

An Empirical Analysis of the Commercial VPN Ecosystem



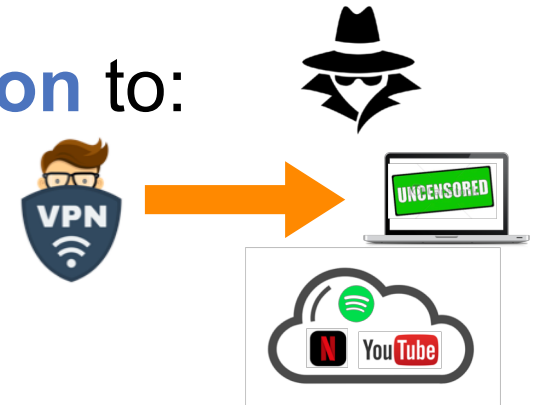
Mohammad Taha Khan*, Joe DeBlasio*, Geoffrey M. Voelker,
Alex C. Snoeren, Chris Kanich & Narseo Vallina-Rodriguez

Commercial VPN Services

VPNs are a **\$15 billion** growing industry*

VPNs advertise a **one stop solution** to:

- Achieve online anonymity
- Evade Internet censorship
- Access geo-filtered content



VPNs make several **privacy** and **infrastructural** claims

* <https://www.marketwatch.com/press-release/virtual-private-network-vpn-market-analysis-by-type-deployment-products-end-user-vpn-market-worth-us-41702-billion-by-2023-at-18-cagr-2018-06-12>

The VPN Ecosystem

VPNs can act **maliciously**

- Monitor and sell traffic
- Inject ads into pages
- Falsely advertise server locations



VPNs can also be **careless**

- Buggy clients software

Prior work* in the Android VPN space

* Ikram M.; Vallina-Rodriguez N.; Seneviratne S.; Kaafar MA. and Paxson V.; "An Analysis of the Privacy and Security Risks of Android VPN Permission-enabled Apps," IMC 2016

The VPN Ecosystem

NEWS

Users of free VPN Hola vulnerable to hacking, researchers warn

Free P2P VPN Hola sold users' bandwidth which was then used for botnets; researchers say to uninstall Hola now as it makes users vulnerable to hacking.

VIRTUAL PRIVATE SNOOPING —

FTC must scrutinize Hotspot Shield over alleged traffic interception, group says

VPN service "can intercept and redirect HTTP requests to partner websites."

FTC Urged to Investigate AnchorFree VPN User Data Privacy Risks

By: eWEEK Staff | August 14, 2017

Today's topics include the FTC being asked to investigate privacy risks with AnchorFree's Hotspot Shield VPN; Microsoft updating Outlook.com with a new look and some AI-inspired functionality; T-Mobile offering smartphone users aged 55

The VPN Ecosystem

Lack comprehensive **audit and verification** tools for users to **investigate** VPNs



Users eventually rely on **rating websites**, driven by **affiliate marketing**

Review site **VPNmentor** has **95%** of the ratings **4/5** or higher



Study Overview

Goal: Objective and quantifiable evaluation of the commercial VPN ecosystem

1. Evaluated ecosystem with 200 VPN provider websites
 - VPNs have multiple marketing strategies and have varying transparency practices
2. Actively tested 62 VPN services
 - Some VPNs monitor traffic, falsely advertise server locations and also leak traffic

Data for Ecosystem Analysis

- VPNs which truly reflect the ecosystem
- Various online data sources:
 - Crawled Google search for “top VPNs”
 - VPN subReddit
 - Personal recommendations
- Further filtered on low costs, vantage points and diversity of users
- Mined information of **200** VPN services



Ecosystem – Marketing

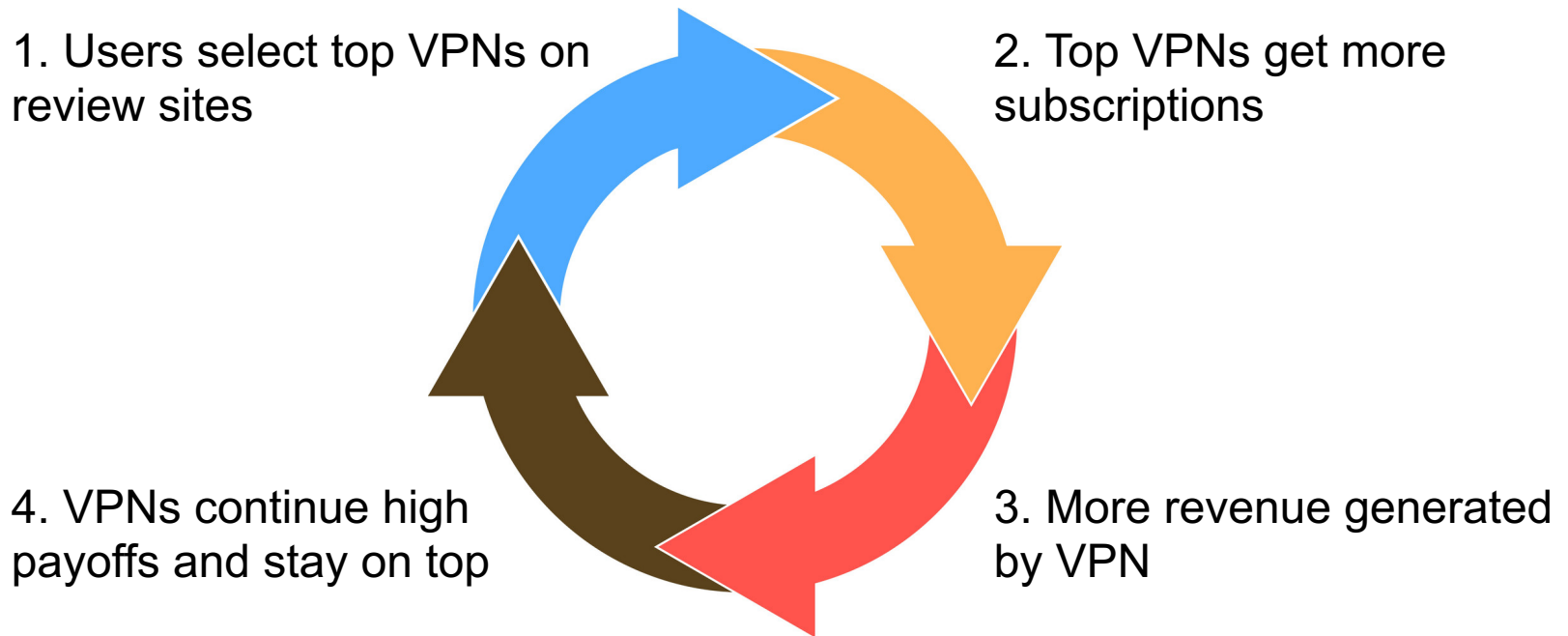
VPNs make use of **social media** for promotion

- **63%** had a **Facebook** page
- **65%** had **Twitter** account

44% of the VPNs offered affiliate marketing

Ecosystem – Marketing

How affiliate marketing affects users?



Ecosystem – Marketing

IPVANISH
VPN

Why VPN Pricing Apps Help

ADDICTIVETIPS + Visitors - Up to 60% off!

Why VPN Pricing Apps Help My Account

c|net Visitors - 25% off Any Plan. Start Now!

Website: AddictiveTips

VPN Rank: #2

Discount: 60%

Website: CNet

VPN Rank: #5

Discount: 25%

Ecosystem – Transparency

25% VPNs did not have a **privacy policy**

VPN privacy policies **varied significantly**

Only 23% VPNs claimed a **no logs policy**

Active Testing of VPNs

Actively tested **62** VPN services

For each service:

1. Register account/install VPN
2. Connect and run test suite
3. Repeat for multiple VPN server locations

Tested **1046** vantage points

VPN Testing Suite

1. Traffic monitoring and manipulation
2. Infrastructural evaluation
3. Traffic leakage

Traffic Monitoring

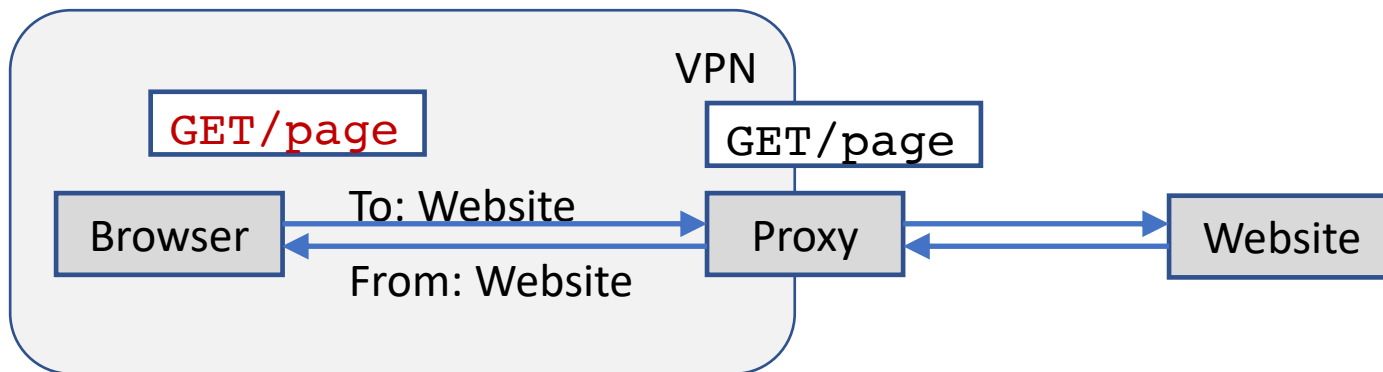
Do VPNs monitor or modify traffic?

Detecting transparent proxies.

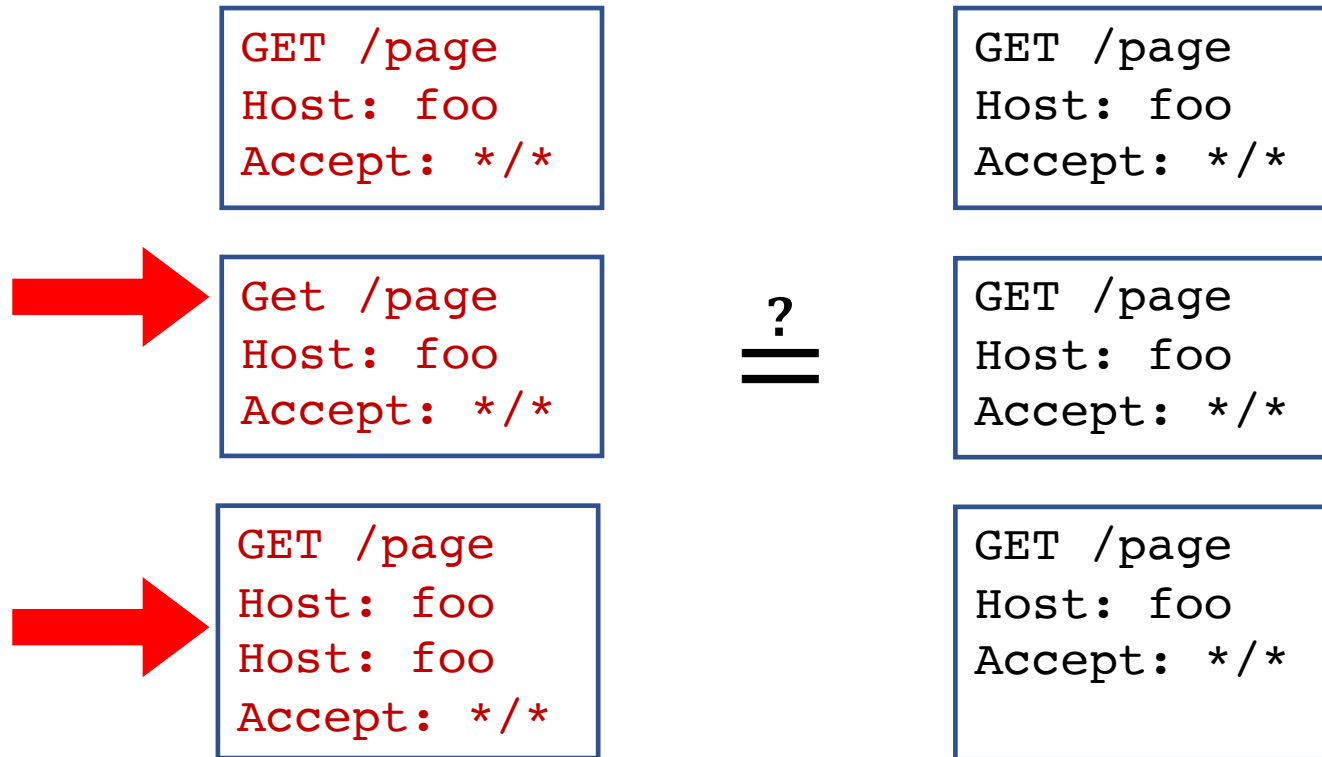
Traffic Monitoring

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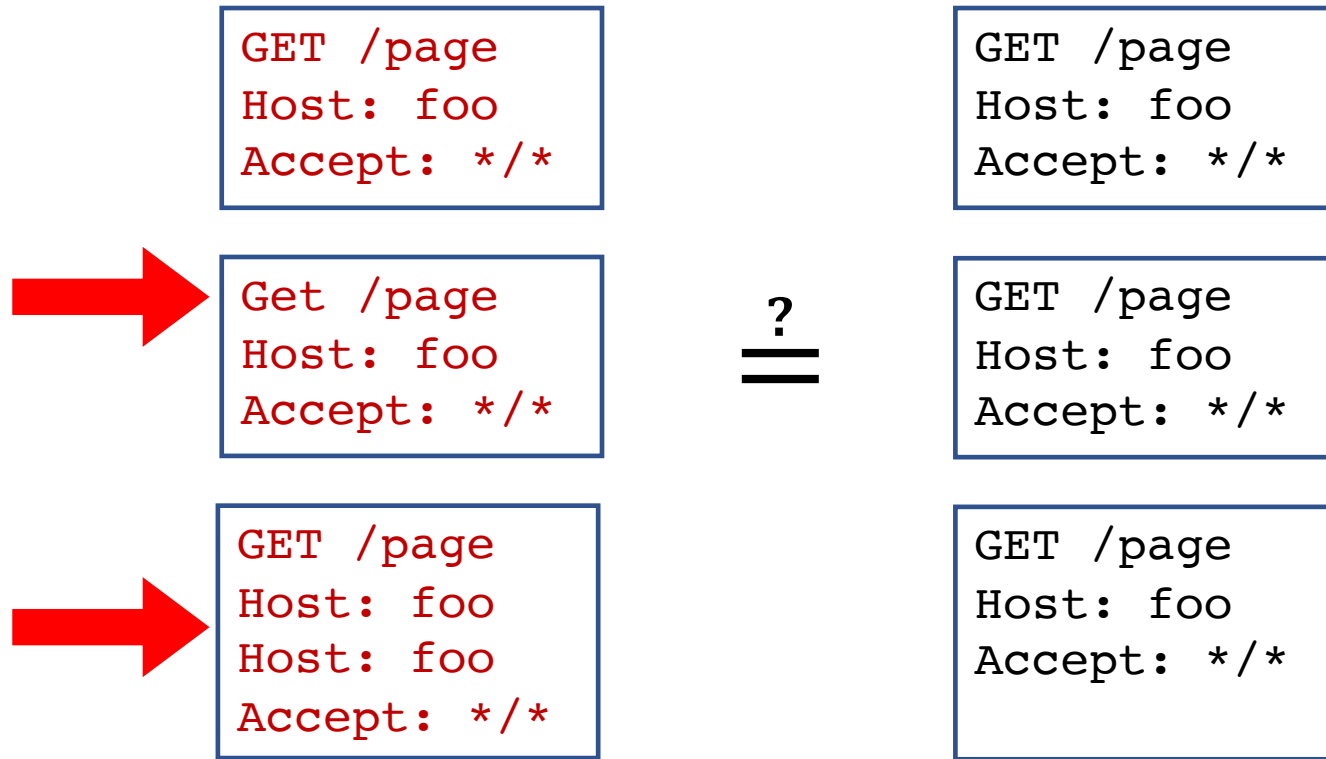
Detecting transparent proxies.



Traffic Monitoring



Traffic Monitoring



At least **5 of 62 VPNs** use **proxies**

VPN Server Geolocations

Do VPNs advertise accurate server locations?

1. Geo-IP Databases

- **Problem:** They are inaccurate*

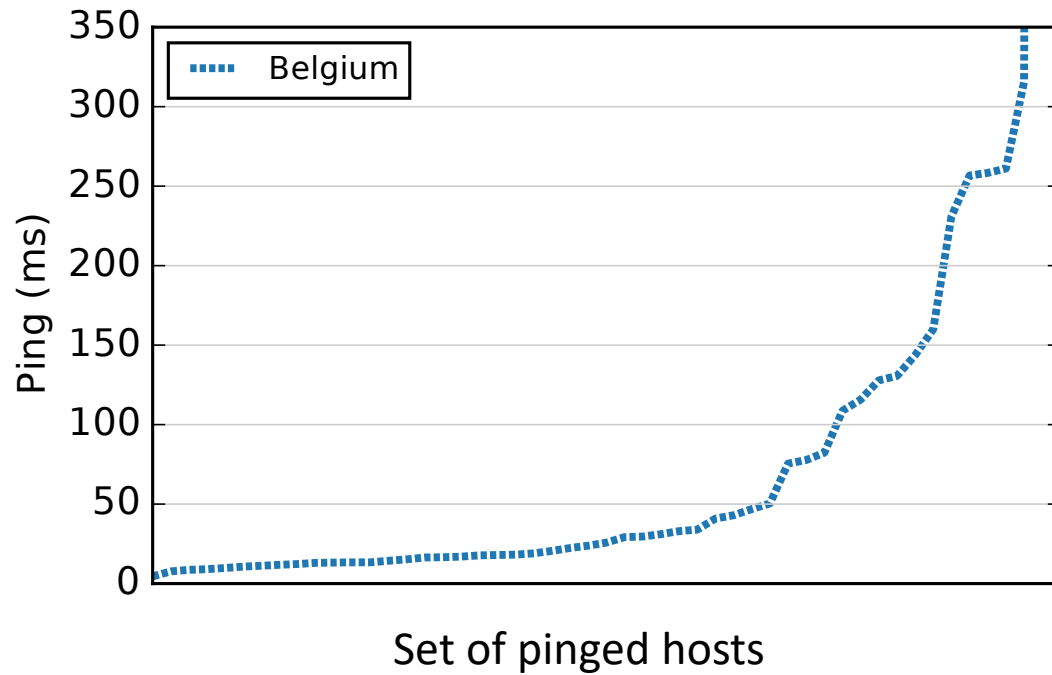
2. Measure RTT to known hosts

- Look for inconsistencies
- Evaluate using RTT fingerprints

* Gharaibeh, M.; Shah, A.; Huffaker, B.; Zhang, H.; Ensafi, R. and Papadopoulos, C. "A Look at Router Geolocation in Public and Commercial Databases," IMC 2017

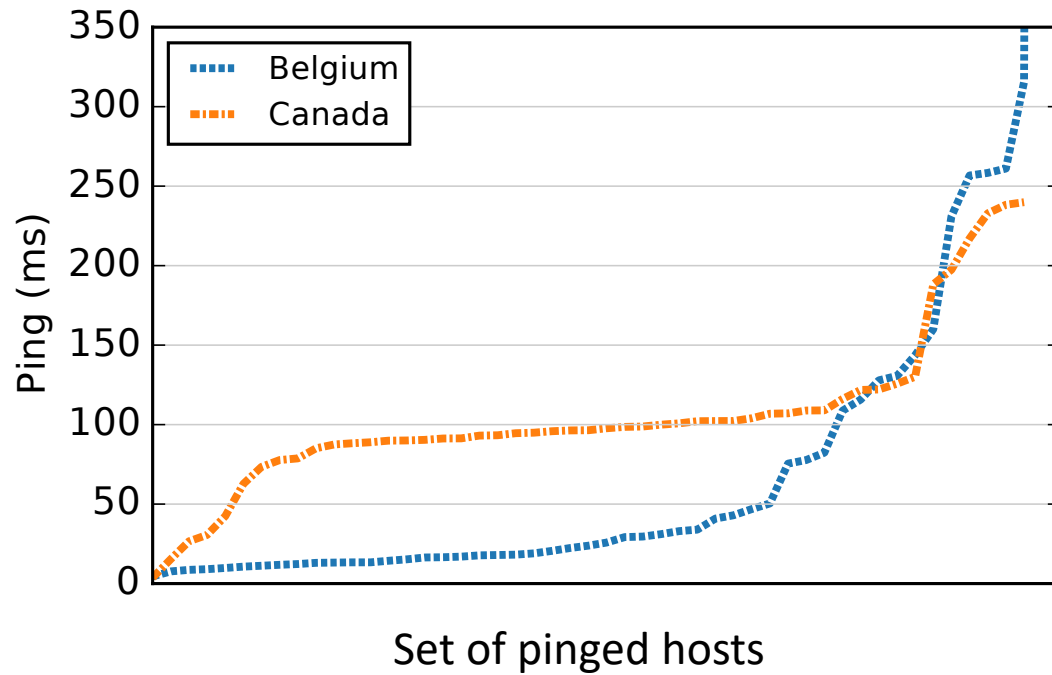
VPN Server Geolocations

MyIP.io



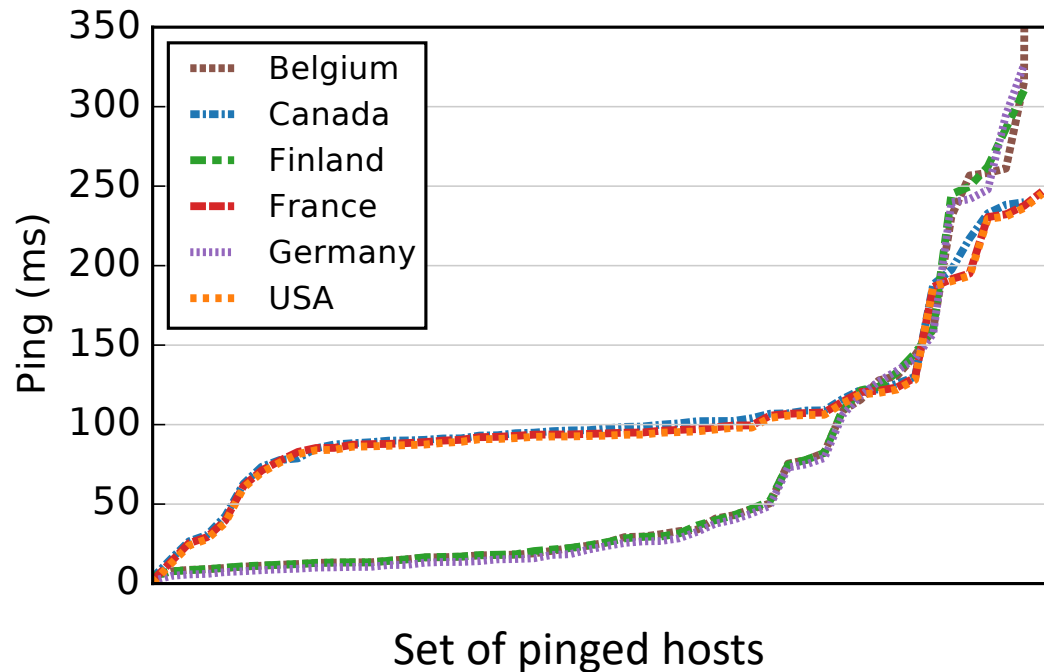
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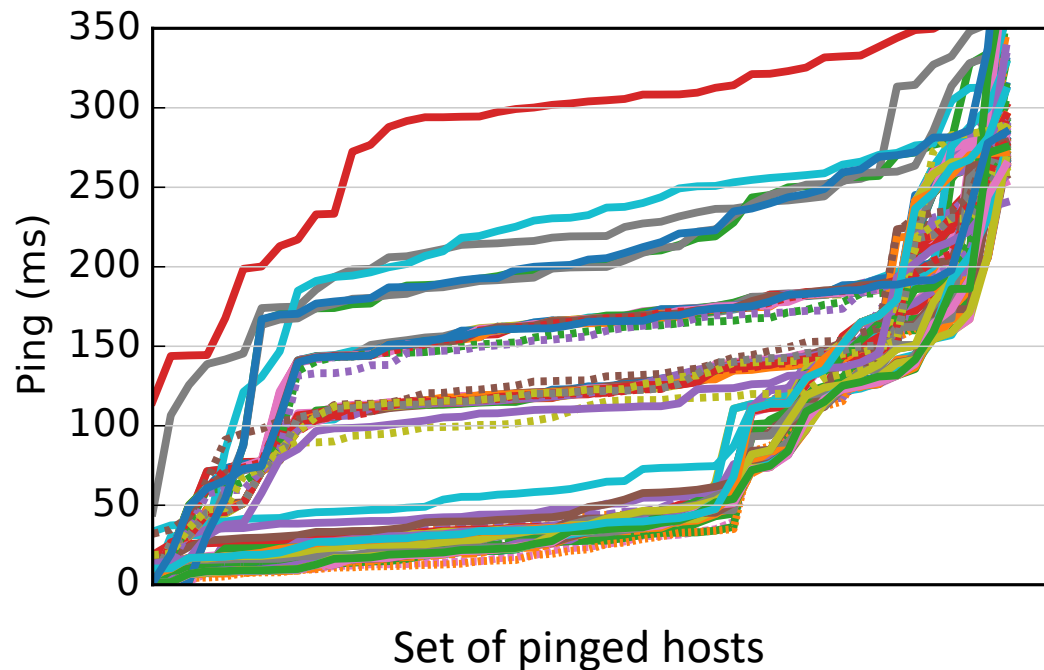
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VPN Server Geolocations

HideMyAss

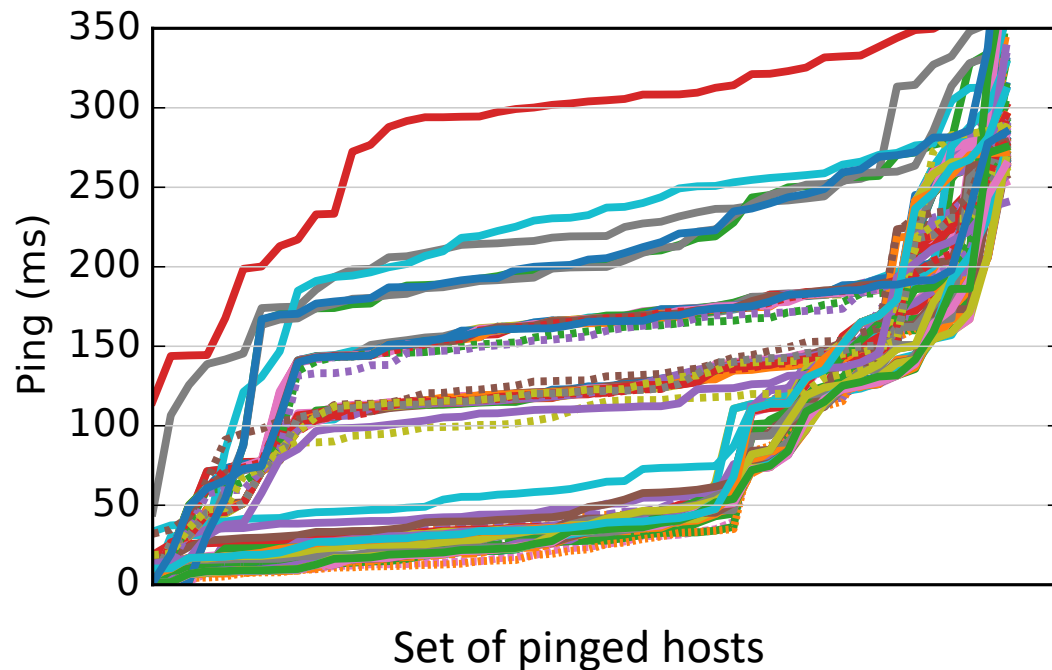
Claims 280+ locations



VPN Server Geolocations

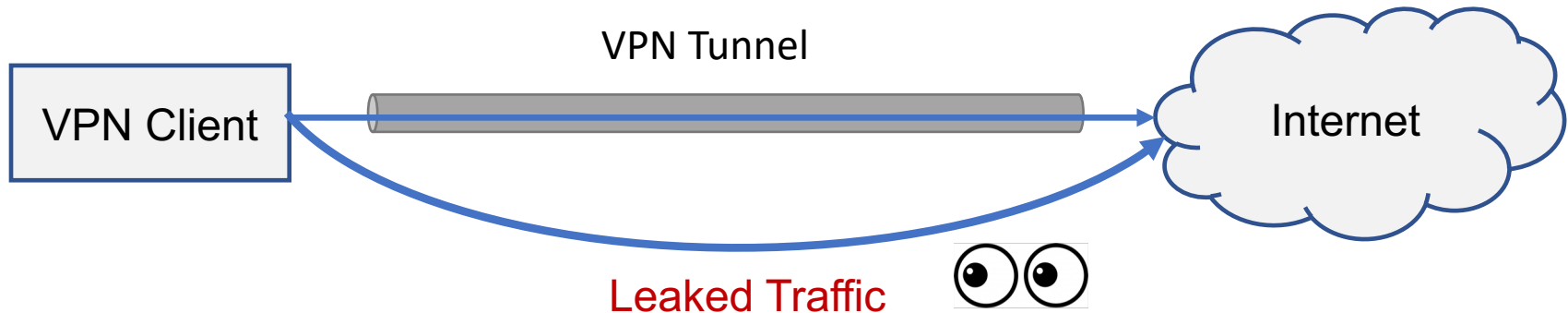
HideMyAss

Claims 280+ locations



At least **6 of 62 VPNs** use **false geolocations**

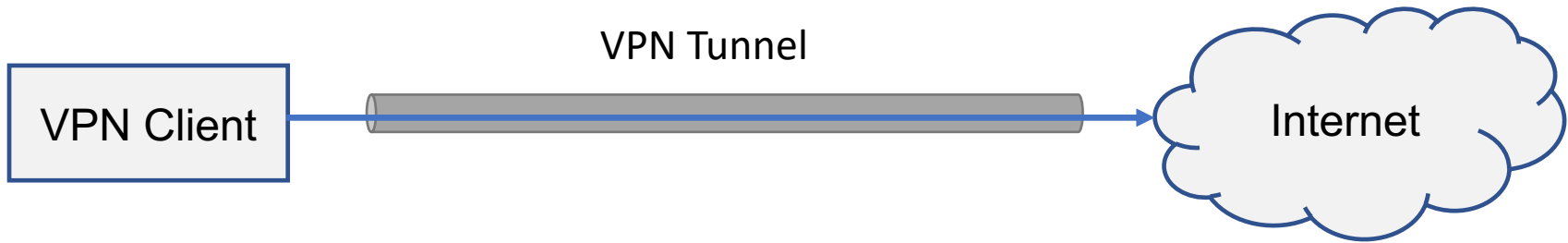
Traffic Leakage



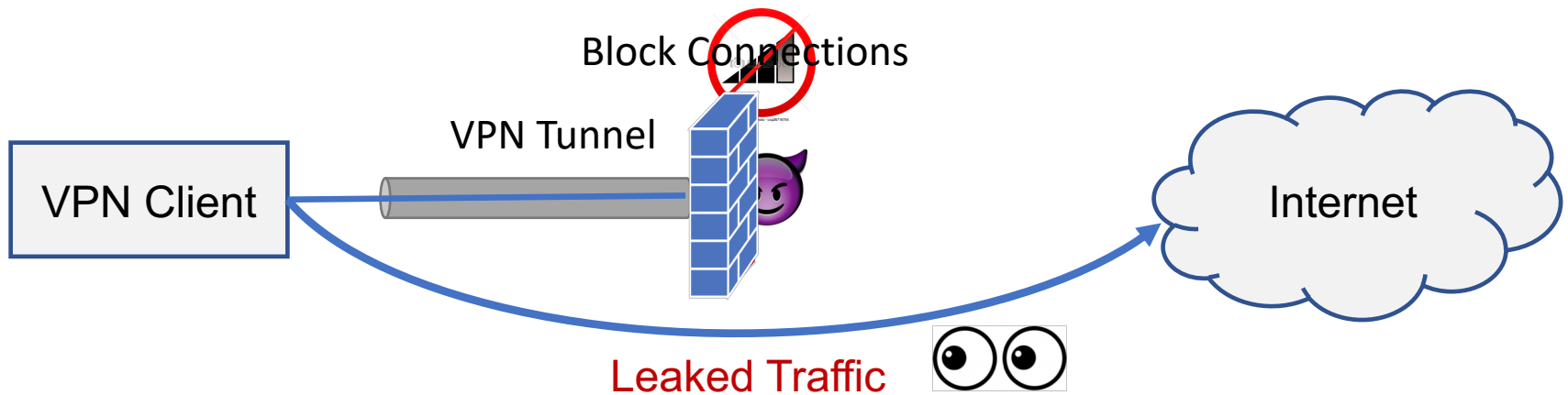
2 VPNs leak **DNS** requests

12 VPNs leak **IPv6** traffic

Traffic Leakage



Traffic Leakage



25 VPNs **leak** traffic due to **tunnel failure**

Summary Findings

- VPNs marketing creates a biased view of the ecosystem.
- Lack of privacy regulation in the industry
- Some VPNs fail to stand up to their claims:
 - 5 VPNs monitor traffic through proxies
 - 6 VPNs Falsely advertise geolocations
 - Over 20 VPNs leak traffic due to misconfigurations

Thank You!

Test Suite: https://github.com/tahakhan5/vpn_tests

Website: <http://vpnselection.guide>

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