eBPF Filtering and Test Setup for eXpress Data Path on Virtual Network Environment

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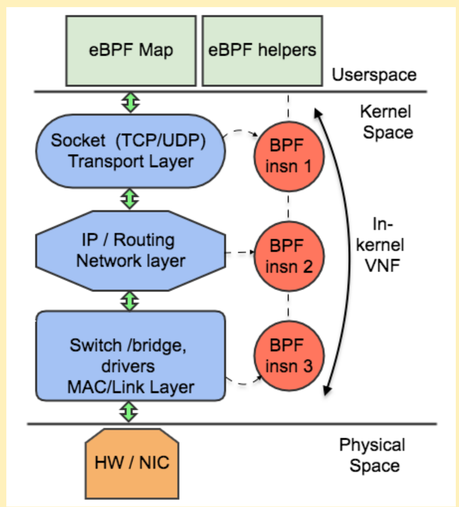
Introduction

BPF :

- Berkeley Packet Filter : In-kernel Virtual Machine for packet & syscall filtering
- eBPF: extended BPF for filtering, tracing, networking etc.
- In-kernel JIT compilation
- eBPF Maps: Share data between userspace and Kernel space
- Enhanced 64 bit register, supports instruction call, load, store, conditional jump
- eBPF programs can be used as hook to different layers of the kernel stack
- bcc : bpf compiler collection

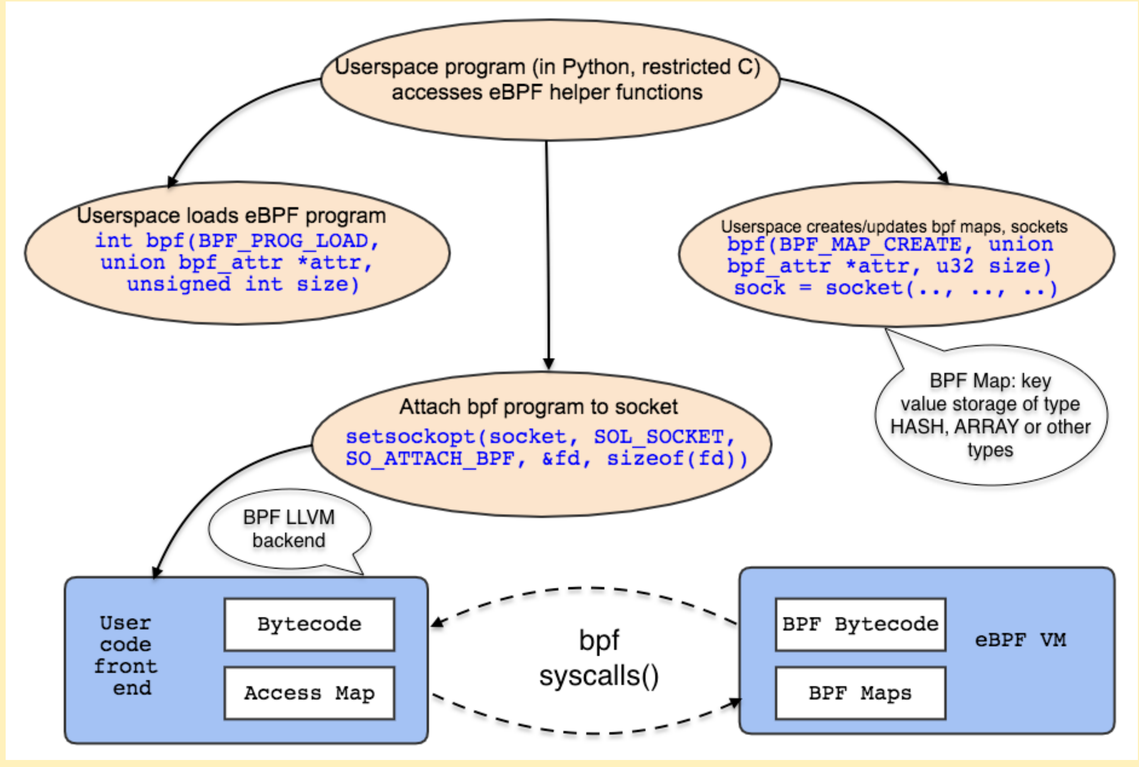


eBPF hook from userspace to kernel space

XDP :

- XDP: eXpress Data Path under IOVisor project
- Programmable, high performance data path at the lowest point of Linux Kernel Software stack
- Very fast packet processing before allocation of skbuff inside device driver Rx function
- Flow table managed by BPF program which is portable to userspace and other OS
- Aim of XDP is to replace the OVS data path with eXpress Data Path

eBPF Implementation and flows



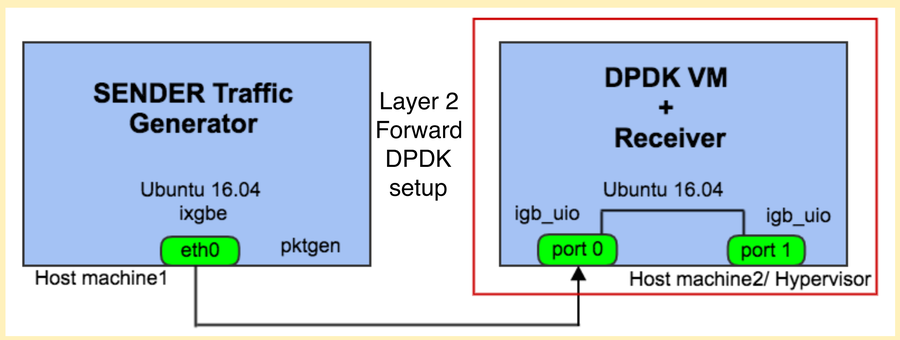
Network Virtualization and Test Setup

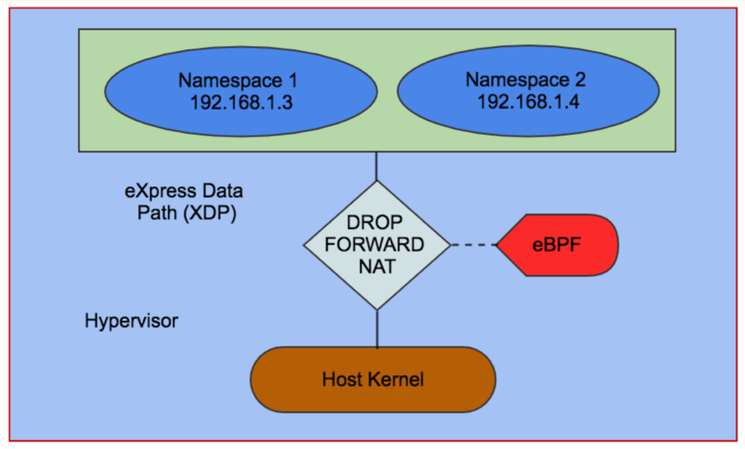
VM vs Container - Comparison and Coexistence

- VM is abstraction of hardware with full hardware stack, virtualized network adapters, memory and CPU.
- Multiple VMs can be instantiated by a hypervisor running on the physical host where a separate OS run for each VM.
- In container, abstraction is mostly done at OS level where the containers share the same Kernel space with the OS but userspace is abstracted.
- The main aim of a container is to provide a runtime environment for applications.
- Containers are lightweight compared to VMs, so many containers can run on a single machine with less overhead compared to VMs.
- In terms of security containers are more vulnerable compared to VMs.
- VM and containers can be used as complementary to each other. Containers can run within a VM providing more isolation, enhanced security and easy manage of hardware.

Test Setup:

- Fast L2 forwarding using dpdk application. The sender generates packet using pktgen and the packets go through dpdk l2fwd application to the receiver.
- XDP testing for fast packet drop in the iovisor container
- NAT implementation with eBPF, testing over two namespaces





XDP with eBPF for different control functions

L2 Forwarding with DPDK

- DPDK (Data Plane Development Kit) is utility program containing data plane libraries and network interface controller driver for fast packet processing.
- Layer2 forwarding for each received packet
- Memory pools and port queues are needed for l2fwding
- Source port and destination port are paired by port mask
- Source and destination MAC address of the received packets are modified to forward to adjacent port.

eBPF experiments

- IOVisor opensource code with eBPF helper functions
- Userspace frontend python program calls BPF system call wrapper functions
- For XDP fast packet drop, the eBPF hook attaches its context to the kernel driver and monitors packet header.
- It drops packets before skbuff allocation
- Source port and destination port are paired by port mask
- For NAT application, it monitors IP header and perform NAT as per control mapping introduced by user

Experiments & Preliminary Results

DPDK l2fwd:

- Connect the traffic generator host with the DPDK host/VM with open switch.
- Install DPDK application on the VM with target as x86_64-native-linuxapp-gcc on ubuntu 16.04
- Setup the device driver virtio or igb_uio and bind the network interfaces
- Allocate huge pages in the system and compile the l2fwd application from dpdk example
- Run the dpdk l2fwd application with command :

```
# /examples/l2fwd/build/l2fwd -c 1 -n 1 — -q 1  -p 1
```

XDP Fast packet drop:

- XDP fast packet drop functionality is tested with Mellanox 40 Gbits/s NIC.
- Sender is running hight speed packetgen application on Ubuntu 16.04 with Linux kernel 4.7
- Receiver machine is running a VM where we execute the XDP code for fast packet drop.
- Test the speed of packet drop using ‘nicstat’
- Got ~13 Mbps packet drop speed with our current setup

NAT functionality with eBPF:

- New NAT functionality is implemented with eBPF using BPF Maps with bcc
- The BPF code reads the IP header and maps it to a destination address which the userspace can see through the BPF map.
- Tested the NAT functionality by creating two namespace containers and NATing from one namespace to another.

Conclusion

- As a third party software DPDK needs licensing and special hardware whereas XDP uses tools from Linux kernel.
- Dedicated CPUs are not required for XDP; also no huge pages is needed.
- XDP is not a kernel bypass, it is a fast path in the kernel stack accessed by the userspace.
- XDP is very flexible in header parsing and packet rewriting and packet steering.
- Fast packet drop by XDP results are currently constrained by hardware limitations
- The NAT functionality is currently tested with containers which can be extended with VMs.

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