Forward Pass: On the Security Implications of Email Forwarding Mechanism and Policy

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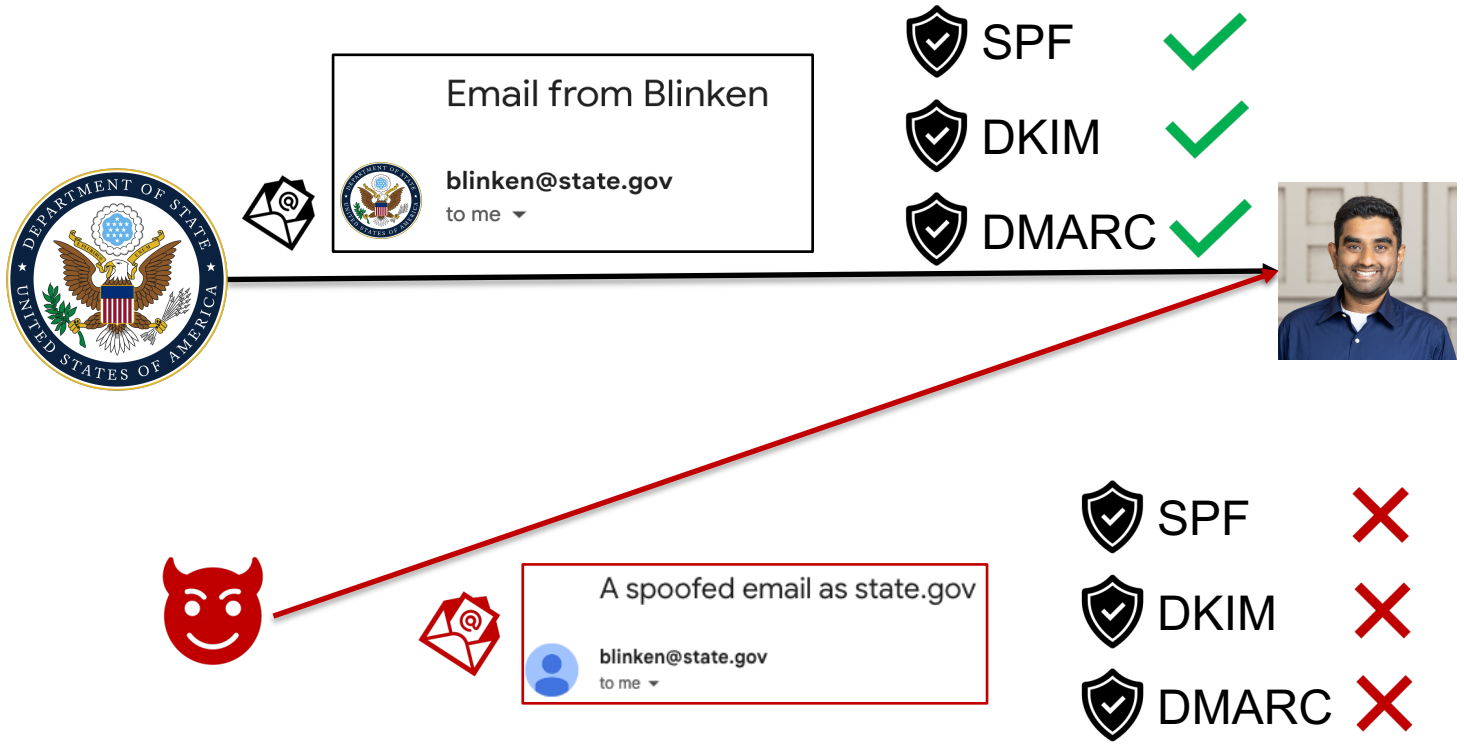
UC San Diego

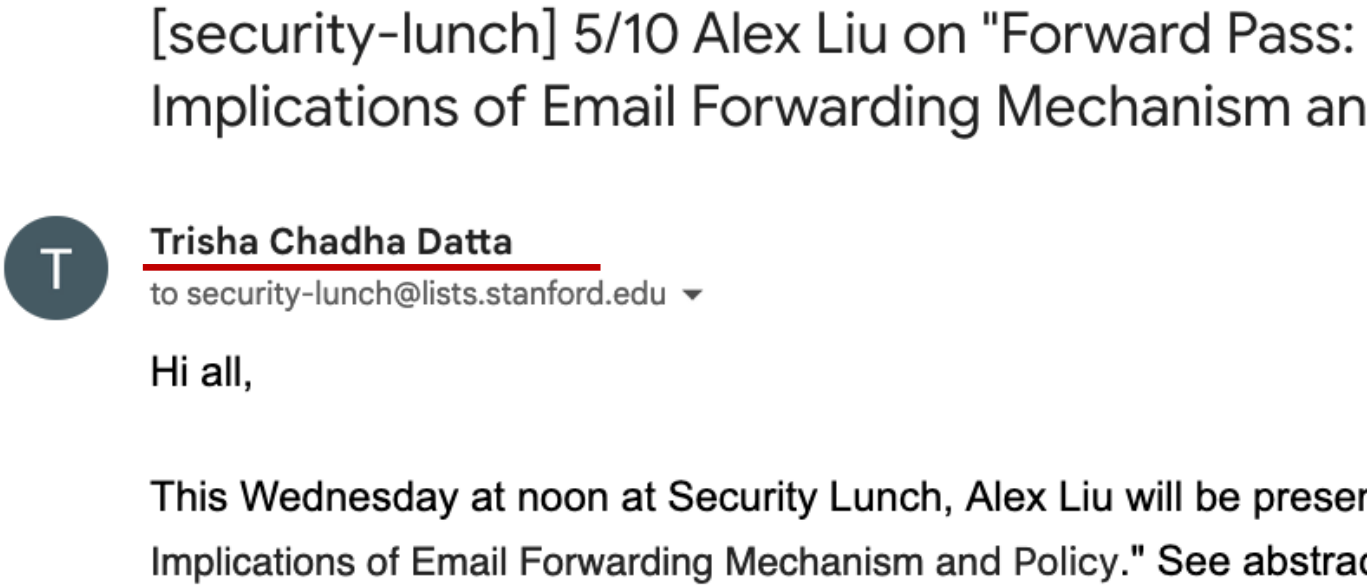
UNIVERSITY OF TWENTE.

https://arxiv.org/abs/2302.07287 *(EuroS&P ‘23)*

Email Authentication in the Simplest Form



Challenges in Email Authentication


[security-lunch] 5/10 Alex Liu on "Forward Pass: Implications of Email Forwarding Mechanism an

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Trisha Chadha Datta

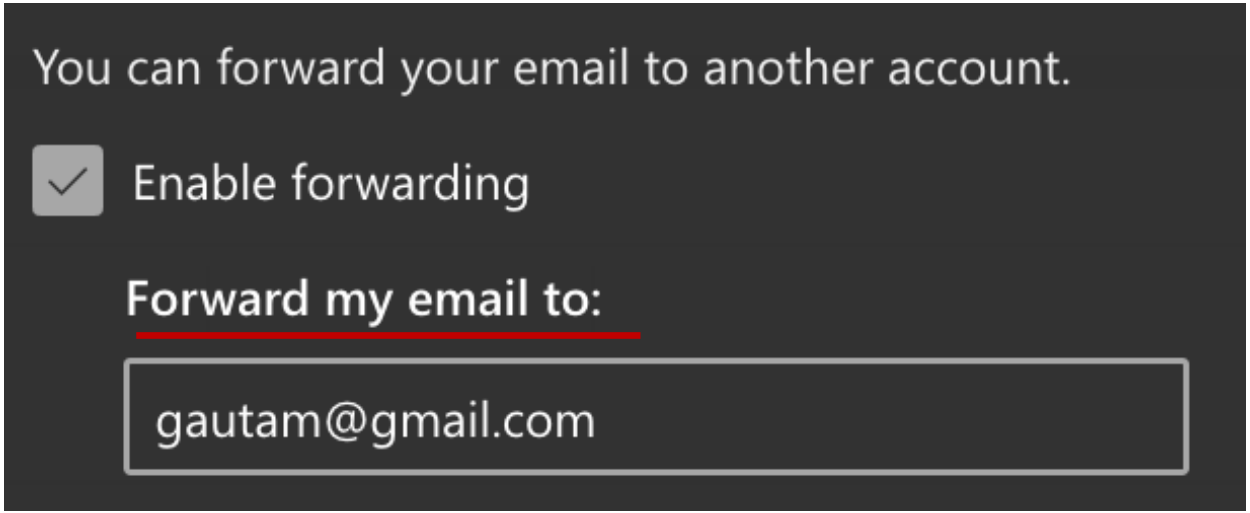
to security-lunch@lists.stanford.edu

Hi all,

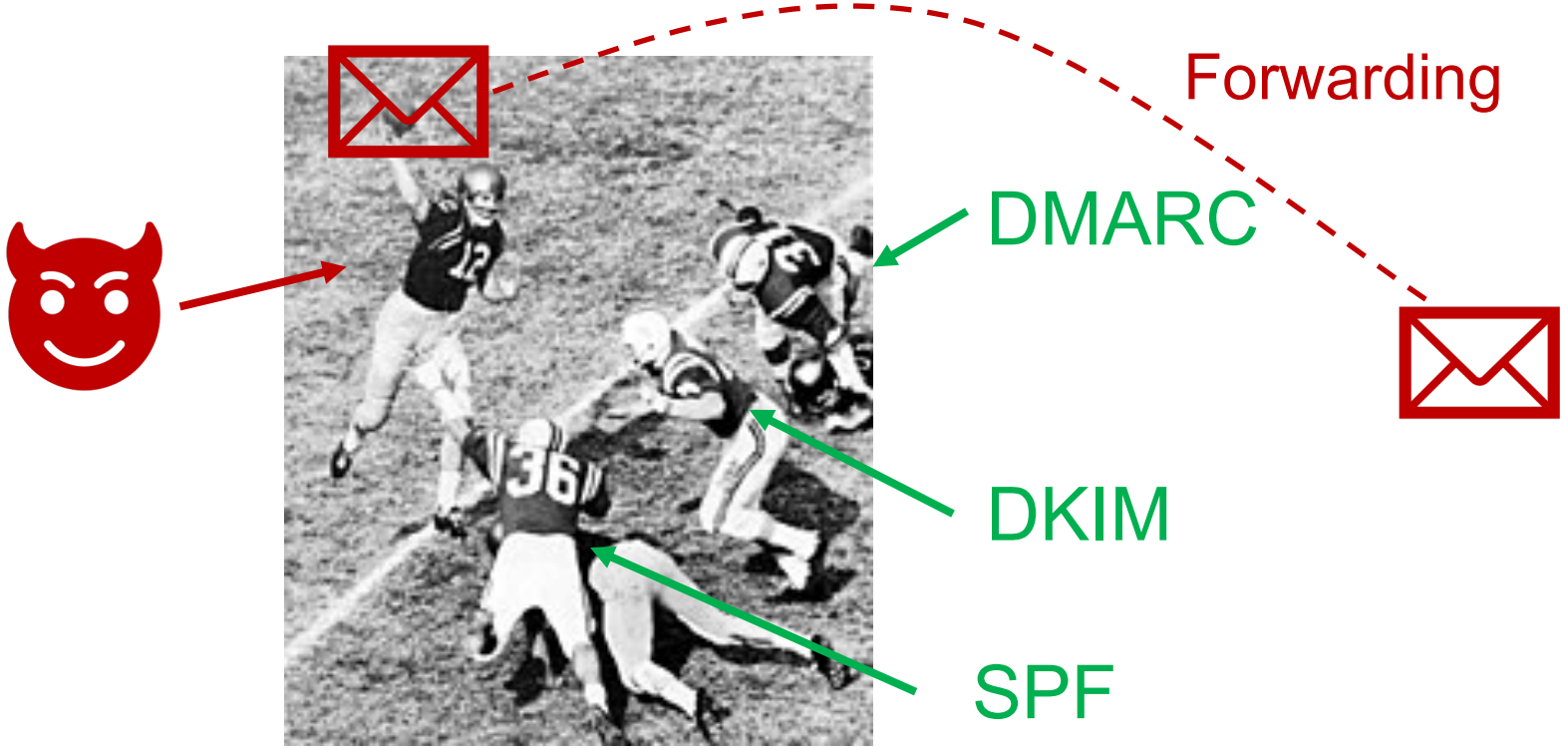
This Wednesday at noon at Security Lunch, Alex Liu will be preser

Implications of Email Forwarding Mechanism and Policy." See abstrac

Challenges in Email Authentication



Forward Pass: A 10,000-foot View



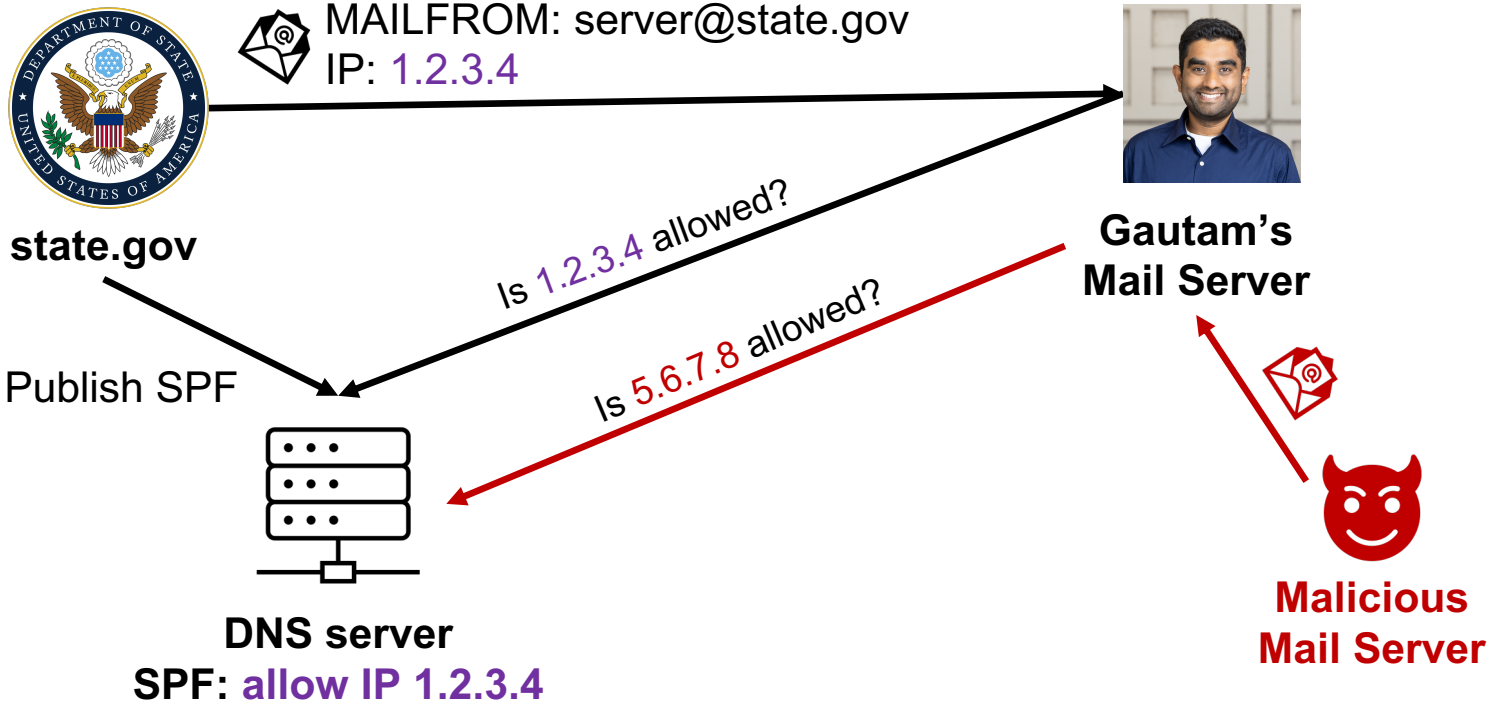
Credit: https://en.wikipedia.org/wiki/Forward_pass

Forward Pass: Contributions

- Goal: forwarding practices and their security implications
- Methodology: 20 services that support forwarding
- Results:
  - A range of assumptions and practices
  - Four distinct kinds of evasion attacks

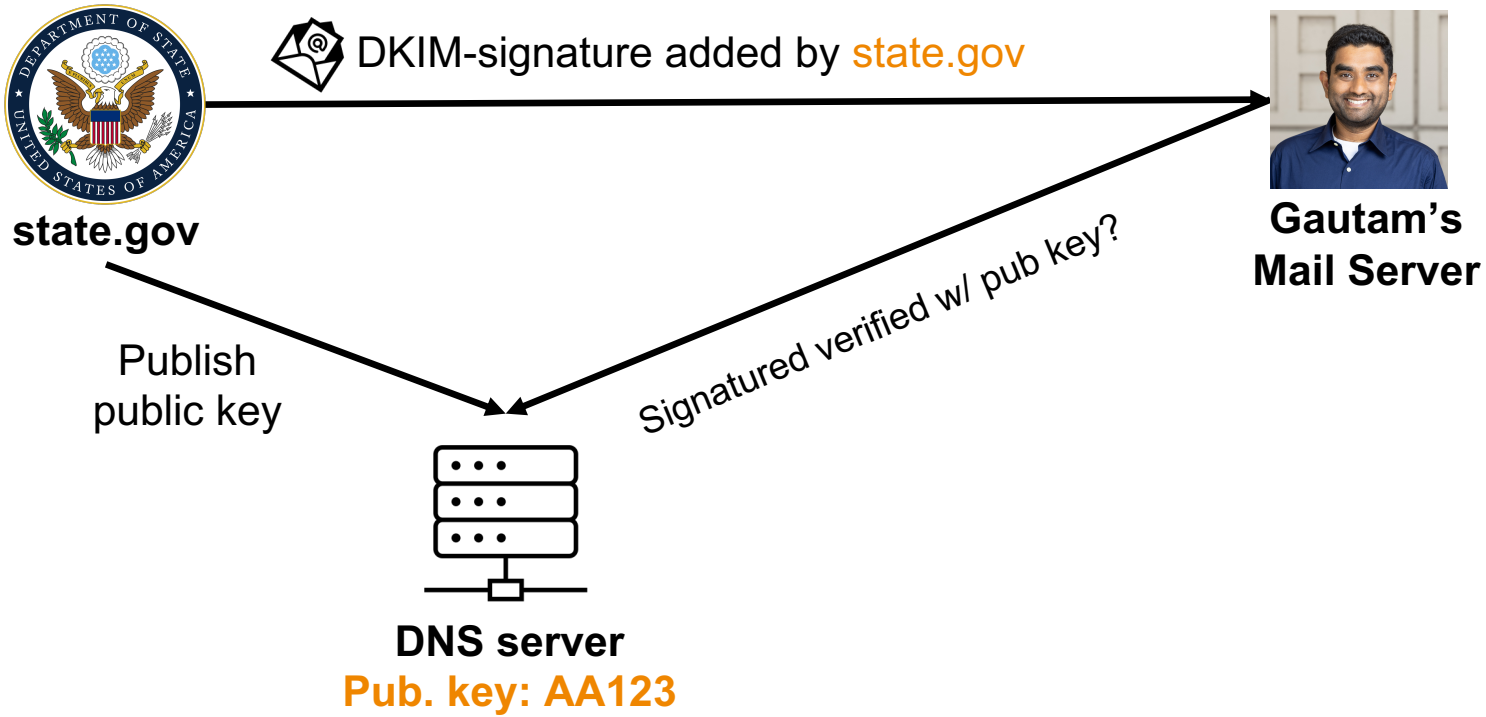
Background: SPF

IP-based authentication



Background: DKIM

Signature-based authentication

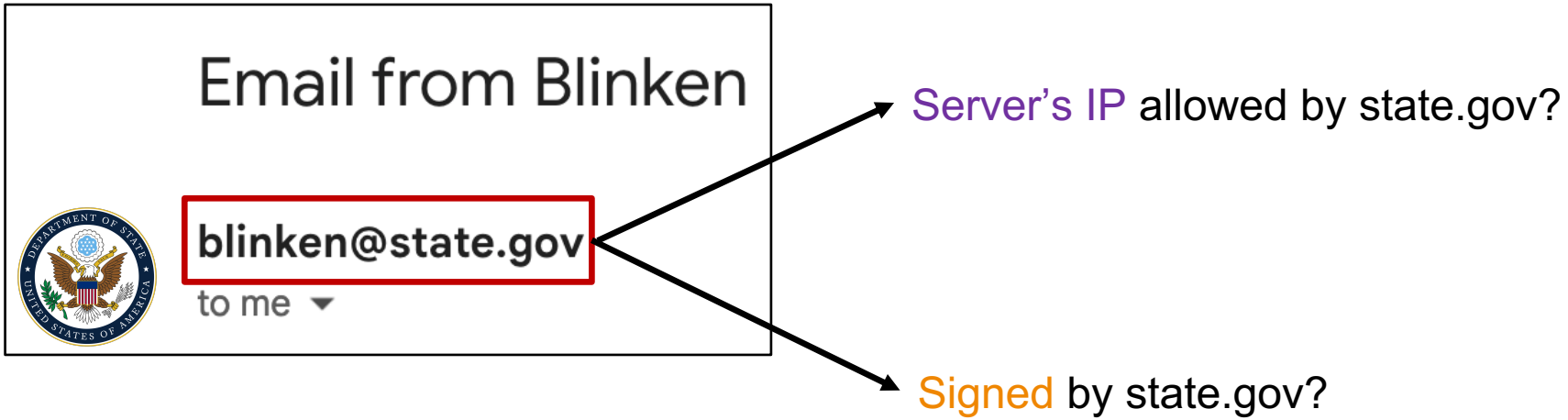


Background: DMARC

- FROM header is not authenticated

- Combines SPF and DKIM to authenticate FROM
  - If SPF passes, check if Domain(MAILFROM) = Domain(FROM)
  - If DKIM passes, check if Domain(DKIM-Sign) = Domain(FROM)

Authenticating an Email from state.gov



Methodology

- Goal: forwarding practices and their security implications
- 16 mail providers + 4 mailing lists

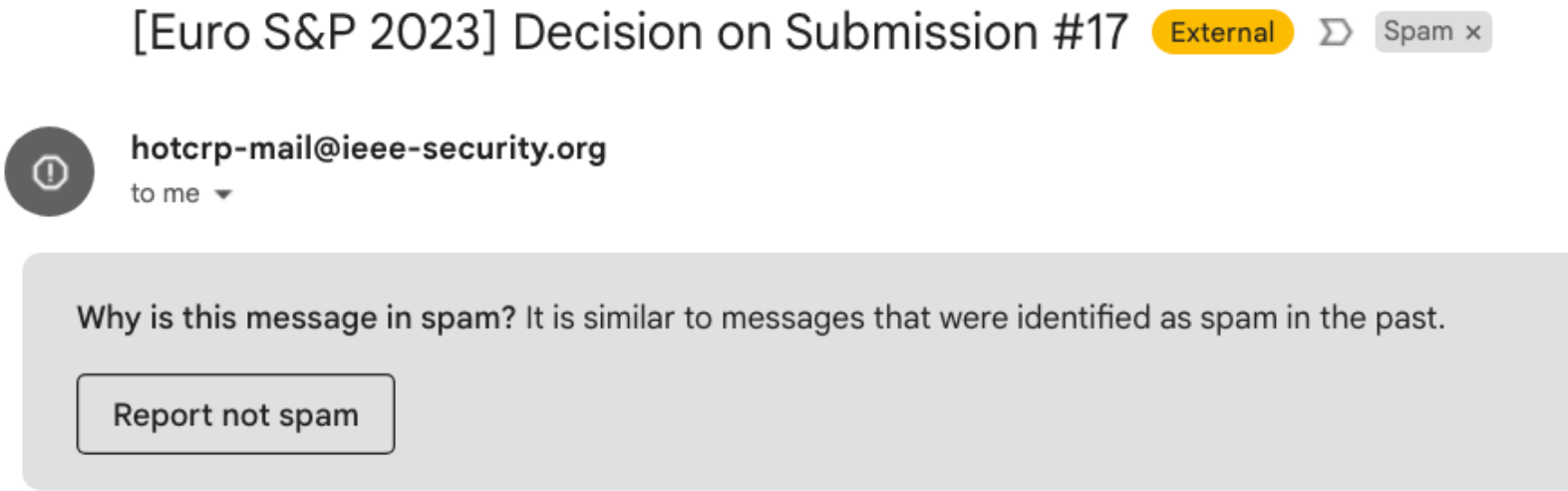
Practices

Assumptions

Attacks

https://arxiv.org/abs/2302.07287

Practice: Whitelisting

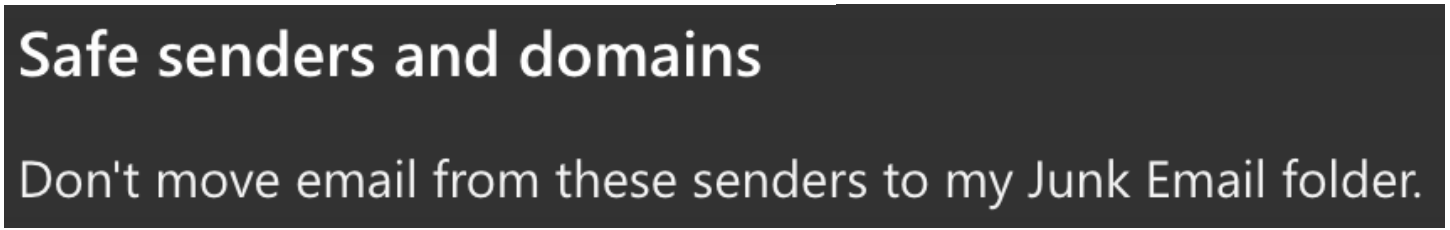


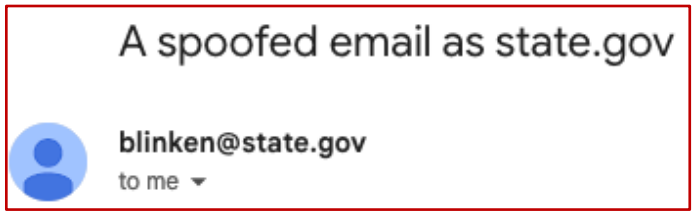
https://arxiv.org/abs/2302.07287

Practice: Whitelisting

Gmail: ☑ Never send it to Spam

Outlook:

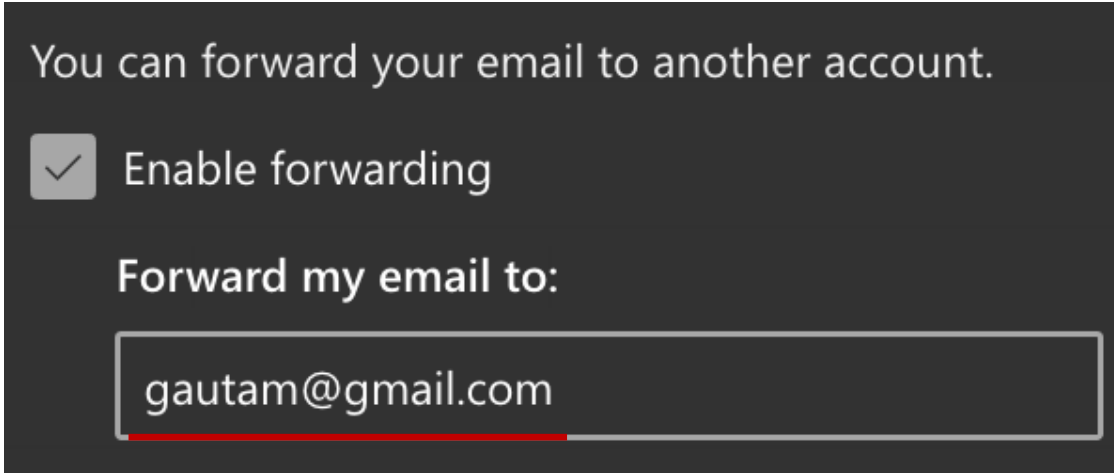




Whitelisting allows a malicious user to bypass authentication checks for spoofed emails

https://arxiv.org/abs/2302.07287

Practice: Open Forwarding



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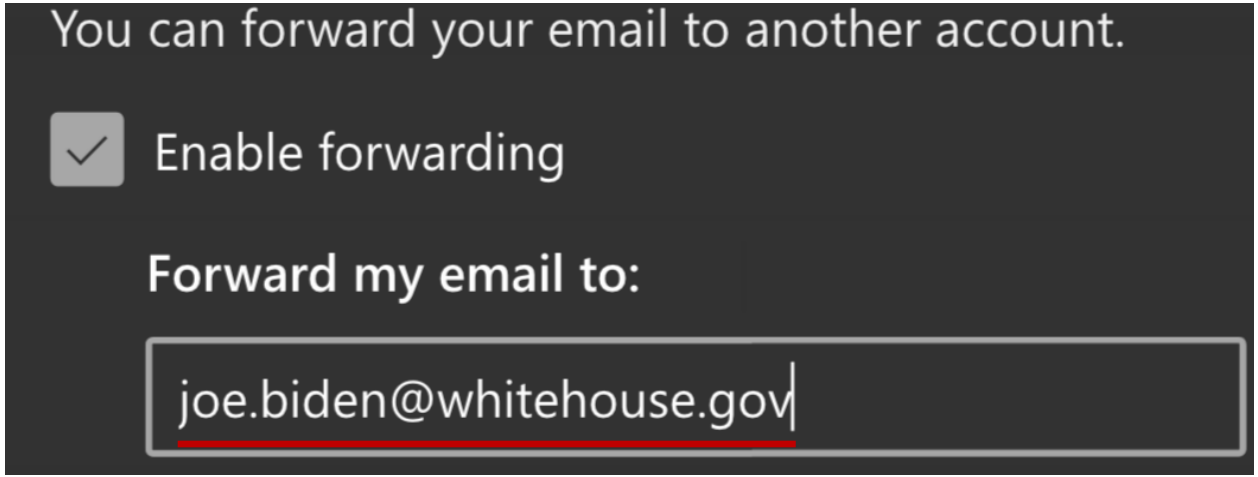
Practice: Open Forwarding

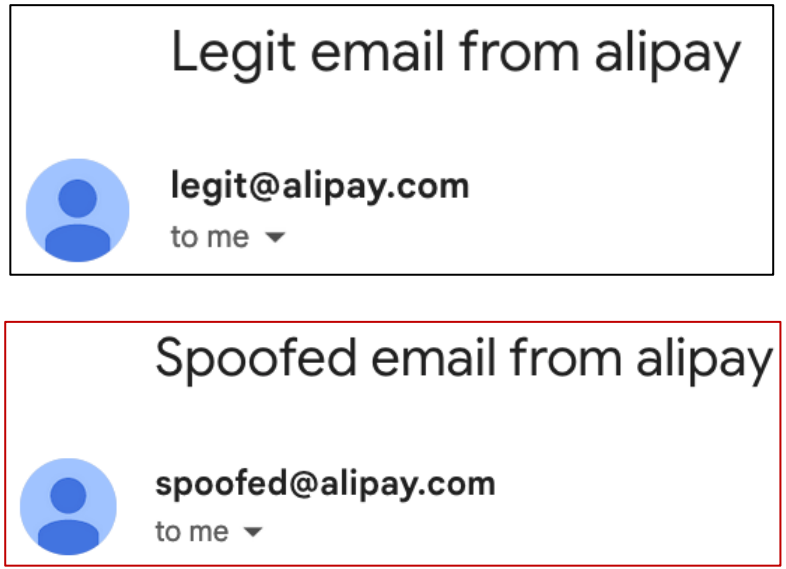


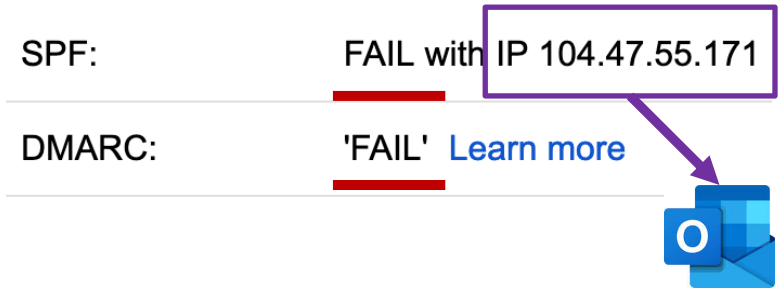
Open forwarding allows a malicious user to forward to arbitrary destination without authorization

https://arxiv.org/abs/2302.07287

Practice: Relaxed Validation

Trusting forwarded email messages from certain providers





Relaxed validation assumes that upstream providers do not forward spoofed emails

https://arxiv.org/abs/2302.07287

Attack: Relaxed Validation

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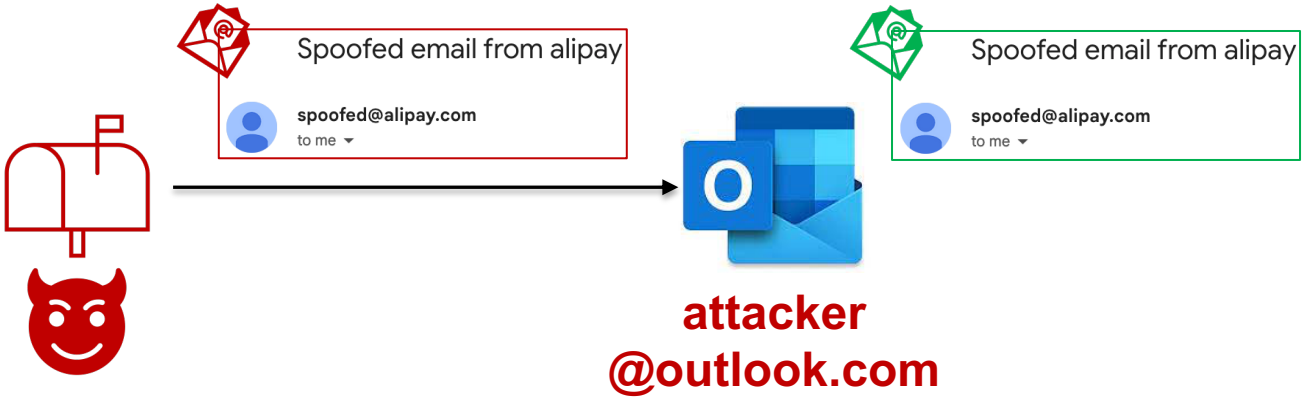
Attack: Relaxed Validation



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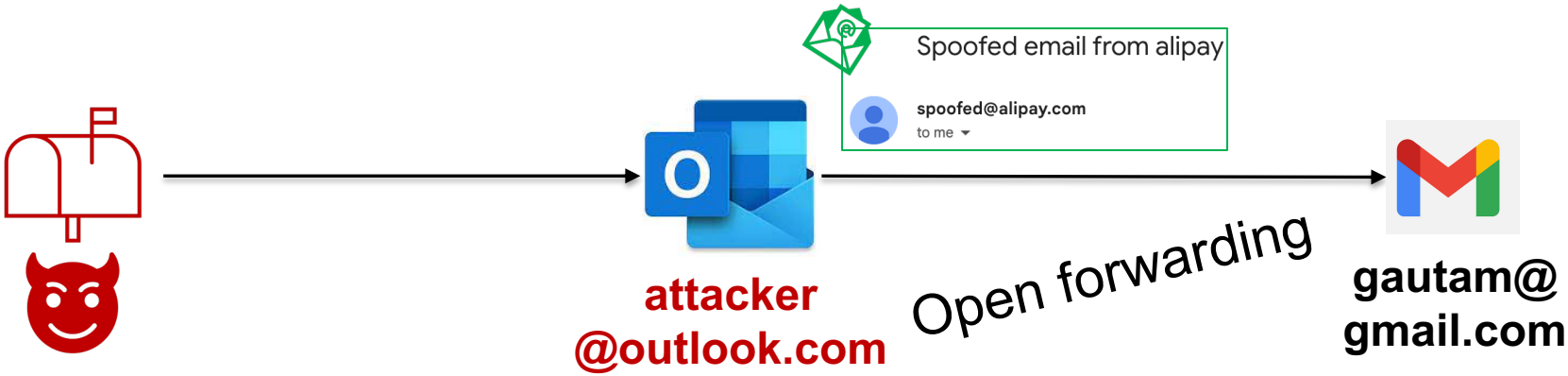
Attack: Relaxed Validation



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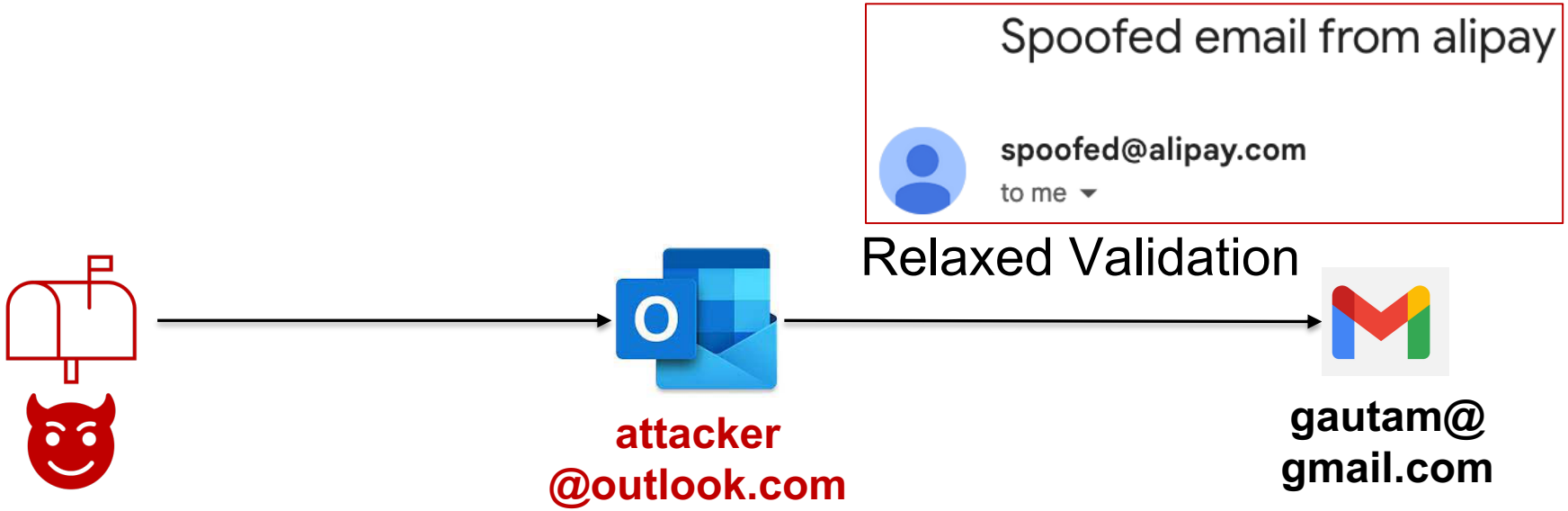
Attack: Relaxed Validation



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SPF's Outdated Assumption

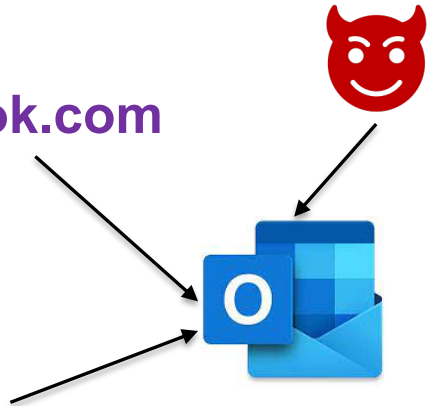
- When SPF was created

SPF: allow 1.2.3.4

SPF: allow 5.6.7.8

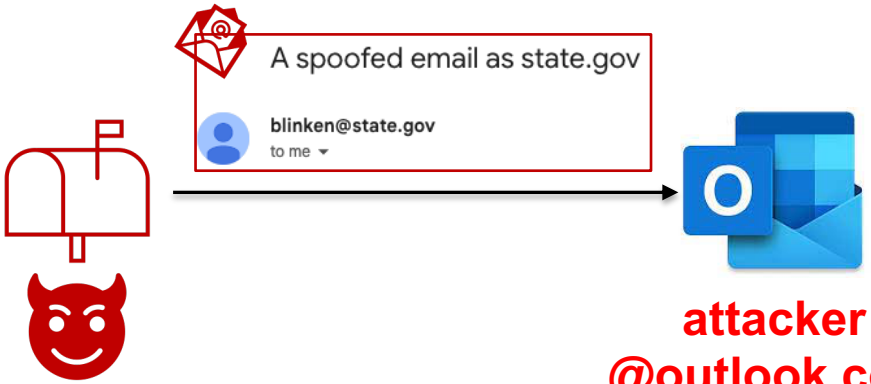
- Nowadays: shared SPF

SPF: allow outlook.com



SPF: allow outlook.com

Attack: Shared SPF



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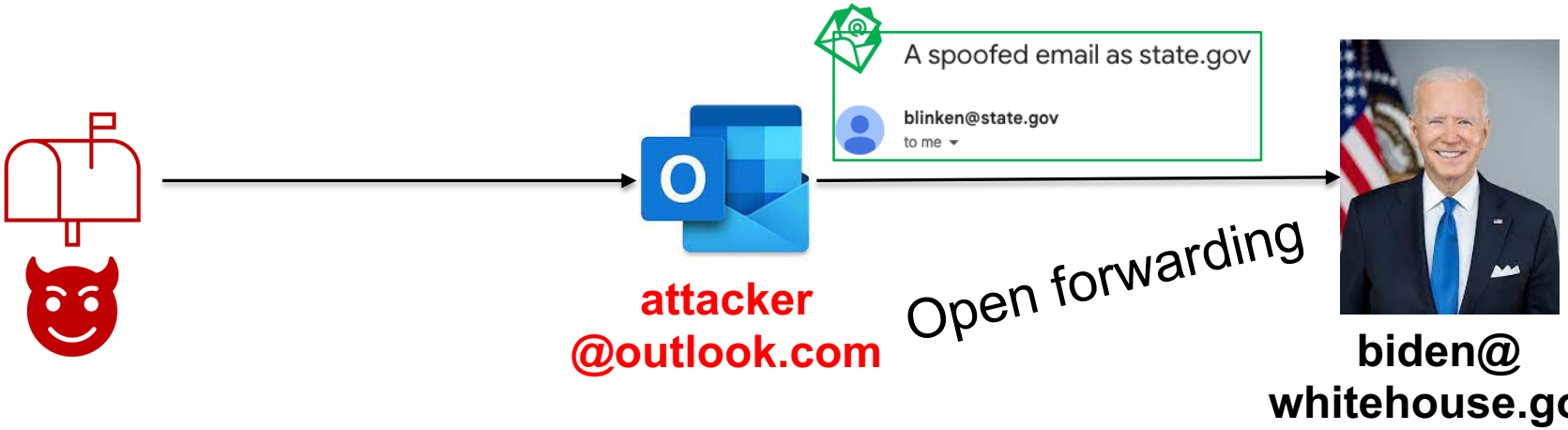

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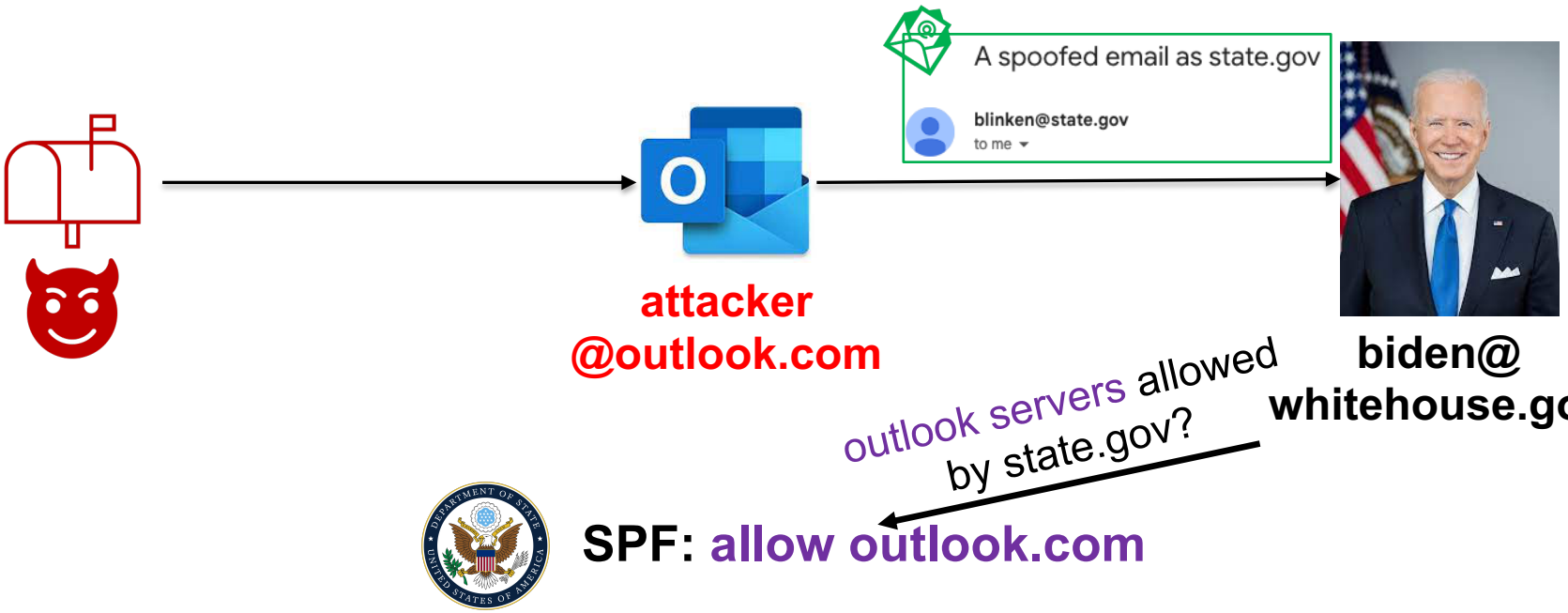
Attack: Shared SPF



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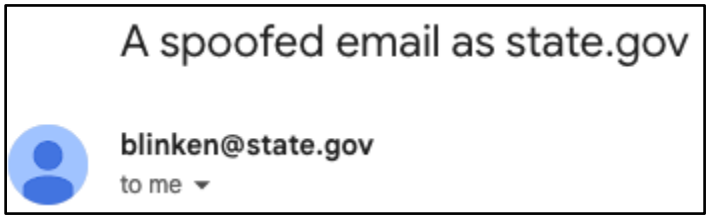

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Root Causes

- Forward works at odds with authentication protocols
- Ad-hoc implementation decisions
- No guidelines on how to implement forwarding
- SPF’s outdated assumption

https://arxiv.org/abs/2302.07287

Mitigations

- Disable open forwarding
- Remove relaxed validation
- Separate servers for sending and forwarding
- New protocols (e.g., ARC)

https://arxiv.org/abs/2302.07287

Disclosure

- All providers acknowledged the reported issues

- Some fixed; some partially fixed; some didn’t

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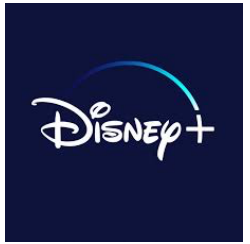
Summary

- Goal: forwarding practices and their security implications
- Large-scale measurement of 20 forwarding services
- Forwarding practices, assumptions, and attacks



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If You Can Only Remember One Thing

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