

Investigating the VPN Ecosystem

through the lens of Security, Privacy, and Usability

Reethika Ramesh

January 17, 2024





FTC Staff Report Finds Many Internet Service Providers Collect Troves of Personal Data, Users Have Few Options to Restrict Use

October 21, 2021



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THE WALL STREET JOURNAL.

NSA's Domestic Spying Grows As Agency Sweeps Up Data

Terror Fight Blurs Line Over Domain; Tracking Email



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PRIVACY INVESTIGATION —

FTC investigates whether ISPs sell your browsing history and location data

AT&T, Comcast, Verizon, T-Mobile, Google face probe into privacy and targeted ads.

Internet traffic is increasingly being **disrupted, tampered with, and monitored** by ISPs, advertisers, and other threat actors

Demand for VPNs

Users are turning to Virtual Private Networks (VPNs) as a **panacea** for security, privacy, and information restrictions.

VPNs are now a **multi-billion dollar** industry

10 / Research / VPN Demand Statistics

VPN Demand Surges Around the World

News

Latest Deep tech Sustainability Ecosystems Data and security Fintech and economi >

VPN searches skyrocket after Congress killed your right to internet privacy

Bloomberg

Technology

VPN Downloads Surge in Response to Hong Kong Security Law

- Privacy advocates warn of more internet controls from Beijing
- Proposed law from China would bypass Hong Kong legislature

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Net neutrality and privacy scandals are increasing VPN use

In this talk...



**User-centric study
and VPN provider
interview, and results**



**VPNalyzer Tool
Development and
Results**

Fundamental Questions Still Unanswered

Why do **users** turn to VPNs?

↳ Dwindling trust in ISPs?

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↳ What is the impact on users?

↳ What are the incentives in sustaining such practices?



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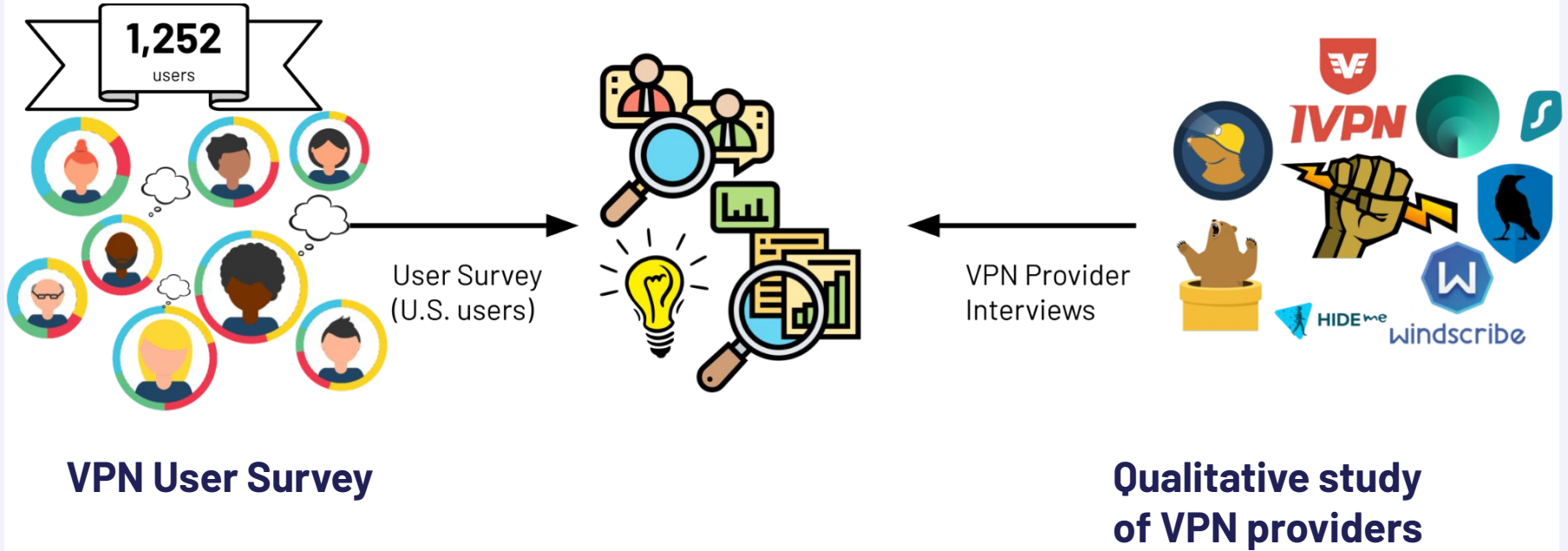
↪ What are the incentives in sustaining such practices?

We must study **both the VPN users and the VPN providers** to gain a clear understanding of such a large consumer ecosystem

We surveyed 1,252 VPN users in the U.S. and interviewed nine popular, VPN providers

We are the first to conduct such a multi-perspective study of the VPN ecosystem

The Study



What did we find?

We systematize our various lines of inquiry into **six** research questions

Research Question 1:

Why do users use VPNs?

Security and privacy are the top reasons

82.1% Protection from Threats

58.4% Make Public Networks Safer to Use

Circumvention, torrenting among the least popular reasons

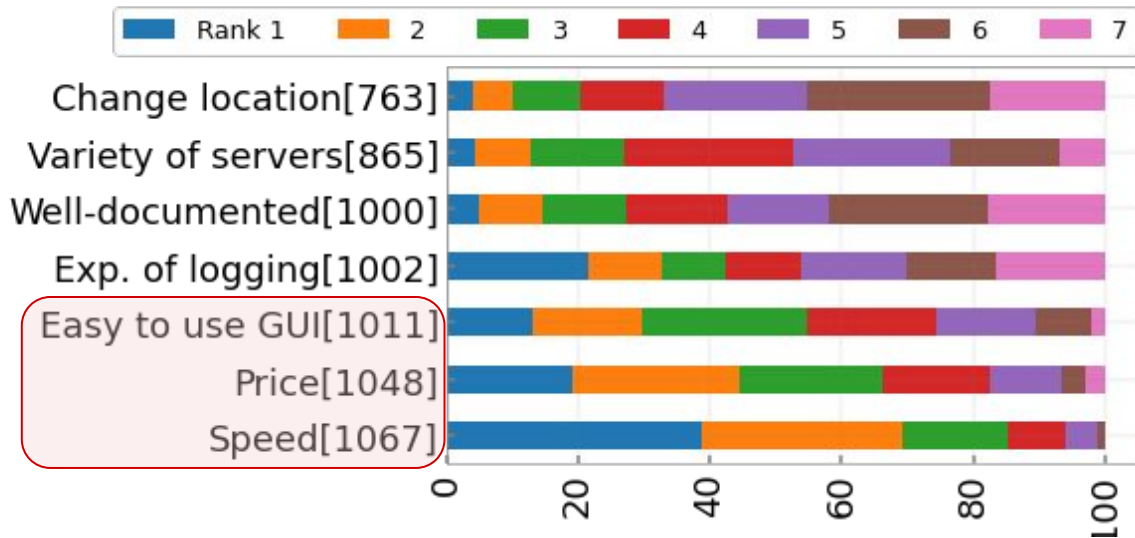
Research Question 2:

What are users' needs and considerations?

Top requirements in a VPN:

- Speed (72.6%)
- Price (55.4%)
- Easy to use app or GUI (44.1%)

Price is a big criteria for **limited-to-moderate expertise** users
→ exploited by malicious marketing

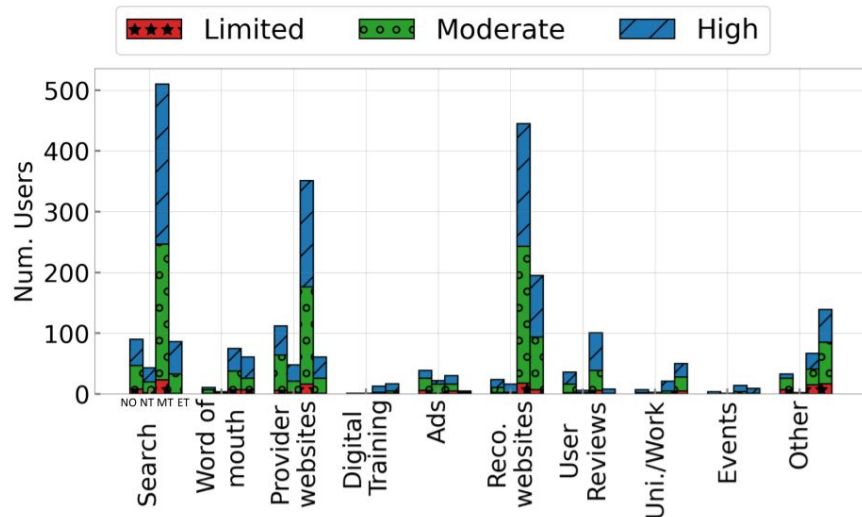


Research Question 2:

Resources to Find VPNs

- Actively researching on the Internet (61.1%)
- **Recommendation websites** (56.5%)
- Reading the VPN providers' websites (48.1%)
- ↳ Rather than traditional methods like word of mouth (5.7%)

Users rate search engines and recommendation websites trustworthy; 93.9% rate them moderately/extremely trustworthy



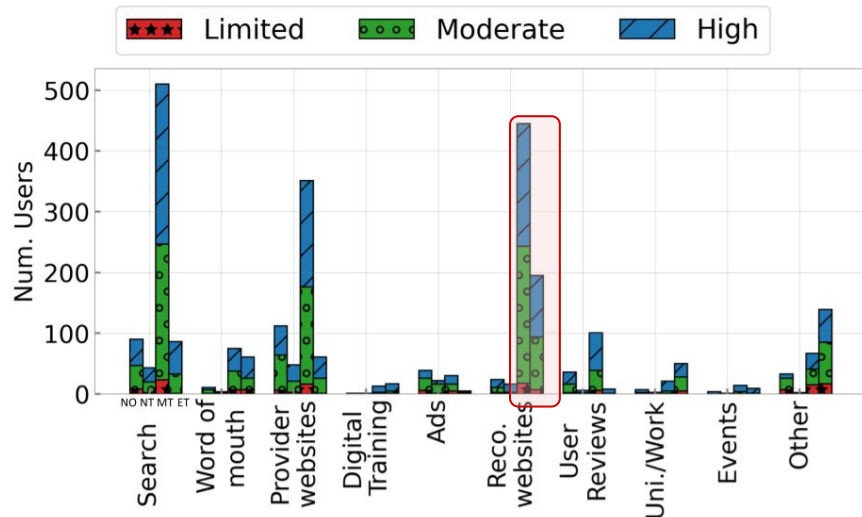
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Research Question 3:

Threat Models

83.9% Hackers or Eavesdroppers

65.4% Advertising Companies

46.9% ISPs (Internet Service Providers)

Possible Shifting attitudes:

Governments → → Hackers/Ads



Research Question 4:

Mental Models

Almost 40% of users have a flawed mental model, including users of all different expertise levels

Focus Area for improvement:

Effective user education campaigns

At least 40% users indicate they are unsure what data VPN providers can collect about them

13% of the remaining users think unreasonable kinds of data are collected by VPNs

Themes from the VPN Provider Interviews

**Key Efforts
from Providers**

**High-level
Challenges**

**Understanding
the User Base**

**Pricing and
Marketing**

**VPN Review
Ecosystem**

**Dark Patterns
in the Industry**

Research Question 6:

Misalignments between VPN users and providers



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Reliance on Recommendation Sites

Users strongly rely on them and believe them to be trustworthy

6 of 9 VPN providers claim recommendation ecosystem is largely money-motivated

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Reliance on Recommendation Sites

Users strongly rely on them and believe them to be trustworthy

6 of 9 VPN providers claim recommendation ecosystem is largely money-motivated

One provider said:

“You honestly cannot find even one ranking site that is honest...just tell people that...so that people know”

Research Question 6:

Misalignments between VPN users and providers

Reliance on Recommendation Sites

Users strongly rely on them and believe them to be trustworthy

6 of 9 VPN providers claim recommendation ecosystem is largely money-motivated

View on Data Collection

Over 40% users unsure what data is being collected about them

VPN providers claim clear communication on logging and data audit practices



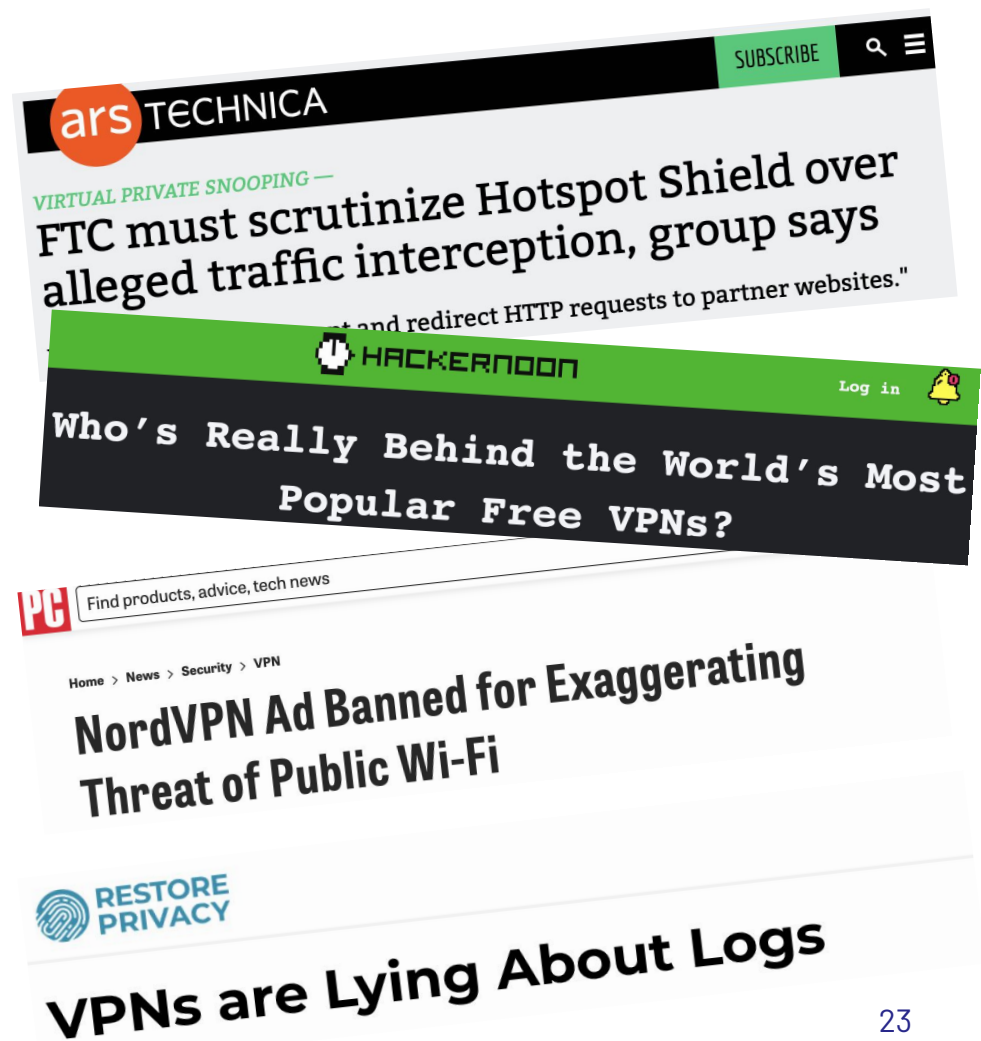
VPNalyzer: Systematic Investigation of the VPN Ecosystem

R. Ramesh, L. Evdokimov, D. Xue, R. Ensafi

Network and Distributed Systems Security Symposium, **NDSS 2022**

🏆 Won **First Place** at the CSAW '22 **Applied Research Competition**

This multi-billion dollar industry is **laxly regulated**, rife with **hyperbolic claims**, and **remains severely understudied**



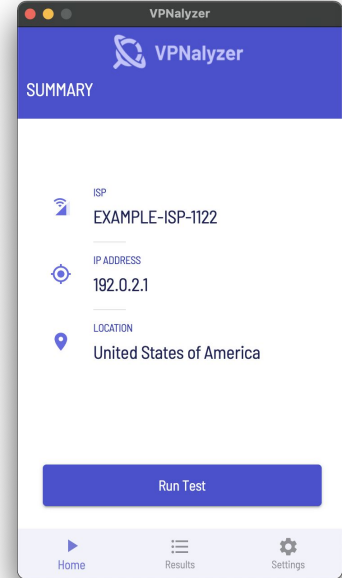
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Building VPNalyzer to Address Key Challenges

Modular, extensible test suite

Repeated VPN evaluations over time should not require starting from scratch

Evolve alongside the VPN ecosystem:
Validating VPN fixes for issues reported as disclosures requires an updatable test suite

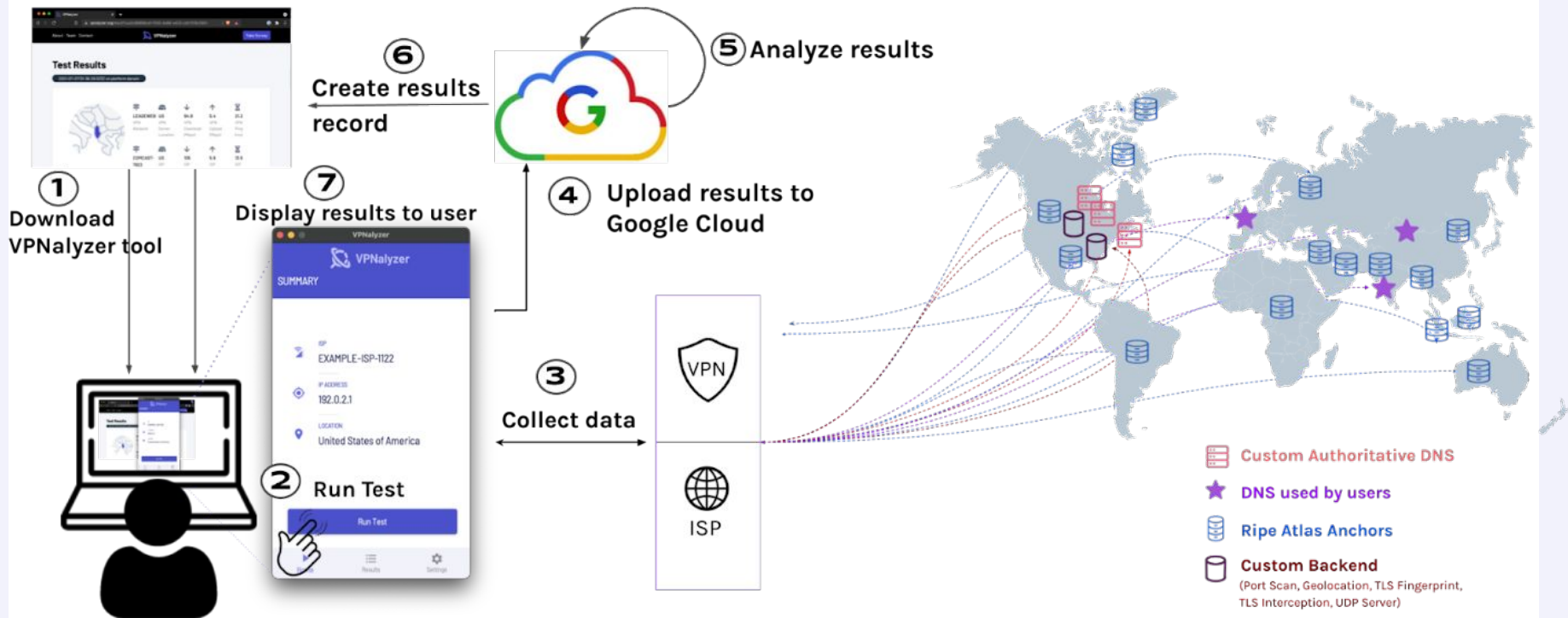
Facilitate Crowdsourced Data

Increasing number of VPN providers

Users have varied threat models and use cases; they may prefer different VPN products



VPNalyzer System Design



VPNalyzer Findings: Misconfiguration and Leakages

We found evidence of many traffic leaks, which seriously risk exposing sensitive user data

IPv6 Traffic

Only 14% support IPv6

Five VPNs leak IPv6 traffic to the ISP by default

UMich VPN is among them

VPNalyzer Findings: Misconfiguration and Leakages

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During Tunnel Failure

In default configuration, **33% of providers leak traffic** to the user's ISP

Even in the most secure setting, 10 providers leak traffic to the user's ISP, 6 even with a **"kill switch"**

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Insecure Default Configuration

Misleading default configuration caused (non-browser) traffic to be exposed to the ISP

Astrill VPN and Psiphon tunneled only browser traffic by default

Security and Privacy of VPNs Running on Windows 10



Congresswoman Anna G. Eshoo
California's 16th Congressional District

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Rep. Eshoo and Senator Wyden Urge FTC to Address Deceptive Data Practices by VPN Providers

Should You Use a VPN?

Virtual private networks can provide a layer of privacy and security, but many people don't need them

By Yael Grauer
December 7, 2021

VPN Testing Reveals Poor Privacy and Security Practices, Hyperbolic Claims

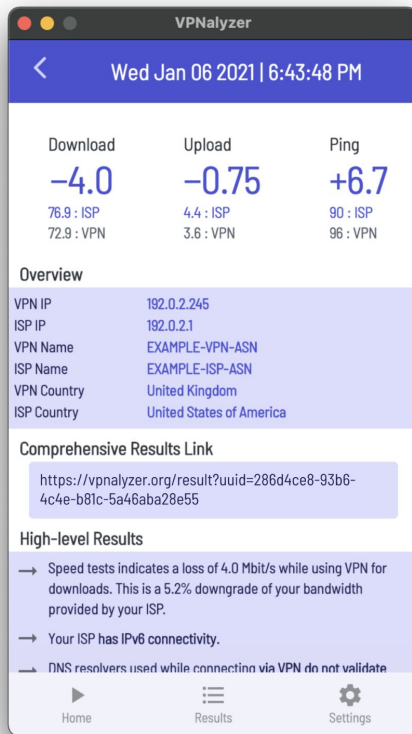
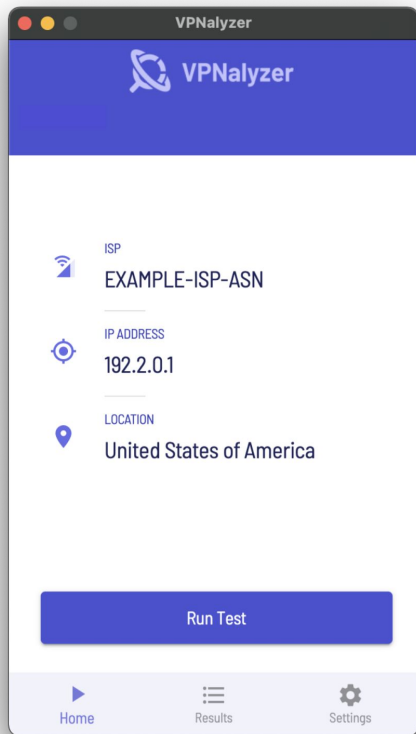
CR evaluated the privacy and security of 16 virtual private networks. Here's where most of them fell short.

By Yael Grauer

Published December 7, 2021 | Updated September 30, 2022

Collaboration with Consumer Reports

- Used our testing methodology and the VPNalyzer tool was as the first in a line of systematic investigation to evaluate a set of popular VPNs
- Report cited by elected officials calling on the FTC to regulate the VPN ecosystem



VPNalyzer

Our studies show that users have a reliance and security and privacy expectations from their VPN providers (Not all of them live up to their promises)

However, identifying and investigating these inadequacies is **non-trivial** for users

Information on our other related projects can be found on our **website**

<https://VPNalyzer.org>

The screenshot shows the website VPNalyzer.org in a browser window. The page features a dark blue header with navigation links for 'About', 'FAQ', 'Report', and 'Stay Informed'. The main heading is 'Crowdsourced Investigation into Commercial VPNs', followed by a sub-heading 'Is your VPN provider delivering on its promise of privacy and security? Find out with VPNalyzer.' Below this is a paragraph stating that commercial VPNs are a multi-billion dollar industry and that VPNalyzer is working to change that. There are two buttons: 'Learn More' and 'Read our NEW Report!'. The page also displays logos for the University of Michigan, Consumer Reports, and the Open Technology Fund. A section titled 'The VPNalyzer Tool!' includes a 'Download and use the VPNalyzer tool!' button and a small image of a smartphone displaying the tool's interface. Below this is a 'What is VPNalyzer?' section with a paragraph explaining the project's goals and a list of three study types: Quantitative and qualitative user studies, The VPNalyzer Tool, and Qualitative VPN provider studies. At the bottom, there is a 'Publications' section and three circular icons representing the study types.

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