Preventing and Remediating Criminal Abuse of Online Infrastructure

Michel van Eeten

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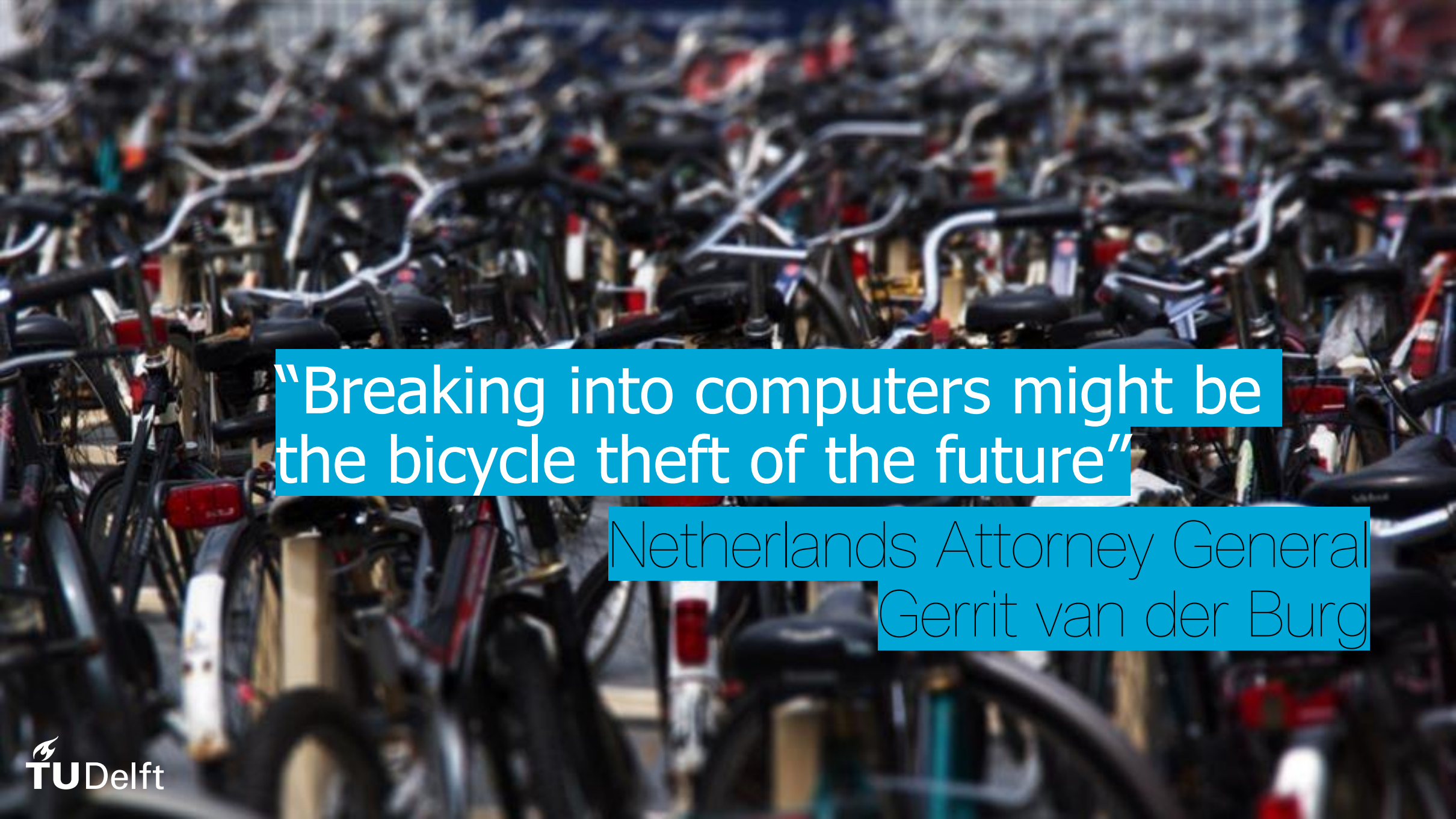

"Breaking into computers might be the bicycle theft of the future"

Netherlands Attorney General
Gerrit van der Burg

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DDoS in Netherlands, 2015

> 30,000 attacks observed in honeypot data

vs.

86 reports filed with the police

Source: Jan Koenders, The DDoS plague: Law enforcement view, 2016

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A lot of criminal abuse is handled by private actors on a voluntary basis

How well does this work?

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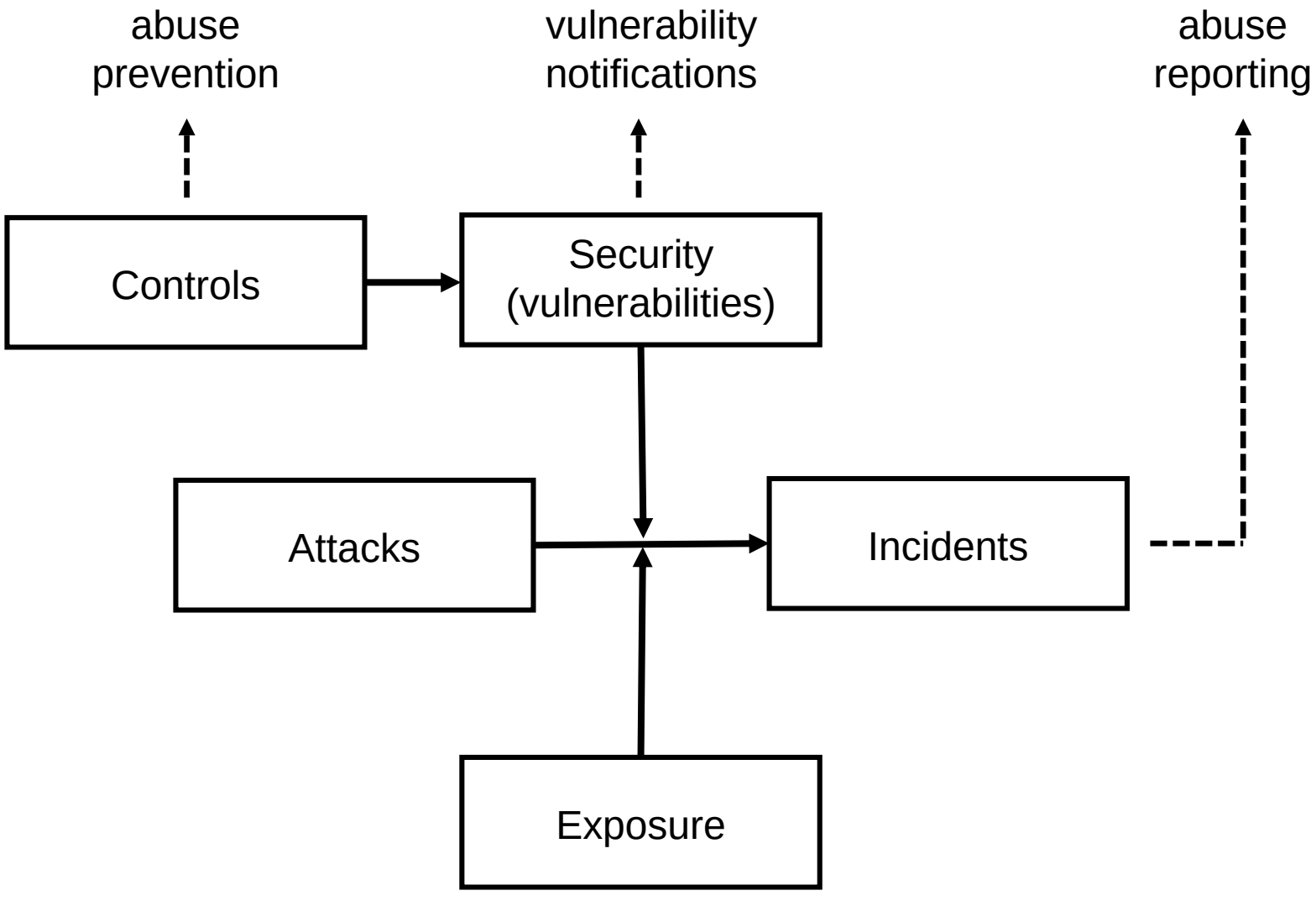
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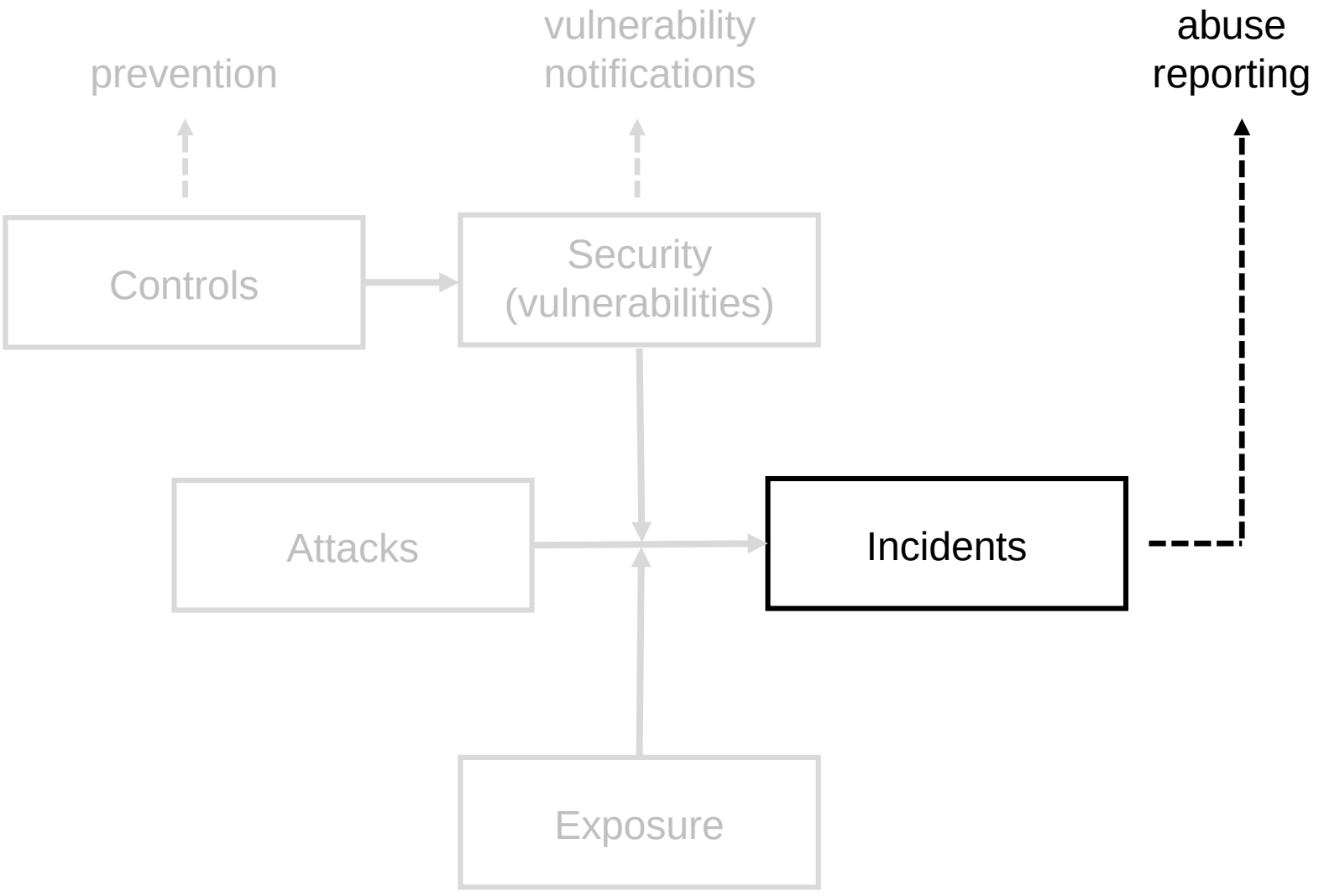
vulnerability
notifications
abuse
reporting
Controls
Security
(vulnerabilities)
Attacks
Incidents
Exposure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I. Abuse Reporting

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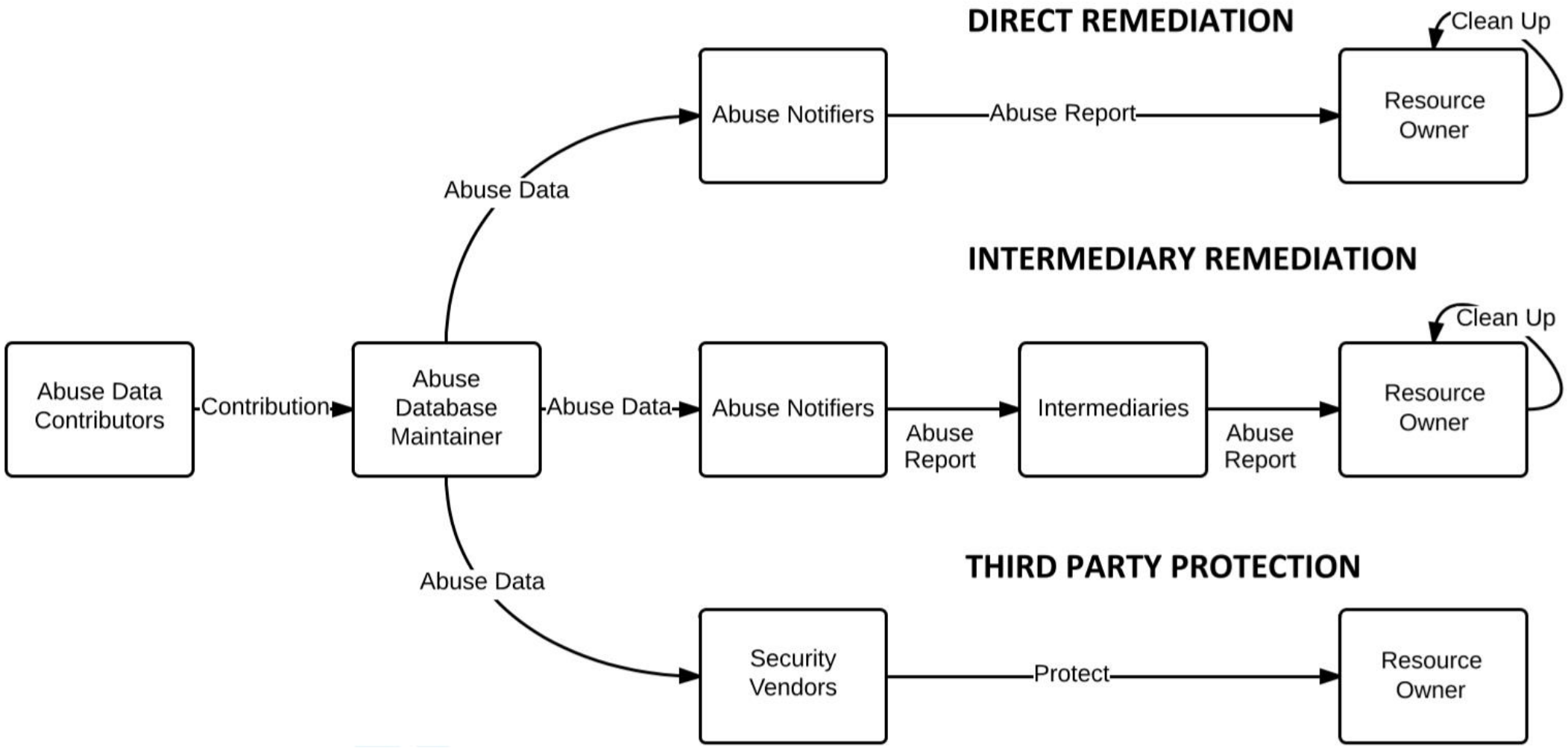
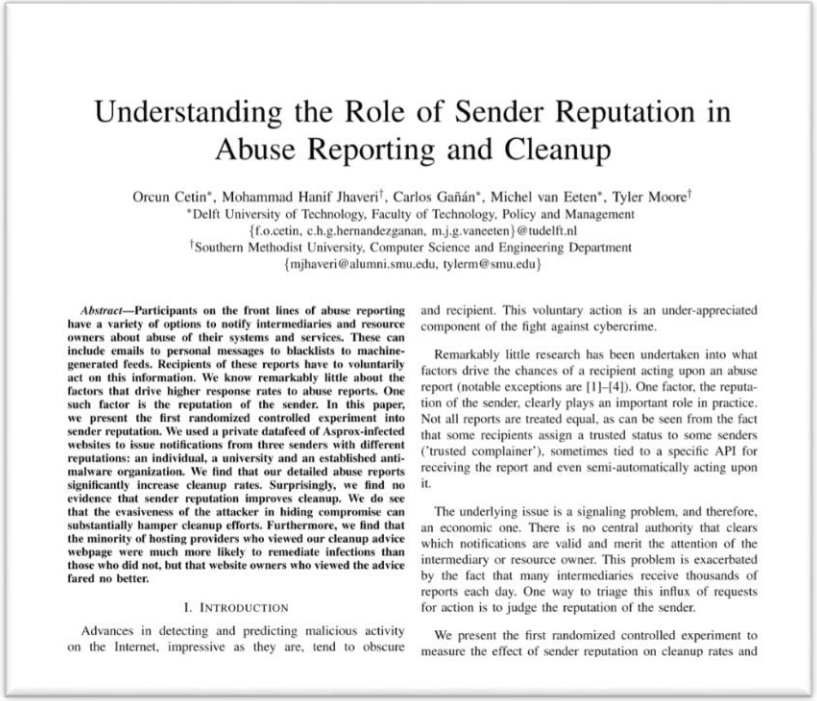

DIRECT REMEDIATION
Clean Up
Abuse Notifiers
Abuse Report
Resource Owner
Abuse Data
INTERMEDIARY REMEDIATION
Clean Up
Abuse Data Contributors
Contribution
Abuse Database Maintainer
Abuse Data
Abuse Notifiers
Abuse Report
Intermediaries
Abuse Report
Resource Owner
THIRD PARTY PROTECTION
Abuse Data
Security Vendors
Protect
Resource Owner

Cleaning up compromised sites

- Most sites get cleaned by customer or hosting provider after receiving abuse report
- How to make abuse reporting more effective and reduce compromise levels?
- New experimental research (WEIS, USENIX, WWW…)



Understanding the Role of Sender Reputation in Abuse Reporting and Cleanup

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***Abstract*—Participants on the front lines of abuse reporting have a variety of options to notify intermediaries and resource owners about abuse of their systems and services. These can include emails to personal messages to blacklists to machine-generated feeds. Recipients of these reports have to voluntarily act on this information. We know remarkably little about the factors that drive higher response rates to abuse reports. One such factor is the reputation of the sender. In this paper, we present the first randomized controlled experiment into sender reputation. We used a private datafeed of Asprox-infected websites to issue notifications from three senders with different reputations: an individual, a university and an established anti-malware organization. We find that our detailed abuse reports significantly increase cleanup rates. Surprisingly, we find no evidence that sender reputation improves cleanup. We do see that the evasiveness of the attacker in hiding compromise can substantially hamper cleanup efforts. Furthermore, we find that the minority of hosting providers who viewed our cleanup advice webpage were much more likely to remediate infections than those who did not, but that website owners who viewed the advice fared no better.**

I. Introduction

Advances in detecting and predicting malicious activity on the Internet, impressive as they are, tend to obscure and recipient. This voluntary action is an under-appreciated component of the fight against cybercrime.

Remarkably little research has been undertaken into what factors drive the chances of a recipient acting upon an abuse report (notable exceptions are [1]–[4]). One factor, the reputation of the sender, clearly plays an important role in practice. Not all reports are treated equal, as can be seen from the fact that some recipients assign a trusted status to some senders ('trusted complainer'), sometimes tied to a specific API for receiving the report and even semi-automatically acting upon it.

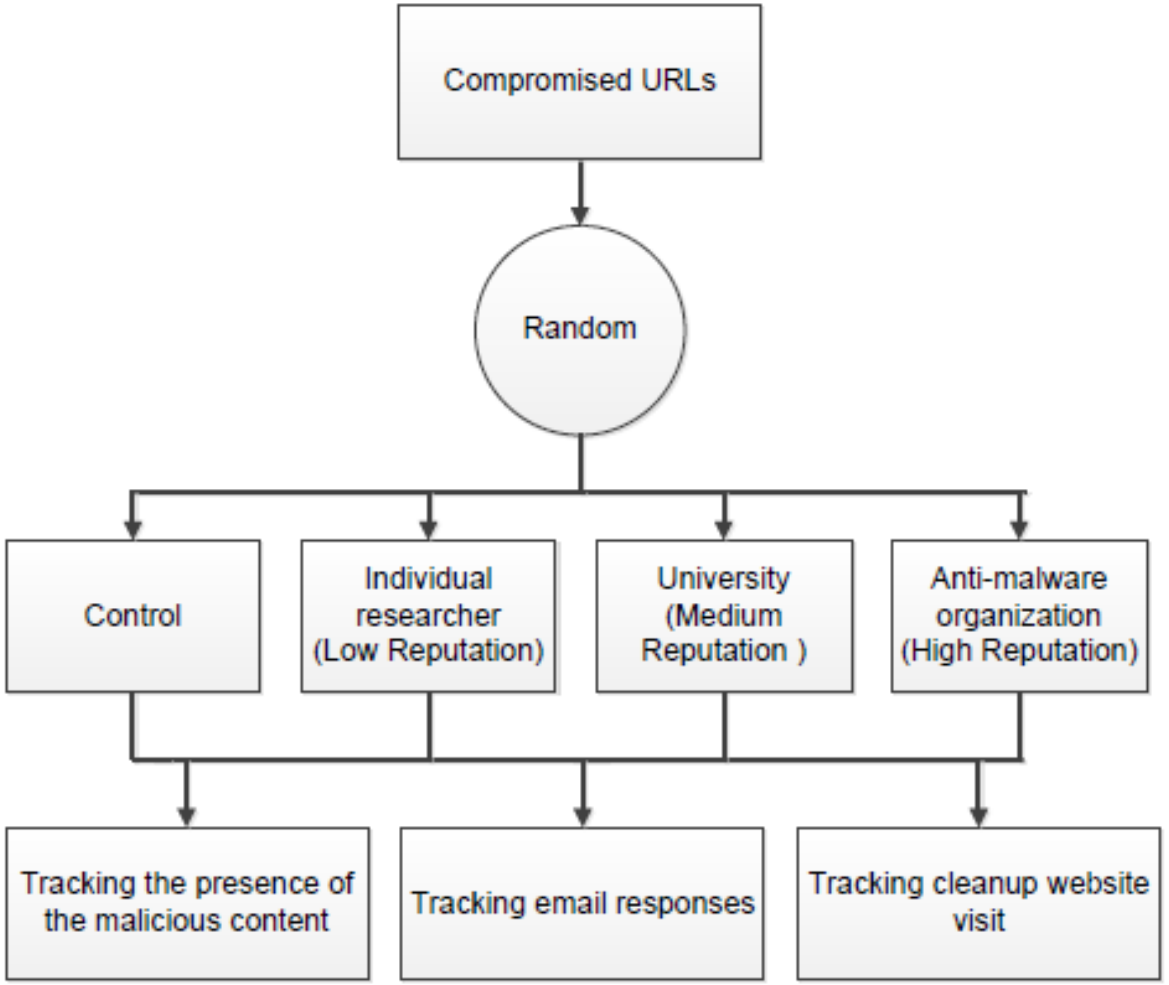
The underlying issue is a signaling problem, and therefore, an economic one. There is no central authority that clears which notifications are valid and merit the attention of the intermediary or resource owner. This problem is exacerbated by the fact that many intermediaries receive thousands of reports each day. One way to triage this influx of requests for action is to judge the reputation of the sender.

We present the first randomized controlled experiment to measure the effect of sender reputation on cleanup rates and

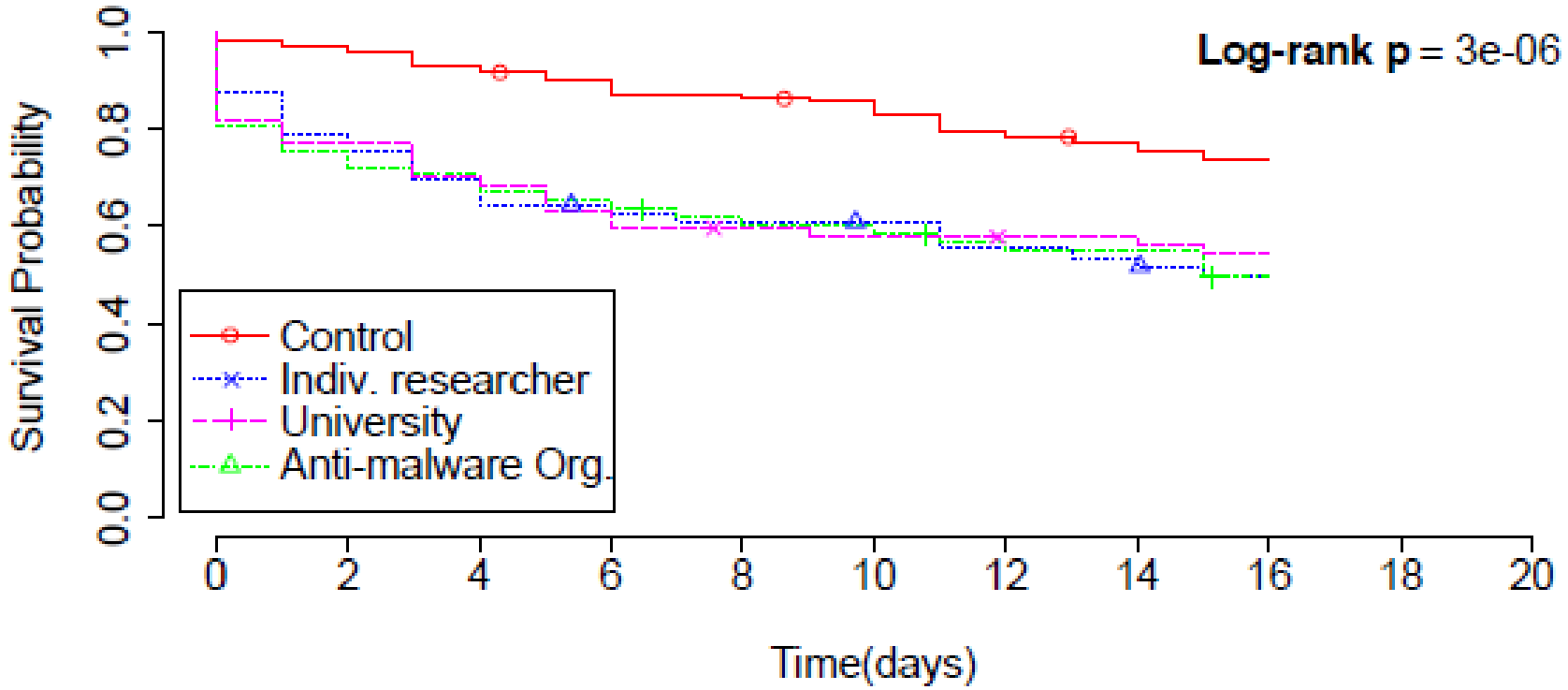
Asprox compromised servers

- Active since 2007
- Uses thousands of compromised websites for spreading malware and redirects to phishing websites
- Deploys countermeasures to tracking and takedown
  - Centralized IP based blacklisting
  - Only serves malware to certain User-Agents
  - Fake error messages to suggest malicious URL is removed

Experimental design

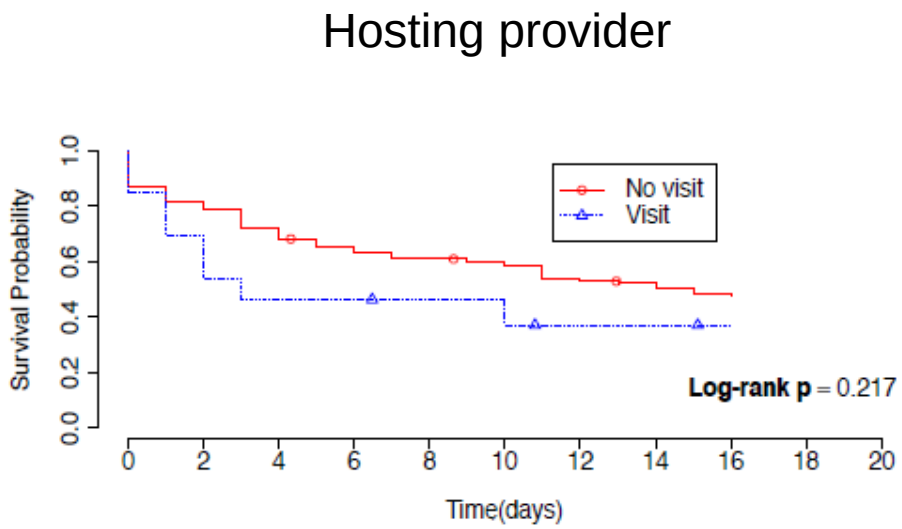


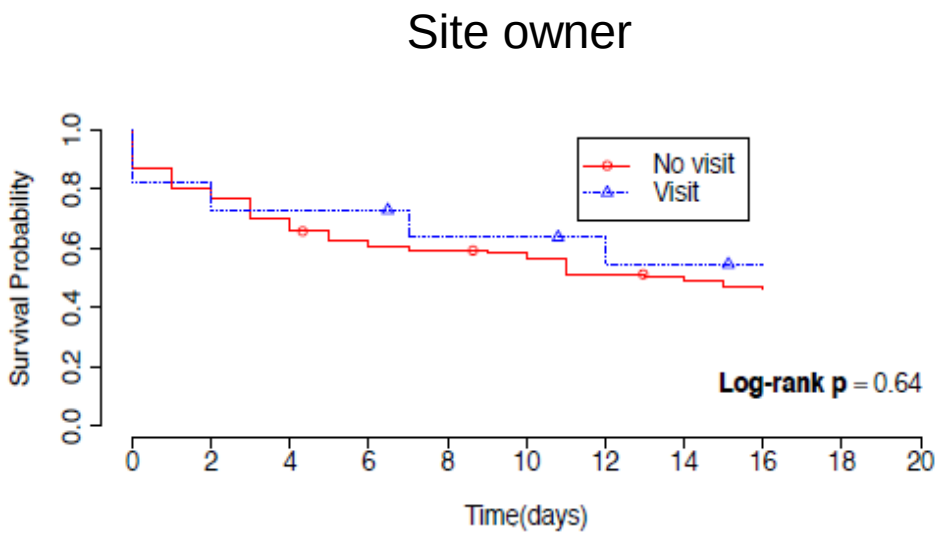
Does sender reputation matter?



- Treatment groups have similar remediation rates (44%-49%)
- Reputation of the sender did not significantly affect cleanup

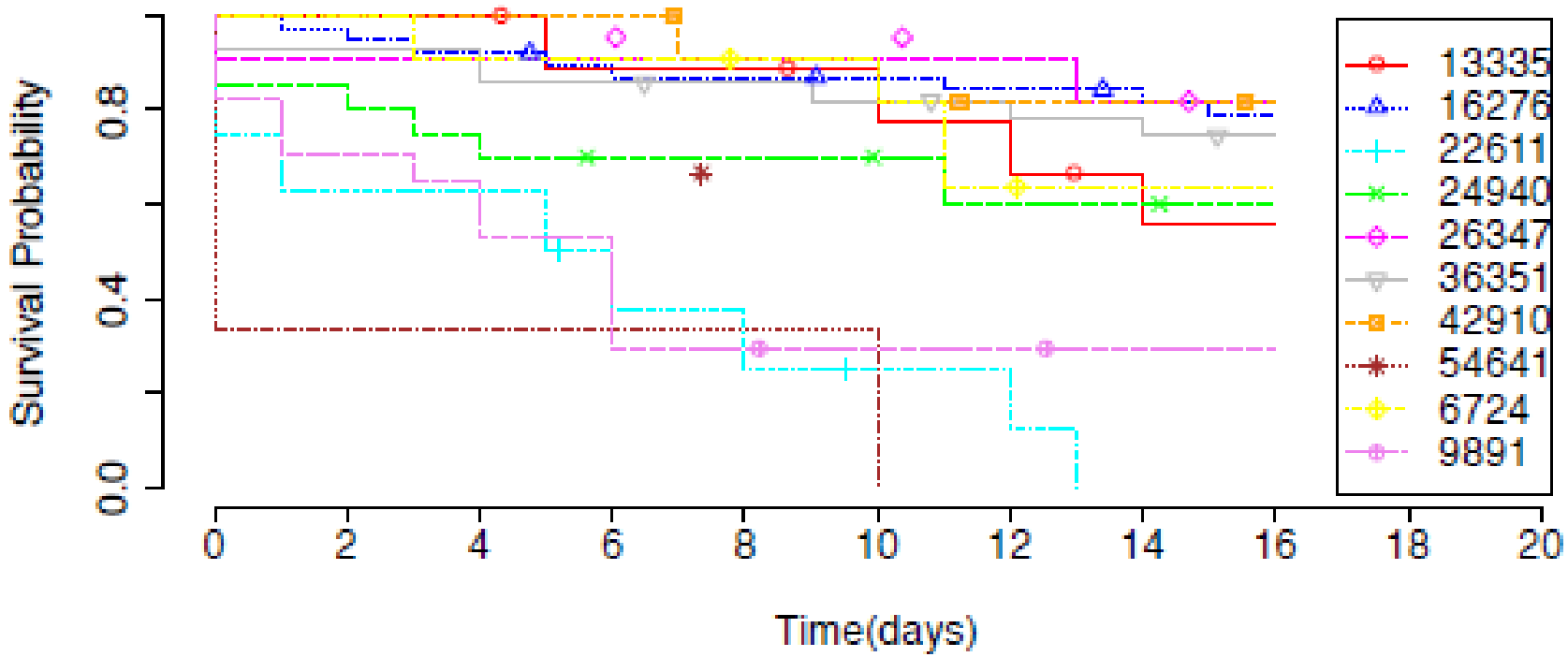
Does cleanup advice help?





- Only 9% of the hosting providers and 7% of the site owners visited our cleanup advice website
- Unlike site owners, hosting providers that visited the site achieved higher cleanup rates

Do hosting providers make a difference?



- Some providers do substantially better than others, from barely any cleanup to total removal
- Suggests discretion: provider policies make a difference

Some lessons from related work

- ~30-60% hacked sites cleaned up in two weeks after notification
- Open channel to resource owner (e.g., Google console) is most effective (Li et al 2016)
- Full technical report works better than short report with key info (Vasek and Moore 2012)
- Getting ISPs to clean up infected customers shows high variance, orders of magnitude difference in infection rates
- Effective incentives: soft regulatory pressure, benchmarking, reduced cost (e.g., centralized clearinghouse, automatic quarantine)

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II. Vulnerability Notfications

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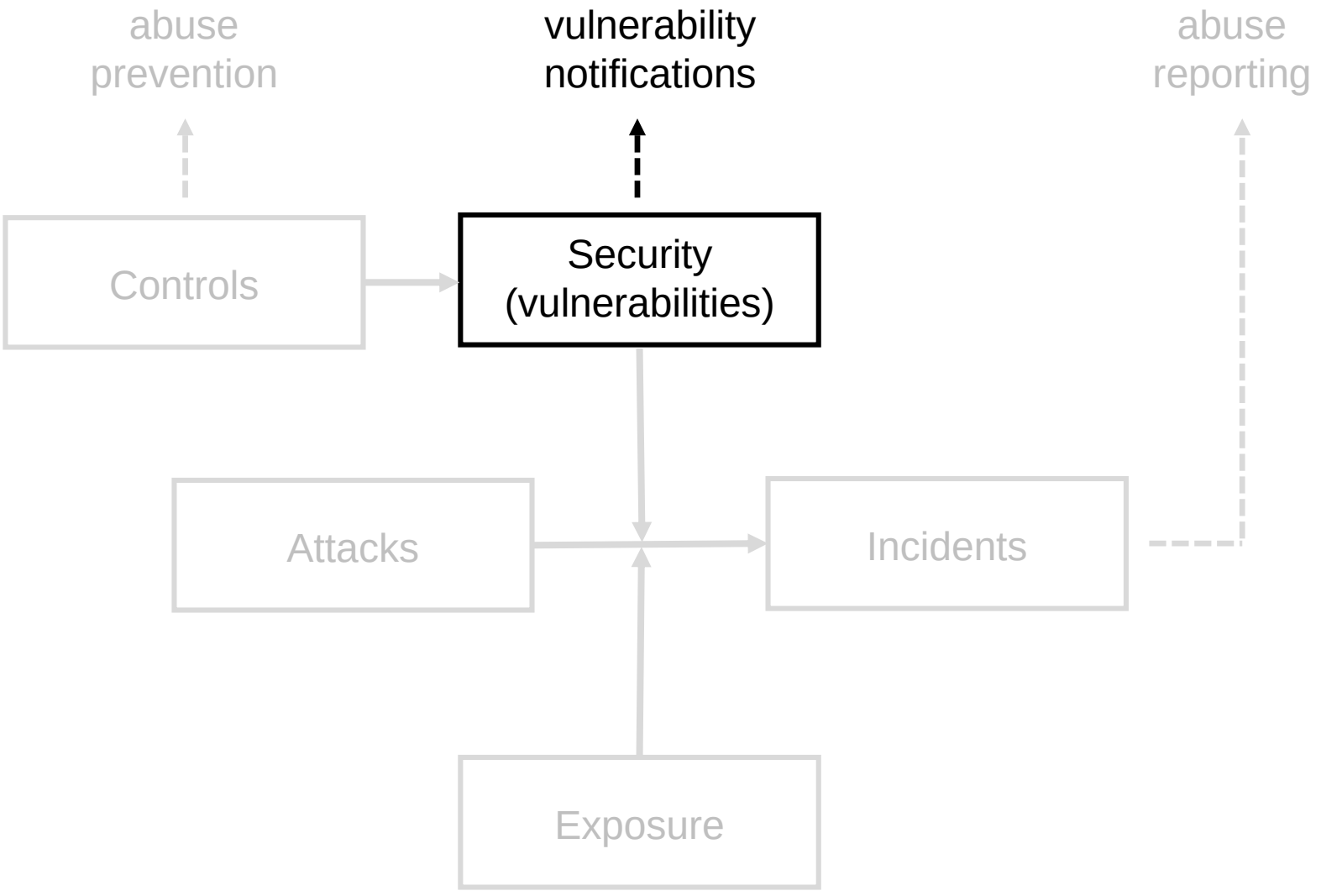
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Age of ZMap and Shodan

- Finding vulnerable devices/systems at scale has become cheap
- How can you reach resource owners at scale?
- Which channel contains the strongest incentive for remediation?
- What factors make notifications more effective?

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How to reach relevant actor at scale?

- Follow standards (RFC 2142, IP WHOIS abuse mailbox, domain WHOIS registrant email)
- Different degrees of failure for different mechanisms
- Network operators are the most reachable, but are further removed from the resource

Campaign	Treatment type	Number of emails sent	Rate of undelivered emails
1	Demonstration	669	70.40%
	Conventional	657	67.73%
2	Demonstration	940	44.68%
	Conventional	1111	35.64%
3	Demonstration	208	12.01%
	Conventional	209	5.2%

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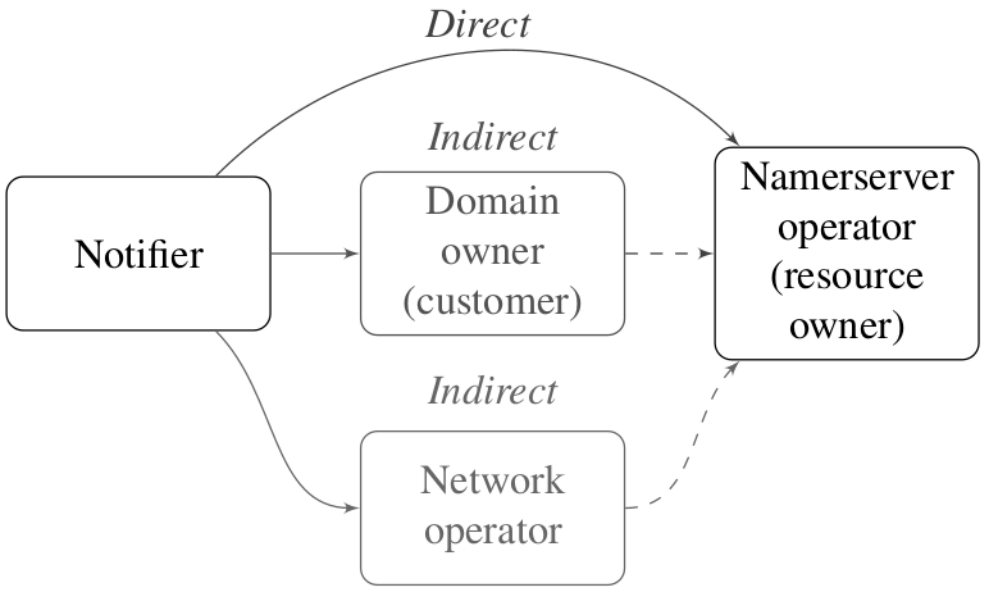
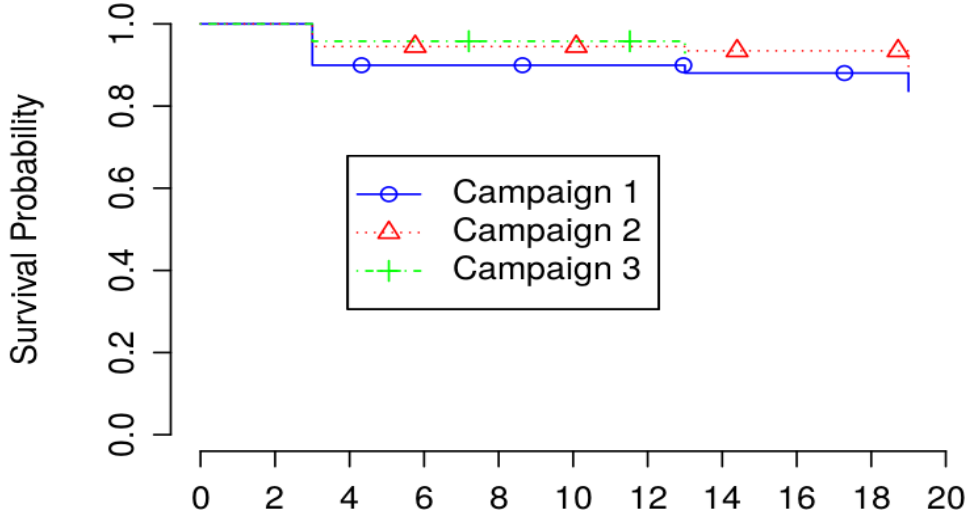
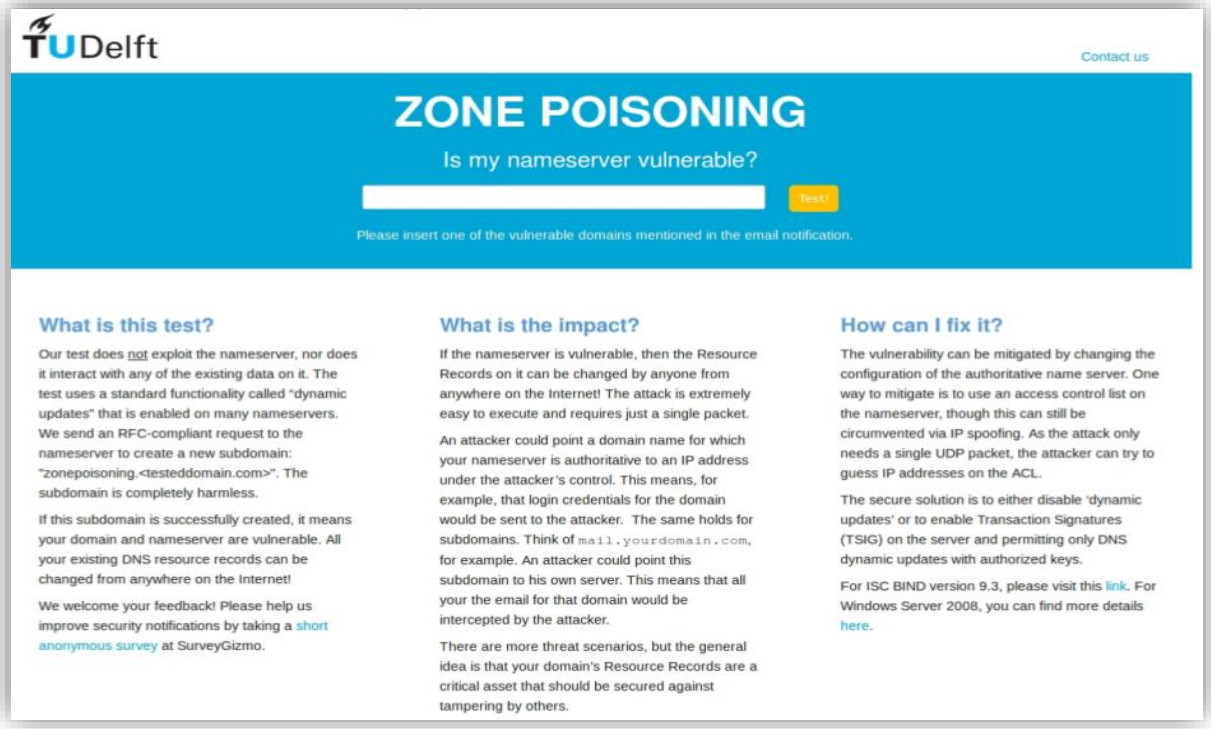
Which channel mobilizes the strongest incentive for remediation?





- All notified groups did better than the control group
- Still, overall remediation rates were low
- No clear difference between the channels

Does it help to demonstrate the vulnerability?



- Short answer: no.

Some lessons from related work

- No good mechanism to distribute wealth of vulnerability data
- Or to incentivize remediation
- Similar problems with poor reachability and low remediation rates reported by Li et al. (2016) and Stock et al. (2016)
- CERTs don't help
- …

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III. Abuse Prevention

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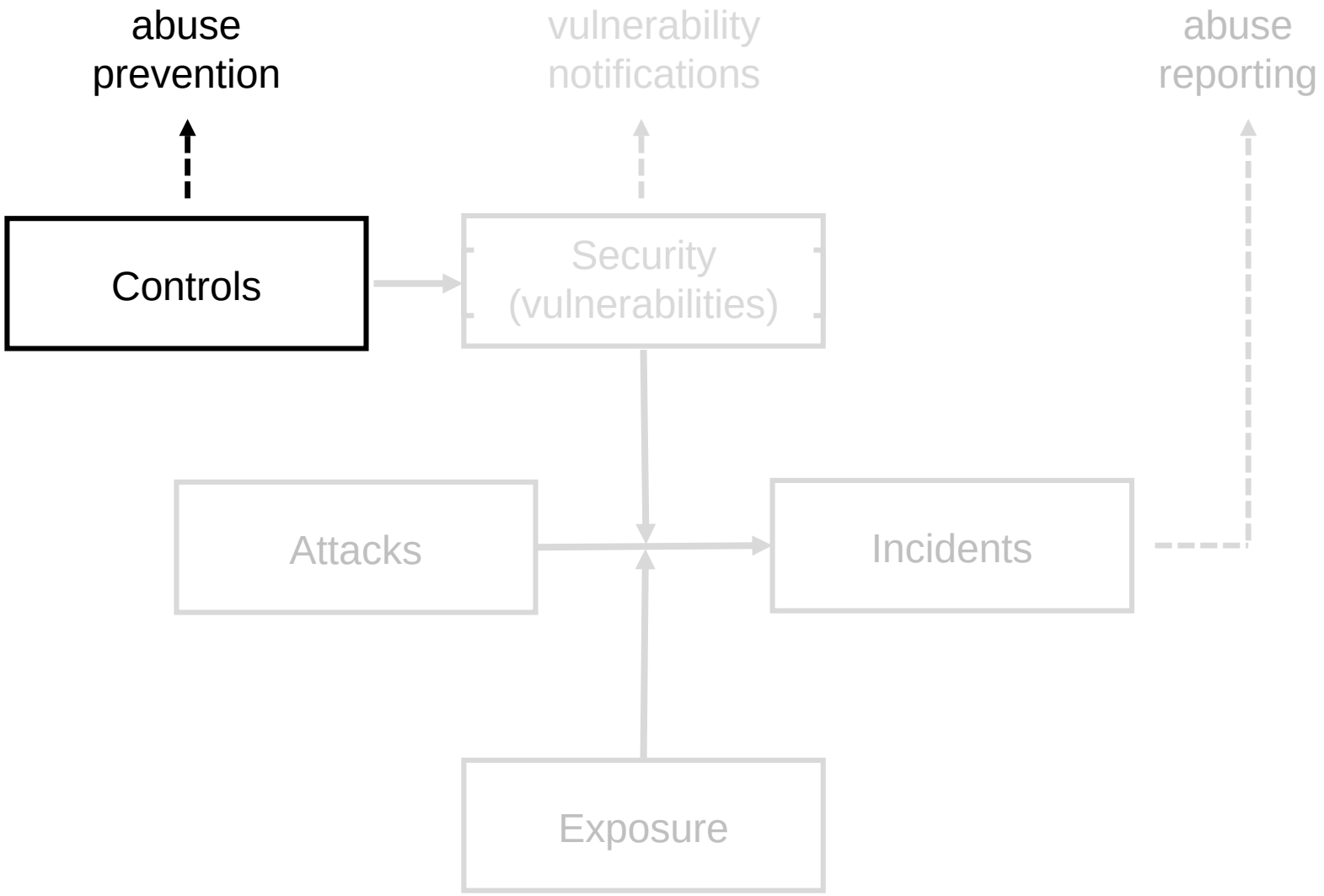
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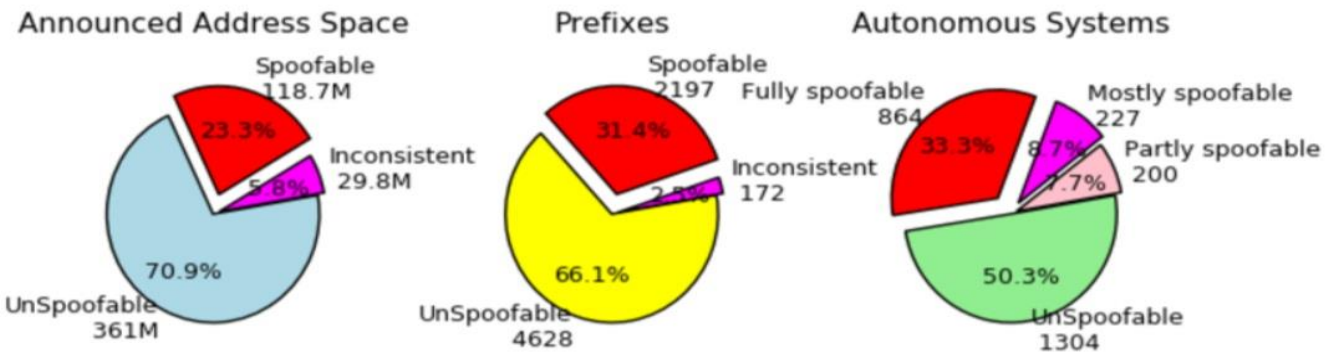
Providers adopting best practices

- BCP38 (anti-spoofing) is a cost to the provider, while all benefits go to the rest of the Internet
- The question is not Why aren't some providers adopting BCP38, but Why would anyone adopt it at all?
- Remarkably, lot of providers are compliant. Why? Social norms within provider community (M3AAWG, NANOG, etc)



Source:
https://www.caida.org/projects/spoofer/

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IV. Conclusion

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Voluntary action against cybercrime

- Glass half full…
  Many thousands of compromised machines are cleaned every day
- Reputation effects help
  Less naming & shaming than benchmarking, a.k.a. correcting self image
- So do social norms
  Many providers do adopt good practices
- Better mechanisms
  Reduce friction, solve reachability, clearinghouses and exchanges
- Role for governments?
  Pressure concentration points, soft regulation, duty to care, liability
- Externalities from the long tail
  Lack of incentives, lack of accountability, out of reach

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Thank you!

More info:

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More info on underlying studies

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