Mizar

Current state and work in progress

https://github.com/futurewei-cloud/mizar

The Problem We are Trying to Solve

- Support provisioning and management of large number endpoints (300K hosts, 10M endpoints)
- Accelerate network resource provisioning for dynamic cloud environments
- Achieve high network throughput and low latency
- Create an extensible cloud-network of pluggable network functions
- Unify the network data-plane for containers, serverless functions, virtual machines, etc!

Problems with Current solutions

- Program every host every time a user provision an endpoint:

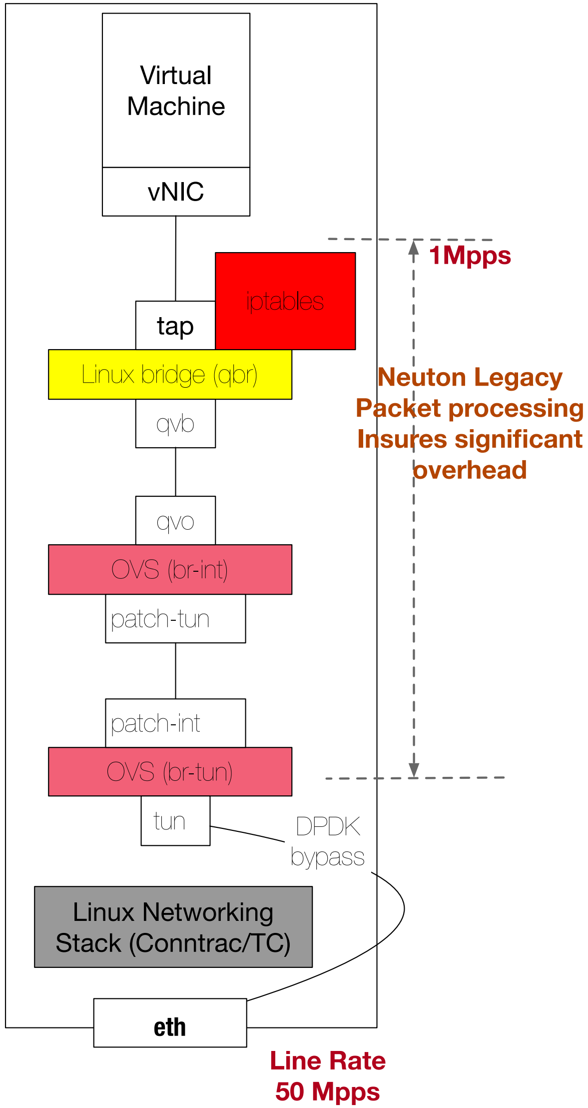
- Approaching cloud-networking with a conventional programming model and network devices
    - e.g. OpenFlow programming in OVS
    - Virtual Switches and Routes are essentially softwareization of hardware switches and routers, but not necessarily programmable to support rapid network changes.

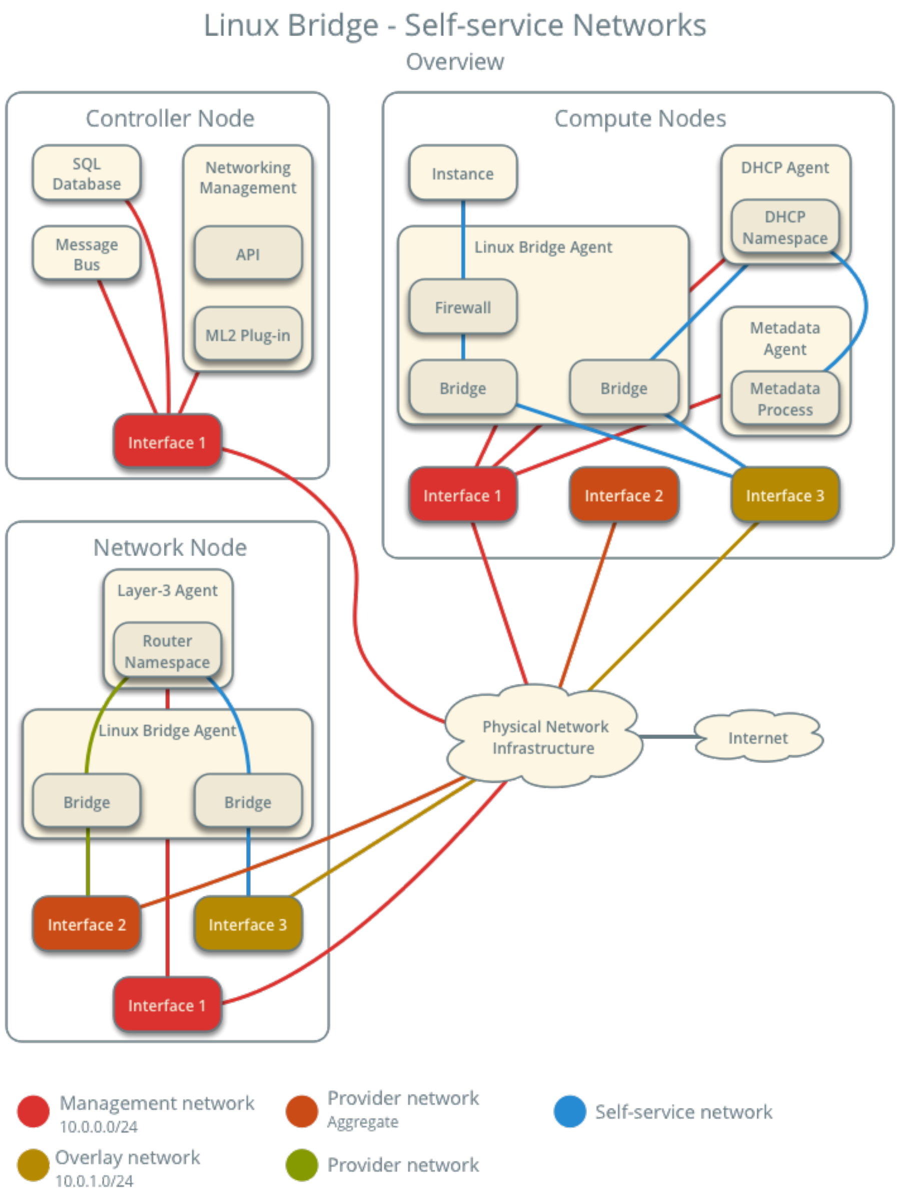
- Existing solution bring up software network devices, that are primarily created for Teleco, ISP, or datacenter networking and run them in virtual machines to support cloud networking.

- Packets traverses multiple network stacks on the same host

- Packets traverses multiple network devices (as if we are operating a data-center), while these functions could be consolidated during design.

Problems with Current solutions (e.g. Neutron)



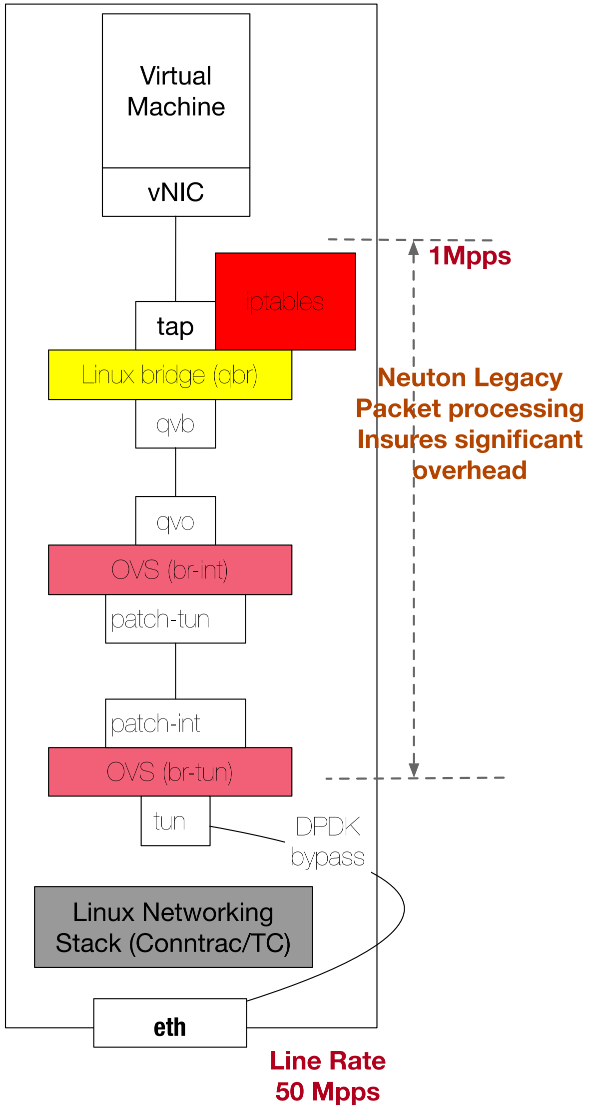


Source: https://docs.openstack.org/neutron/pike/admin/deploy-lb-selfservice.html

Observation (not really a new one):

- In a cloud network (overlay), **<u>most</u>** functions can be reduced to
  1. Encapsulate/decapsulate a packet
  2. Modify the outer packet header and forward it
  3. Modify the inner packet header and forward it
  4. Drop unwanted packets

- Several network functions can be thought of in a similar way:
  1. Responding to ARP
  2. DHCP
  3. NAT
  4. Passthrough load-balancing



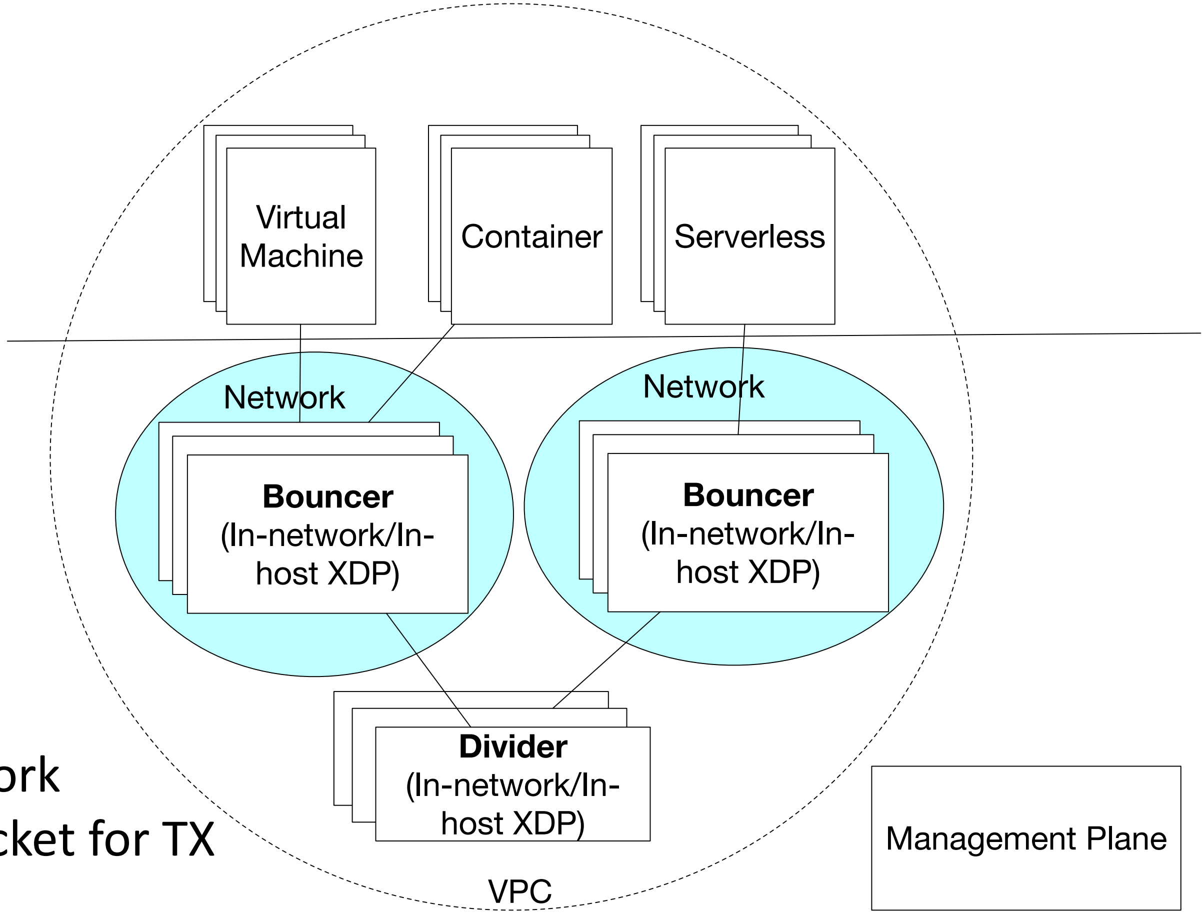
Mizar Overall Architecture!

- Natural Partitioning domains of Cloud Network
  - Virtual Private Cloud VPC
  - Networks within a VPC
  - Endpoints within a network

- Goal: Constant time provisioning of endpoints

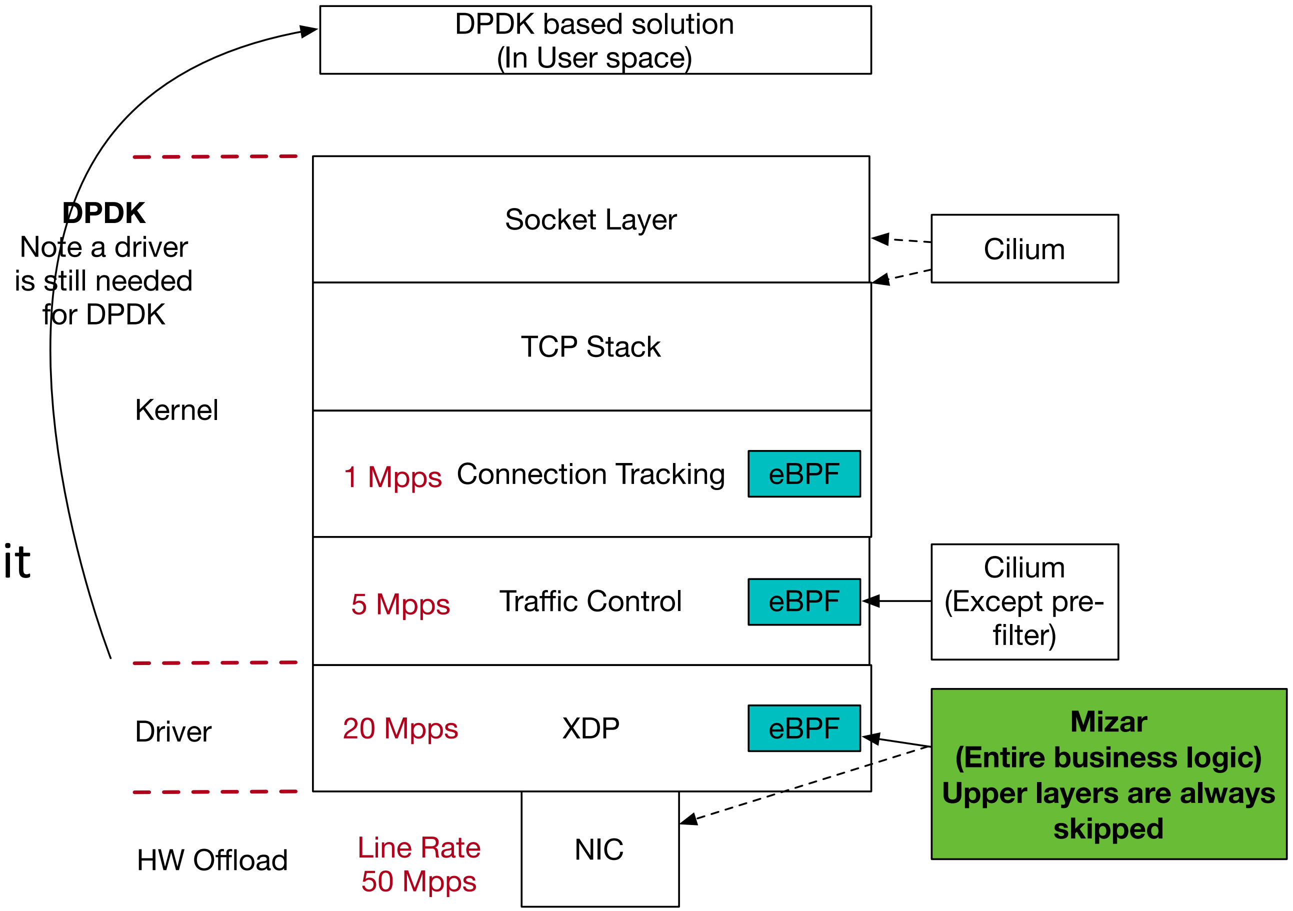
- Bouncer:
  - In-network hash tables
  - Holds the configuration of endpoints within a network
  - Determines flow modifications, and **bounce** the packet for TX
  - Implements all middleboxes within a network

- Divider
  - In-network hash tables
  - Holds the configuration of **Bouncers** within a VPC
  - **Divides** the VPCs endpoint’s configuration into clusters of **Bouncers**
  - Implements all middleboxes at the VPC level

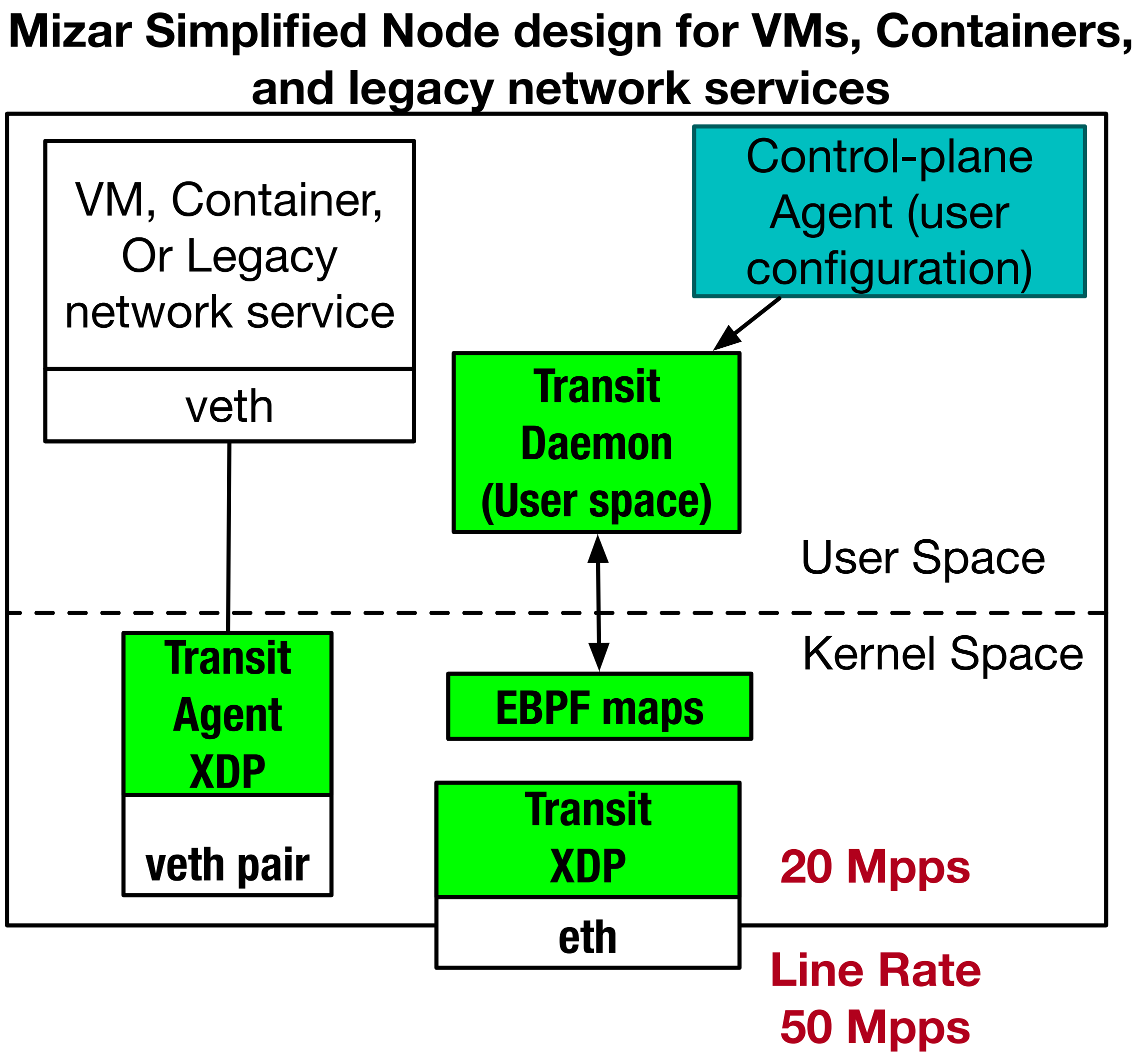


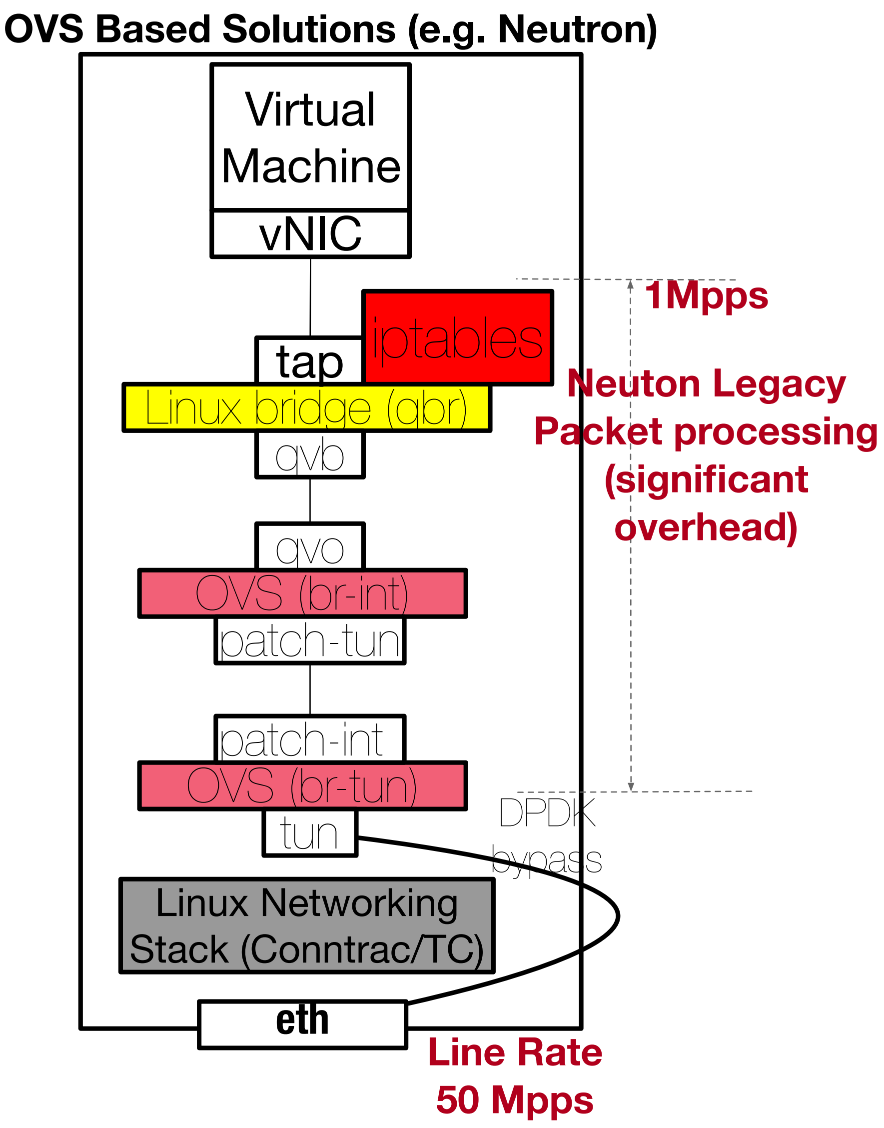
Background XDP: Simplified and Extensible Packet Processing Near Line Rate

- Packet processing is entirely in-kernel.
- Makes the best use of kernel packet processing constructs without being locked-in to a specific processor architecture.
- Skip unnecessary stages of network stack whenever possible and transit packet processing it to smart NICs.
- Very small programs < 4KB



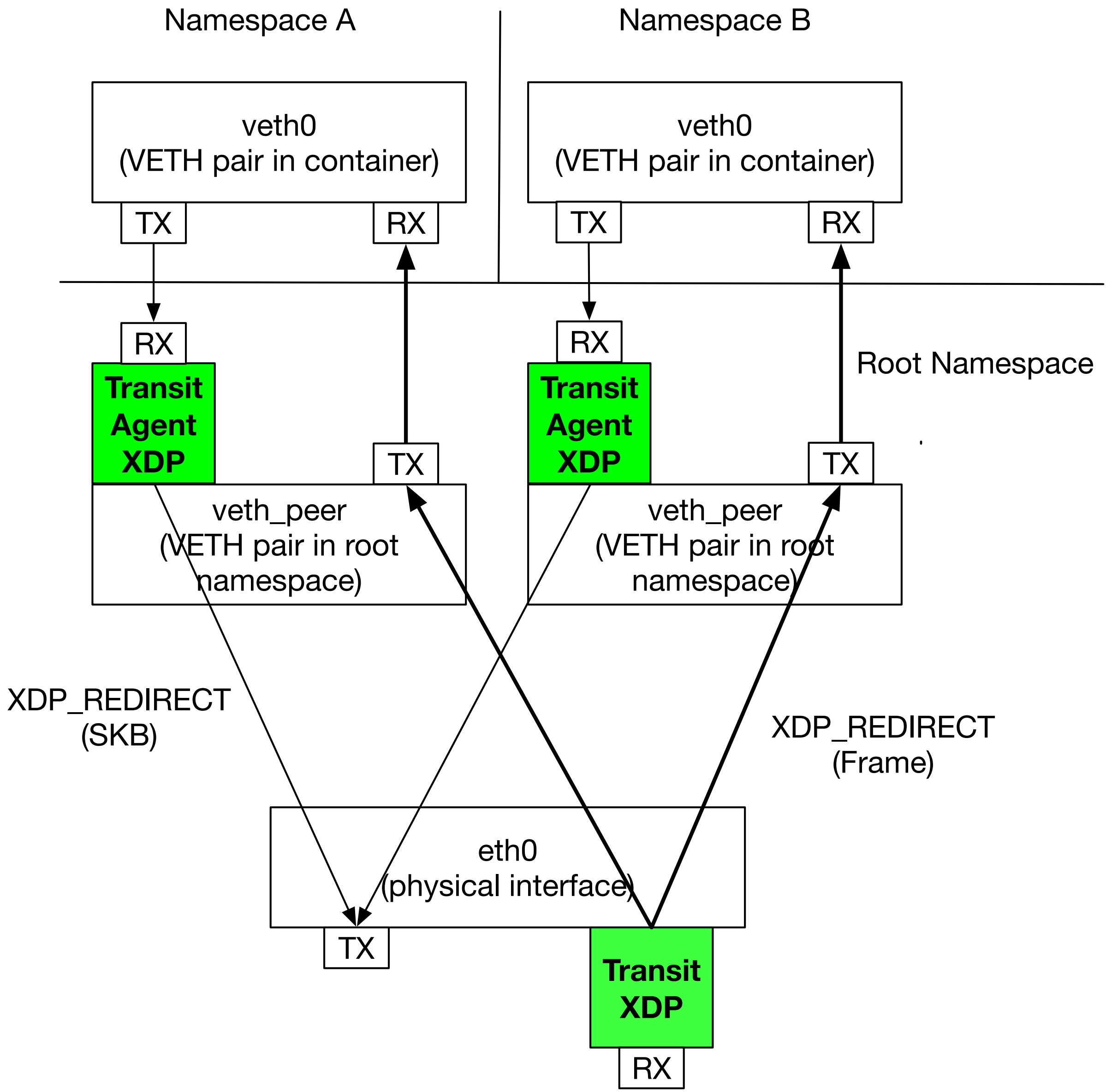
Inside a Mizar host





In-host packet flow: Bypass network stack

- Packets traverses only the container stack
- On egress packets are redirected (SKB) to the main interface after tunneling
- On ingress packets are redirected directly to the container veth peer in the root namespace.

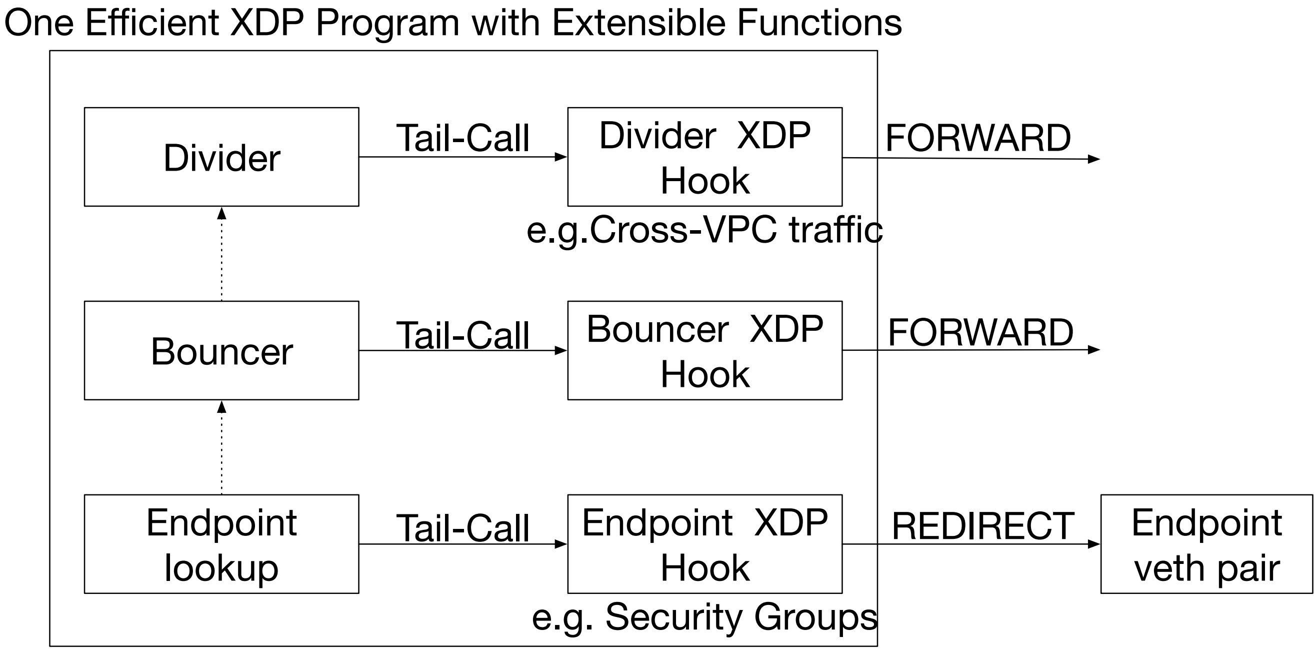


Extensible Packet Processing inside the main XDP program!

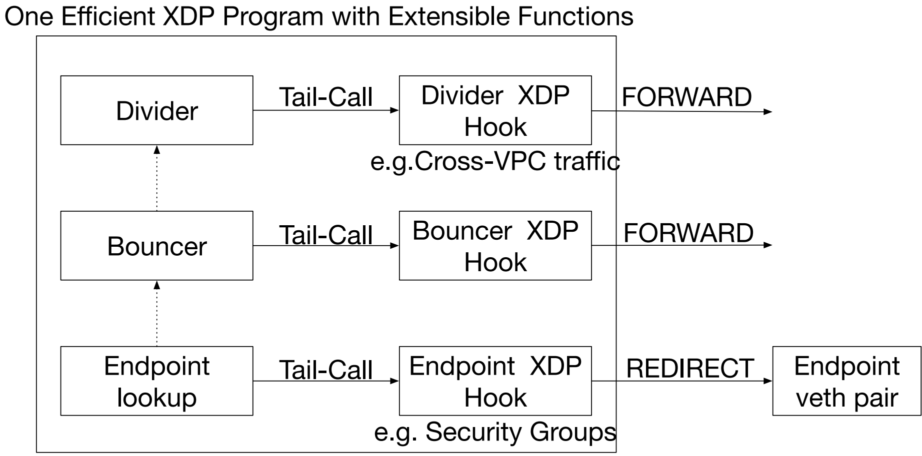
- Implements essential logical networking function within the same XDP program that provides multi-tenant cloud networking solutions
  through **new** Bouncer and Divider concepts

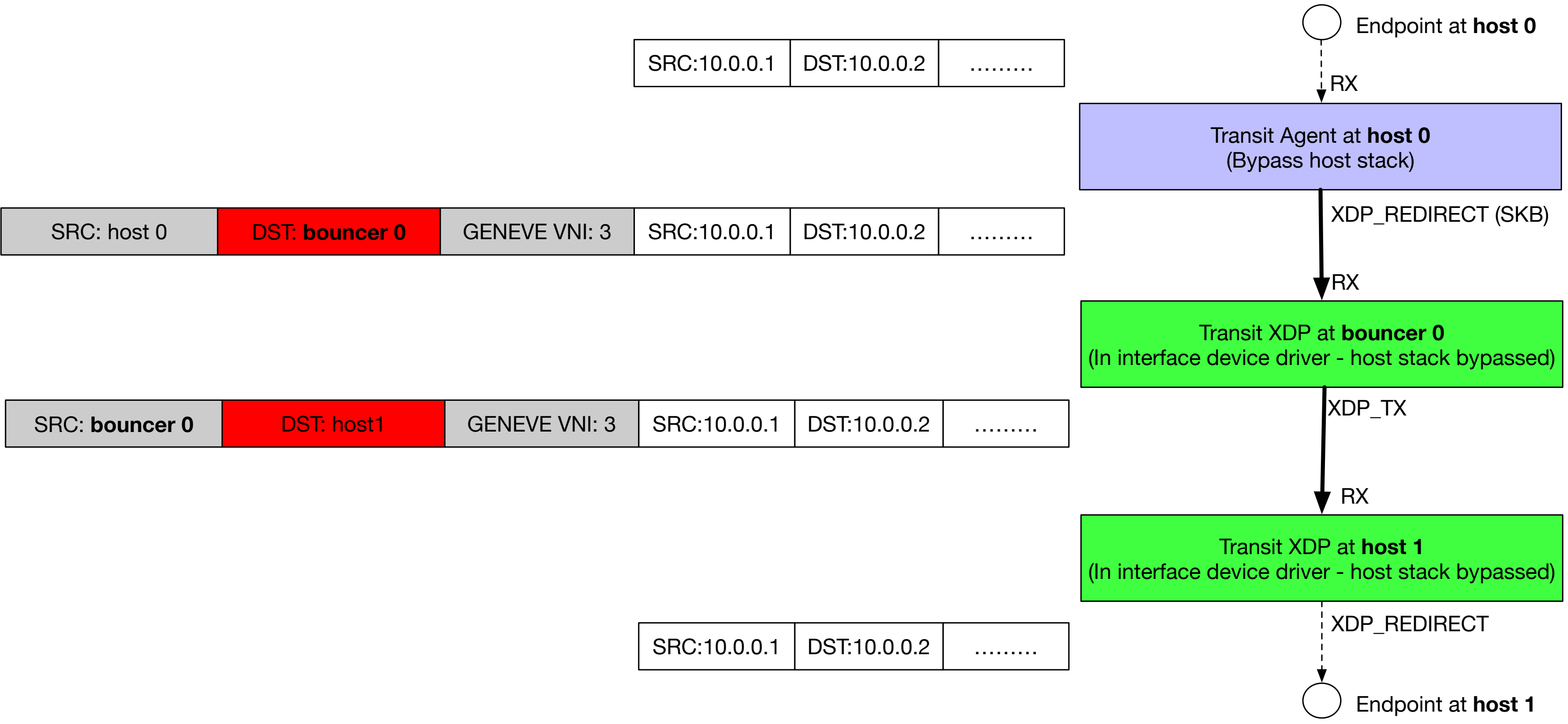
- Mizar autonomously adapts to various traffic demands in immense scale cloud environments. Allowing Mizar to serve various cloud workloads in a multi-tenant environment optimally.

- Extensible support of native networking features through custom chains of optimized XDP programs hooks and Geneve protocol options. **Future** possible Features including: Security, Load-balancing, Connectivity, Traffic Shaping Control



Example packet within a network

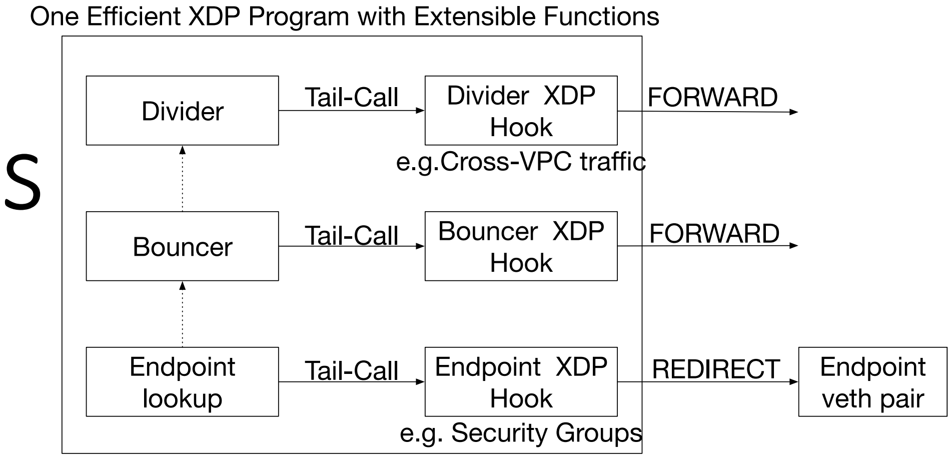


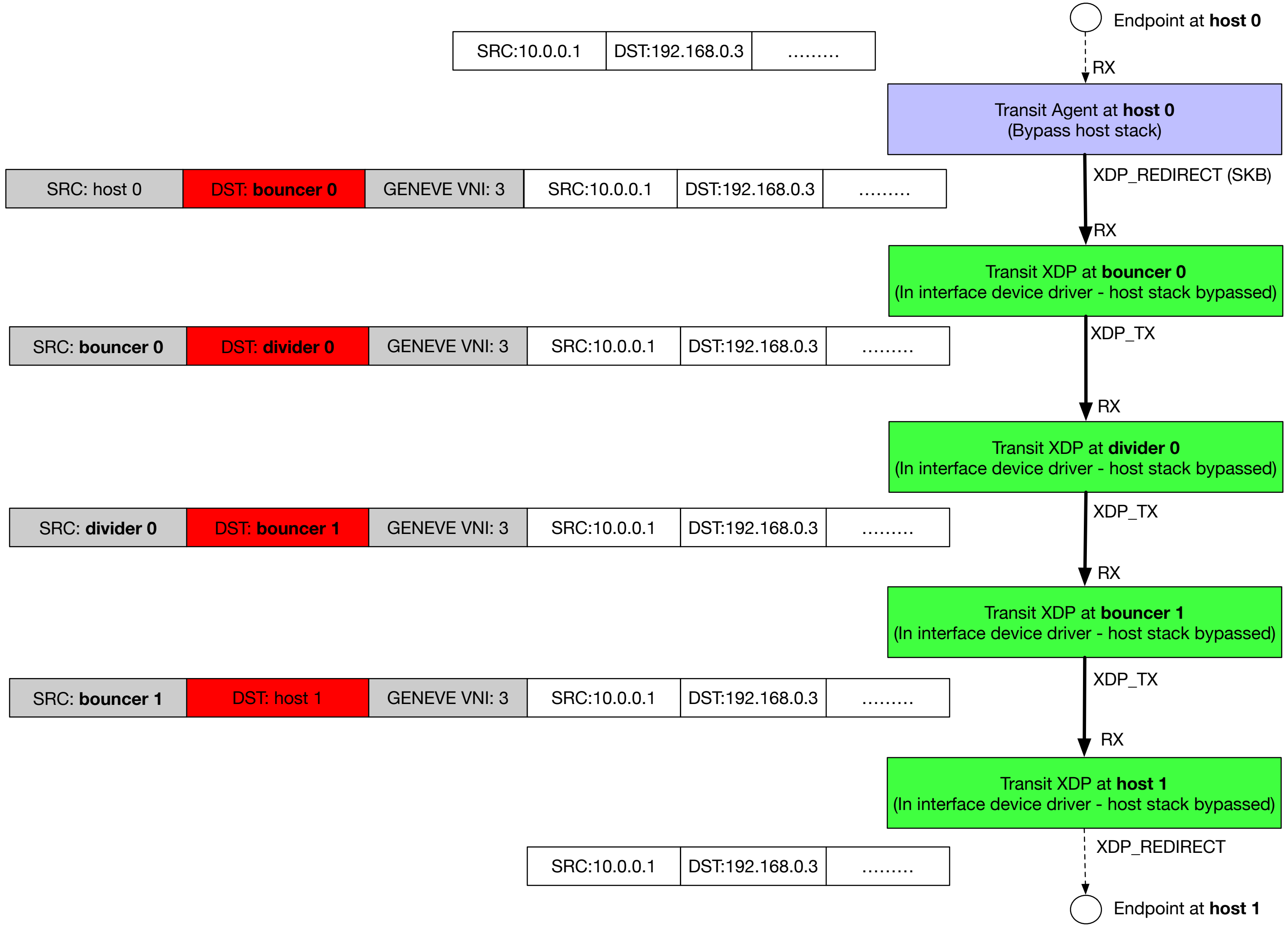


Three steps to provision an endpoint

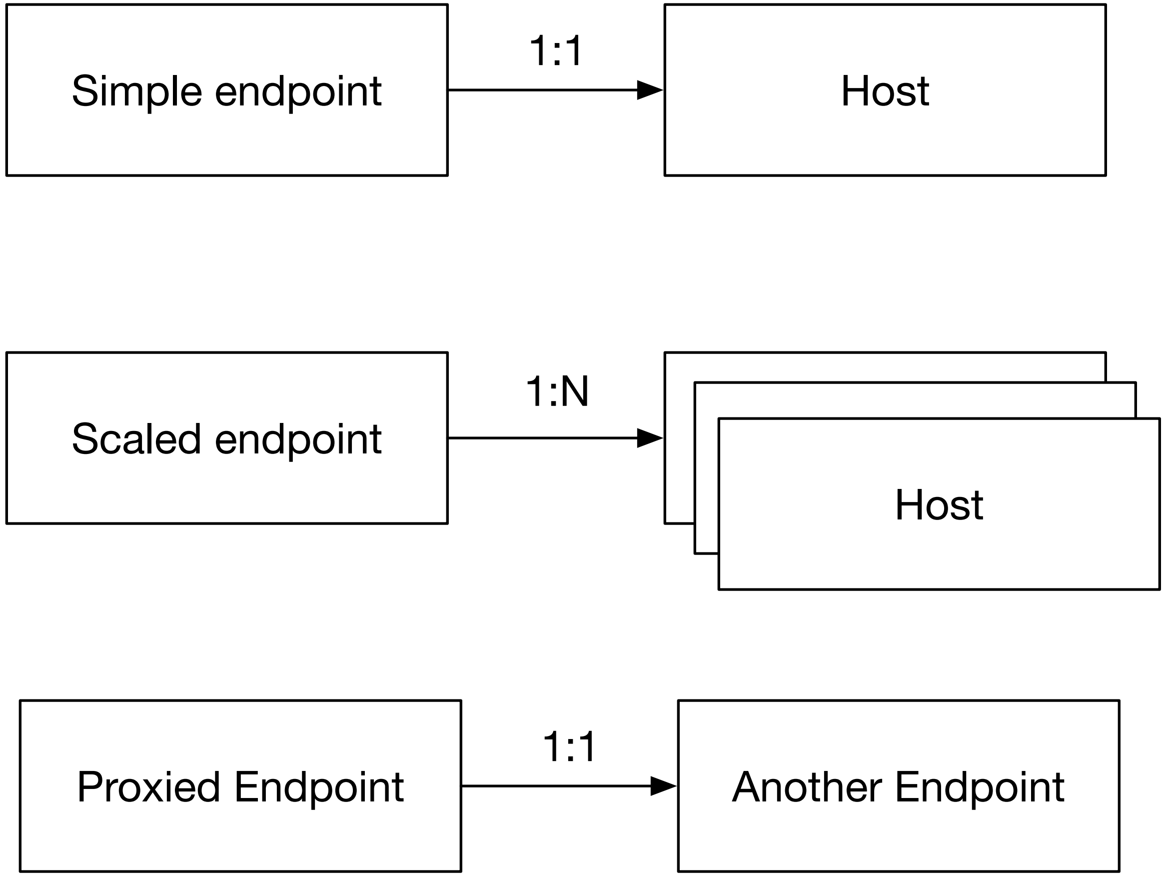
1. Add the endpoint to N Bouncers
2. Provision the endpoint on the host
3. Configure the host transit agent to tunnel the endpoint traffic to a Bouncer out of N

Example packet cross networks





New endpoint types



e.g. container, VM

e.g. autoscaling network function: load-balancer, NAT

e.g. inter-connect services

Problems we are working on

What’s next?

New Problems: Self-optimizing data-plane

- **Smart Placement of bouncers and dividers:**
- **Auto scaling the bouncers and dividers:**
- **Can scaling and placement ensure SLAs?**
- **Implementation for a self-contained data-plane (no dependency on another layer of management)?**

New Problems: Constant Time Distributed Data-plane

- **Minimize Hops:**
- **Distributed Flow Tables:**
- **Example services:**
  - Load-balancer
  - NAT
  - Cross-VPC routing

New Problems: Packet Forwarding optimization

- **Improvements to the veth device driver:**
- **Per-hop congestion control:**
- **Ongoing: What Linux stack functions shall be reused and what to avoid?**

New Problems: Application Centric Data-plane

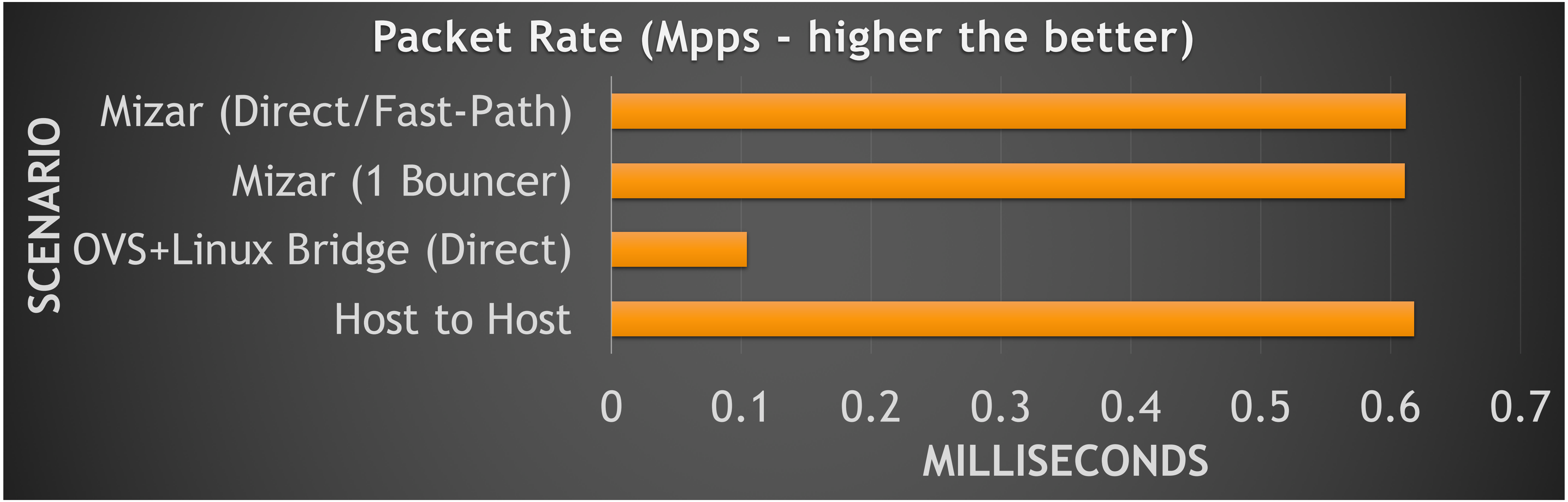
- **Coworking with TCP as a service.**
- **What can we learn about the application and inject as Geneve options? And what to do about?**
- **How to support a network as a group of applications (not a conventional subnet)?**
- **New types of endpoints?**

Results we have so-far…

Notes

- **All the following tests are done in SKB mode (XDP Generic), which has a performance disadvantage**
- **We wanted to test Mizar’s XDP program in driver mode, but for now we don’t have the needed hardware**

Packet Rate (non-TCP) – Scaling Network Services



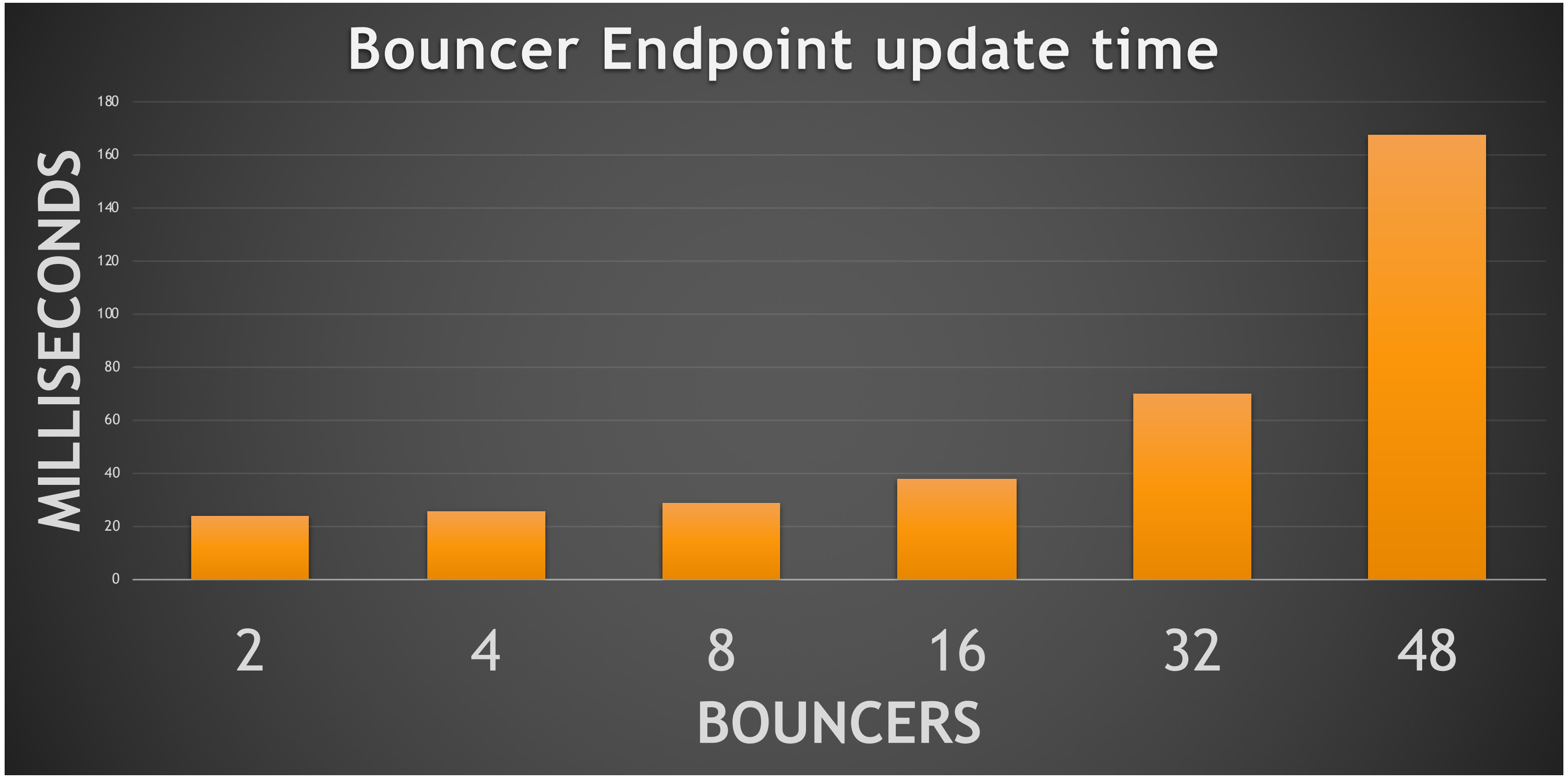
- **HIT:** Near line rate packet per second

Endpoint Update Time with multiple Bouncers

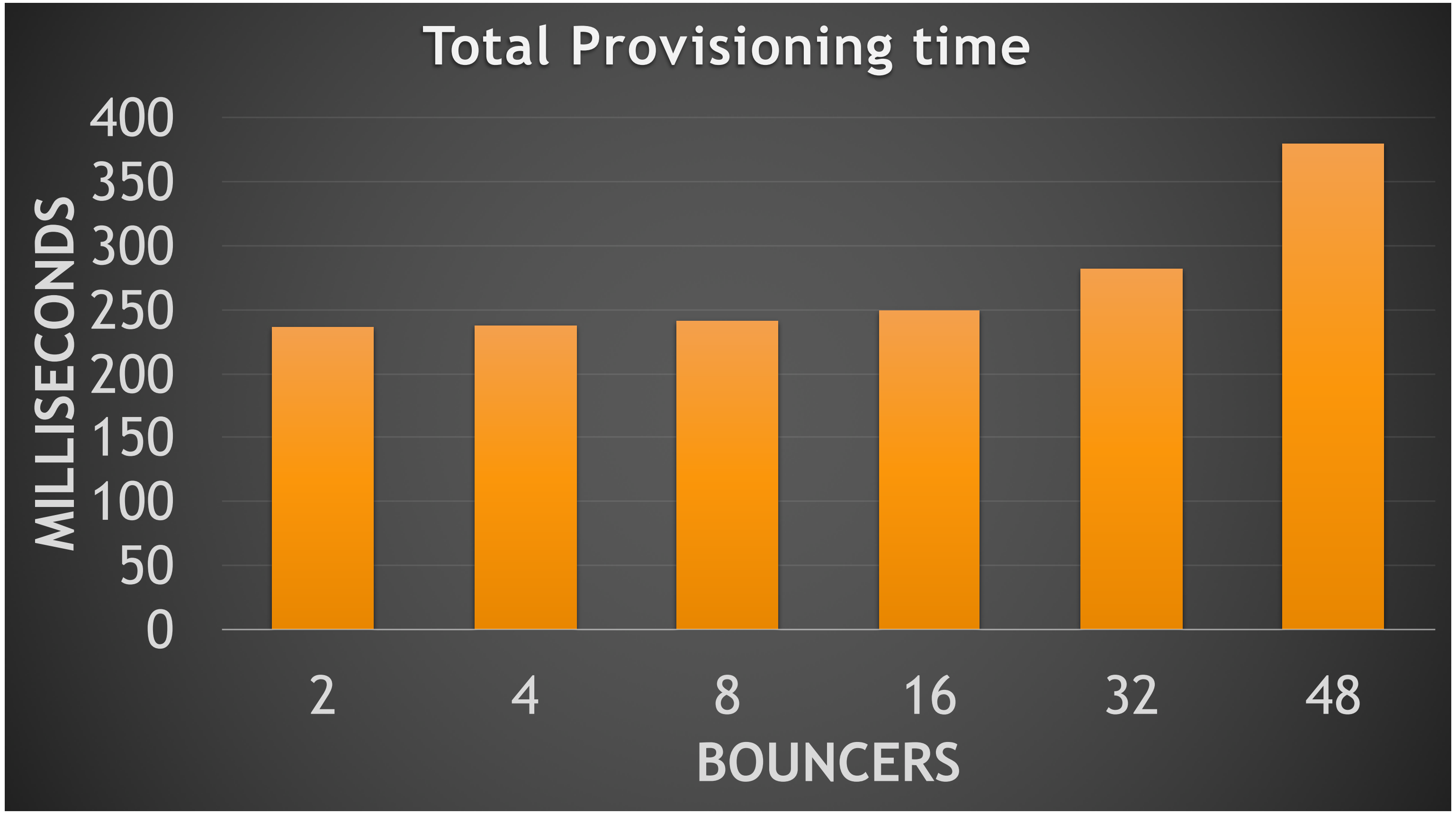
- **HIT:** Constant time with parallel updates (20ms) until the Test Controller starts to Hit its re

- With a scalable management-plane (on multiple machines), we foresee maintenance of constant time scaling.

- **IMPROVEMENT:** Simplifications in data-plane as we introduce the scaled endpoint. One core required.

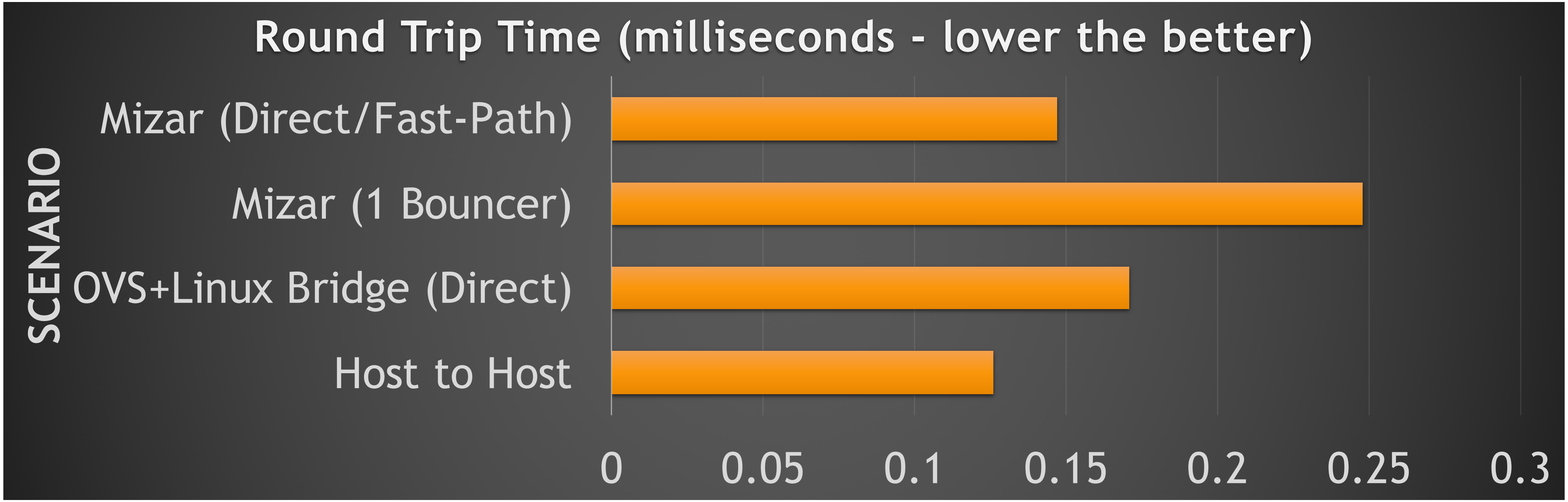


Endpoint E2E provisioning time multiple Bouncers



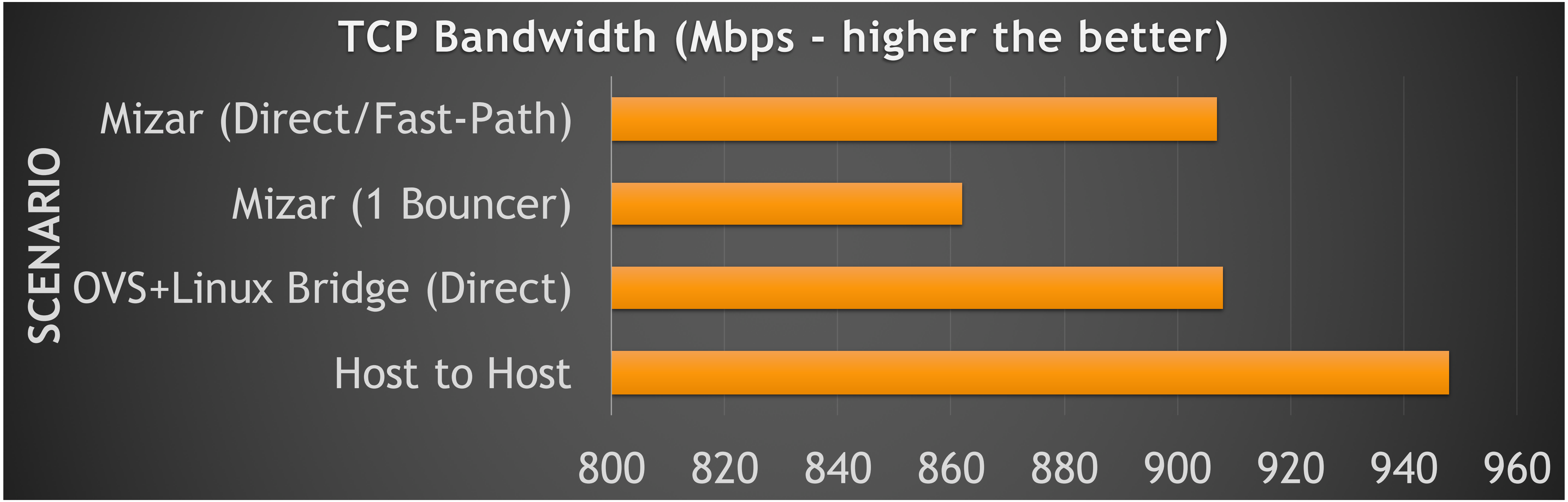
- **HIT:** Scale remains constant (until hitting test controller machine limits)
- Primarily overhead on the host from creating the virtual interfaces by executing shell command (~250 ms).
- **IMPROVEMENT:** Expected to improve with production ready control-plane as it makes use of netlink.

Round Trip Time Effect on End-user



- **HIT:** Mizar direct path is faster than OVS+Linux Birdge. Though, Still has minimal impact on PPS and TCP BW
- **HIT:** Even with an increased latency due to the extra hop, the packet per second processed by endpoints remains close to line rate
- Primarily benefit of fast-path is latency sensitive applications.

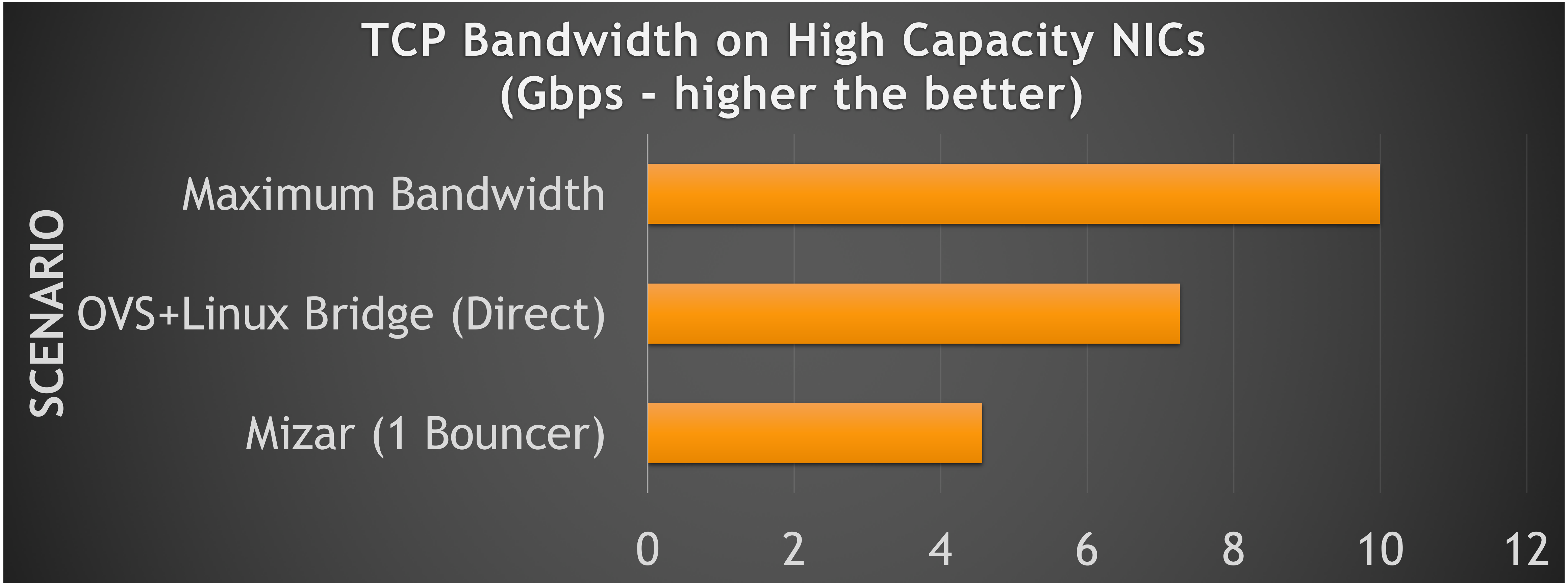
TCP Bandwidth (On a slow NIC 1Gbps)



- **HIT:** Comparable throughput to OVS+Bridge (even though we don't use XDP driver mode). *This is applicable for NICS < 4Gbps*

- The bouncer hop accounts only for 5% less TCP throughput, which shall be negligible for very high bandwidth NICs. This is despite that RTT of the extra hop accounts for 45% more latency.

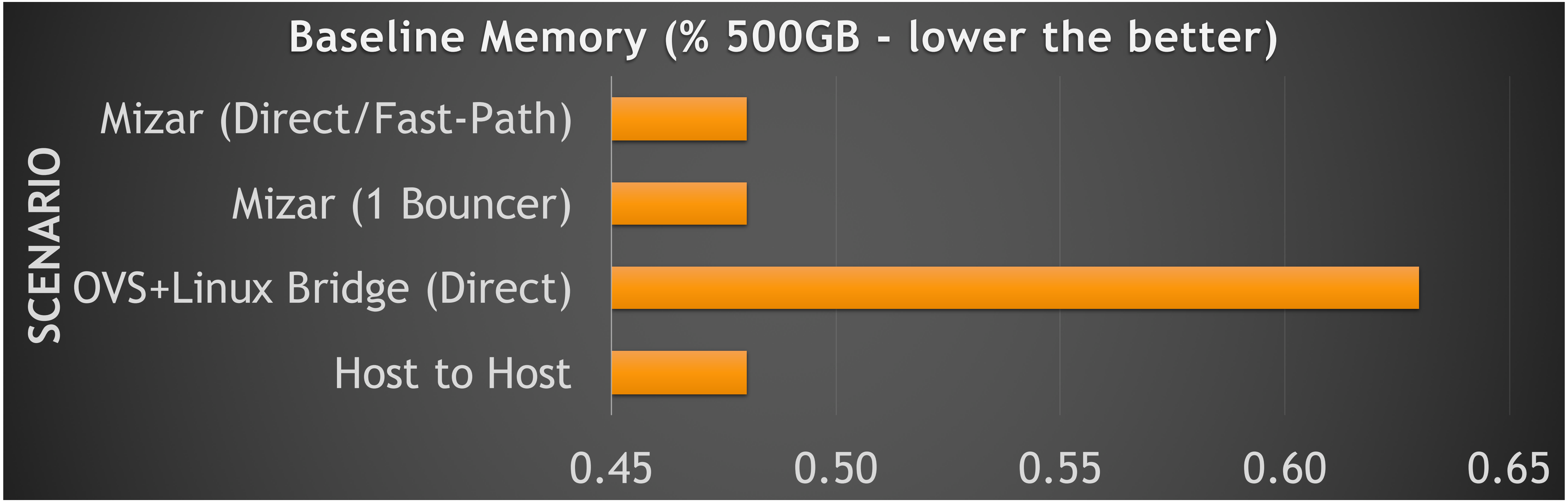
TCP Bandwidth (On a faster NIC 10 Gbps)



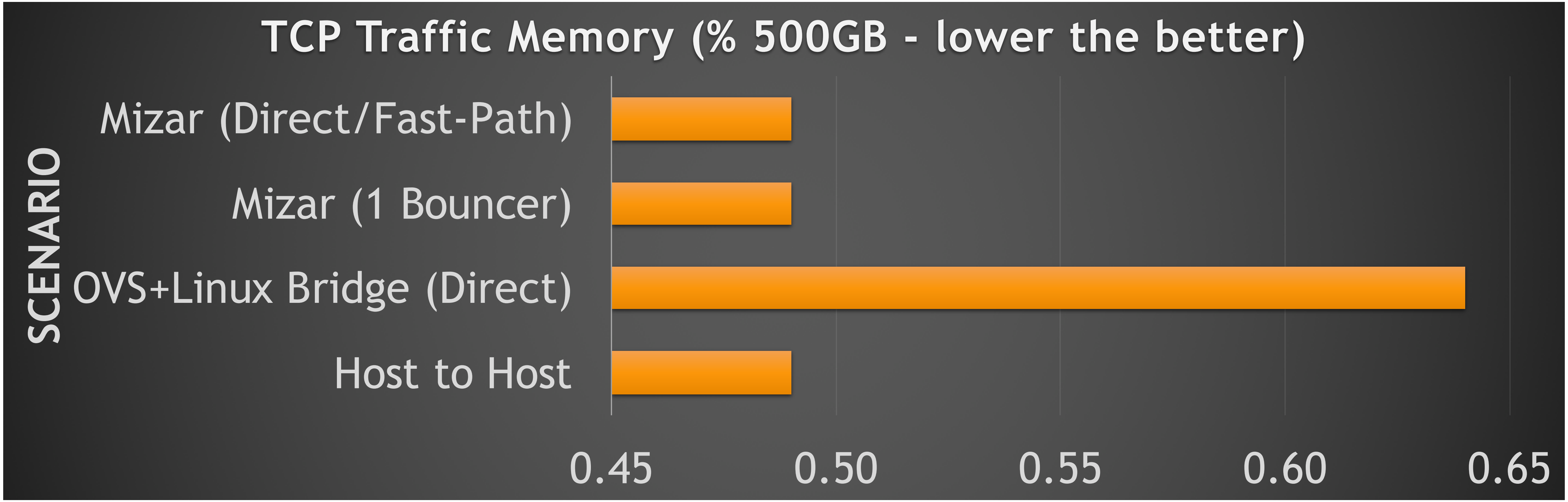
- **MISS:** The TCP bandwidth caps at around 4Gbps.

- **IMPROVEMENT:** Change to Driver mode (require support in NIC)
- **IMPROVEMENT:** Change on-host wiring architecture and reduce reliance on Transit Agent
- **IMPROVEMENT:** Improved device driver for veth

Memory Idle case

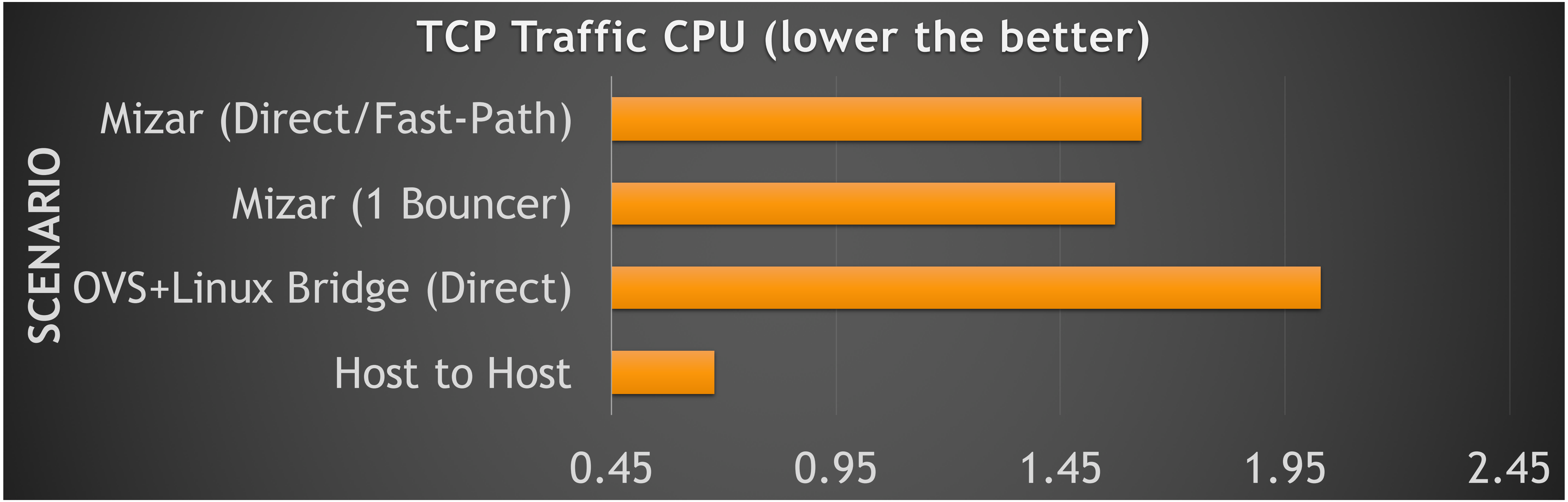


Memory During TCP Performance Tests



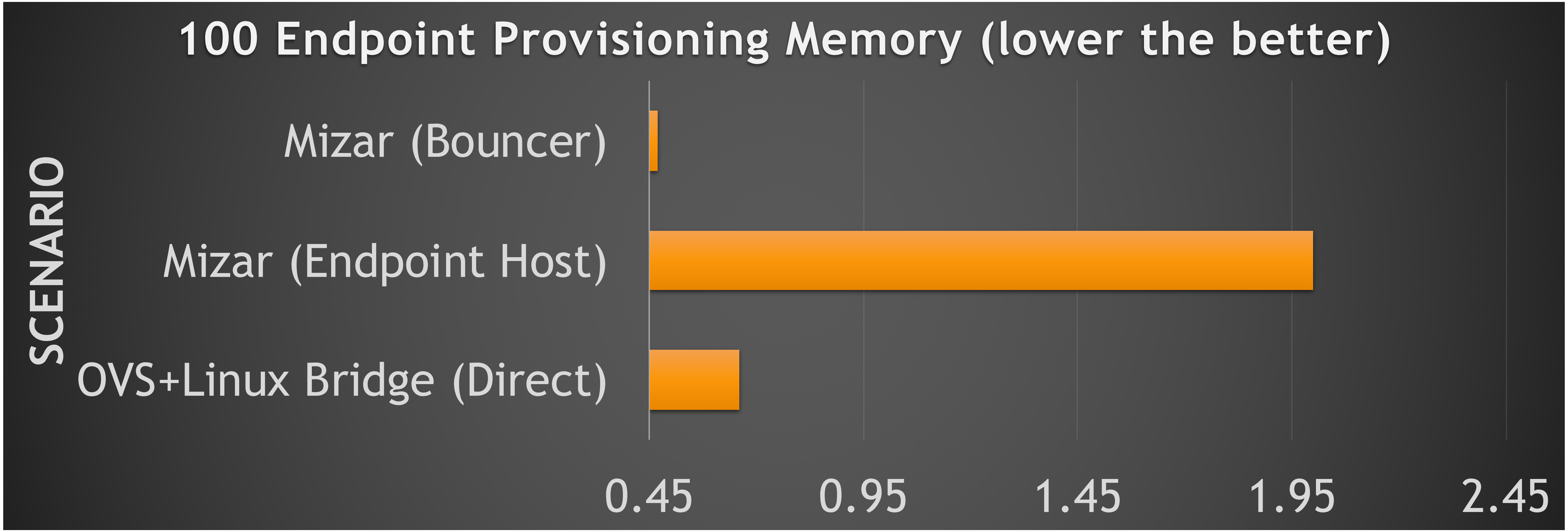
- **HIT:** Negligible Memory overhead very close to an idle host without networking constructs event with Traffic processing

CPU TCP Performance Tests



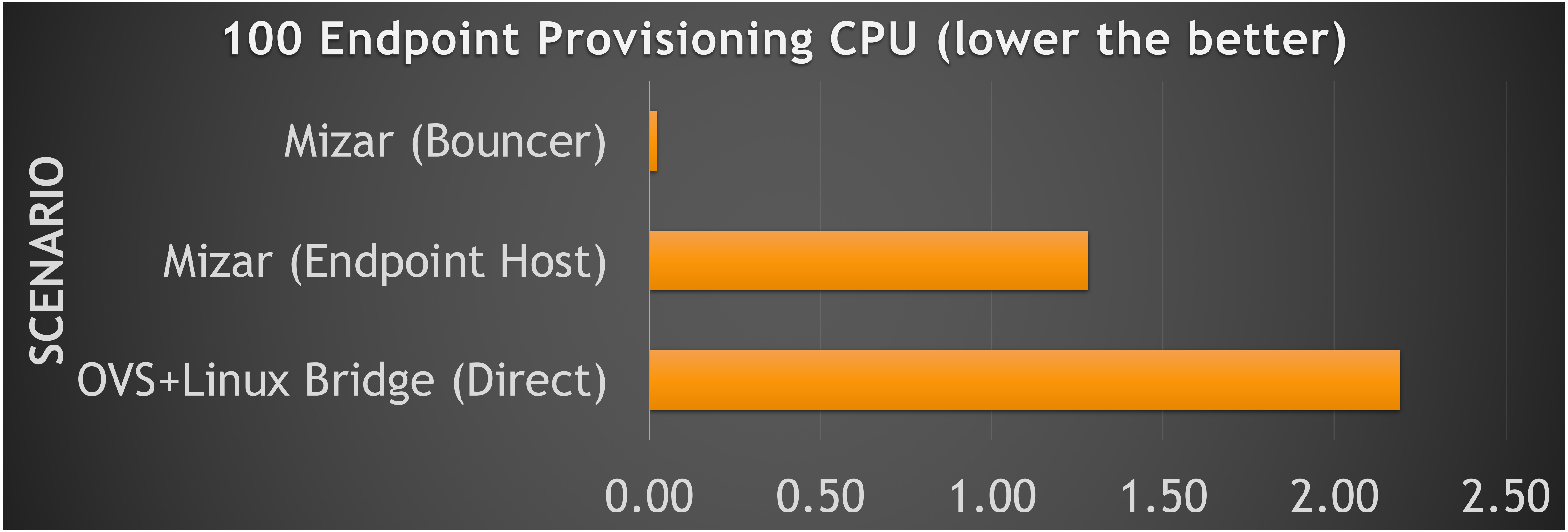
- **HIT:** CPU Overhead is much better than OVS + Linux bridge scenario

Memory Idle case (100 Endpoints per host)



- **HIT:** Memory overhead on Bouncer remain at baseline level
- **MISS:** On Host memory increases as we provision more endpoints
- **IMPROVEMENT:** Share one transit agent across multiple endpoints

CPU During TCP Performance Tests



- **HIT:** Significantly less CPU overhead during provisioning on both bouncer and host