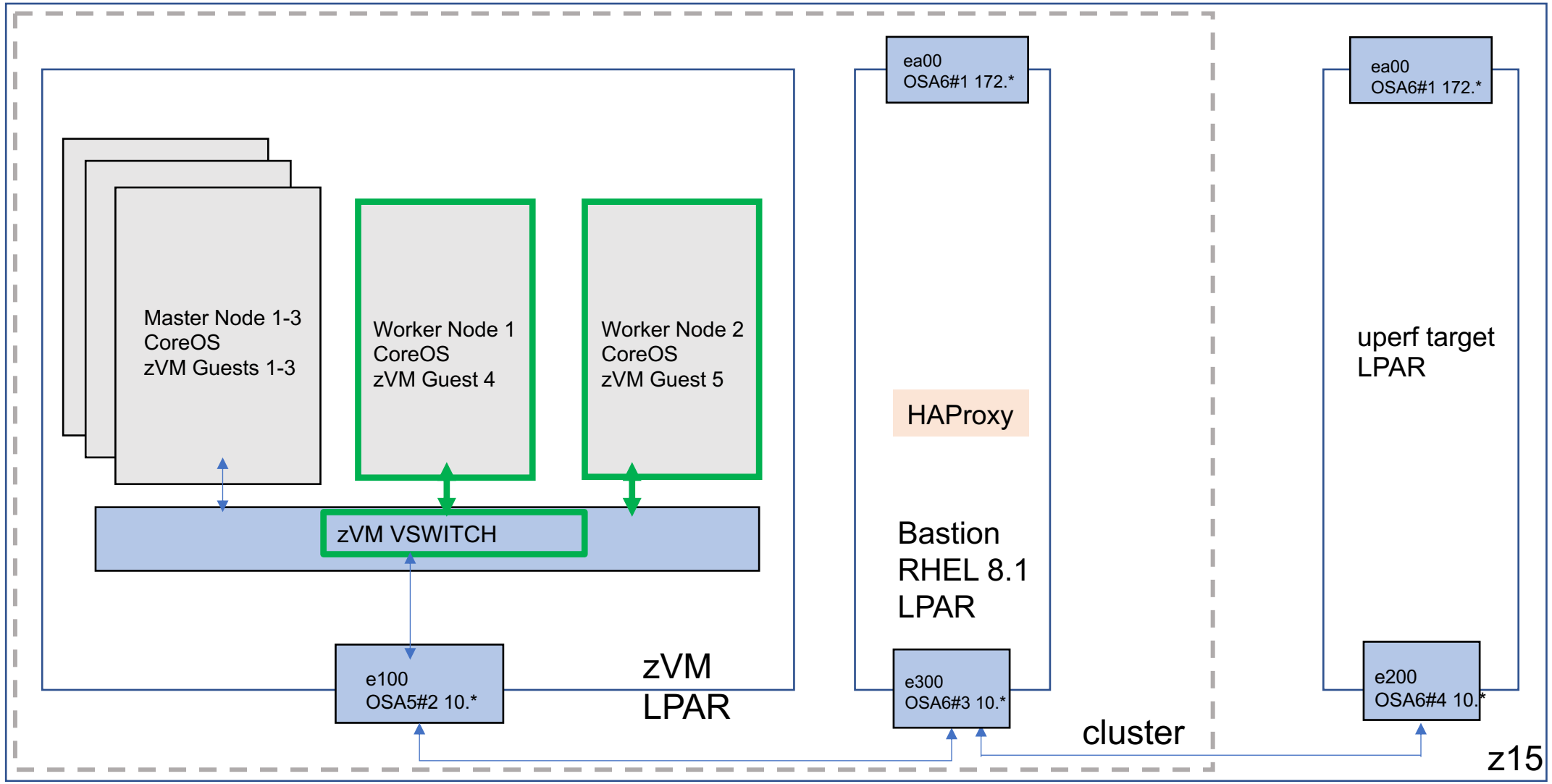
How to Benchmark the Network: uperf & workloads

Uperf: A network (micro) benchmark
- Two sets of workloads
  - **Request Response** (latency)
  - **Streaming** (throughput)
- Several numbers of simultaneous **connections** (1-50-250)
- Different **request sizes** (1x1-200x1000-200x30000 B)
- Typically used in distro regressions
- (Distro results used as OCP baseline to be compared to)



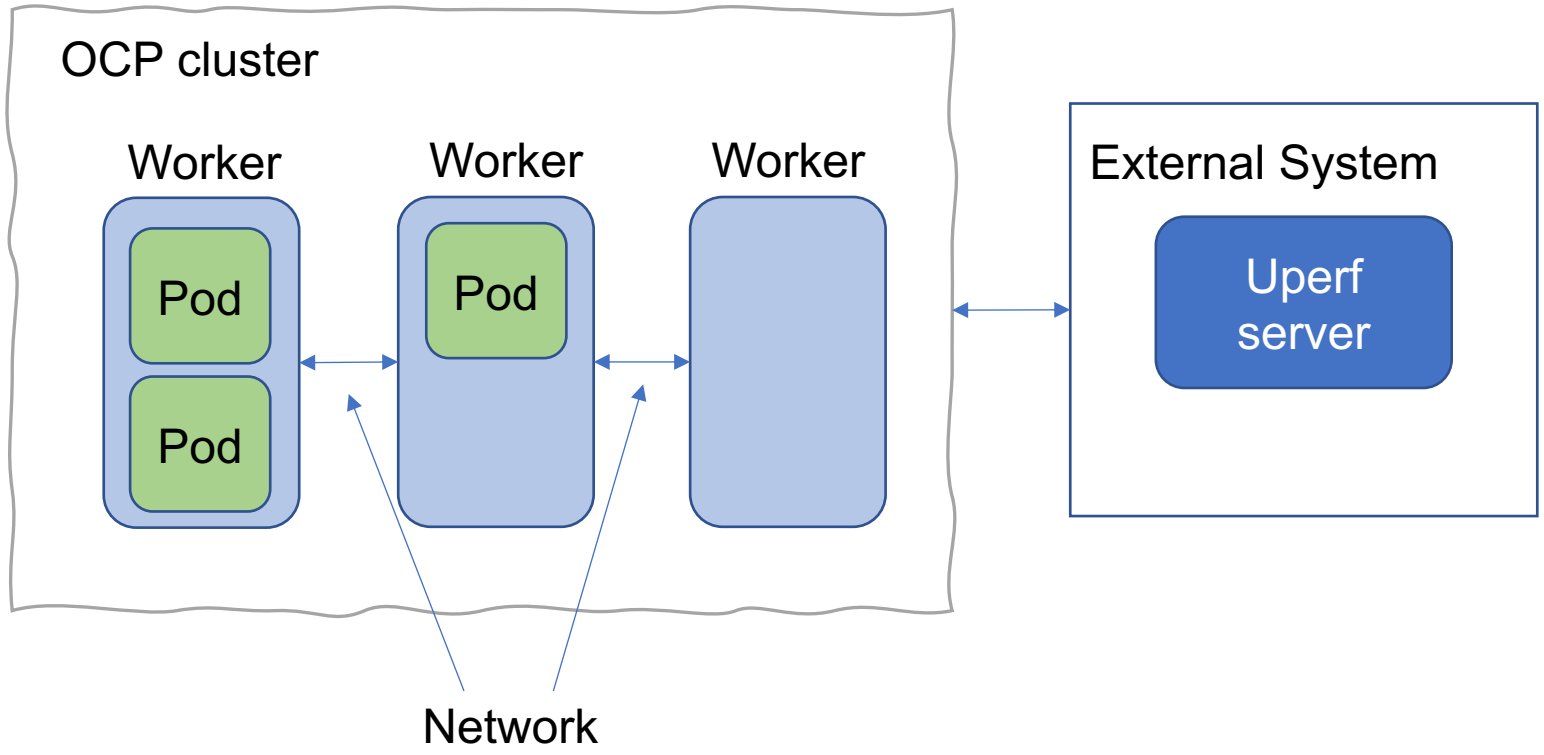
Results:
- Latency in us/ms
- Throughput in MiB/s

OpenShift (on z) Container Platform: System Architecture



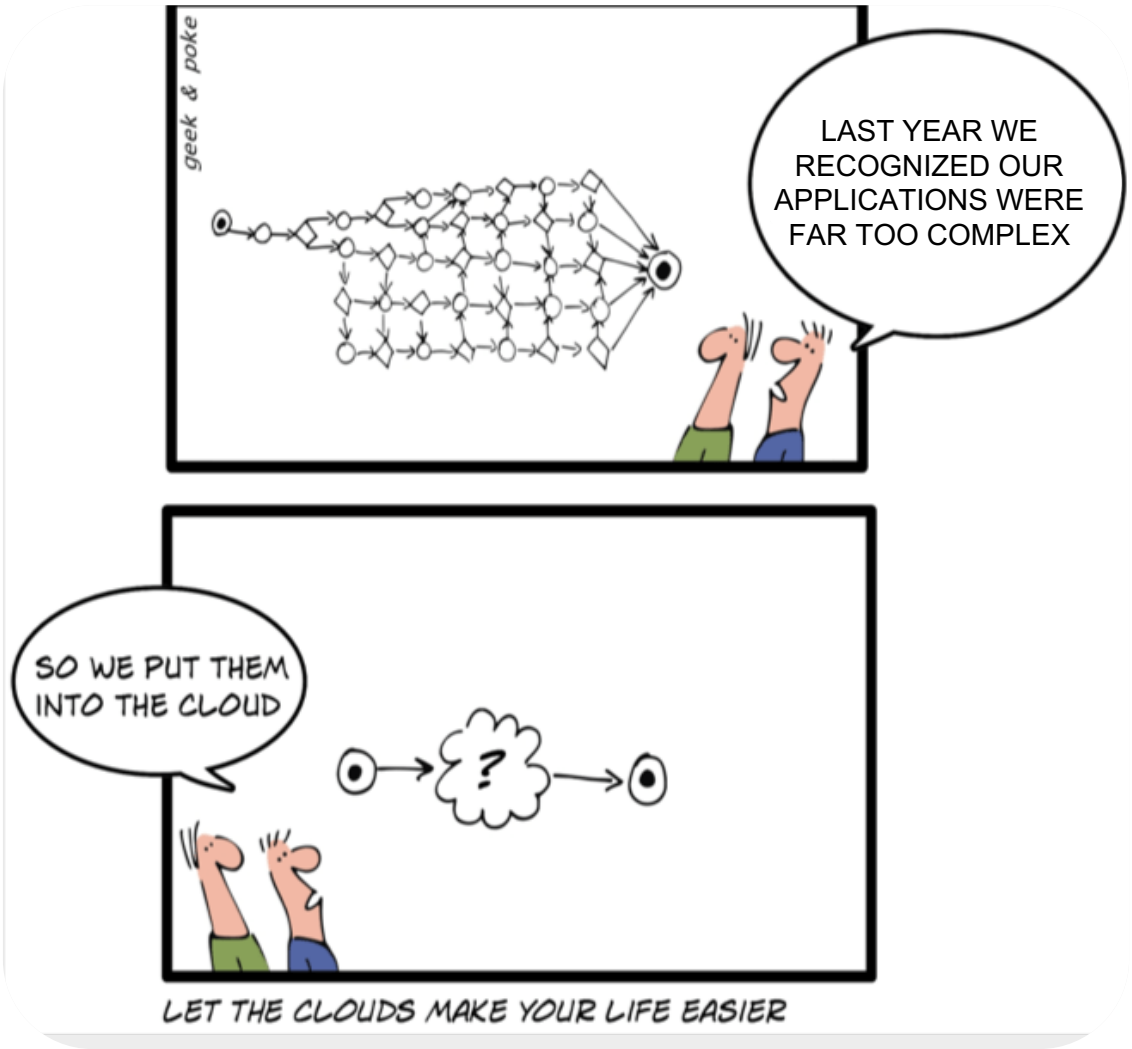
How to Benchmark the OCP Network: scenarios

1. Worker 2 Worker performance
2. Pod 2 Pod performance
3. Pod to external service performance



Focus on pod 2 pod and pod 2 external configuration!

Complexity



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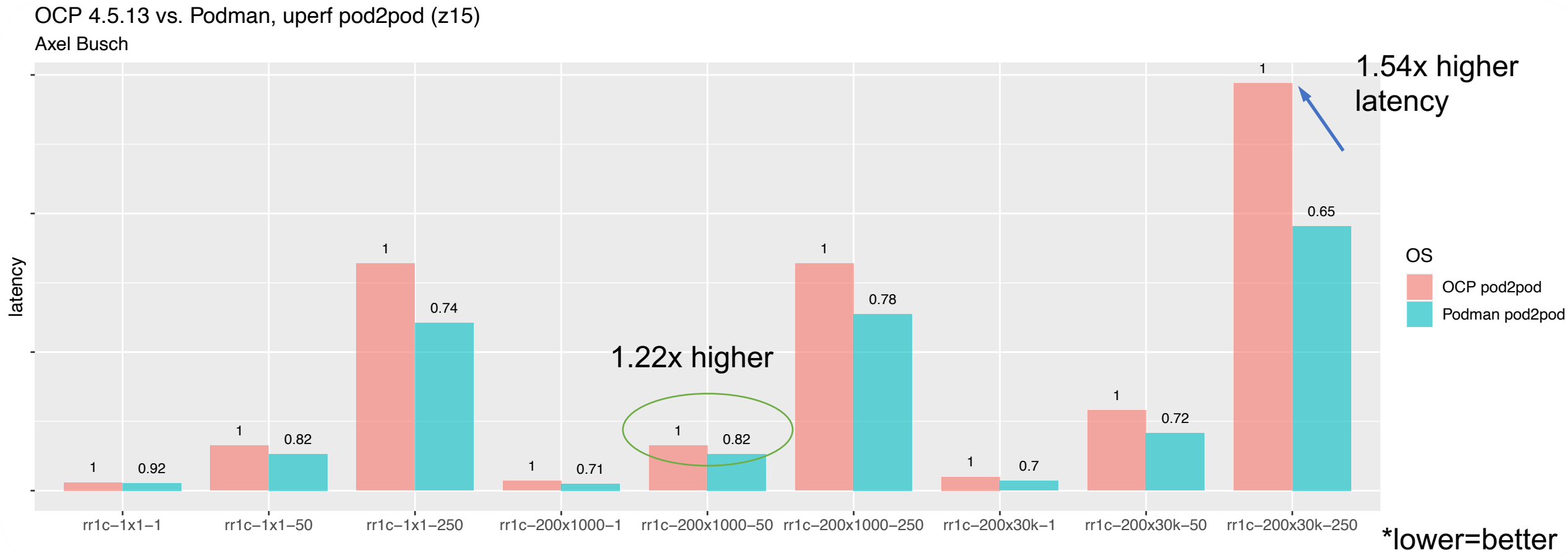
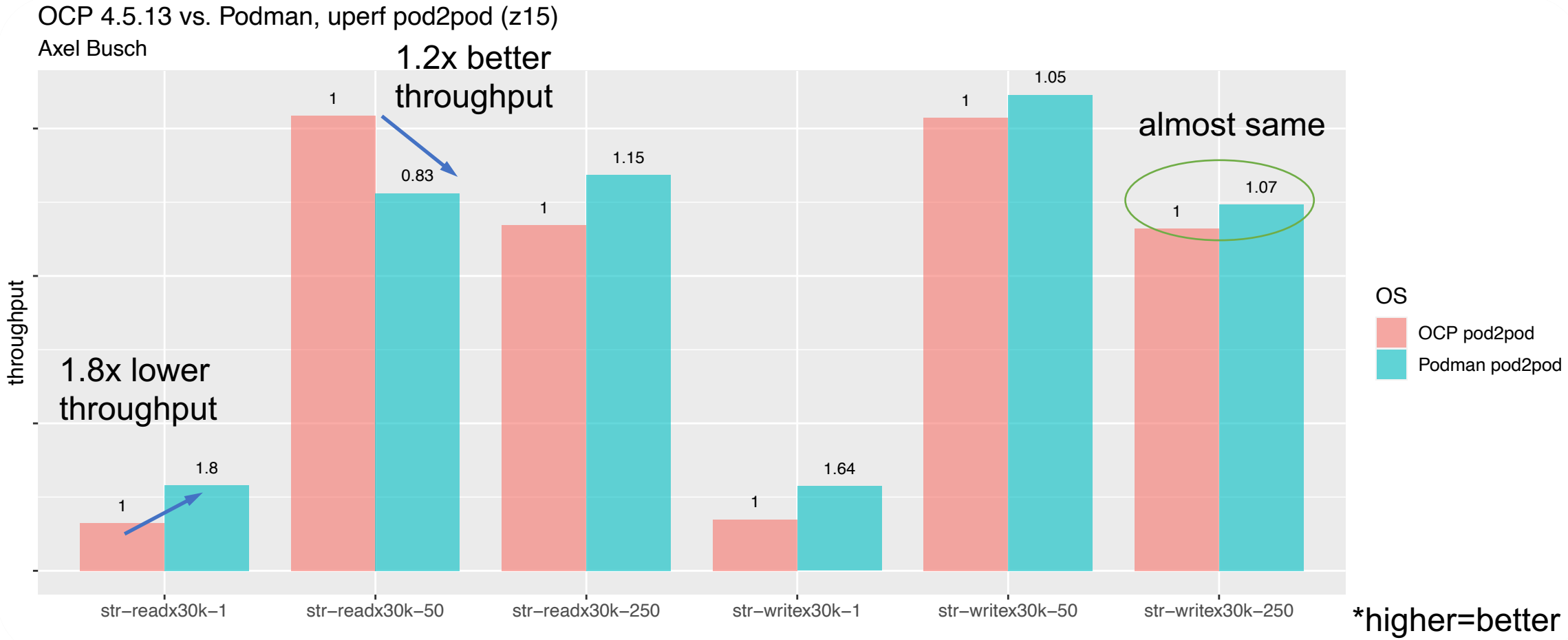
Scenario results: Pod to pod performance (1)

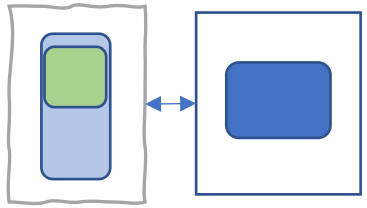


Scenario results: Pod to pod performance (2)



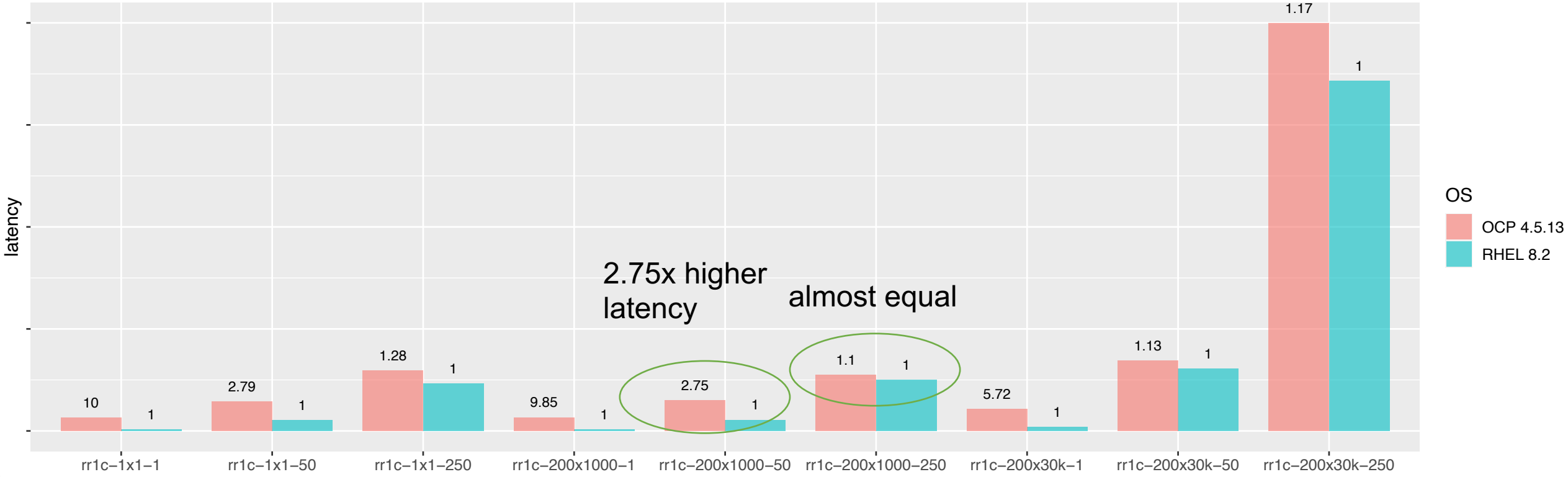
*higher=better

Scenario results: Pod to external performance (1)



RHEL 8.2 vs. OCP 4.5.13, uperf LPAR (server) to OCP guest (client), z15 z/VM vswitch

Axel Busch



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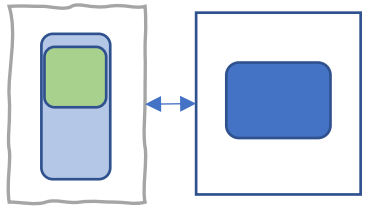
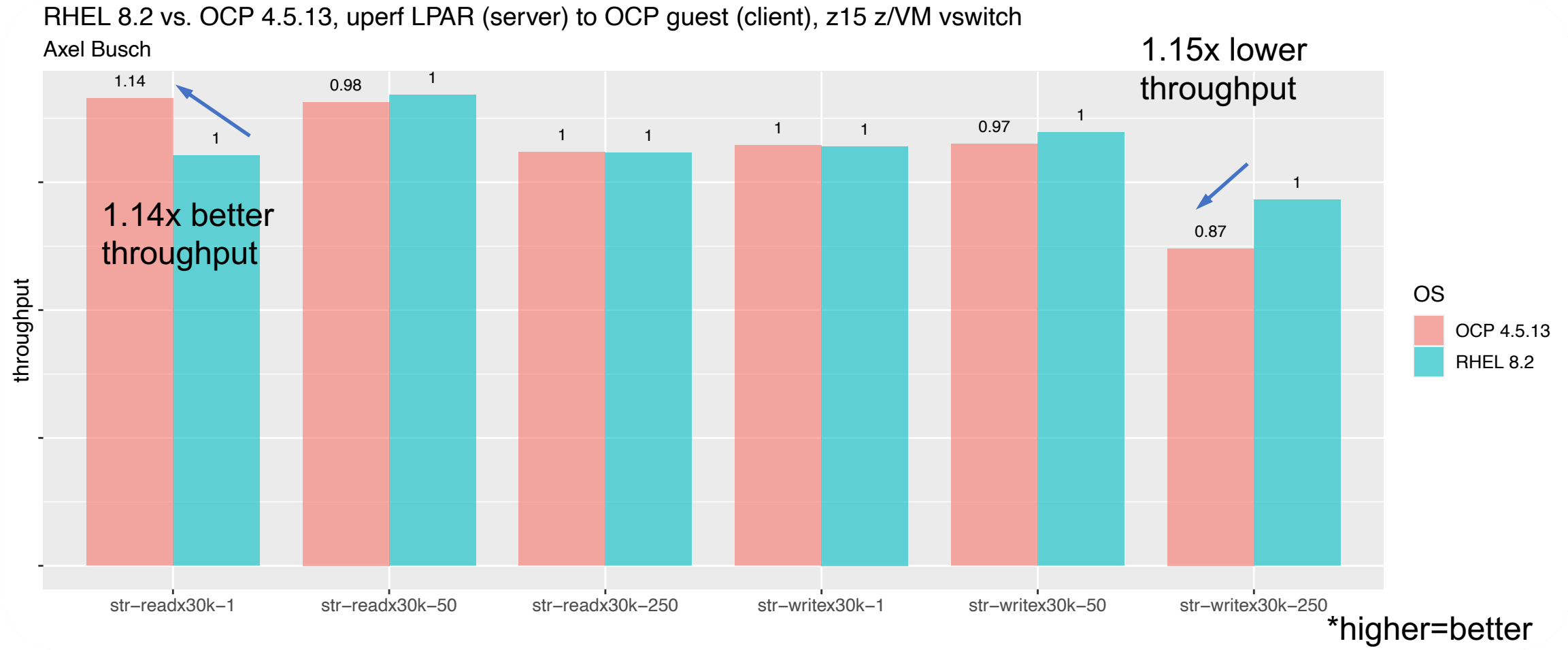
Scenario results: Pod to external performance (2)

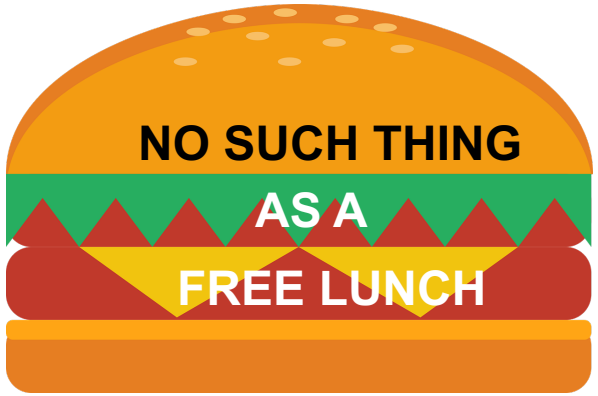




Almost same throughput for most workloads!

Scenario results: Discussion

- Pod 2 Pod performance
  - 1.09 - 1.5x higher latency
  - From 1.2x higher - 1.8x lower throughput compared to podman2podman
- Pod to external service performance
  - For typical workloads only from 10% to 2.75x higher latency, but can be up to 10x higher latency
  - Almost same throughput, up to 1.15x lower throughput compared to RHEL8.2 in z/VM



High automation…

Scalability…

Availability…

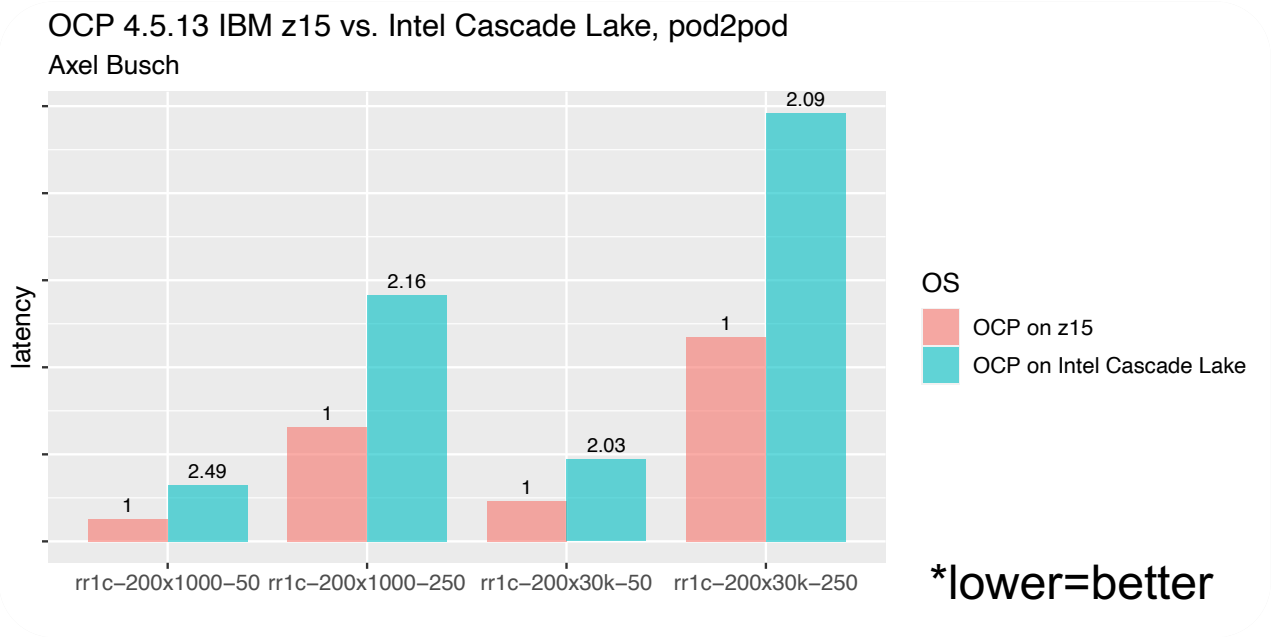
Flexibility…

… does **not** come for **free**…

… but has **improved significantly** and we are **working to improve it further**

Scenario results: Comparison to competitors

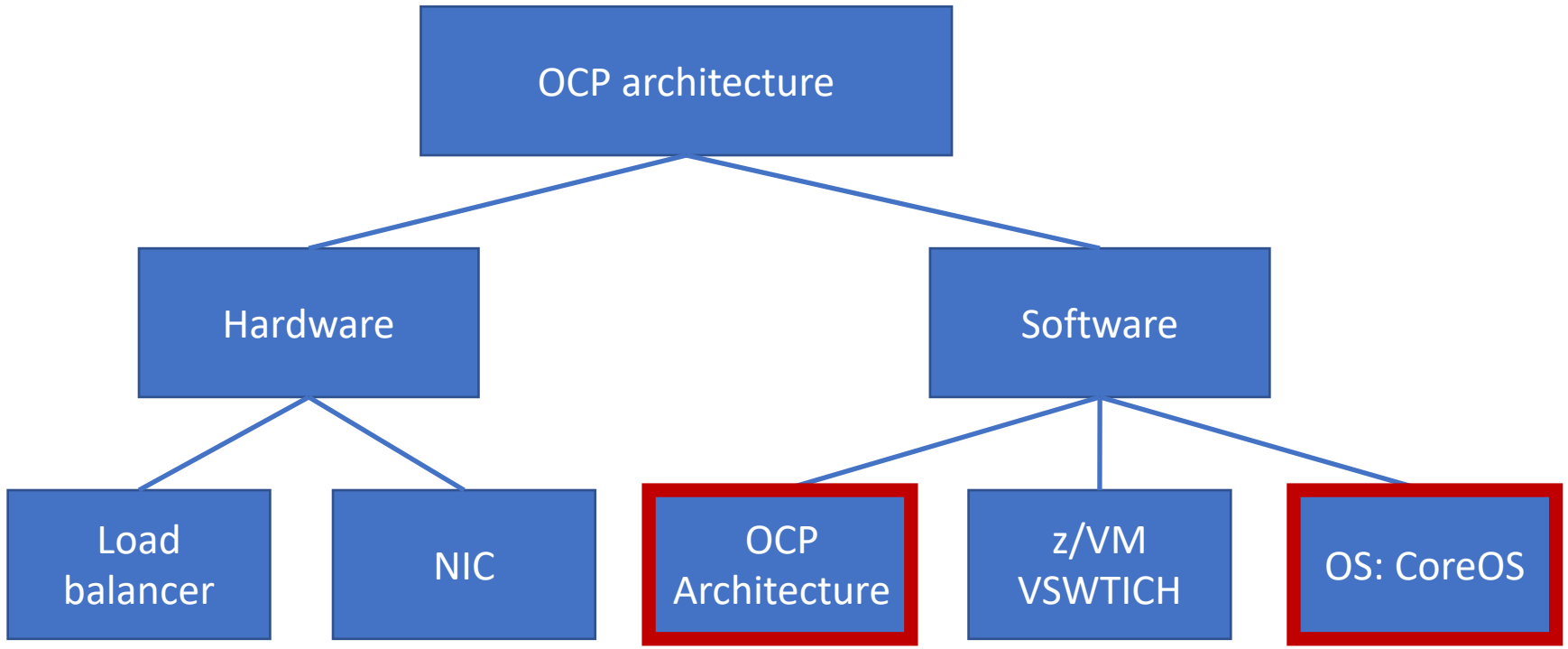
Pod 2 Pod performance on Intel cascade lake cluster up to 1.7x higher latency compared to podman2podman

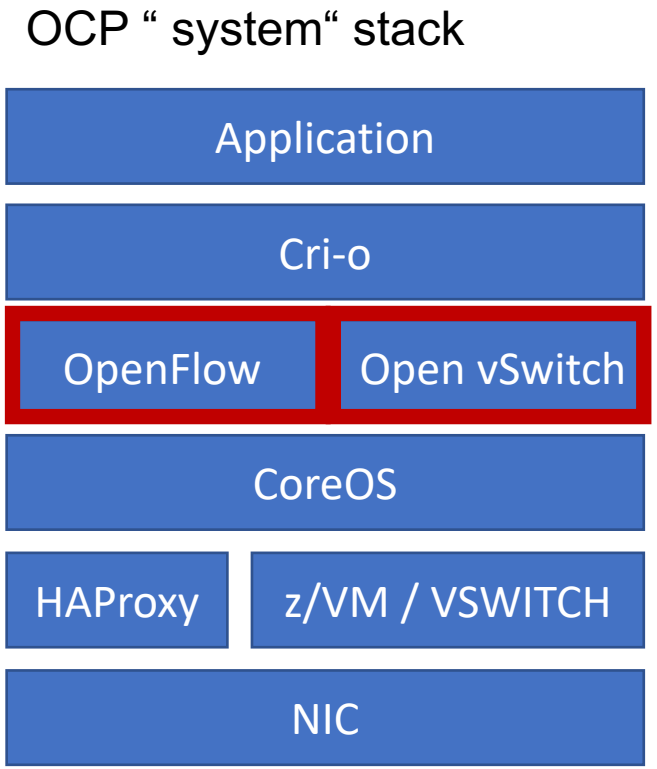


- Up to **2.49x better response times** on IBM z15
- Up to **2.00x better throughput** on IBM z15

Possible reasons

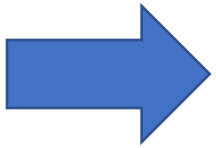
Software & hardware architecture highly influences quality attributes such as performance!





OCP Architecture: Software defined network (SDN)

- Used for (automated) **dynamically configurable network** in changing environments
  - **Physical resources** change according to load
  - **Pods** come and go dynamically
  - (Allowed) **Routes change** during runtime
- Pods (sometimes) need **connection to outside world**
- Reliability, Security, Scalability **QoS guarantees** supported by dynamic networks
- OCP 3.x - 4.6 mainly use open vSwitch, OpenFlow and openshift-node-agent
- OCP (on z) 4.7 uses Open Virtual Network (OVN)

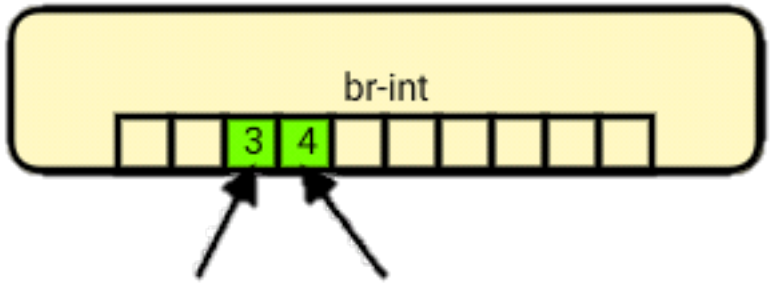


Open vSwitch and OpenFlow main components of OpenShift SDN

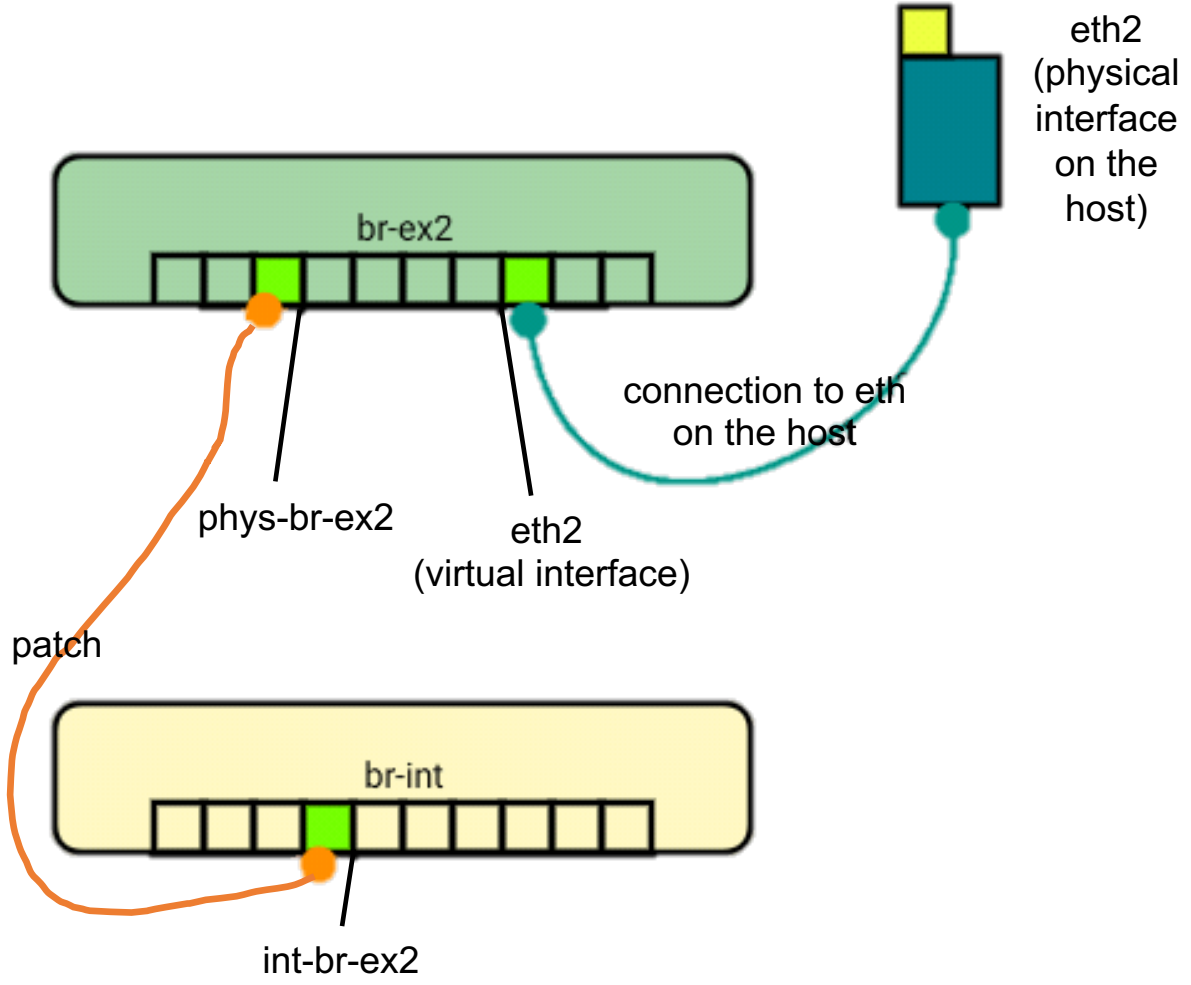
Open vSwitch (OVS)

OPEN vSWITCH
An Open Virtual Switch

- Needed when many virtual machines (or containers) run on one physical node
- Virtualizes network layer
  - Virtual ports
  - Virtual bridges
  - Used for connecting several virtual machines
- Connects virtual machines to physical network

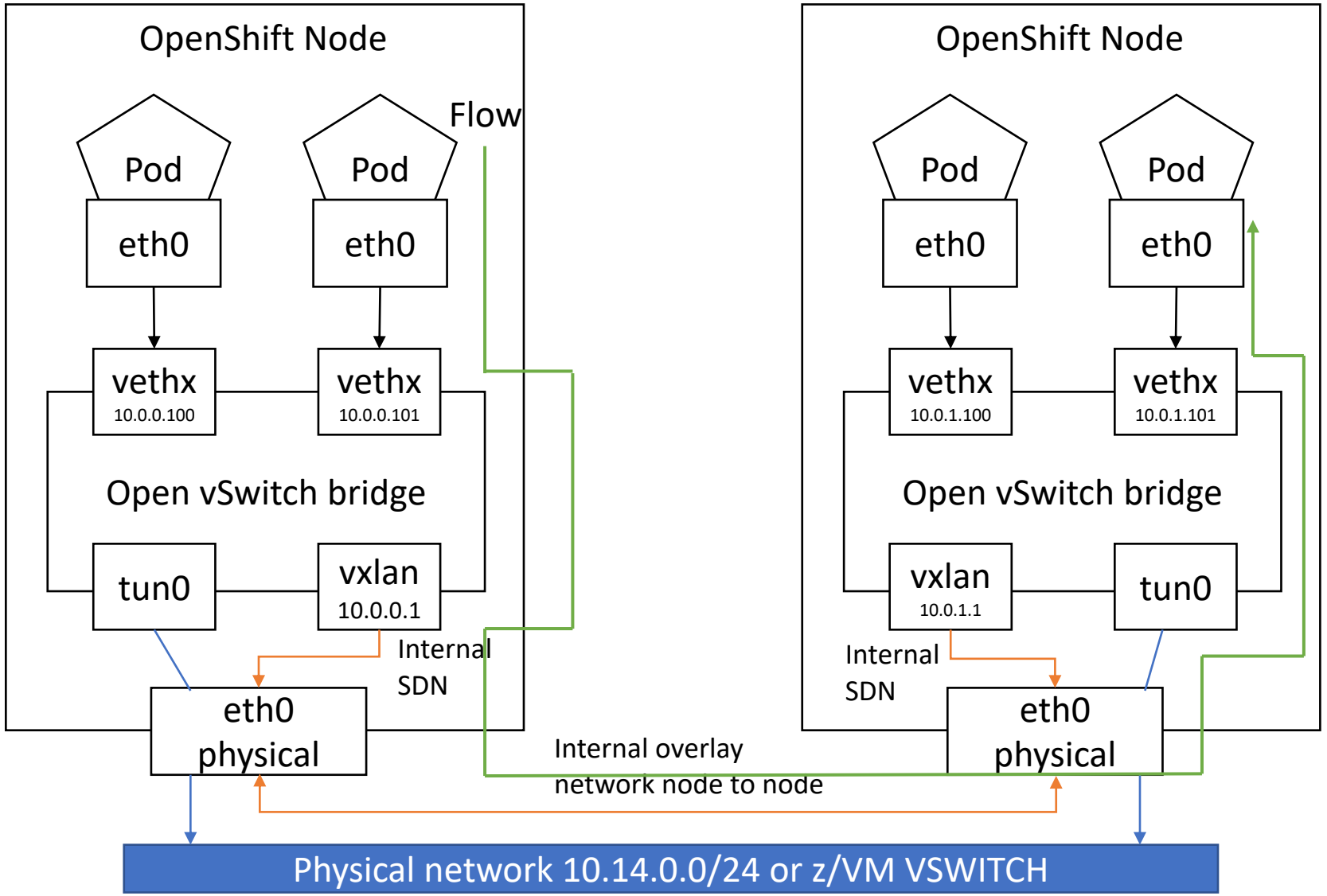


Virtual bridge with its corresponding ports. Each port has a corresponding name and number



see https://superuser.openstack.org/articles/openvswitch-openstack-sdn/

OpenShift software defined network



vethx: virtual interfaces

vxlan: forwards traffic to internal (overlay) network

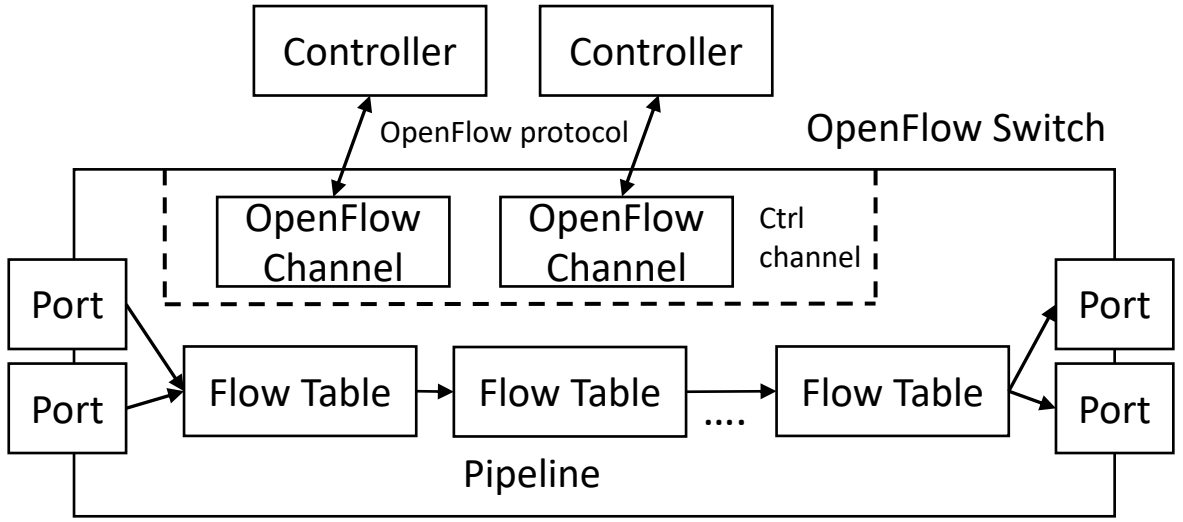
tun0: forwards traffic to external network

Open vSwitch and OpenFlow

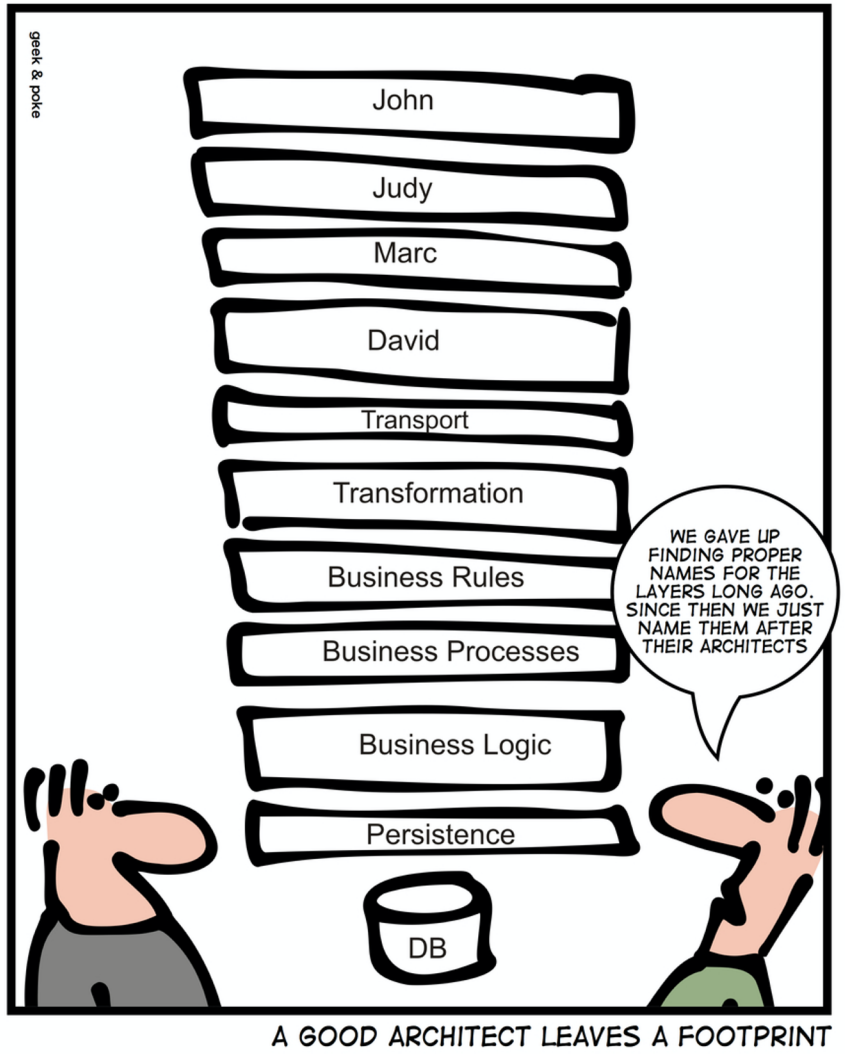
How to define which pod can access other pods and/or external network?

OpenFlow rules control communication between ports on virtual bridges

- OpenFlow separates control of packet flow from packet forwarding
- Integrates functions directly in the network (e.g. firewall)
- Channel controllers configure and manage the switch



Hang on…



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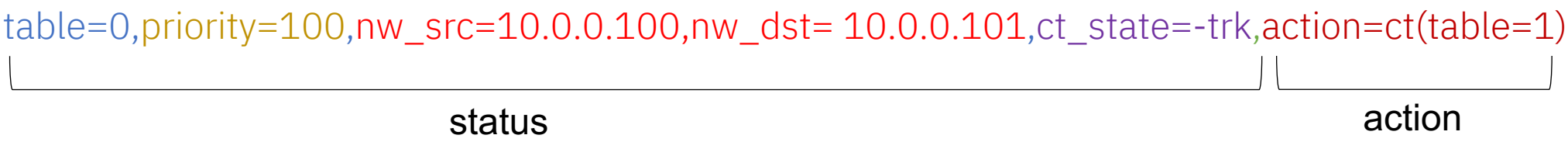
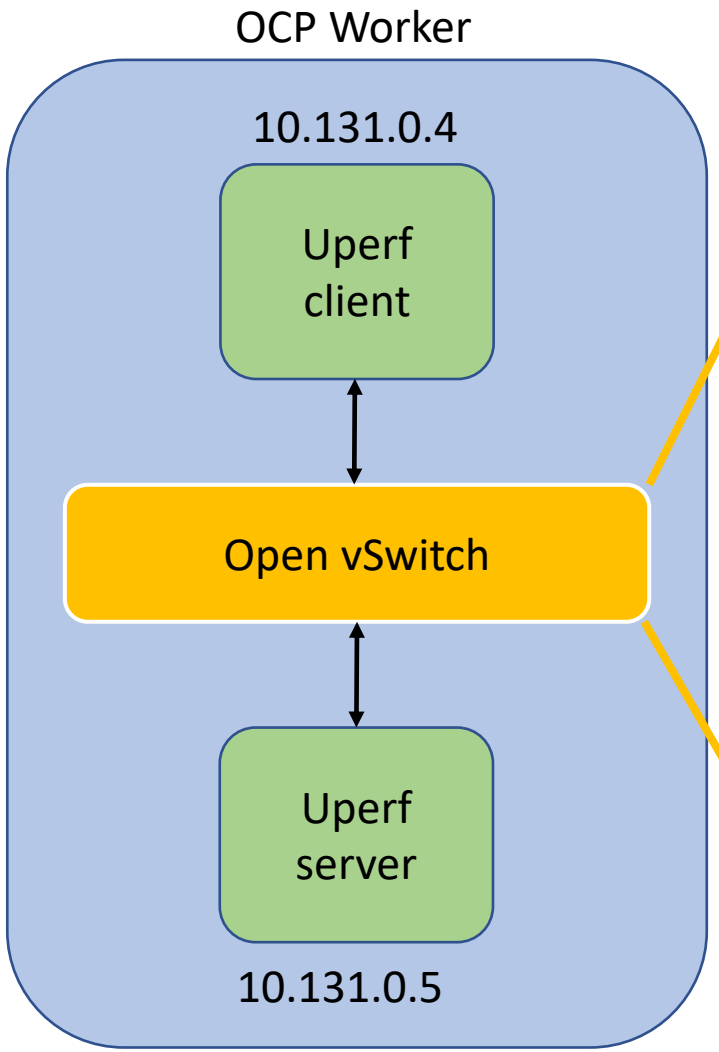
OpenFlow rules architecture



- Connection tracking (contrac or ct) keeps track of connection states of individual TCP sessions
- ct allows to control packet flows by using ACLs
- Can be used to implement (stateful) firewall
  - Selectively commits some traffic
  - Matches ct states to allow established connections but deny new connections
- Works with tables that realizes pipeline

OVS & OpenFlow architecture OpenShift



Pipeline

Table=0

1. priority=300, ct_state=-trk, ip, actions=ct(table=0)
2. priority=100, ip, actions=goto_table:20

Table=20

1. priority=100,ip,in_port=5,nw_src=10.131.0.4 actions=load:0->NXM_NX_REG0[],goto_table:21
2. priority=100,ip,in_port=6,nw_src=10.131.0.5 actions=load:0->NXM_NX_REG0[],goto_table:21

Table=21

priority=200,ip,nw_dst=10.128.0.0/14 actions=ct(commit,table=30)

Table=30

1. priority=300,ct_state=+rpl,ip,nw_dst= 10.131.0.0/23 actions=ct(table=70,nat)
2. priority=200,ip,nw_dst=10.131.0.0/23 actions=goto_table:70

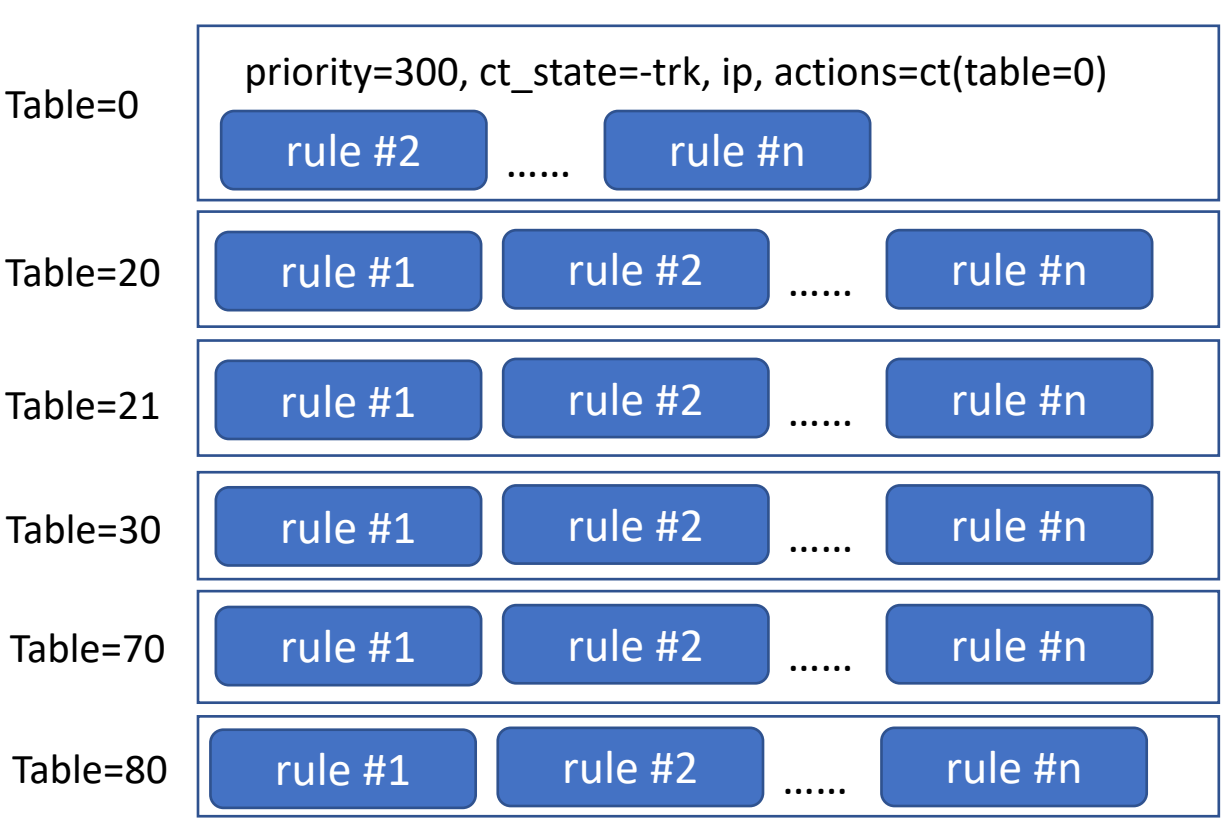
Table=70

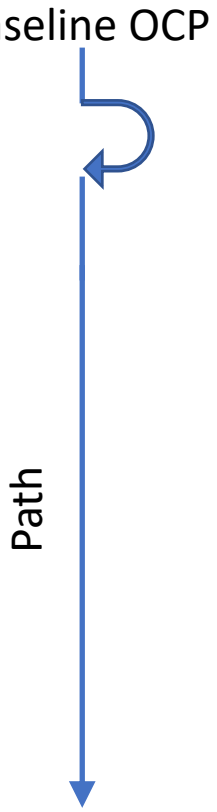
priority=100,ip,nw_dst=10.131.0.4 actions=load:0->NXM_NX_REG1[],load:0x5->NXM_NX_REG2[],goto_table:80

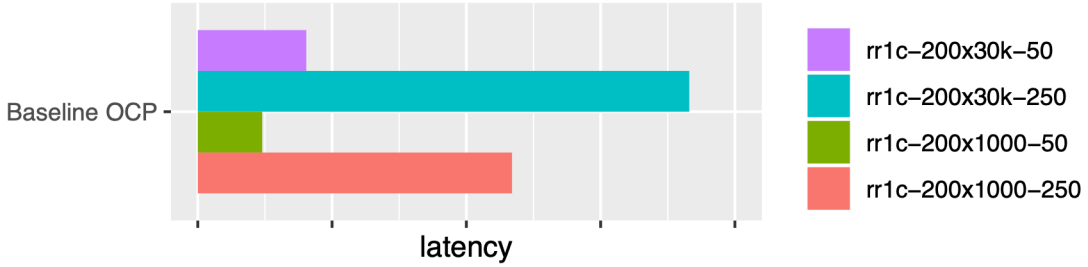
Table=80

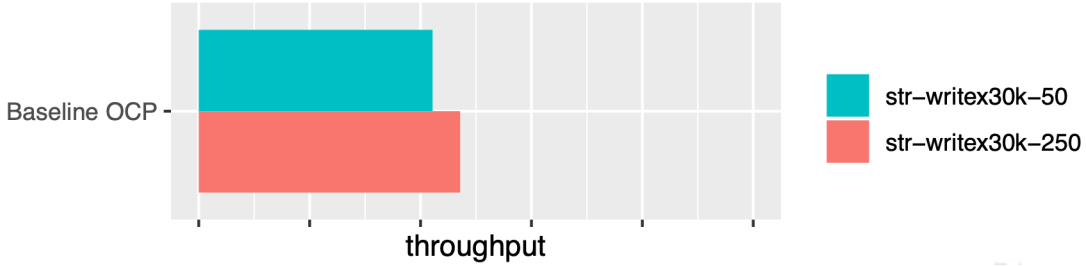
1. priority=200,ct_state=+rpl,ip actions=output:NXM_NX_REG2[]
2. priority=50,reg1=0 actions=output:NXM_NX_REG2[]

OpenFlow rules performance: uperf request response & streaming









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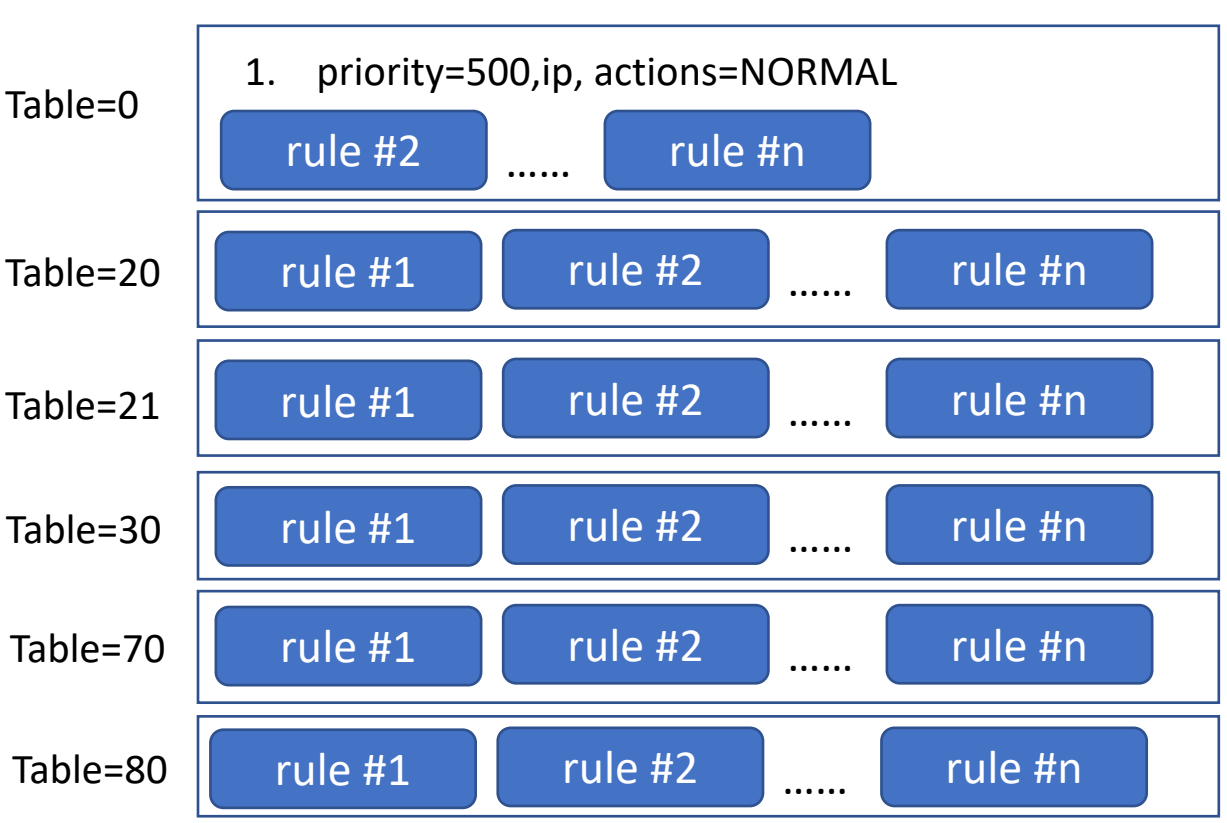

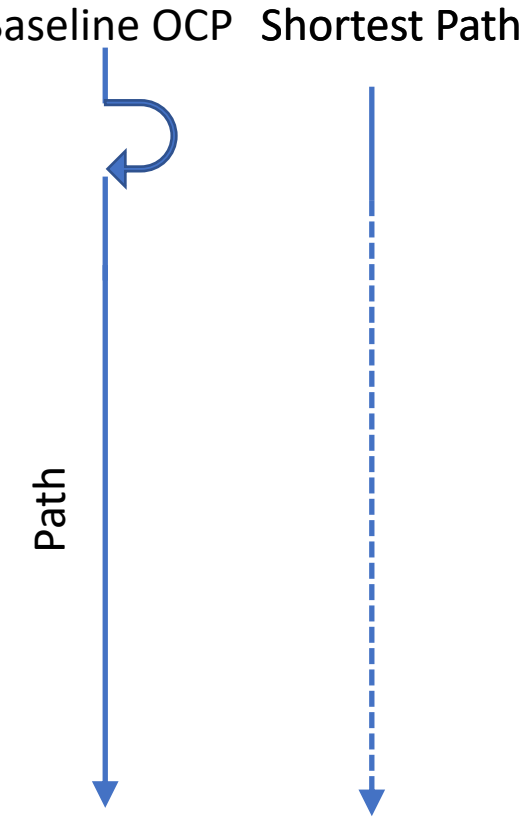

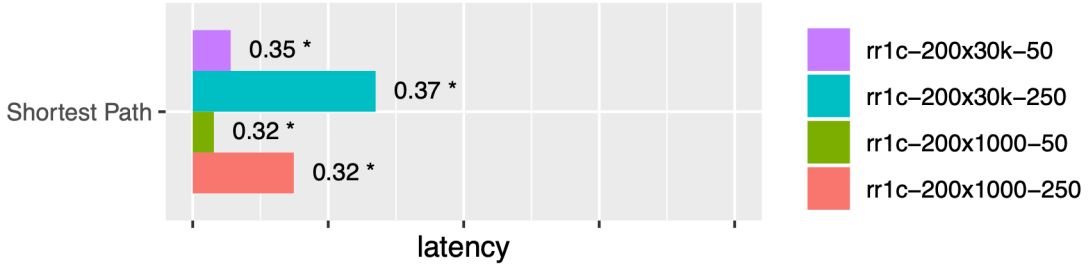

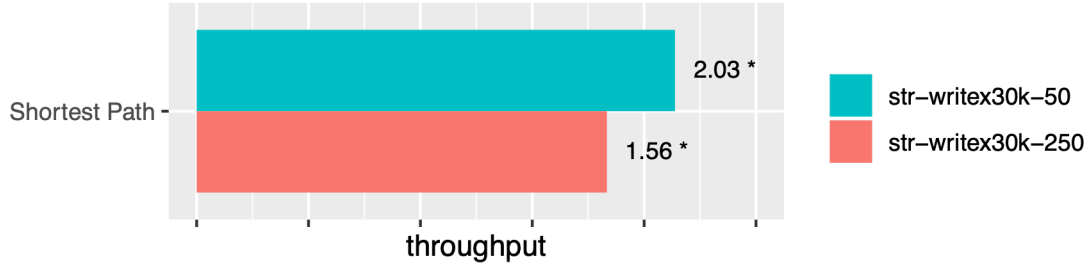

* relative to Baseline OCP

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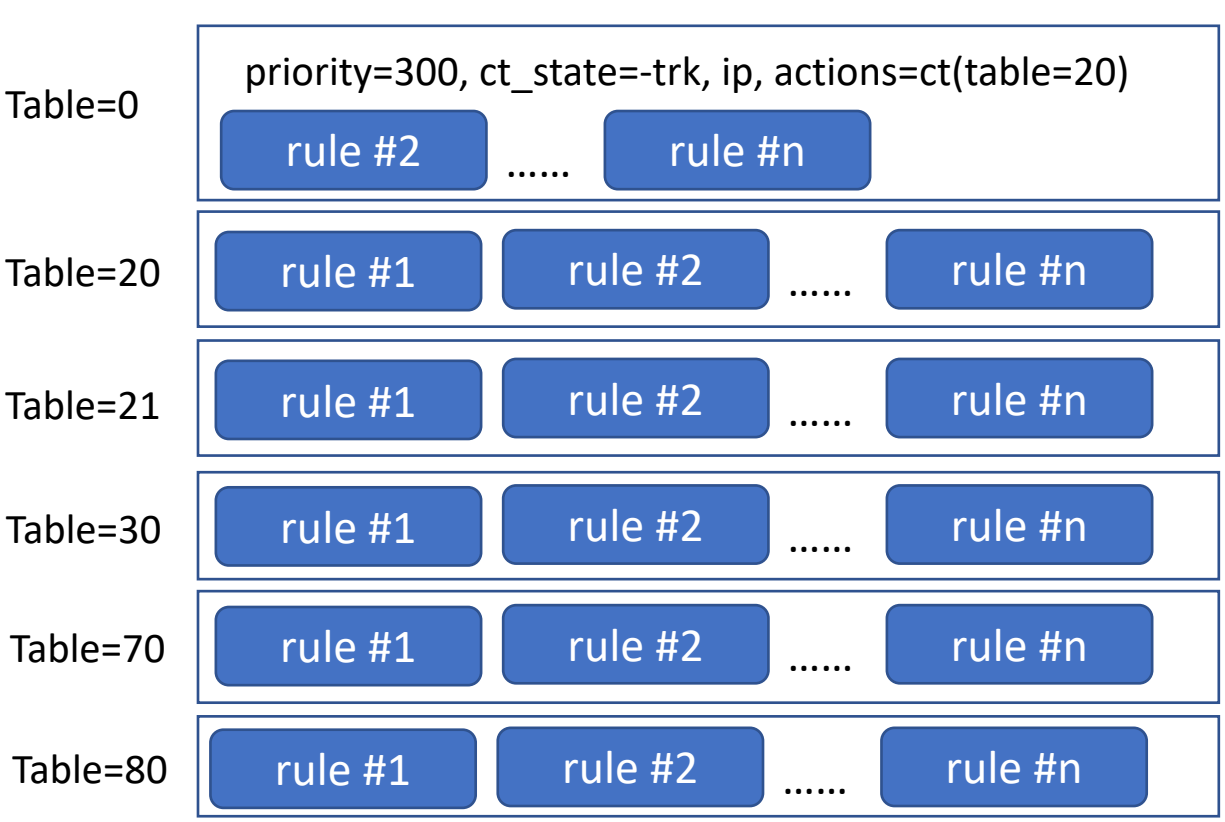

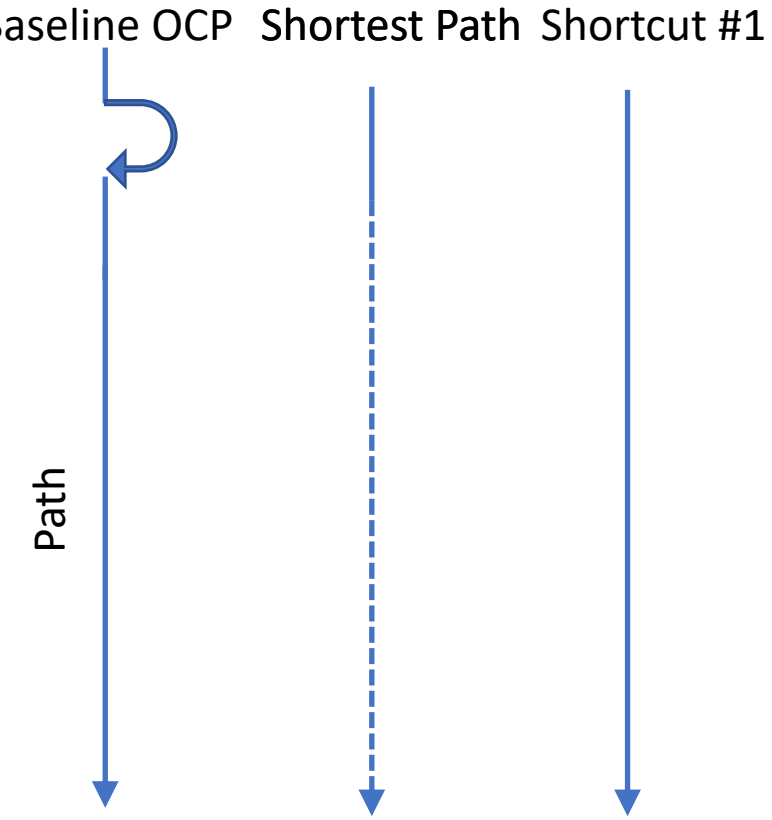

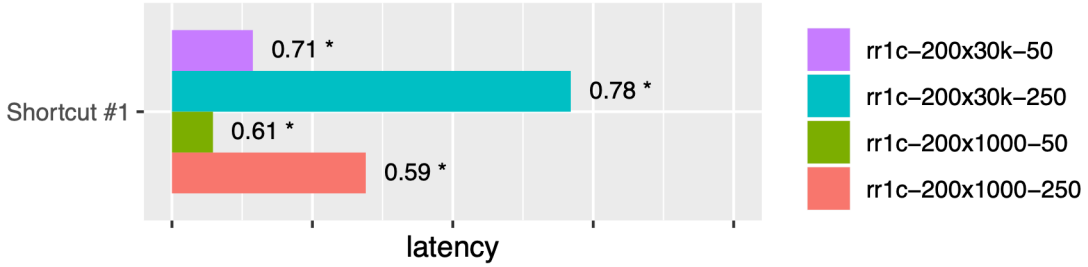

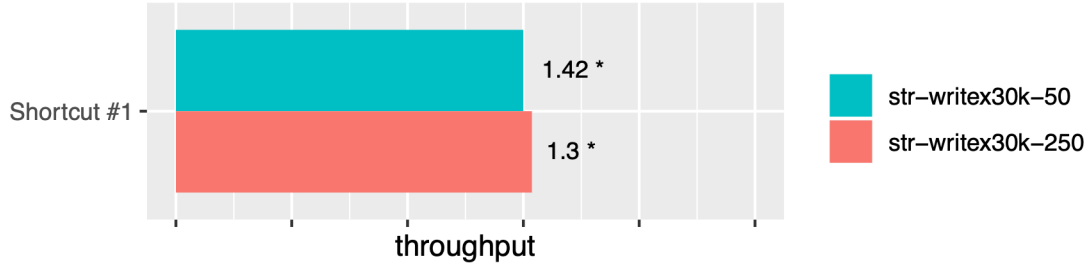

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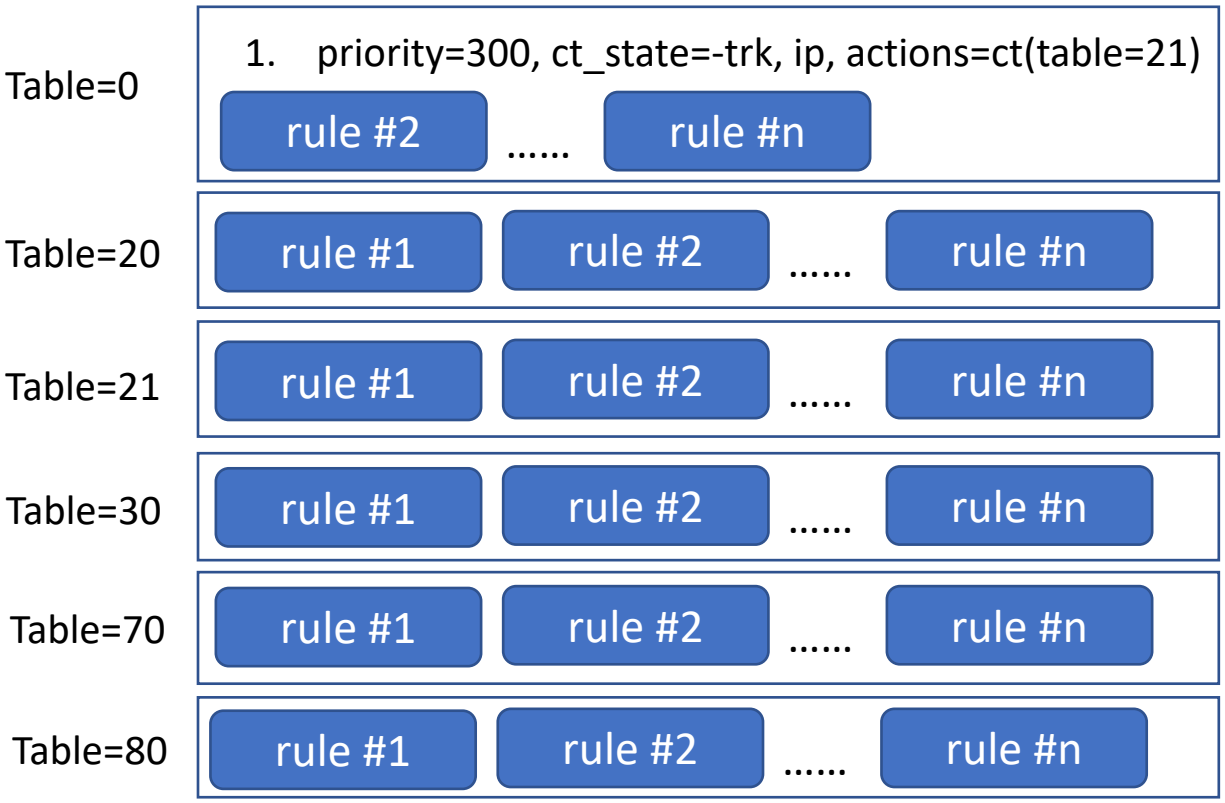

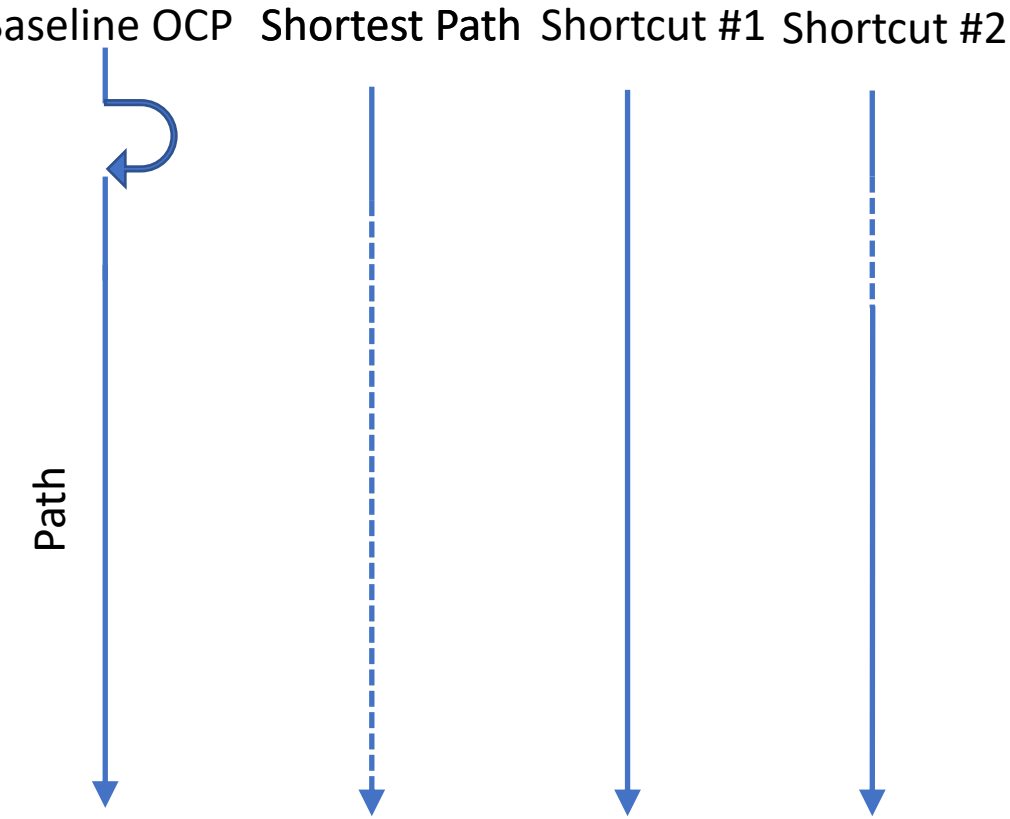

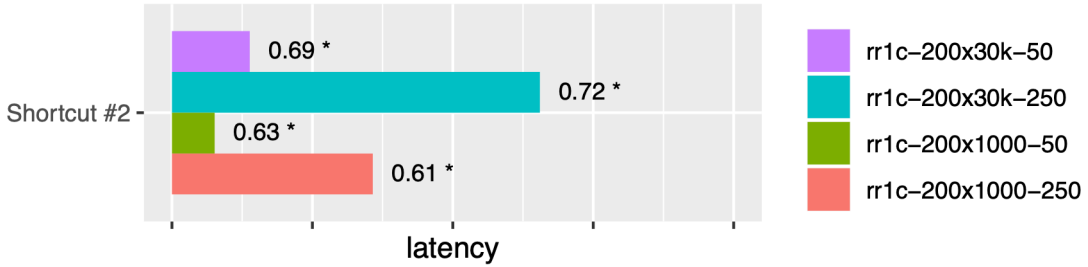

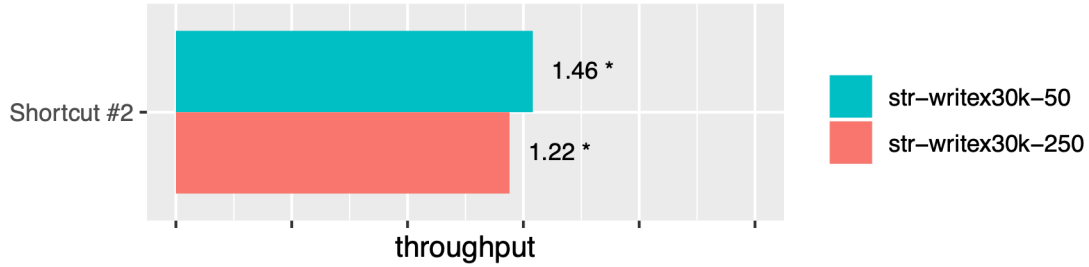

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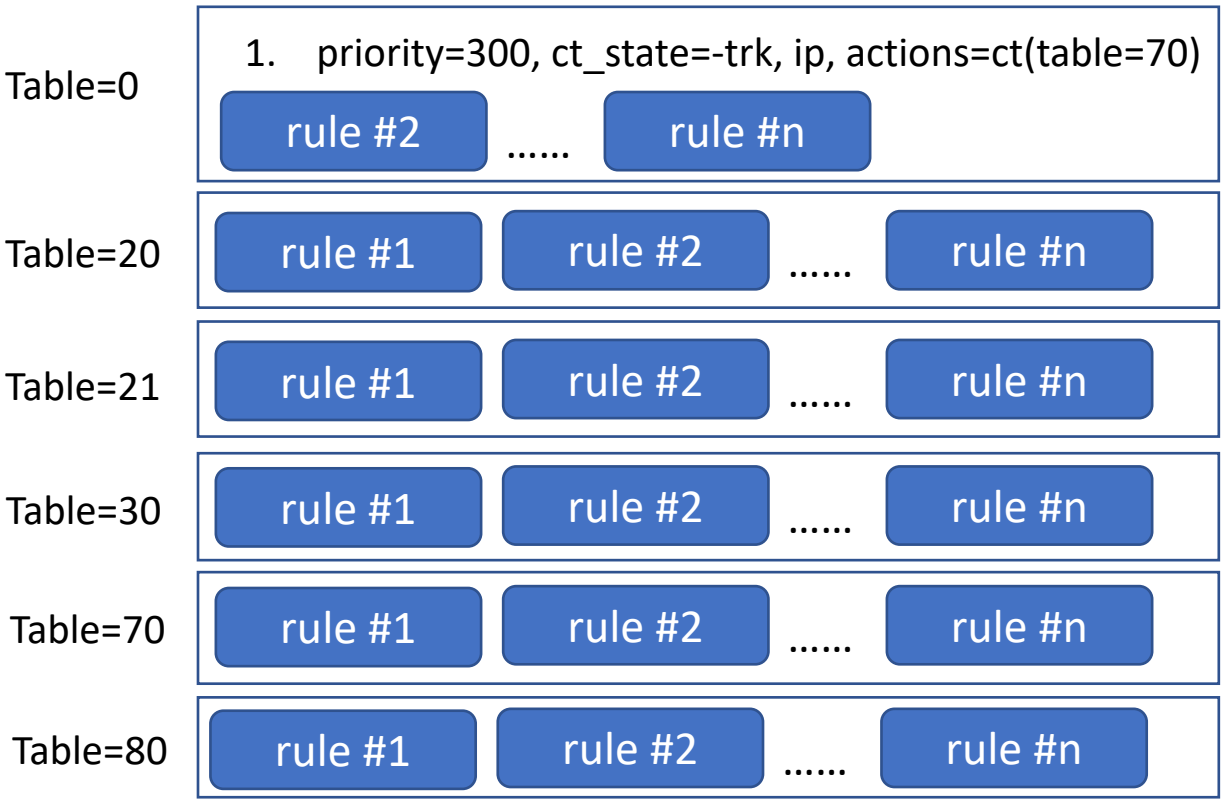
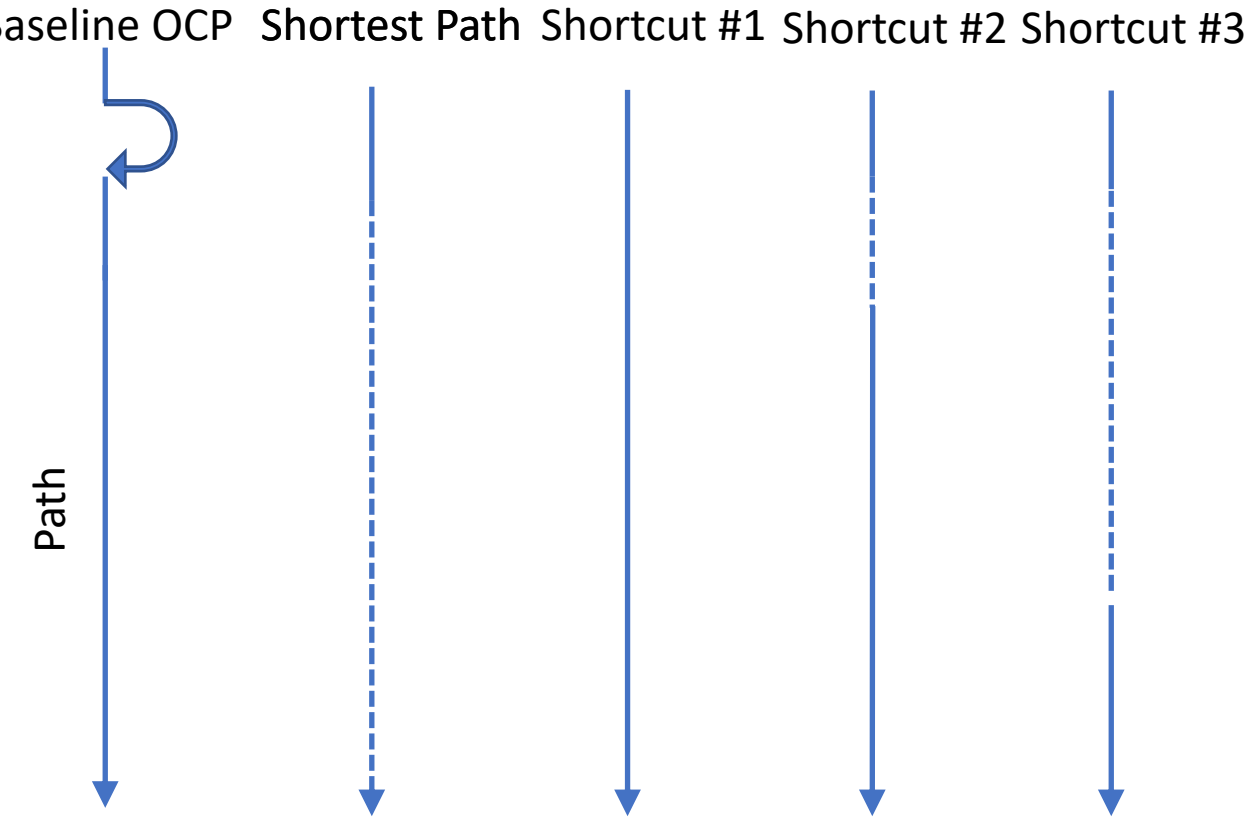
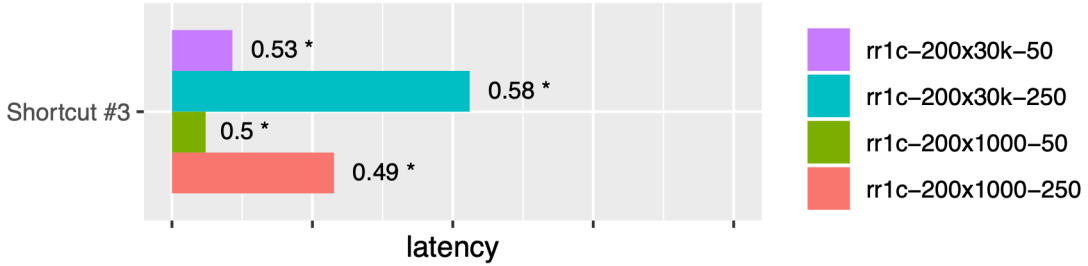
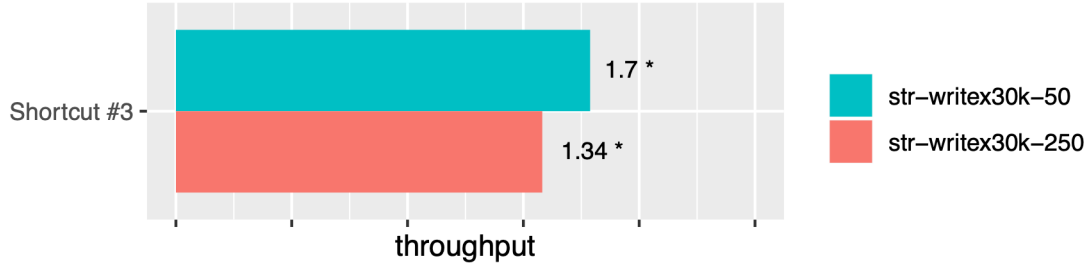


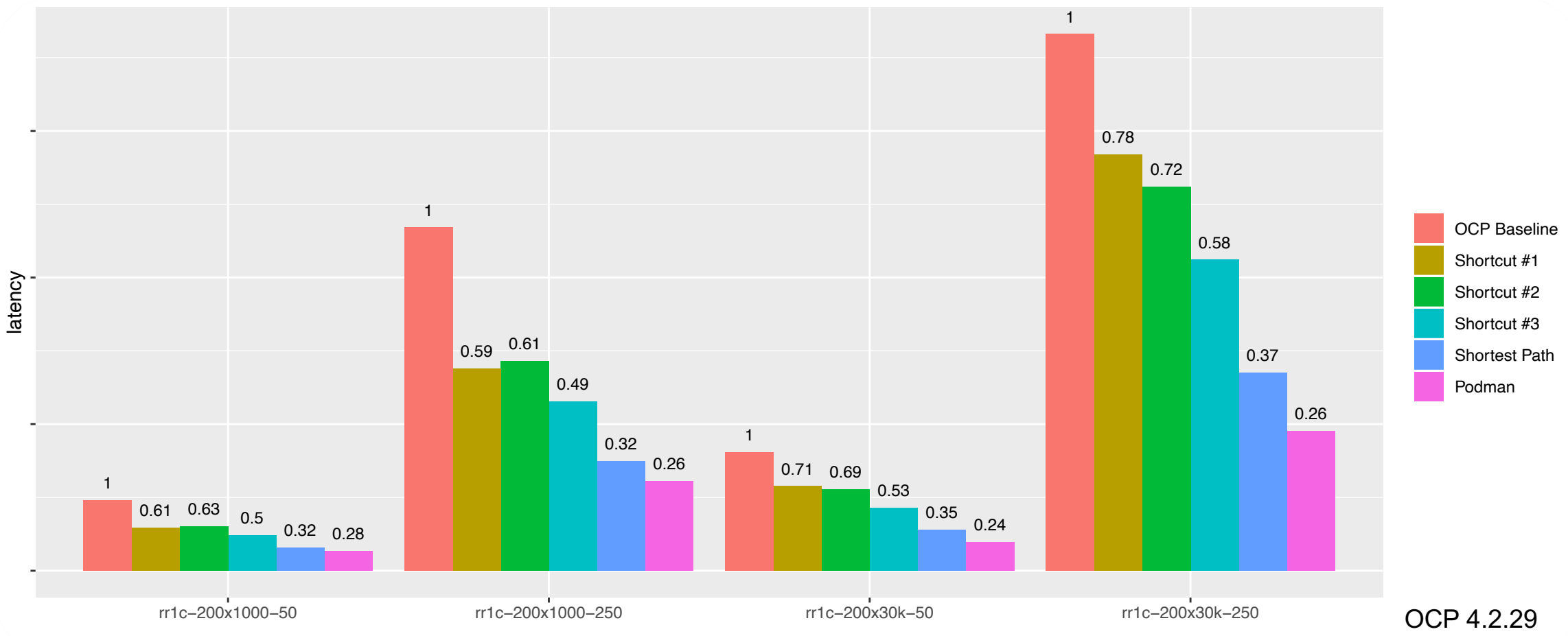






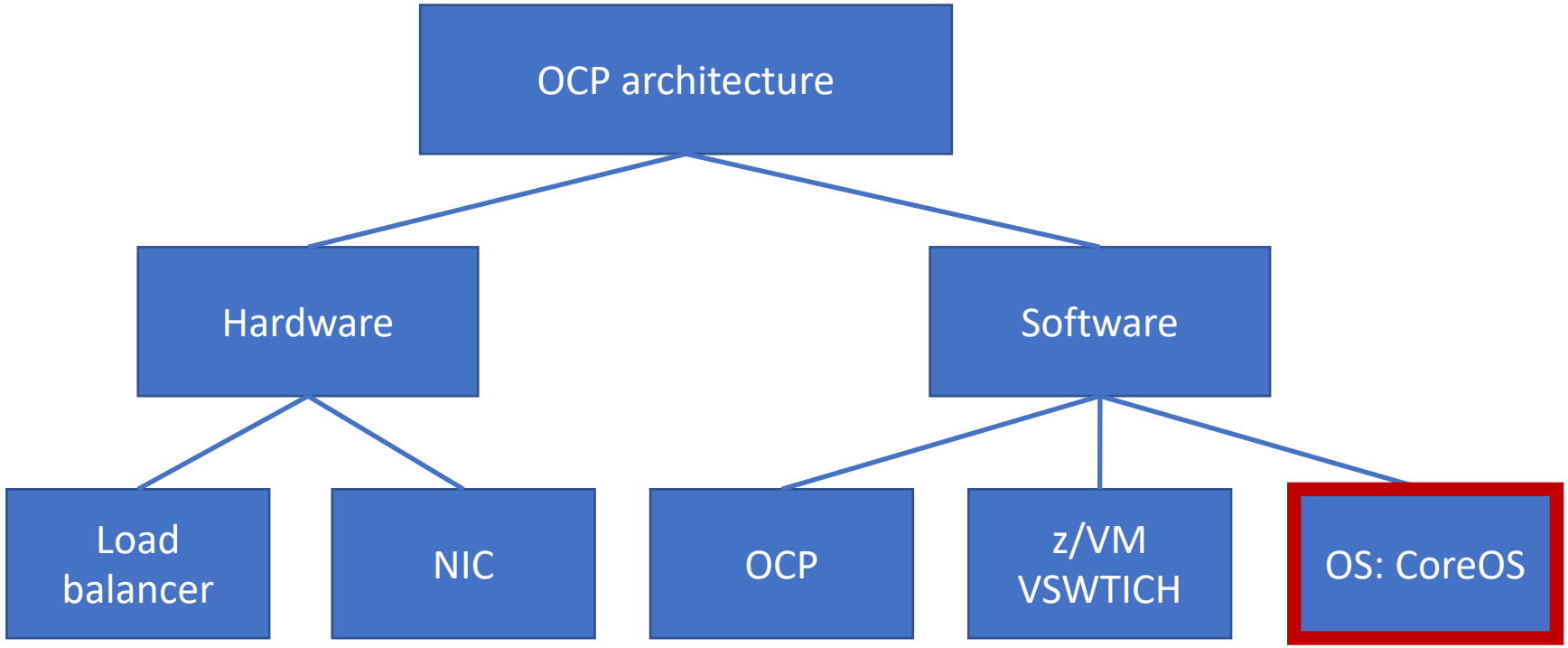
* relative to Baseline OCP

OpenFlow rules performance: Summary



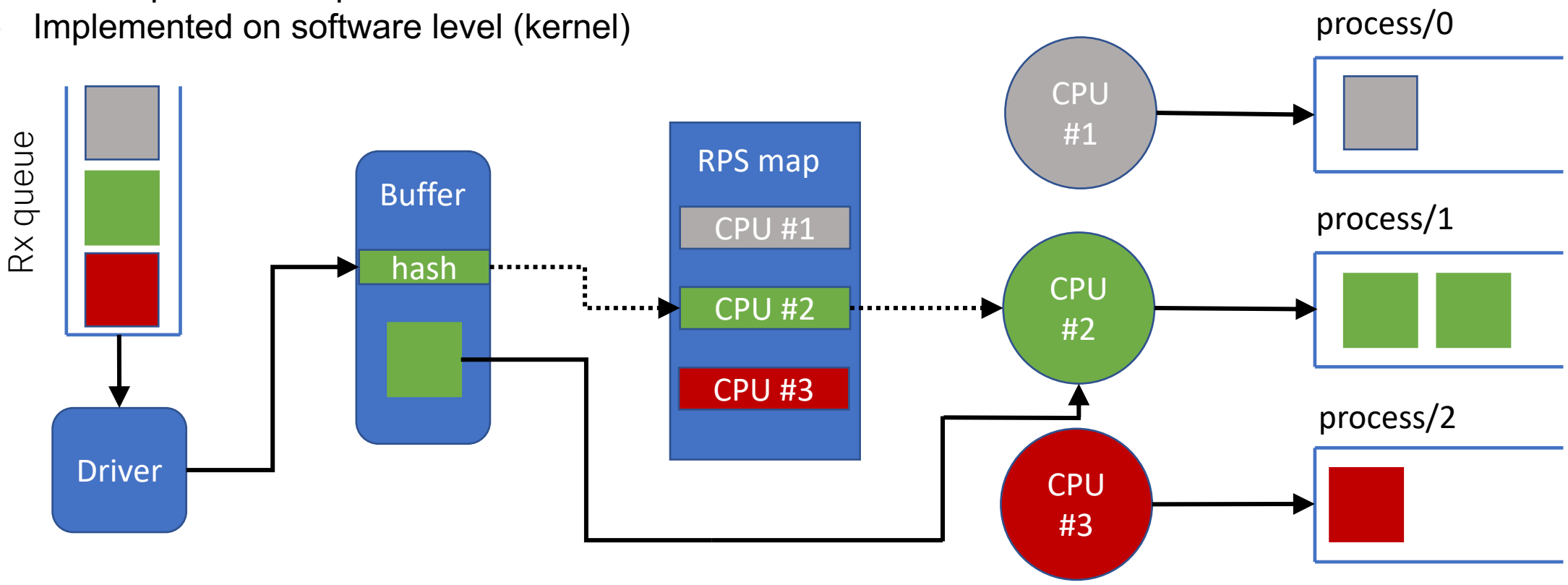
OCP 4.2.29

Performance Optimizations



CoreOS/OCP optimizations: Receive Packet Steering (RPS)

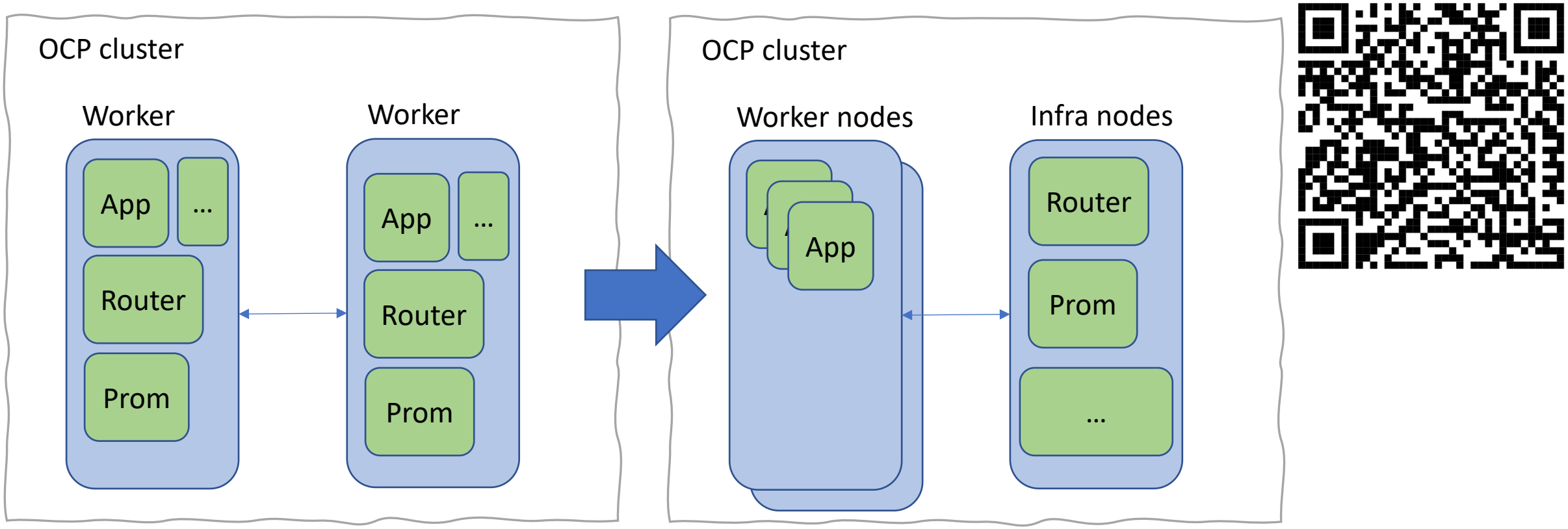
- Prevents hardware queue of network card beeing bottleneck
- Directs packets to specific CPUs
- Implemented on software level (kernel)



Latency can be improved significantly with RPS setting on (depending on workload).

CoreOS/OCP optimization results: Using infrastructure nodes

How to setup infra nodes:



- Move all infrastructure services to infrastructure nodes to keep worker for application workload exclusive
- Consume resources of worker and slow down applications

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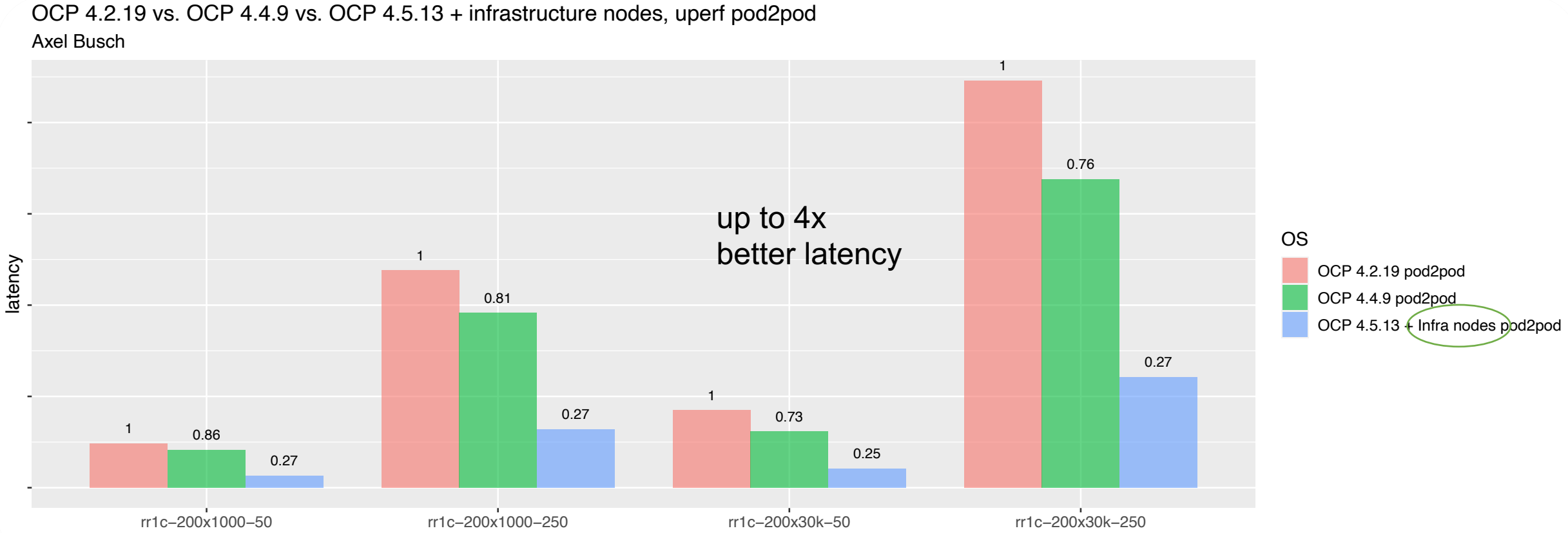
- Consume resources of worker and slow down applications

https://www.linkedin.com/pulse/boosting-performance-using-infrastructure-nodes-your-cluster-miranda/

CoreOS/OCP optimization results: update on OCP 4.5.13 and use of infra nodes



Further optimizations

Updates on
- Receive Packet Steering (RPS)
- Static routes
- Infrastructure nodes

Red Hat OpenShift on IBM Z - Performance Experiences, Hints and Tips

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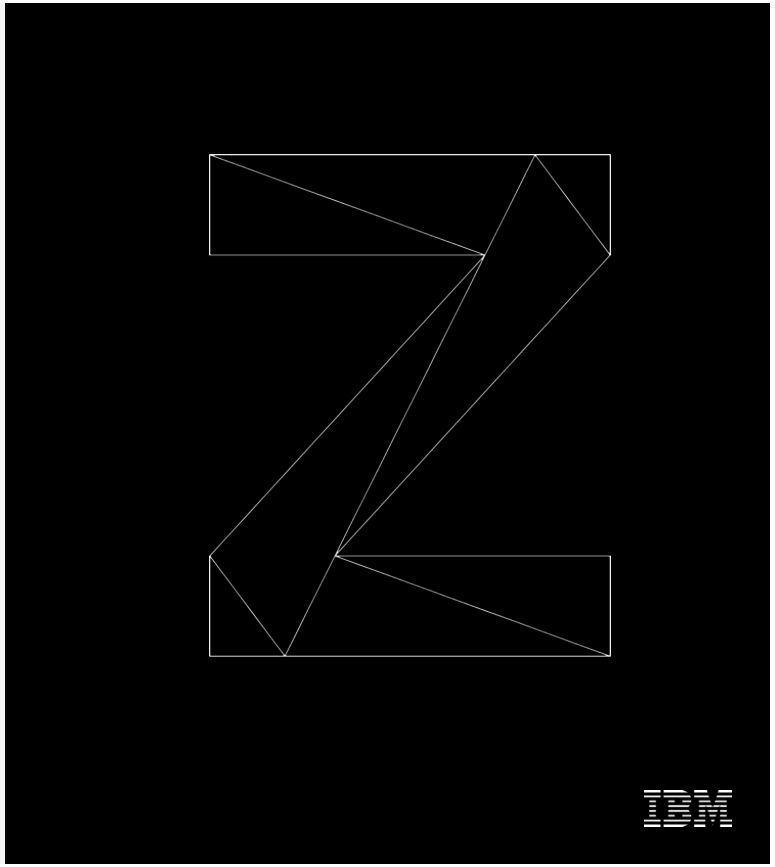
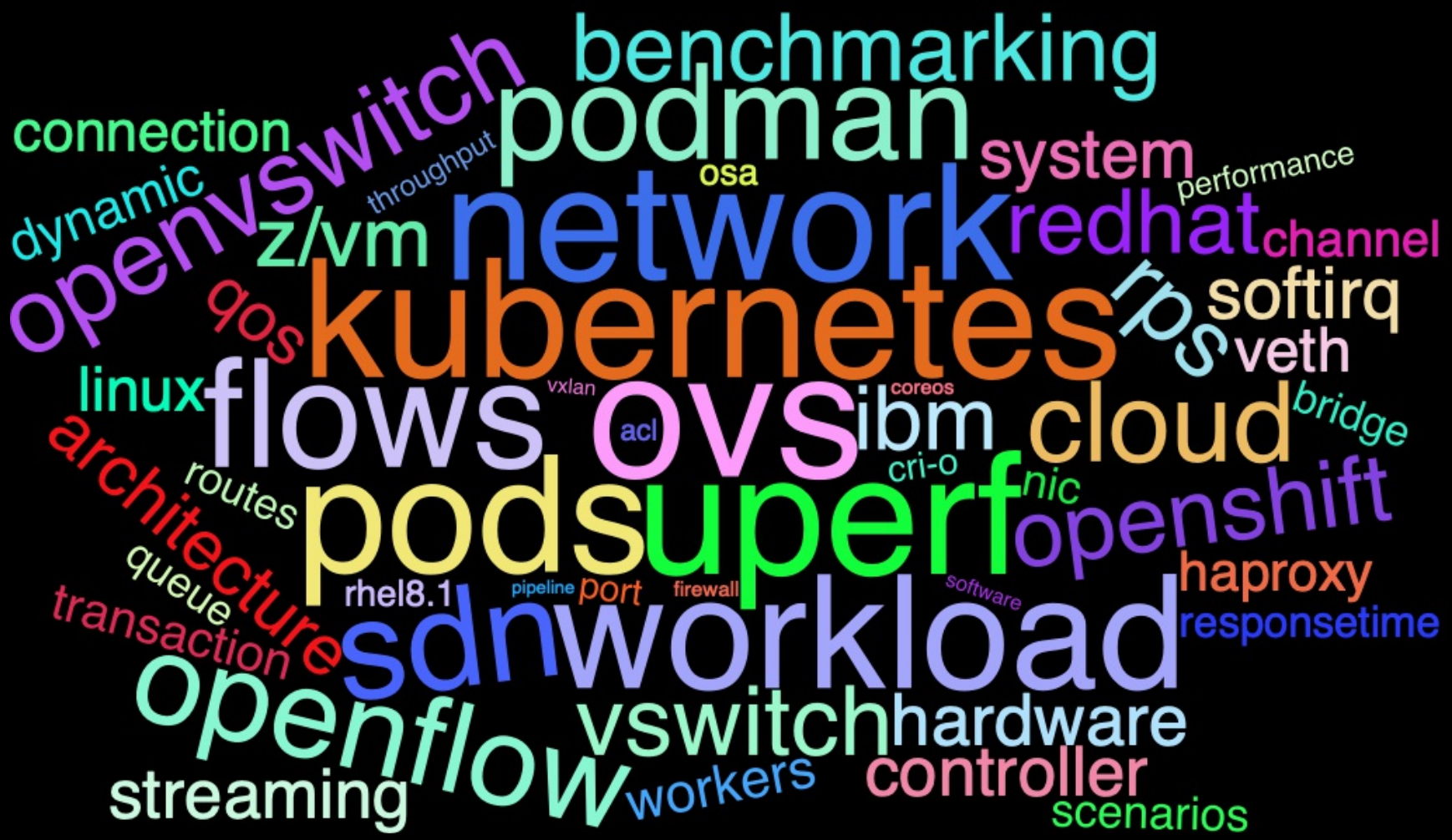


http://public.dhe.ibm.com/software/dw/linux390/perf/OpenShift_on_IBM_Z_-_Performance_Experiences_V11.pdf

Summary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connection
dynamic
throughput
osa
system
performance
network
z/vm
redhat
channel
qos
kubernetes
rps
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linux
flows
ovs
vxlan
coreos
ibm
cloud
bridge
acl
cri-o
nic
architecture
routes
podsuperf
openshift
haproxy
queue
rhel8.1
pipeline
port
firewall
software
responsetime
transaction
sdnworkload
openflow
vswitch
hardware
streaming
workers
controller
scenarios

Thank you!

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Linux on IBM z Performance

ibm.biz/perfradar – the Performance Radar Blog