USENIX SECURITY 2022

Security at the End of the Tunnel

The Anatomy of VPN Mental Models Among Experts and Non-Experts in a Corporate Context

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Problem Motivation

- VPN is one of the popular security and privacy measures on the Internet
- The end-users' perspective is well covered by recent empirical research[1]
- Increased VPN usage due to work-from-home orders during the COVID-19 pandemic
  - During the lockdown in March'20, VPN traffic increased by 200% vs February'20[2]
- Highly sensitive and confidential data flowing through the corporate VPNs
- Corporate users' perspective on VPN usage is neglected

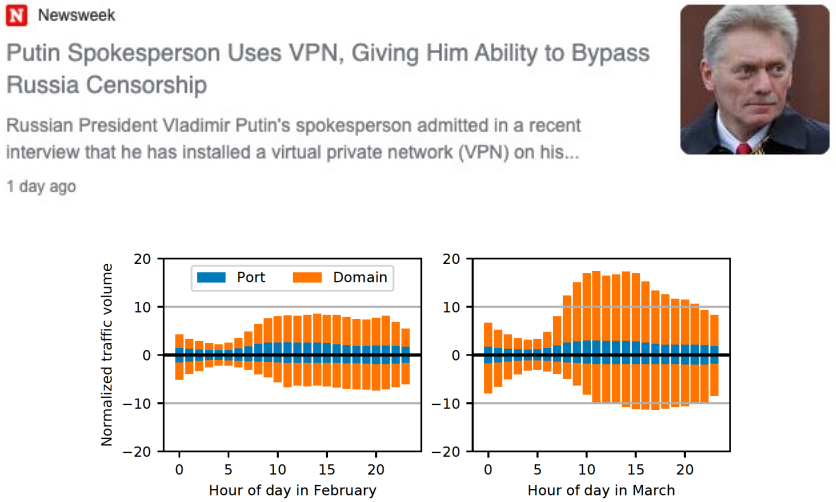


Figure 11: VPN traffic at the IXP-CE*

[1] See references in paper: [26, 34, 45, 61].
[2] See reference in paper: [22].

Research questions

1. How, when, and why do (or do not) corporate users* use VPNs?
2. How do they think VPNs work?
3. How do they see the impact of VPNs on the threat landscape?

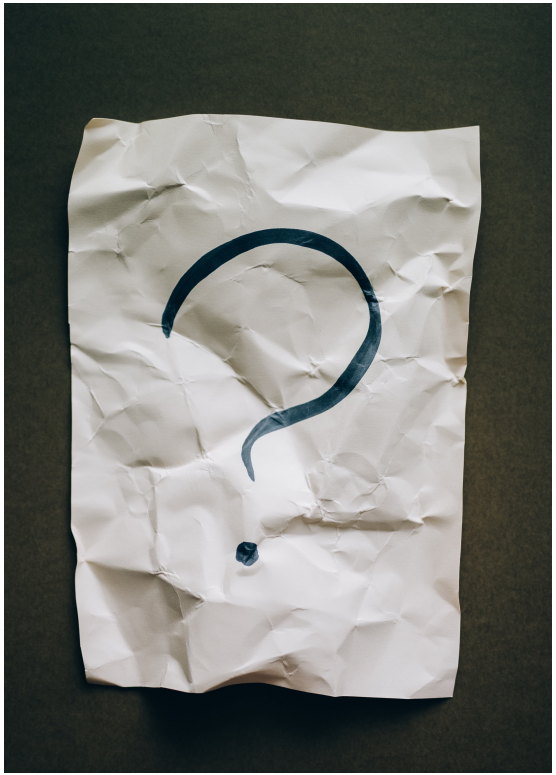


Photo by Olya Kobruseva

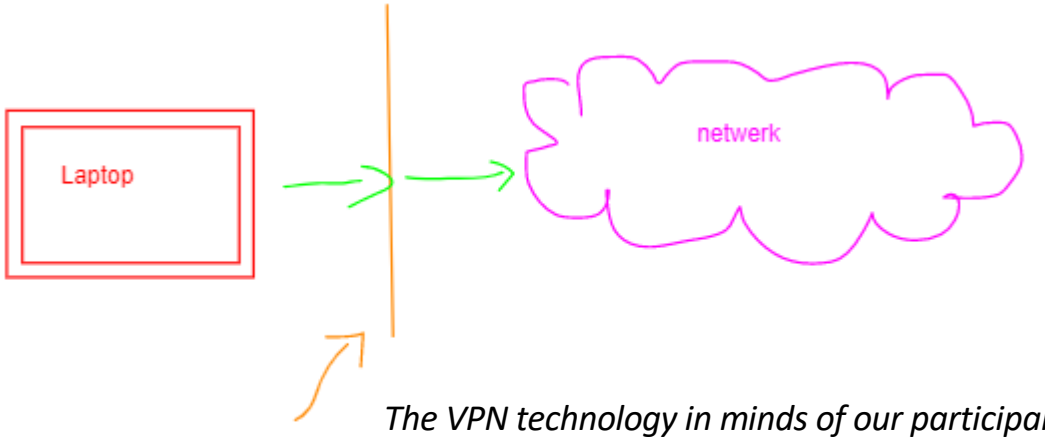
* corporate users = trained IT professionals + non-experts

(Research Method) How to get inside one's mind?

A mental model is a representation of a person's knowledge of a subject

- Elicitation techniques:
  - Semi-structured interview (reasoning + relationships between concepts);
  - Drawing task (to visualize interviewee's mental model);

- Three scenarios of a VPN usage:
  - From a home-office;
  - At a cafe/bar;
  - Sending email via the corporate VPN;



The VPN technology in minds of our participants. Illustration of the 'shield' metaphor by Expert 6.

Data Analysis

- Coding process -> Codebook
  - Open coding;
  - Axial coding;
  - Selective coding;
  - Model generation;
- Codebook reliability
  - 2 authors independently coded 3 interviews;
  - Krippendorff c-alpha-binary = 0.837 (after resolving disagreements);
- Final codebook
  - 86 codes
  - 4 core themes

Participants and the VPN they used

Who

- Employees of a Dutch office of a professional consulting firm;
- 7 non-experts
  - Legal, finance, and HR departments;
  - Employed in avg. 6 years in the firm;
- 11 experts in IT security
  - At least 2 years in IT department OR hold a relevant certification (e.g., CISSP, CISA, etc.);
  - Employed in avg. 4 years in the firm;

What VPN

- VPN supplied by a major network device vendor
- Custom white-labeled client
- Complete tunnel connection

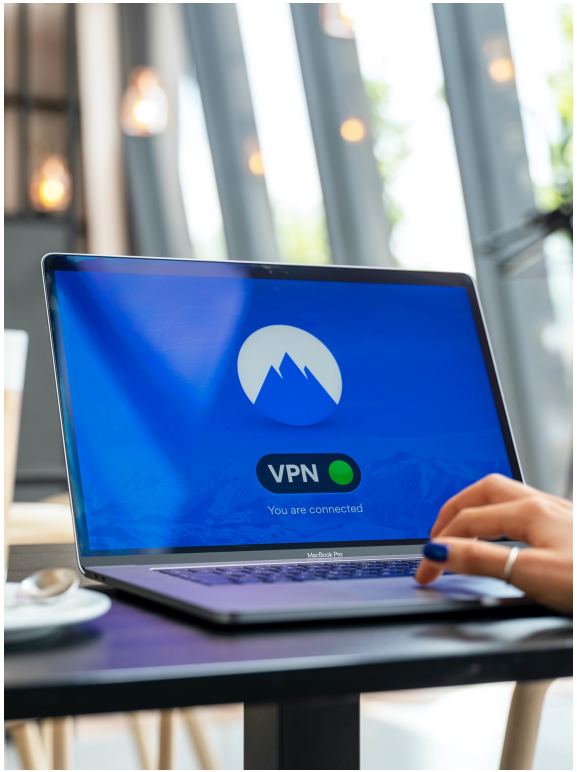
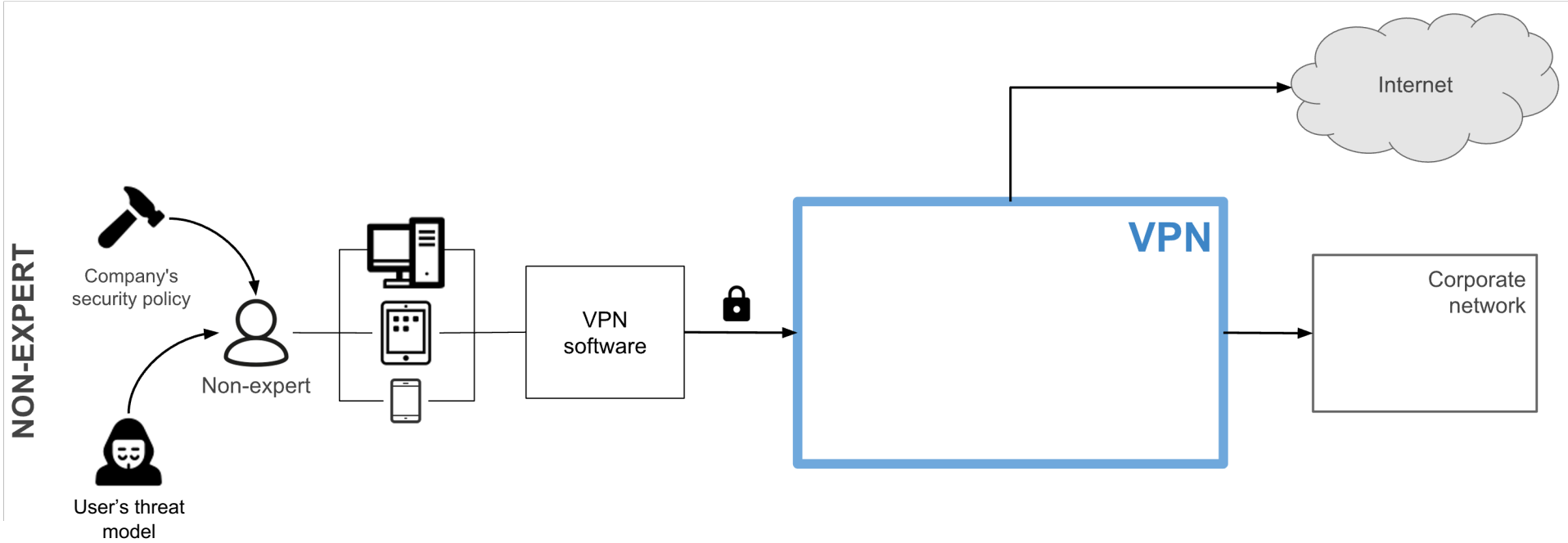


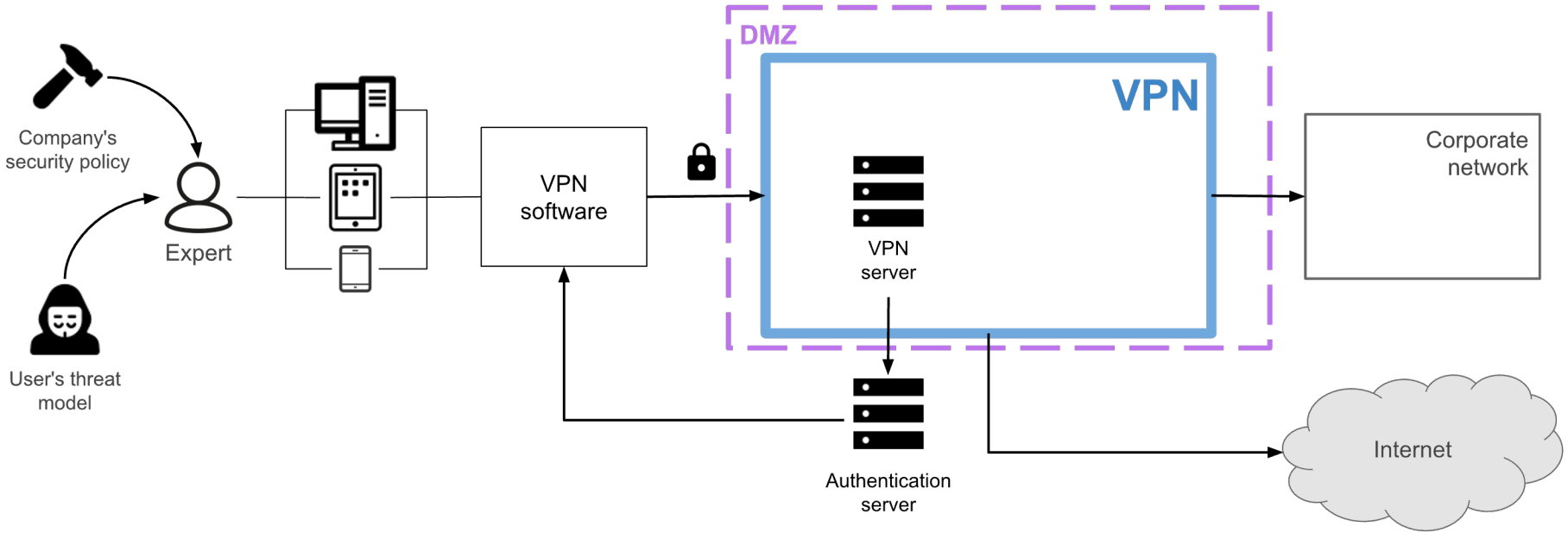
Photo by Petter Lagson

[Non-Expert Model] How a VPN works and used

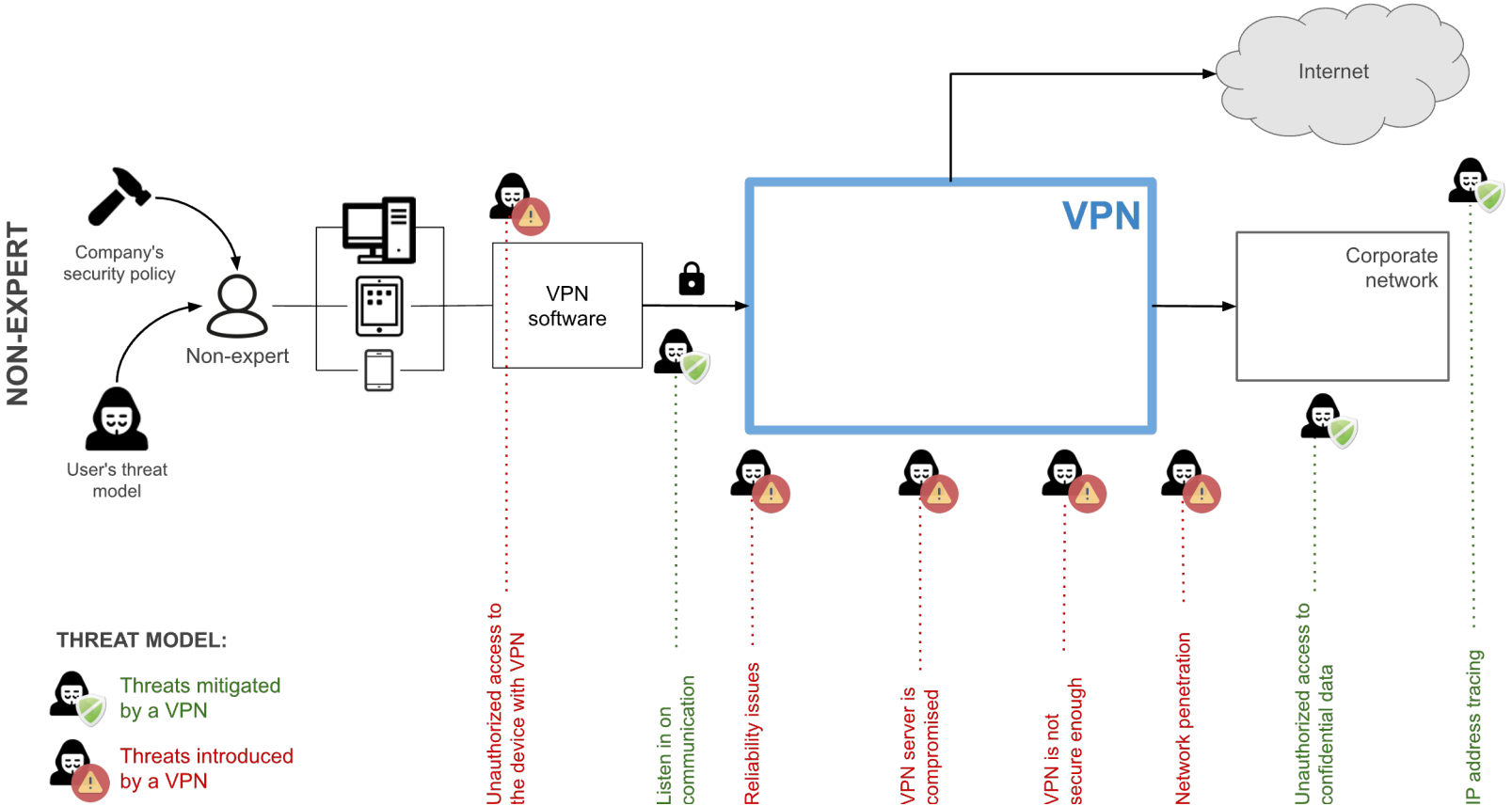


[Expert Model] How a VPN works and used

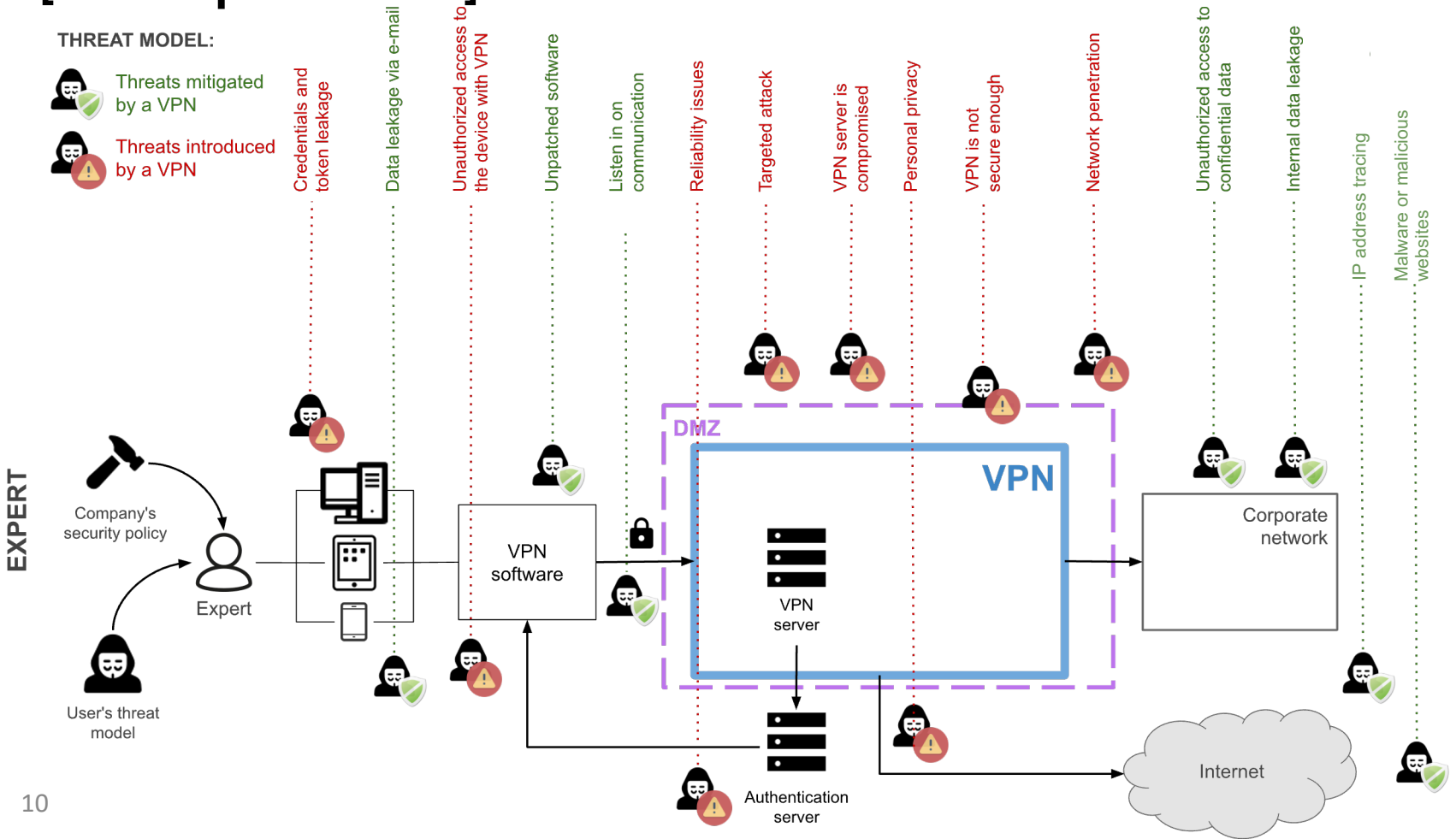
EXPERT



[Non-Expert Model] Threat model



[Expert Model] Threat model



Recommendations

- VPN Automation
  - make VPN usage invisible and the default for users
- Privacy Communication
  - accommodate a degree of private VPN use and communicate it to the employees proactively
- Device Management
  - Adjust device management solutions to securely work even without a VPN
- Technical Training
  - Focus on what people need to know based on mental models
  - Use the ‘tunnel’ metaphor to make training accessible

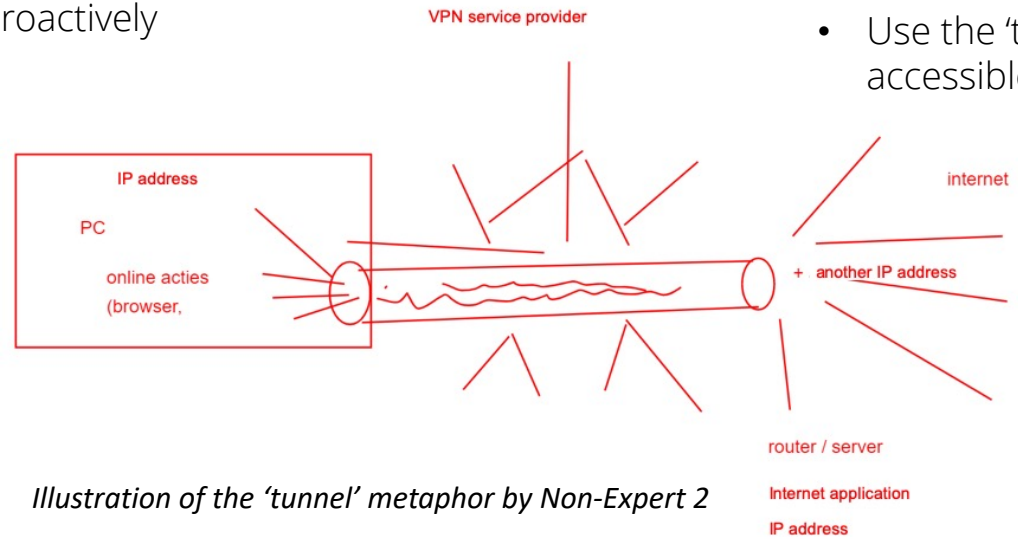


Illustration of the ‘tunnel’ metaphor by Non-Expert 2

Future Research

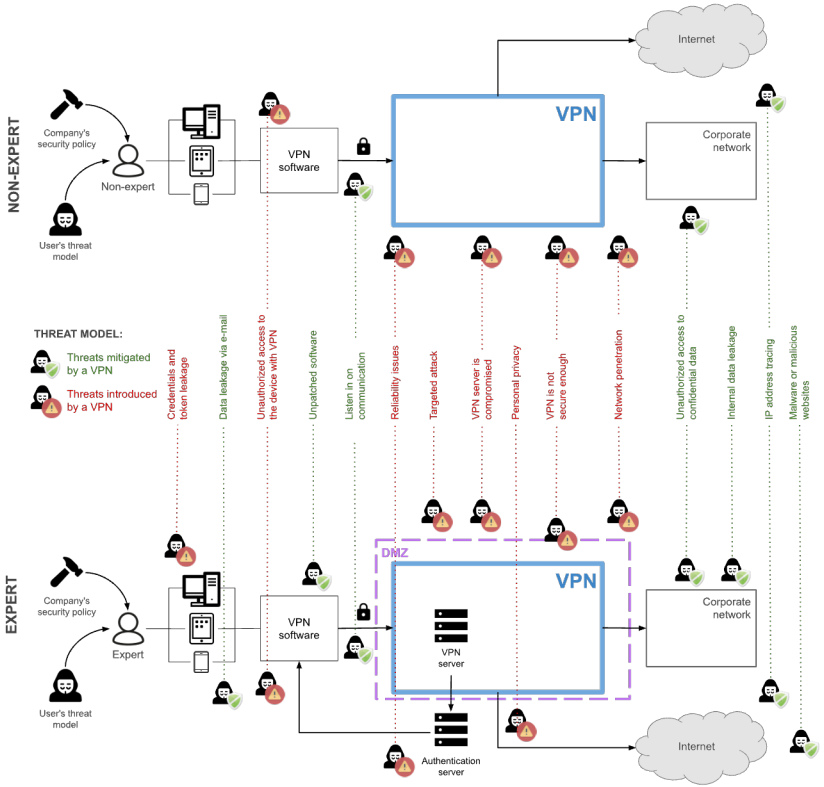
Photo by Startup Stock Photos

- Explore the privacy concerns made by experts in the context of privately used VPNs
- Trust interdependencies between end-users and their local Internet Service Providers (ISPs)
  - our VPN mental model of non-experts can serve as a basis for interview script
- Quantitative study of the use of VPNs in various contexts
- Empirical validation of the interventions based on our recommendations through controlled experiments

Summary

- At a high level, non-expert and experts have similar mental models of VPN technology;
- Experts have a deeper technical understanding of VPNs;
- Experts are also concerned about the privacy implications of using a corporate VPN;
- Experts found VPNs to be an integral part of fleet management and policy/compliance enforcement

- Automate VPN usage, improve privacy communication, and focus training on what people need to know following their mental models.



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Thank you for your attention!

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