High-Speed, Multi-Tenant Bro System

using SR-IOV and Containers

(…Proof -of-Concept…)

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Who R U?

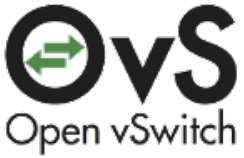
- Hailing from Columbia, MD
- Been in IT Security for ~12 years (see grey above head for more details)
- Support Federal customers in security engineering and evaluation, defensive cyber exercises, and other random work that pays for toys + high electric bills
- Big fan of Bro-IDS and the community
- Have a love of squeezing max performance out of things (more of an tester/improver than a builder)

Agenda

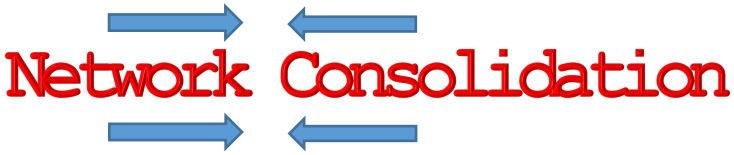
1. Why a multi-tenant Bro system?
2. Quick refresher on SR-IOV & Containers/VMs
3. Overview of proposed solution
4. Hardware/Software used for demo
5. Demonstration of multi-tenancy
6. Taking it to the next level NFV/SDN concepts

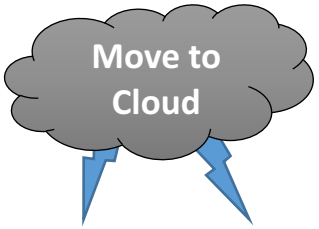
What problems are we solving?

- Security Consolidation
  - Being implemented in service-providers and data-centers (IDSaaS)
  - Numerous tenants on one hardware platform
  - Already seeing a lot of movement in Govt
- Network Function Virtualization (NFV)
  - Coming to a security stack near you!
  - Bandwidth isn't getting any slower

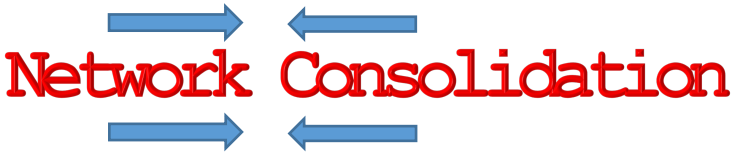


Where NFV and Consolidation meet

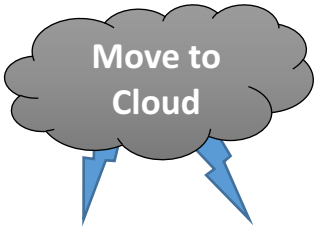




Where NFV and Consolidation meet

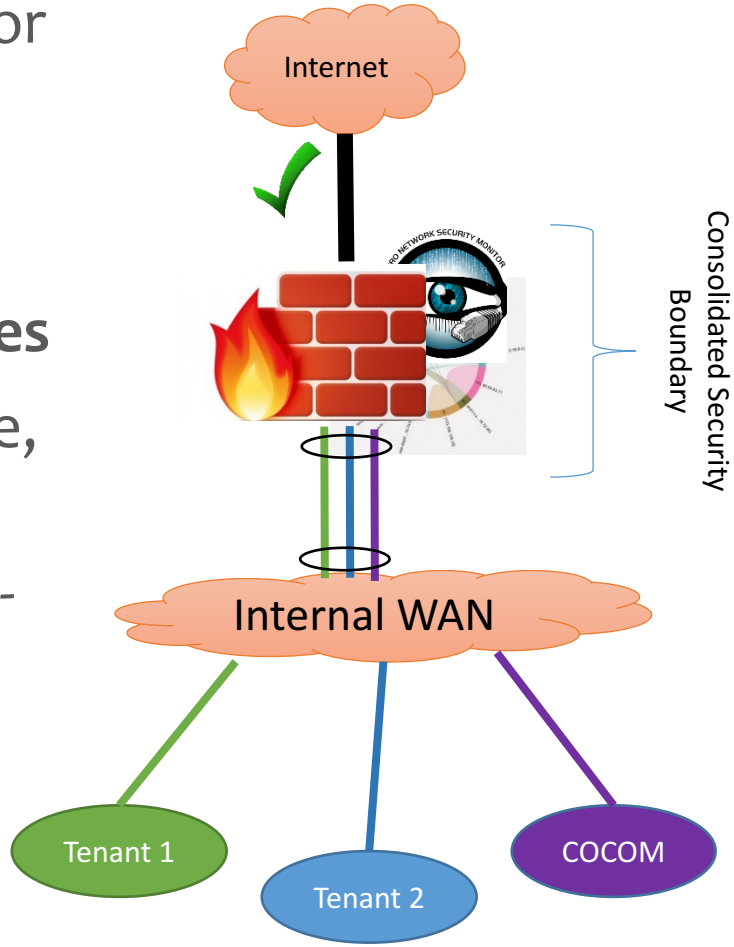


Virtual Multi-Tenant System

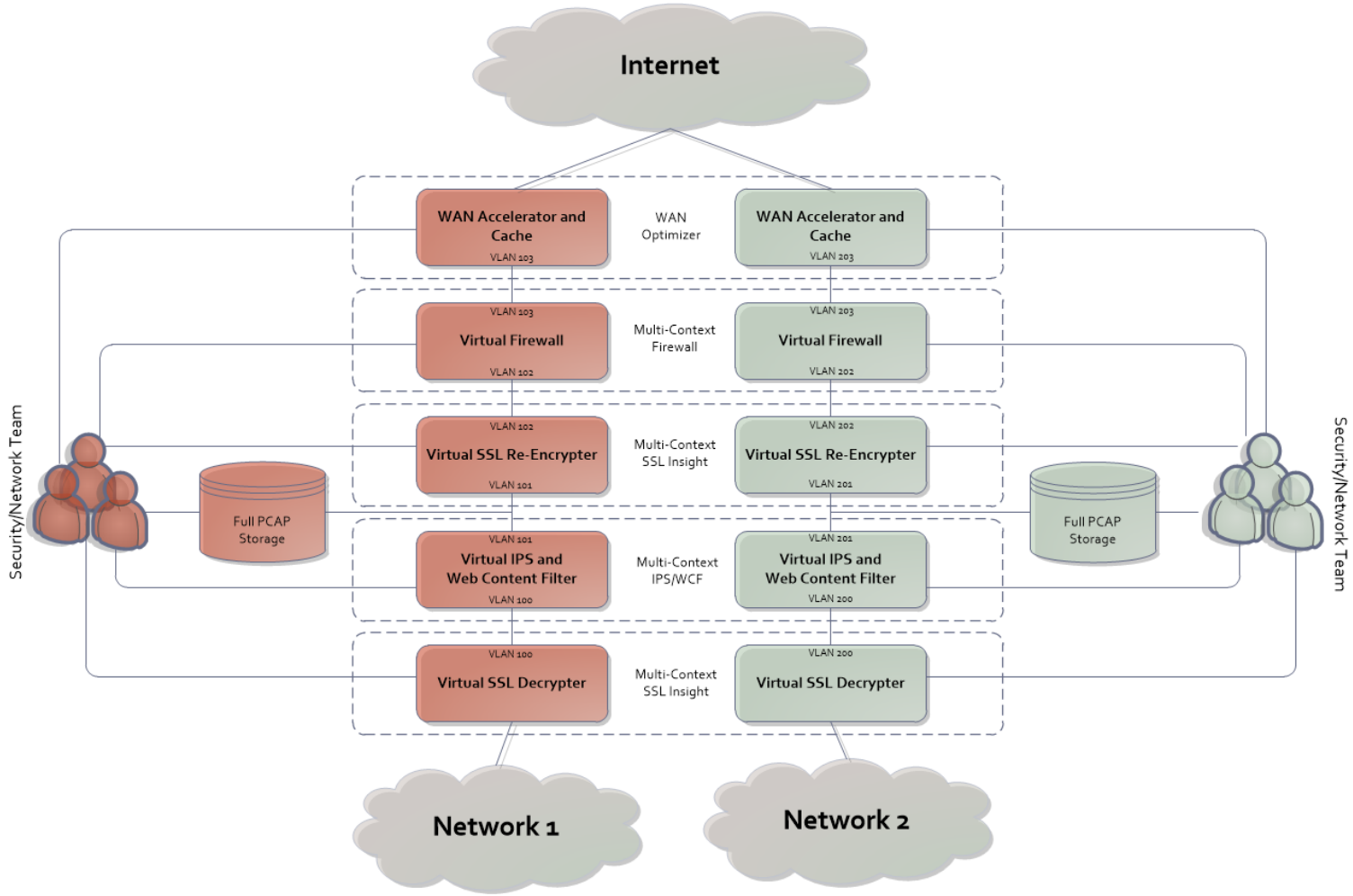


What is "Multi-Tenancy" to our customers?

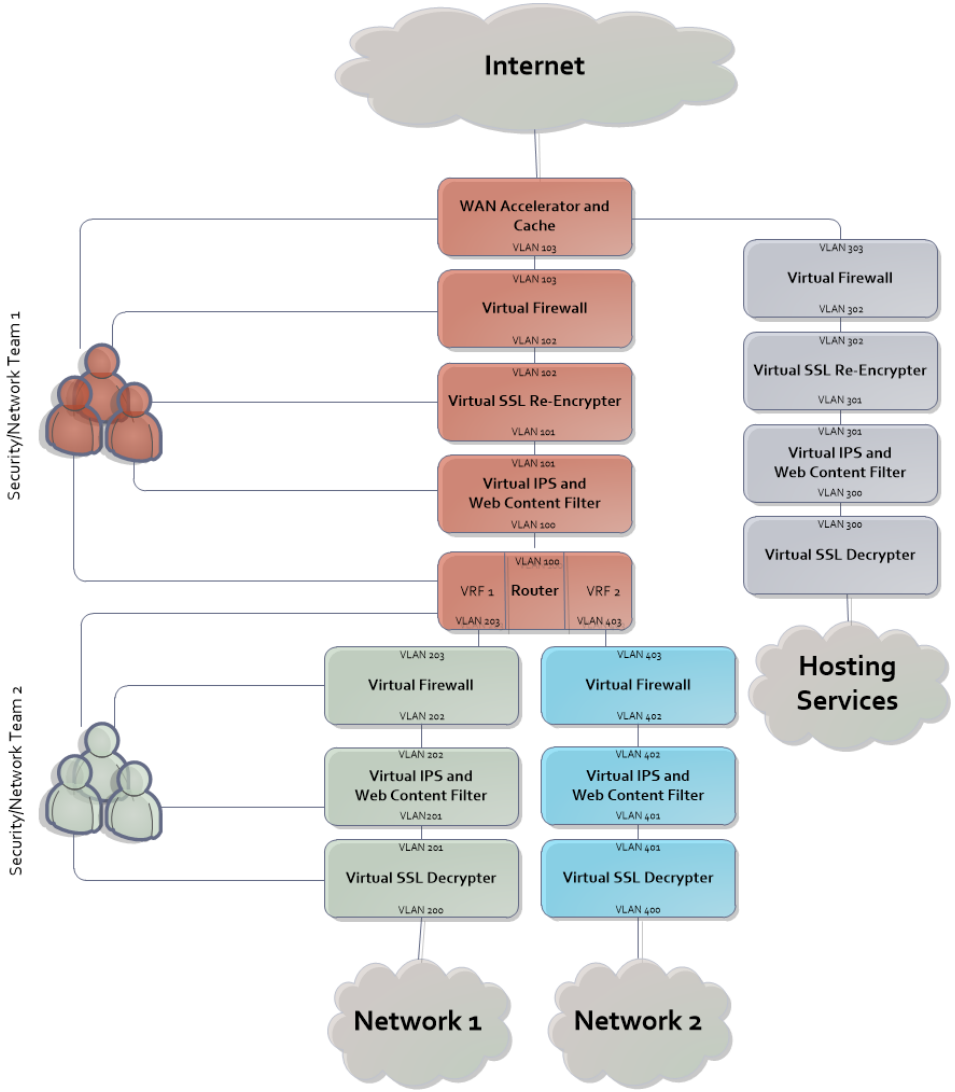
1. Utilize **VLANs** as the segregator
   - VLAN 1000 = Tenant 1
   - VLAN 1002 = Tenant 2
   - …
2. **Tenant** controlled **policies/rules**
3. If one tenant puts in a bad rule, shouldn't affect anyone else.
4. Logs should be sent to tenant-specified location
5. Applicable to Boundary and Datacenters



Autonomous Multi-Tenant Perimeter (ISP or Shared Datacenter)



Higher Headquarters Example

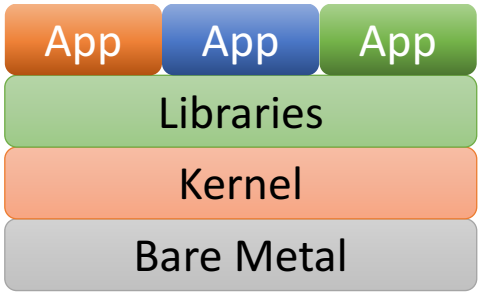


Enough overview,

Let’s talk tech…

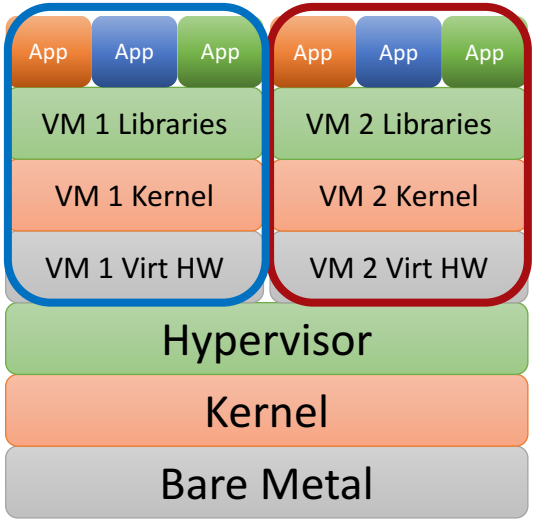
Bare vs VM vs Containers

Traditional Bare Metal



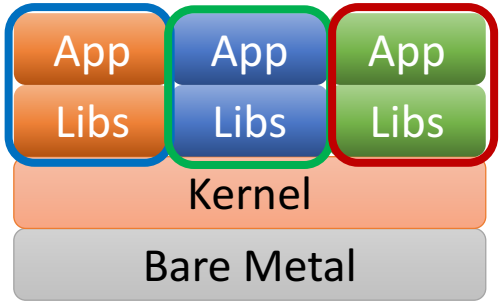
- No inherent app separation
- Shared Kernel and Libraries
- Maximum performance of security applications

Virtual Machines



- Two sets of hardware (real and virt)
- Two kernels (bad)
- Max security and autonomy

Containers



- One set of hardware
- One kernel
- Separation of libraries
- Separation of kernel resources

VMs vs Containers

Virtual Machines

Benefits
- Hardware abstraction provides better isolation/security
- Tenants have control over Kernel in VM
- Proven resource quota system

Cons
- 2x Kernel network stack
- Hardware abstraction is slower
- Slow start-up times

Containers

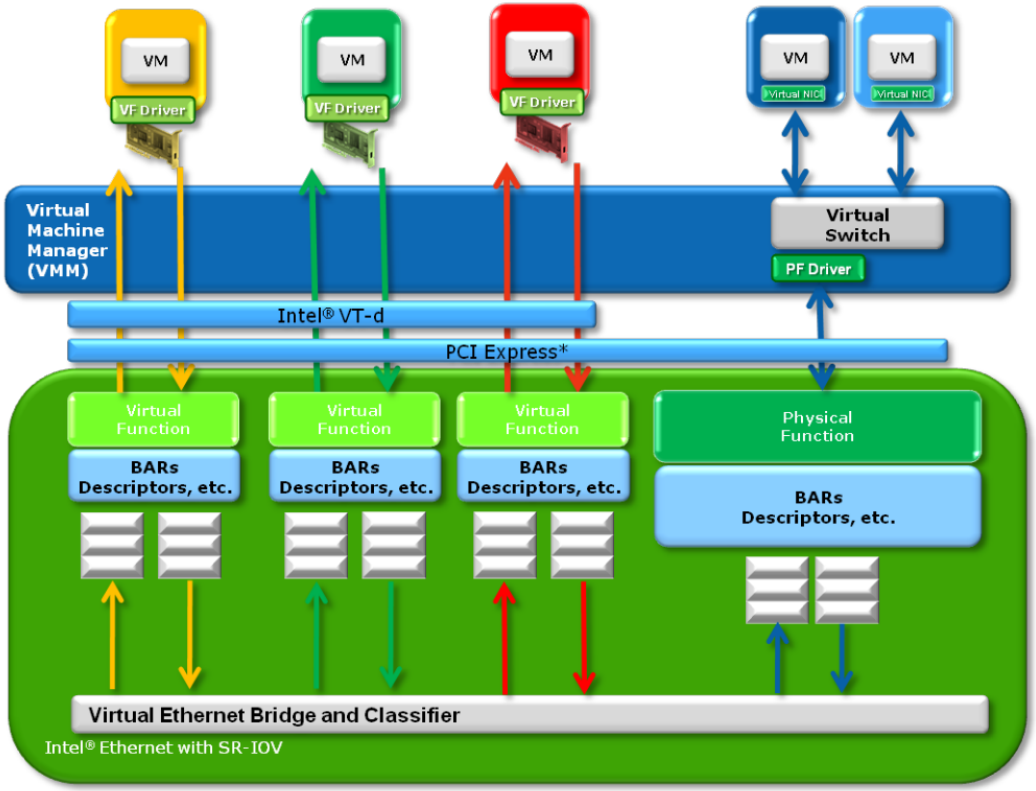
Benefits
- Only one kernel we need to bypass/accelerate
- Startup/Shutdown measured in milliseconds
- Templating built-in to design

Cons
- Any change to kernel takes down all applications
- Bro needs privileges for NIC access

chosen for PoC…

Brief overview of SR-IOV

- Divides a NIC into numerous “Virtual Functions (VF)” that appear as separate NICS
- Separate Hardware RX/TX queues
- Can be used with host application, VMs, or containers
- Cards support up to 32 or 64 VFs depending on the chipset
- Hardware supported VLAN forwarding to each VF



**Source: http://dpdk.org/doc/guides/nics/intel_vf.html

Kernel Drivers with SR-IOV

1. Most Intel drivers have a “VF” Equivilent
   - igb = igbvf
   - ixgbe = ixgbevf
   - i40e = i40evf
2. This is what the Kernel or VM will load.
3. Causes problems with kernel bypass

Bypass Tech	Supported in Bro	Supports VF drivers
PF-RING	YES	NO
DPDK	NO	YES
AF-PACKET	YES	YES**
Netmap	YES	ixgbevf

Hardware used for PoC

Supermicro
SYS-5018D-FN4T ($1400)

Intel Xeon D-1541

- 8-core 2.10 GHz w/ HT
- 16 Logical Procs
- Turbo to 2.70 GHz
- CPU only uses 45 Watts

Memory/HDD

- 32 GB PC4-2133 ($70)
- (2) Samsung 850 Pro SSD 256GB ($250)

Network

(2) 10 Gbps x552/x557 ports (built-in)
(4) 10 Gbps Intel XL710-DA4 (x8 PCIe Gen 3) ($498)

Total Cost = ~$2300

Need more power? Checkout the D-1567 (12/24 and MORE L3 cache!)

Enable SR-IOV & isolcpus

Kernel Settings:

- Isolated CPU cores 1-7,9-15
- Enable IOMMU in “passthrough”

```
#vim /etc/default/grub
```

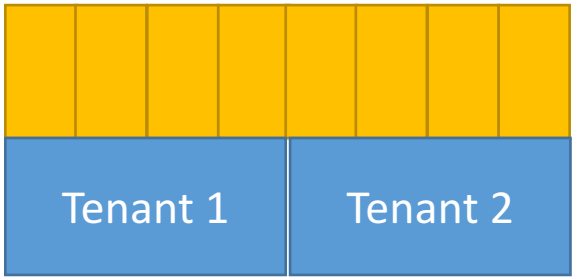
```
GRUB_CMDLINE_LINUX="crashkernel=auto rd.lvm.lv=centos/root
rd.lvm.lv=centos/swap isolcpus=1-7,9-15 intel_iommu=pt rhgb quiet"
```

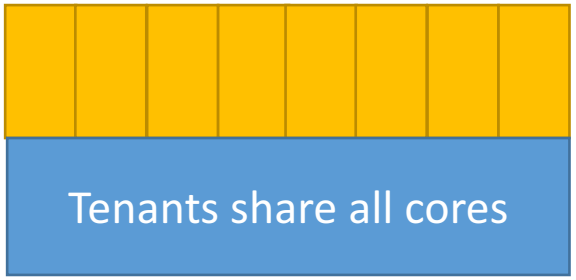
```
#grub2-mkconfig -o /boot/grub2/grub.cfg
#reboot
```

NOTE: No need for NUMA settings since PoC system only have one socket.

Multi Tenant Cache Coherency

- Trade off of granting tenants maximum resources vs. providing cache coherency





Benefits

Dedicating Cores	Sharing cores
Cache thrashing won't occur	Tenants can "burst" consuming more cores
Better if tenant bandwidth is uniform	Better if tenant bandwidth isn't uniform

Enable Promiscuous & VLANs

- SR-IOV + Promiscuous is new in kernel 4.5
- Currently only **Intel X710 & XL710** cards support it
- Must enable "trust mode"
  - kernel/iproute 4.5 or above
  - RHEL/CentOS 7.3 or above (backported patch)**

```
#echo 2 > /sys/class/net/ens2f0/device/sriov_numvfs
#ip link set dev ens2f0 vf 0 trust on
#ip link set dev ens2f0 vf 0 vlan 1000
#ip link set dev ens2f0 vf 1 trust on
#ip link set dev ens2f0 vf 1 vlan 2000
```

```
#ip link show
#ens2f0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP mode DEFAULT qlen
1000
    link/ether 3c:fd:fe:a2:0f:70 brd ff:ff:ff:ff:ff:ff
    vf 0 MAC 00:52:44:11:22:30, vlan 1000, spoof checking off, link-state auto
    vf 1 MAC 00:52:44:11:22:31, vlan 1001, spoof checking off, link-state auto
```

**https://access.redhat.com/solutions/2620231

Build Bro Container (CentOS base image)

- Install Docker (http://lmgtfy.com/?q=install+docker)
- Dockerfile for installing Bro 2.5 container located at
  - https://github.com/sealingtech/bro-docker

```
#git clone https://github.com/sealingtech/bro-docker.git
#docker build -t bro-docker ./bro-docker/
```

… Build takes ~20 min… go enjoy your scone

```
[root@localhost ~]# docker images
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
bro-docker          latest              47a09a29cfd5        3 hours ago         568 MB
centos              latest              67591570dd29        5 weeks ago         192 MB
```

Performance Issues/Tuning

1. Lower Ring Descriptor (< 256 worked best in PoC) to keep IRQs from maxing out.

```
#ethtool -G enp5s2 rx 128
```

2. Disable “irqbalance”

```
#systemctl stop irqbalance
```

3. Check for cache misses and tune appropriately

```
#perf stat perf stat -e LLC-loads,LLC-load-misses, \
LLC-stores,LLC-prefetches -C 2
```

Shamelessly borrowed from
Mozilla/Intel/Suricata Performance Guide: **https://github.com/pevma/SEPTun**

Helper Scripts on Github (Tests)

./reset-network.sh <num vfs>

- deletes all namespaces
- automatically adds VFs, adds vlans, etc for testing
- reloads kernel drivers
- some performance settings

./start-bro-docker.sh <interface>

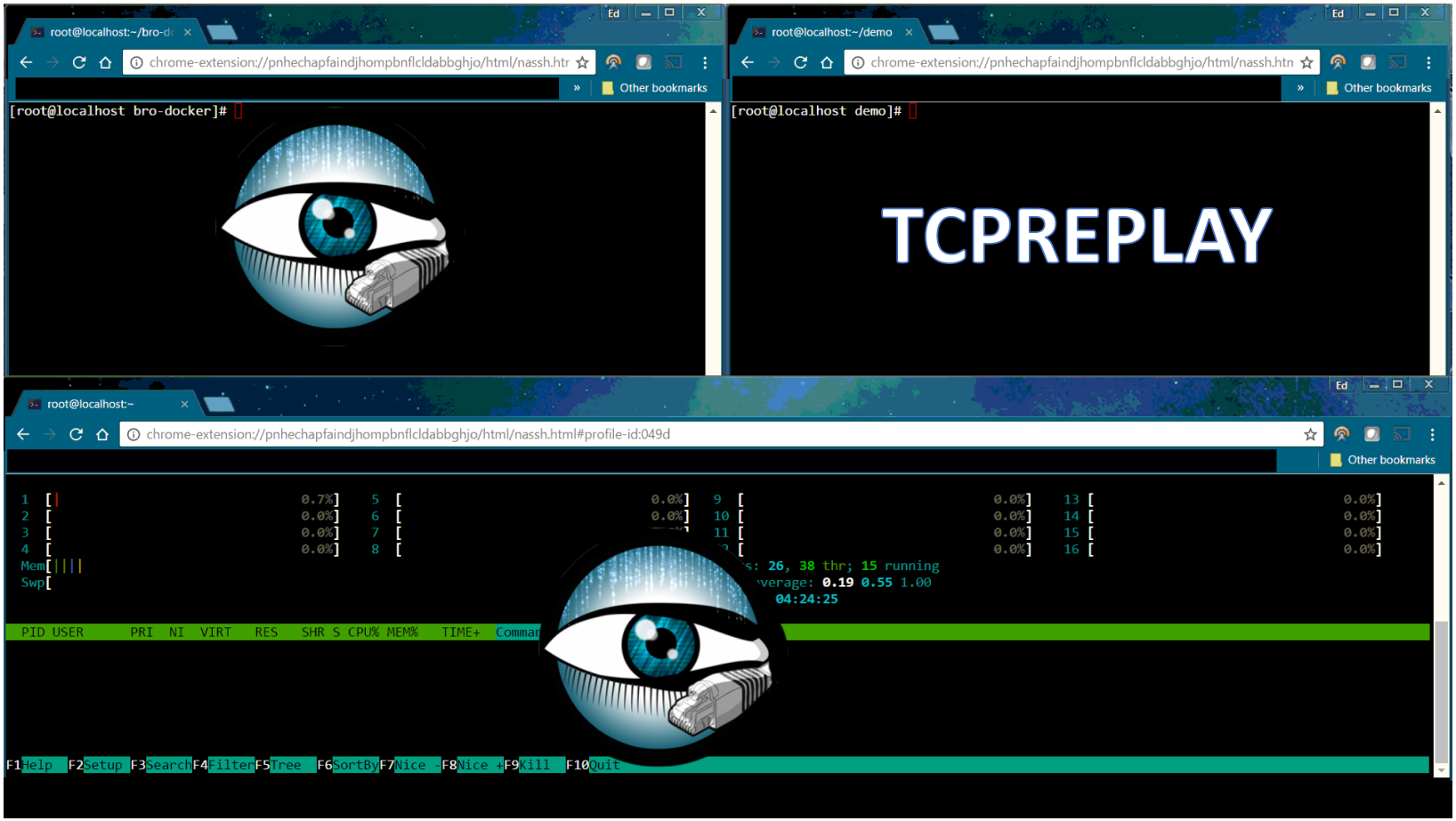
- places interface in docker instance's namespace
- creates eth1 inside of container and matches to SR-IOV interface
- configures bro with appropriate CPU pinning
- starts bro application in container

DEMO

Steps:

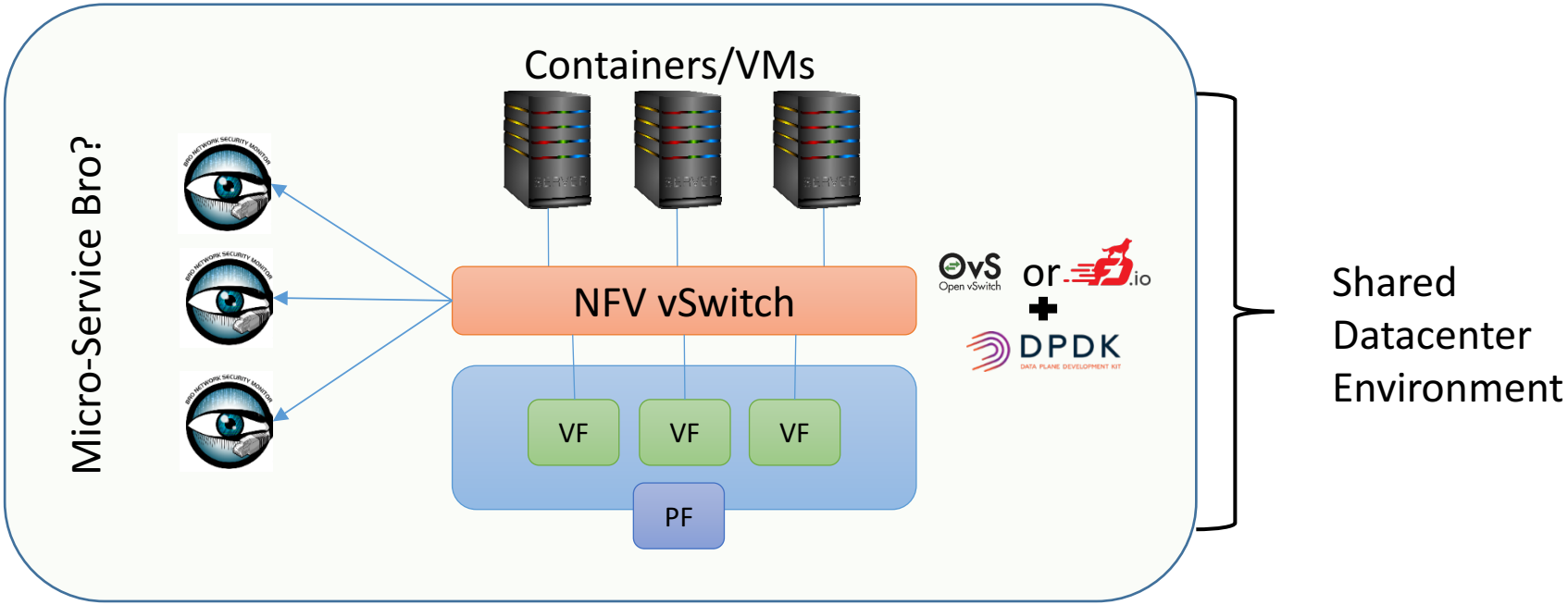
1. Start-up one, two Bro containers (shared & Isolated)
2. Send traffic to each VLAN with tcpreplay
3. Profit

Demo


root@localhost:~/bro-d
chrome-extension://pnhechapfaindjhompbnflcldabbghjo/html/nassh.htr
Other bookmarks
[root@localhost bro-docker]#
root@localhost:~/demo
chrome-extension://pnhechapfaindjhompbnflcldabbghjo/html/nassh.htn
Other bookmarks
[root@localhost demo]#
TCPREPLAY
root@localhost:~
chrome-extension://pnhechapfaindjhompbnflcldabbghjo/html/nassh.html#profile-id:049d
Other bookmarks
PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+
F1Help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice - F8Nice + F9Kill F10Quit

Where can we go from here?

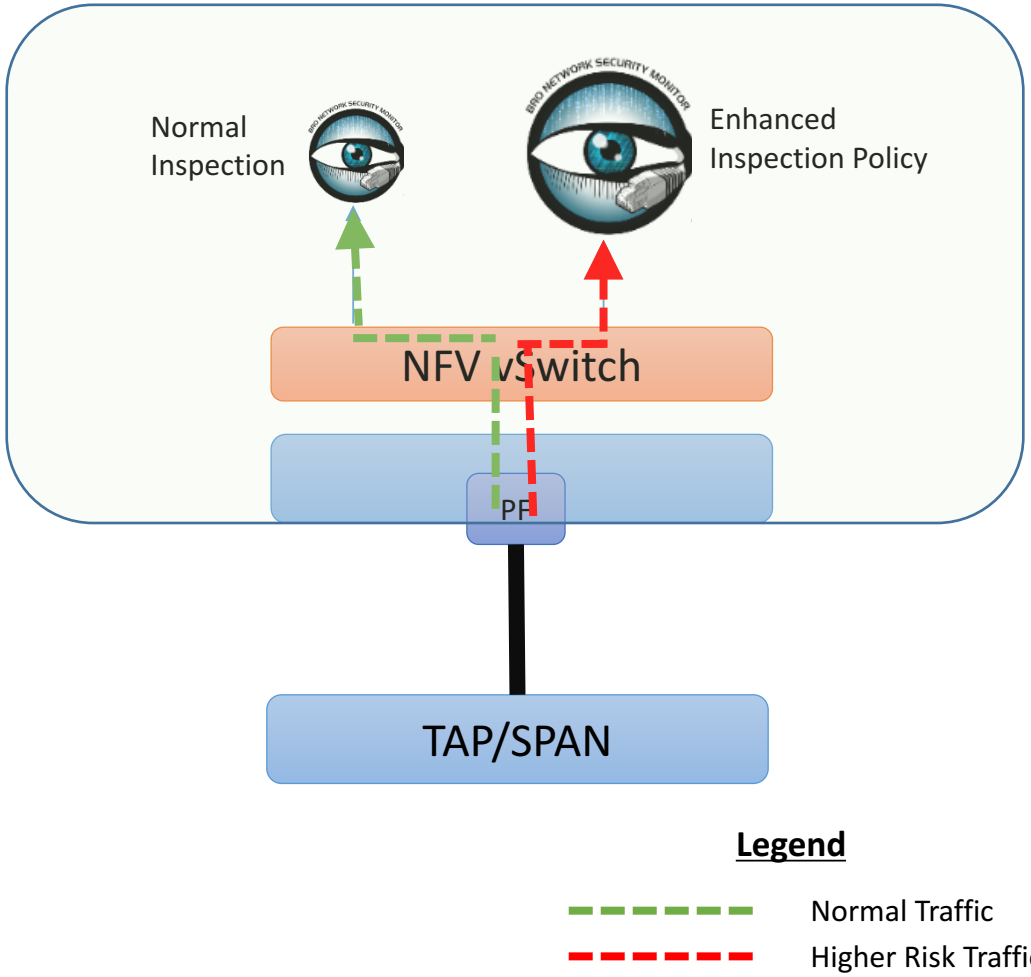
Security offering for Data-Center Providers…



- OvS supports SPAN ports to other VMs/Containers.
- Use case for Bro micro-service or NSMaaS?

Policy-based Use Case for enhanced inspection

- Used in environments that require resource intensive scripts
- Traffic is directed to “Normal” or “Enhanced” Bro instance based on 5-tuple
- Better than bypassing inspections all-together for normal traffic (Google/AWS/etc.)



Thank you!

Questions?