DDoS attacks on electronic payment systems

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image source: http://www.submarinecablemap.com/
image source: equens
image source: uva

Scope

- High volume DDoS attacks
- Electronic payment systems
  - Low bandwidth requirements:

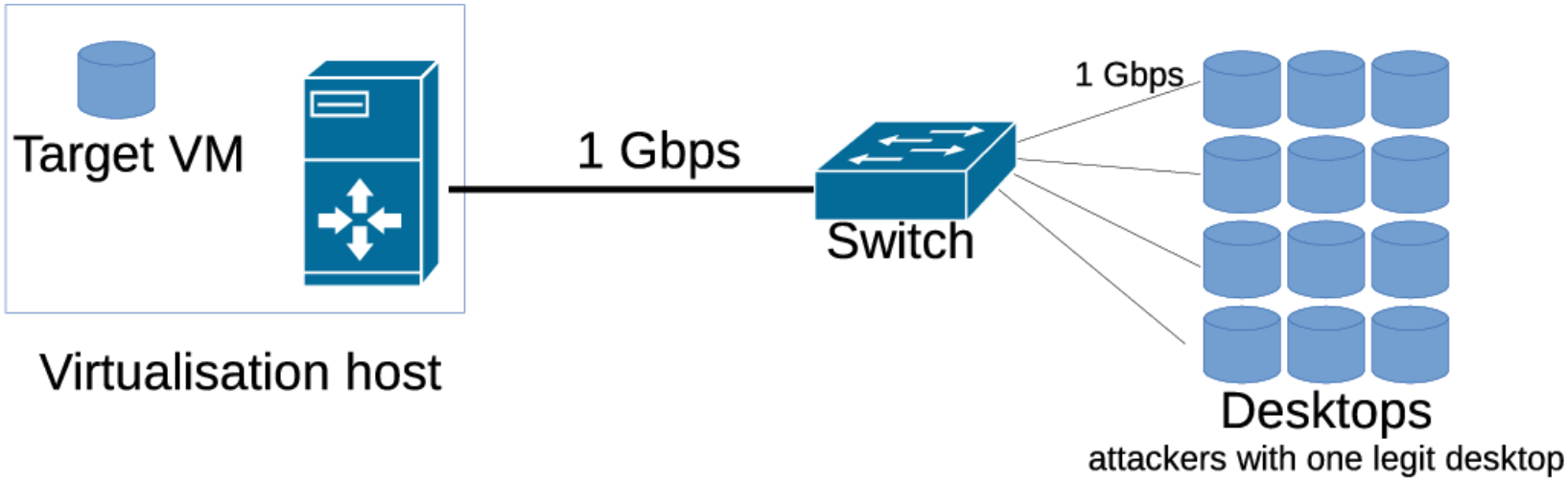
    €5 from account X to account Y

Research Question

What is the implementation difficulty and how effective is a subset of DDoS protection measures to keep electronic payment systems available?

- Whitelisting
- Robust DNS resolution
- Scrubbing

DDoS testing environment

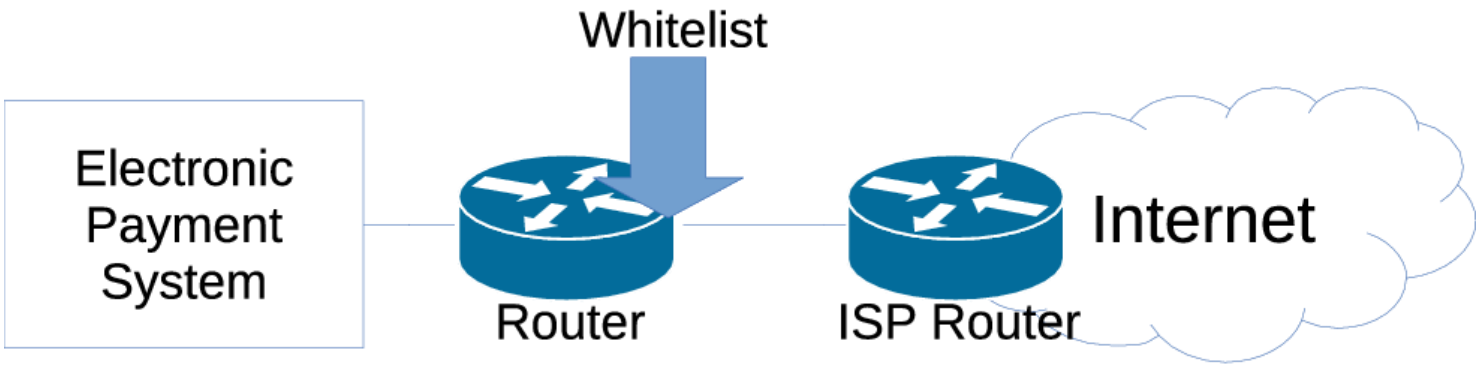


DDoS testing environment

Generate attack packets from our C&C desktop:

```
parallel-ssh -h nodes \
sudo hping3 --flood -S 172.16.1.10 \
--destport 5001 --data 8000
```

Whitelisting



Whitelisting

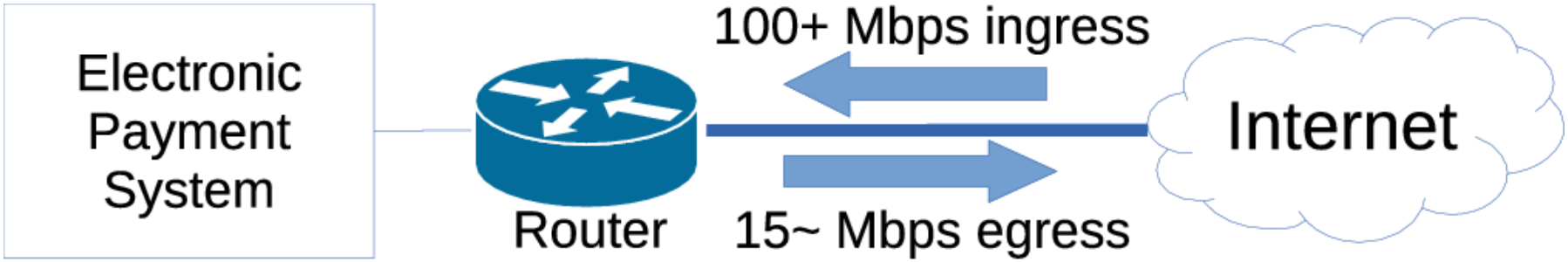
Implementation difficulty:

```
iptables - A FORWARD -i eth0 - s 145.100.0.0/15 - j ACCEPT
iptables - A FORWARD -i eth0 - j DROP
ip6tables - A FORWARD -i eth0 - s 2001:610::/32 - j ACCEPT
ip6tables - A FORWARD -i eth0 - j DROP
```

Whitelisting

Hyphotisis:

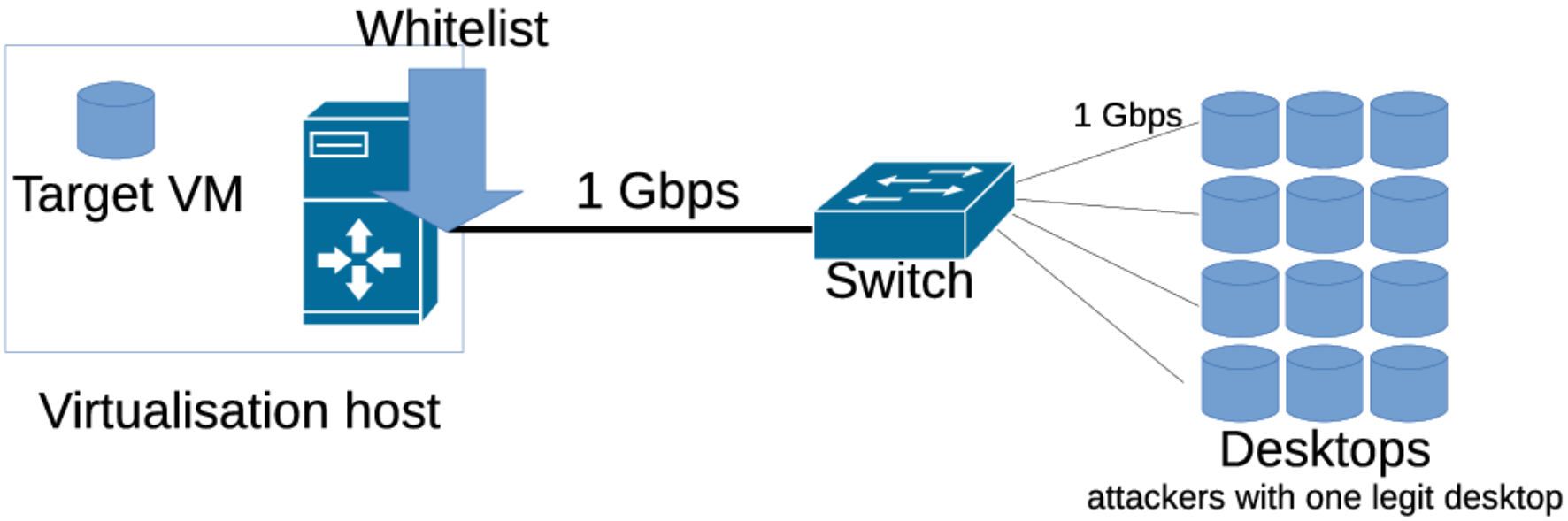
- Ingress link will be saturated
- Packet loss will occur on the opposite port
- Whitelisting should not be effective



Whitelisting

Test:

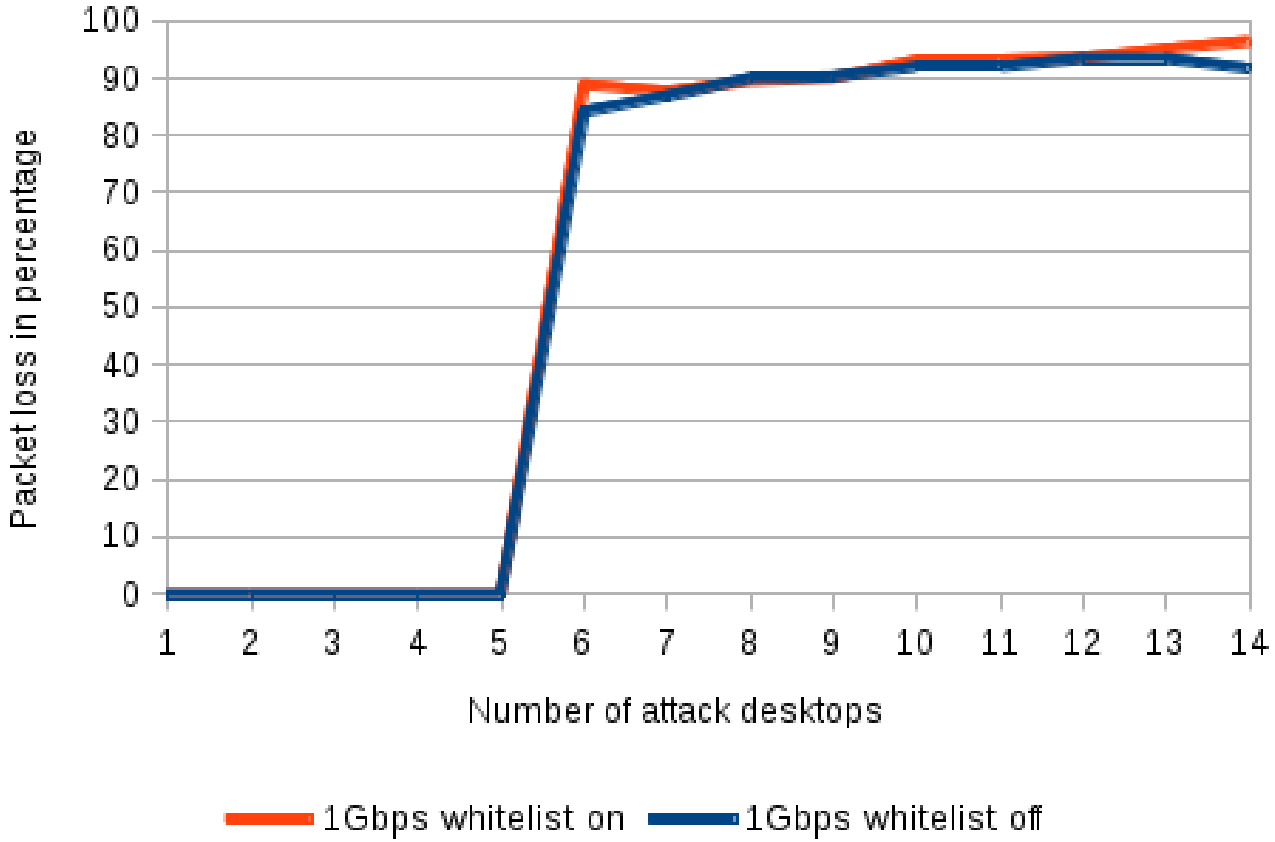
- hping3 -c 1000 --fast targetvm
- sends 1000 TCP packets, 10 packets per second



Whitelisting

Results:

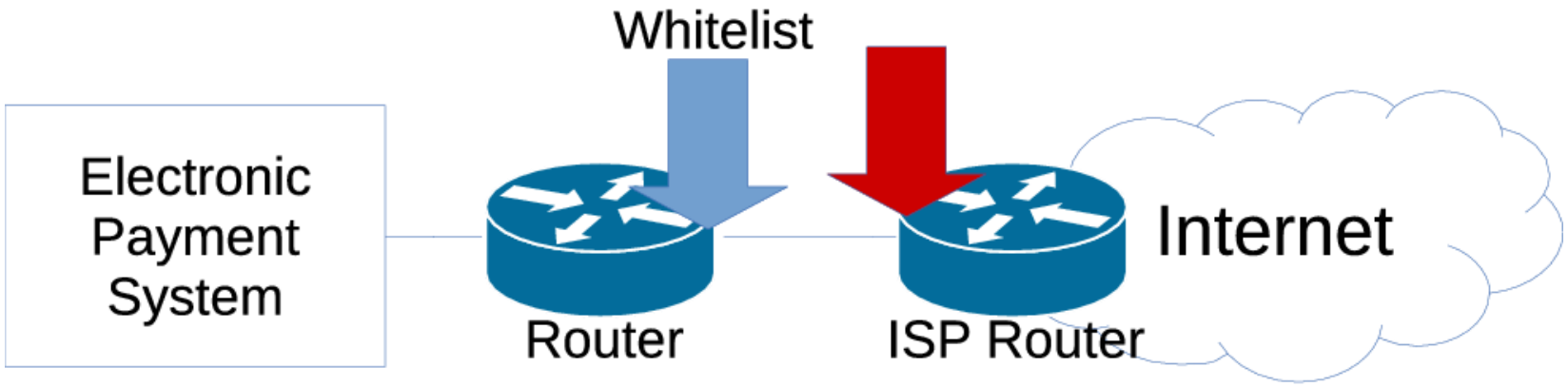
- DDoS attack on VM with 1Gbps link



Whitelisting

Cause:

- Packets never reach the whitelist



Whitelisting

```
$snmpwalk -Os -c public -v 1 switchaddress
ifOutDiscards
ifOutDiscards.1 = Counter32: 3248
...
ifOutDiscards.20 = Counter32: 3251
ifOutDiscards.21 = Counter32: 272661695
```

RFC1158:

"The number of outbound packets which were chosen to be discarded even though no errors had been detected to prevent their being transmitted. One possible reason for discarding such a packet could be to free up buffer space."

Robust DNS Resolution

- DNS
  - Not designed with DDoS in mind
- Confidentiality, Integrity, Availability
  - DNS is not confidential
  - Integrity can be guaranteed using DNSSEC
    - But falls out of scope
  - Availability

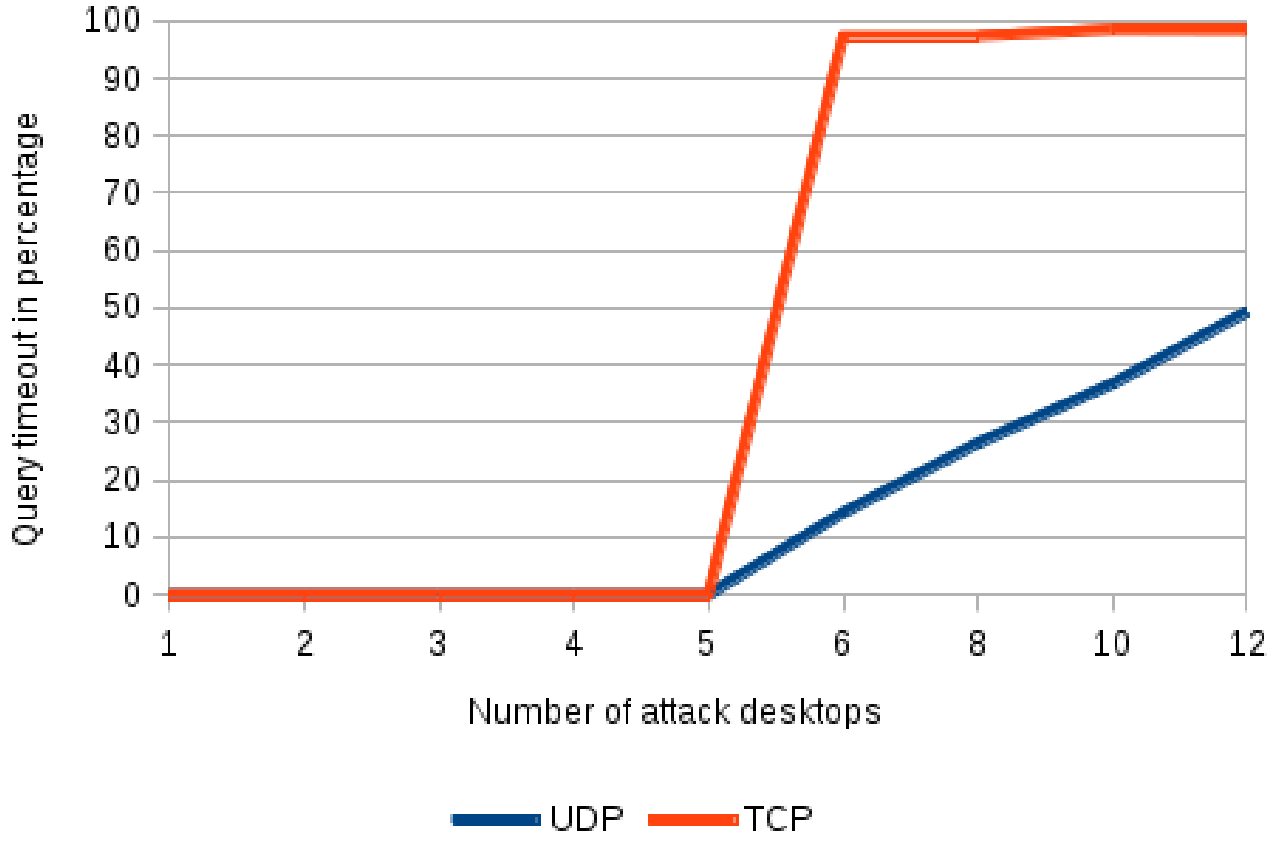
Robust DNS Resolution

Hypothesis:

- TCP should be more reliable
  - Due to retransmitting of packets
- Distributing DNS
  - Anycast

Robust DNS Resolution

Test; UDP vs TCP:



Robust DNS Resolution

Cause:

- TCP ACK retransmit failed
  - More congestion
    - More TCP retransmits
  - TCP slows down packet flow
    - But this does not even matter
    - DDoS keeps the ingress link full

Robust DNS Resolution

- Anycast does work
  - Global network required
- DNS Root servers
  - Attacked many times

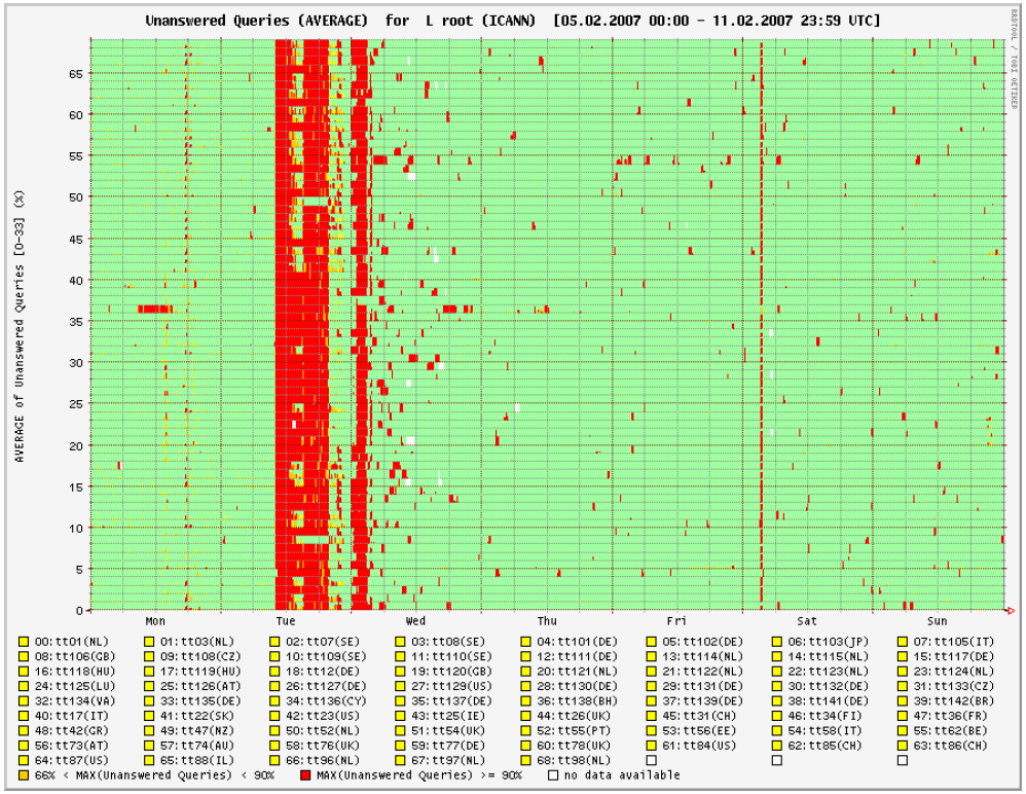
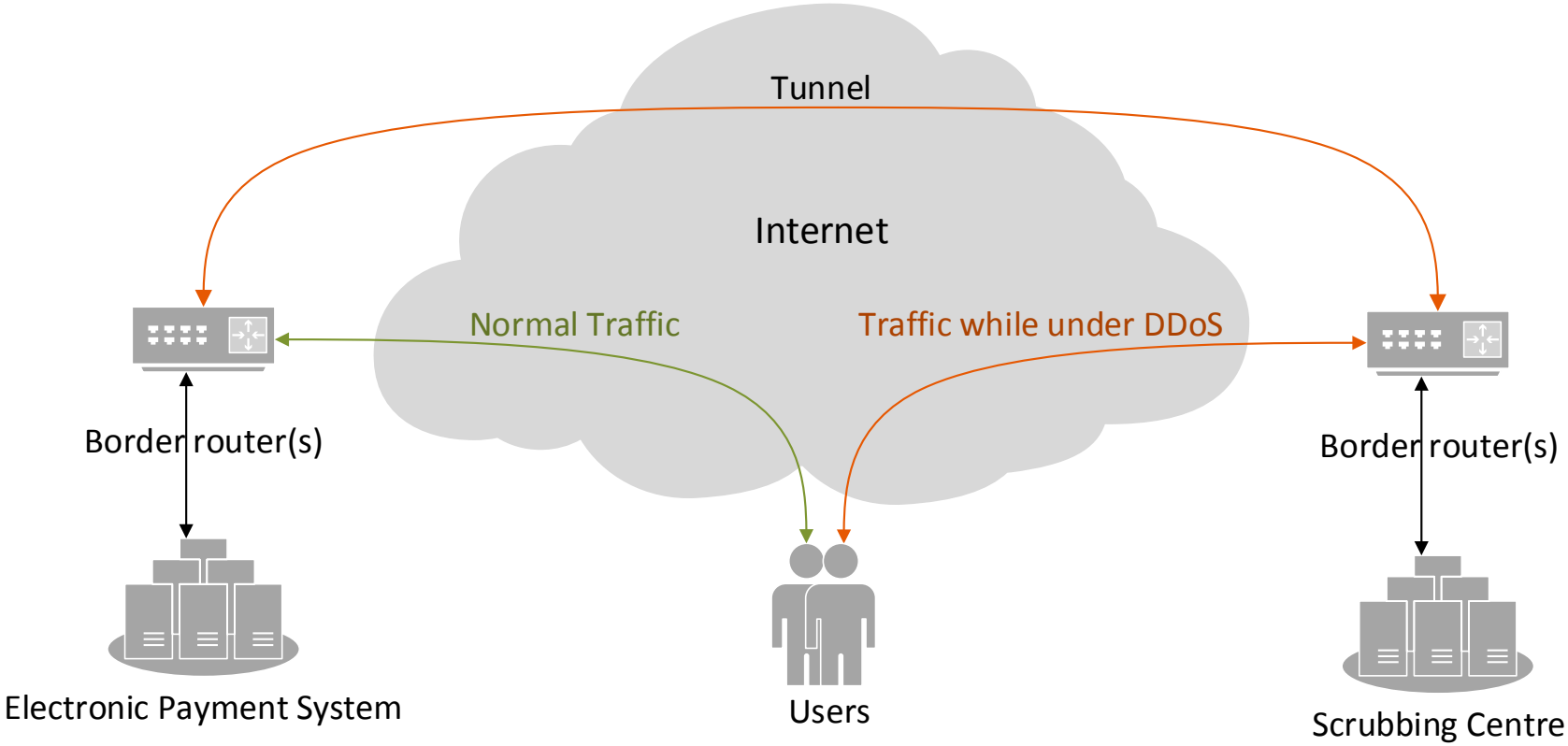


image source: RIPE NCC dnsmon

Scrubbing


Tunnel
Internet
Normal Traffic
Traffic while under DDoS
Border router(s)
Border router(s)
Electronic Payment System
Users
Scrubbing Centre

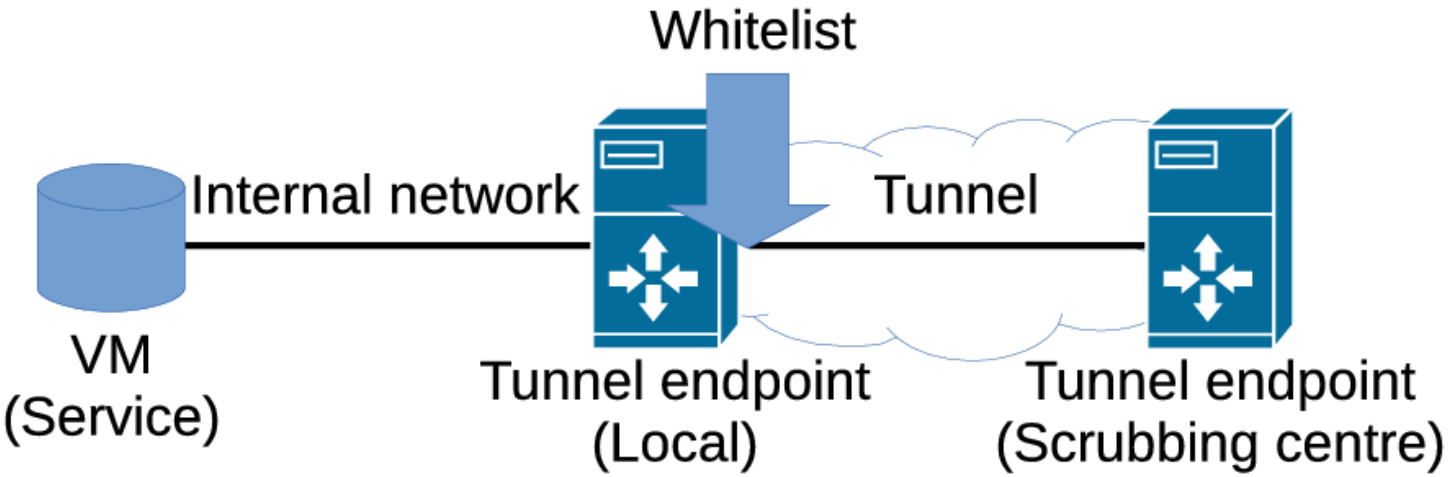
Scrubbing

- Traffic redirection
  - BGP anycast
  - On-demand / always-on
- Scrubbing Centre
  - Blackholing
  - Sinkholing

Scrubbing

Hypothesis:

- The local endpoint is vulnerable
- We can hide the local tunnel endpoint



Scrubbing

Test; hiding the local endpoint; no filter:

```
user@client:~$ traceroute 172.16.1.2
traceroute to 172.16.1.2 (172.16.1.2), 30 hops max, 60 byte packets
 1  172.16.1.1 (172.16.1.1)  0.267 ms  0.255 ms  0.246 ms
 2  172.16.1.2 (172.16.1.2)  0.401 ms  0.356 ms  0.338 ms

user@client:~$ traceroute -U 172.16.1.2
traceroute to 172.16.1.2 (172.16.1.2), 30 hops max, 60 byte packets
 1  172.16.1.1 (172.16.1.1)  0.293 ms  0.268 ms  0.250 ms
 2  172.16.1.2 (172.16.1.2)  0.358 ms  0.342 ms  0.326 ms

user@client:~$ sudo traceroute -T 172.16.1.2
traceroute to 172.16.1.2 (172.16.1.2), 30 hops max, 60 byte packets
 1  172.16.1.1 (172.16.1.1)  0.235 ms  0.207 ms  0.183 ms
 2  172.16.1.2 (172.16.1.2)  0.347 ms  0.326 ms  0.320 ms
```

Scrubbing

Test; hiding the local endpoint; applying filter:

Drop all incoming packets

```
iptables -A INPUT -i eth0 -j DROP
ip6tables -A INPUT -i eth0 -j DROP
```

Accept packet forwarding from tunnel endpoint

```
iptables -A FORWARD -i eth0 -s 172.16.1.3/32 -j ACCEPT
iptables -A FORWARD -i eth0 -j DROP
ip6tables -A FORWARD -i eth0 -s 2001:DB0::1/128 -j ACCEPT
ip6tables -A FORWARD -i eth0 -j DROP
```

Prevent packets to be sent out

```
iptables -A OUTPUT -i eth0 -j DROP
ip6tables -A OUTPUT -i eth0 -j DROP
```

Scrubbing

Test; hiding the local endpoint; after applying filter:

```
user@client:~$ traceroute 172.16.1.2
traceroute to 172.16.1.2 (172.16.1.2), 30 hops max, 60 byte packets
 1  * * *
 2  172.16.1.2 (172.16.1.2)  0.309 ms  0.324 ms  0.317 ms

user@client:~$ traceroute -U 172.16.1.2
traceroute to 172.16.1.2 (172.16.1.2), 30 hops max, 60 byte packets
 1  * * *
 2  172.16.1.2 (172.16.1.2)  0.519 ms  0.530 ms  0.525 ms

user@client:~$ sudo traceroute -T 172.16.1.2
traceroute to 172.16.1.2 (172.16.1.2), 30 hops max, 60 byte packets
 1  * * *
 2  172.16.1.2 (172.16.1.2)  0.386 ms  0.352 ms  0.394 ms
```

Scrubbing

But…

- No golden ticket
- Depends on secrecy of IP address
  - Of the local tunnel endpoint
  - Social engineering
    - Internal documents

Conclusion

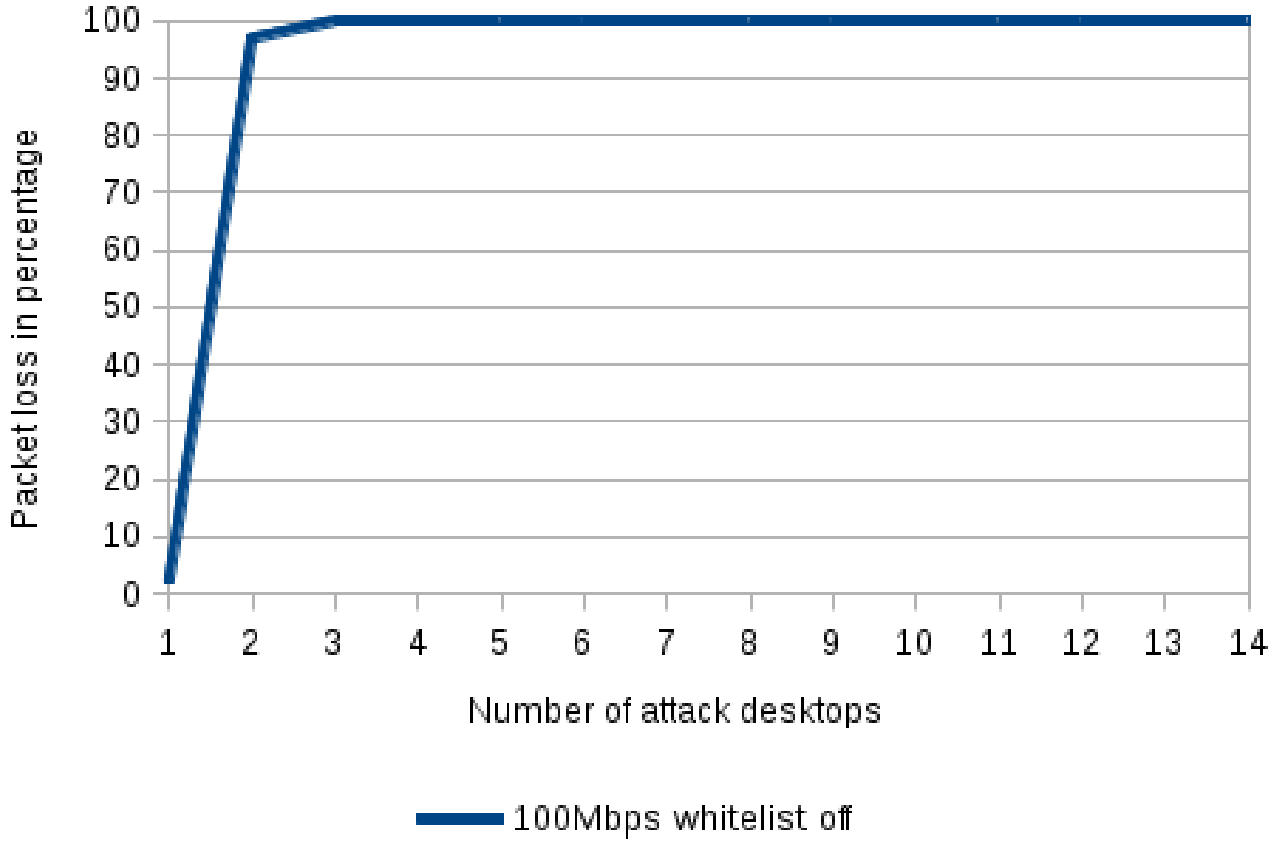
- Whitelisting
  - Does not protect against high volume DDoS attacks
- Robust DNS Resolution
  - TCP performs worse then UDP
  - Anycast works
    - And helps keeping DNS-based applications available
- Scrubbing
  - Does protect against high volume DDoS attacks
  - But…
    - Only when combined with whitelisting
    - And secrecy of the local tunnel endpoint IP

Future research

- Layer 7 DoS attacks in electronic payment systems
- Combining layer 3/7 attacks also known as "smoke and mirrors"
- What is the best way to create a deterministic DDoS setup

Future research

DDoS attack on VM with 100Mbps link



Questions

image source: http://www.submarinecablemap.com/
image source: anonymous