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Evaluating the Influence of Multi-Factor Authentication and Recovery Settings on the Security and Accessibility of User Accounts

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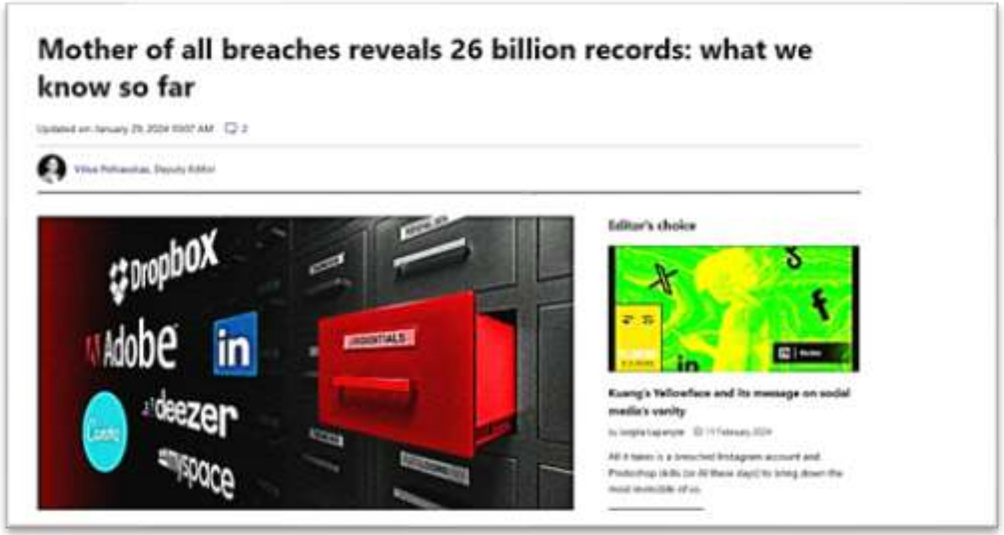
27th February 2024

Motivation



Mother of all breaches reveals 26 billion records: what we know so far

Updated on: January 29, 2024 10:07 AM 2

Vilius Petkauskas, Deputy Editor

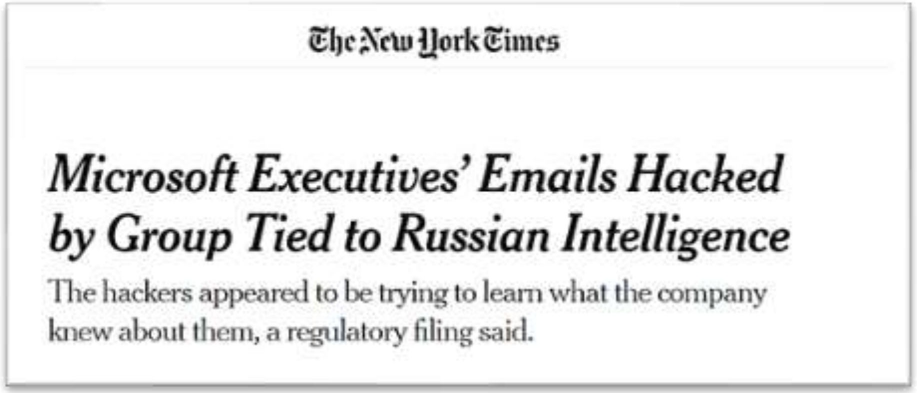
Editor's choice

Kuang's Yellowface and its message on social media's vanity

by Jurgita Lapienytė 11 February 2024

All it takes is a breached Instagram account and Photoshop skills (or AI these days) to bring down the most invincible of us.

Source: https://cybernews.com/security/billions-passwords-credentials-leaked-mother-of-all-breaches/

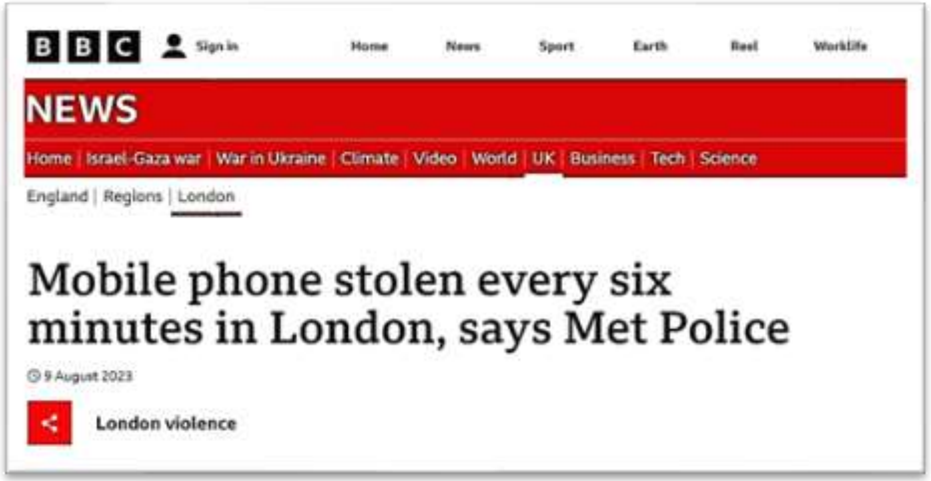


The New York Times

Microsoft Executives' Emails Hacked by Group Tied to Russian Intelligence

The hackers appeared to be trying to learn what the company knew about them, a regulatory filing said.

Source: https://www.nytimes.com/2024/01/19/technology/microsoft-executive-emails-hacked.html



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Mobile phone stolen every six minutes in London, says Met Police

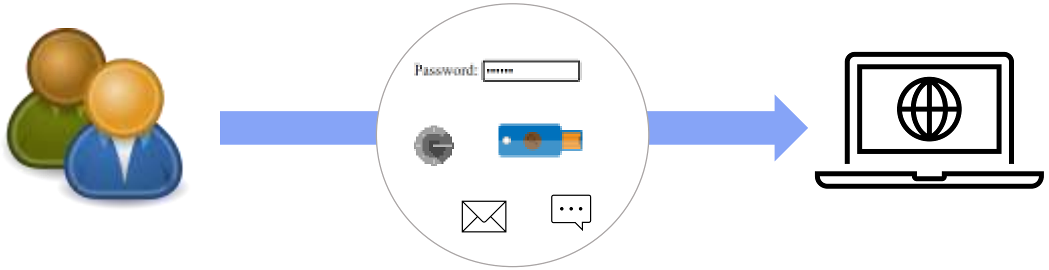
9 August 2023

London violence

Source: https://www.bbc.com/news/uk-england-london-66442069

Motivation

- Online services offer different authentication methods
  - Password
  - Multi-Factor Authentication (MFA)
    - SMS
    - Authenticator app
    - Security key
  - Account recovery methods
    - Email
    - SMS



- Well-known problems with passwords: phishing, credential stuffing, dictionary attacks, etc. [1]
- Problems with MFA and Recovery: usability[2], authentication bypass / account lockout[3]

[1] Taneski, Viktor, Marjan Heričko, and Boštjan Brumen. "Systematic overview of password security problems." *Acta Polytechnica Hungarica 16.3* (2019): 143-165. 2019.
[2] Das, Sanchari, Bingxing Wang, and L. Jean Camp. "MFA is a Waste of Time! Understanding Negative Connotation Towards MFA Applications via User Generated Content." *arXiv e-prints* (2019): arXiv-1908. 2019.
[3] Amft, Sabrina, et al. "We've Disabled MFA for You": An Evaluation of the Security and Usability of Multi-Factor Authentication Recovery Deployments." *Proceedings of the 2023 ACM SIGSAC Conference on Computer and Communications Security*. 2023.

Problem Statement

➔ Analysis of **security** and **accessibility** for Apple and Google user accounts

With respect to Apple and Google users…

- **RQ1** How do the users access their passwords?
- **RQ2** Which MFA and recovery methods did the users enable?
- **RQ3** How secure are the account setups?
- **RQ4** How many access methods do the user accounts depend on?

Account Access Graphs I

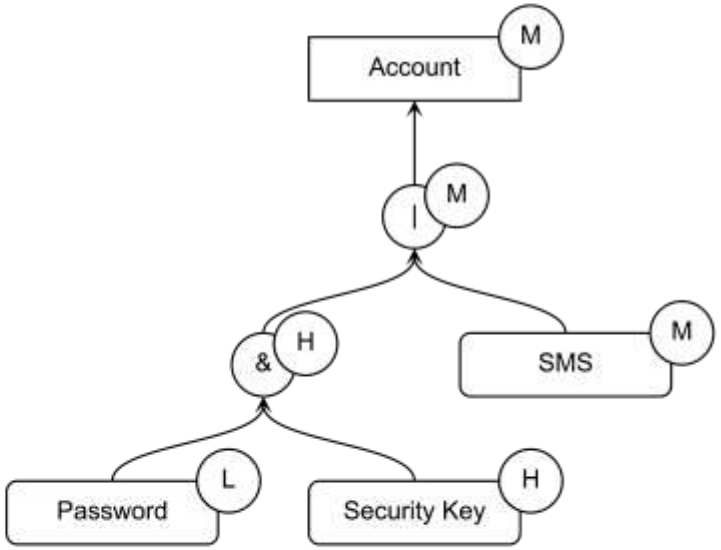
Account access graphs (AAGs)[4,5] can be used to model authentication methods and account interdependencies.

Security scores

- Security of authentication methods
- Evaluation:
  - Scores (adopted from NIST[6] / eIDAS[7])

Score	Category	Authentication methods (examples)
High	Hardware-based	Security key, smart card
Medium	Software-based	SMS Code, OTP Apps
Low	Knowledge-based	Password, PIN

  - & = maximum of child node scores
  - | = minimum of child node scores

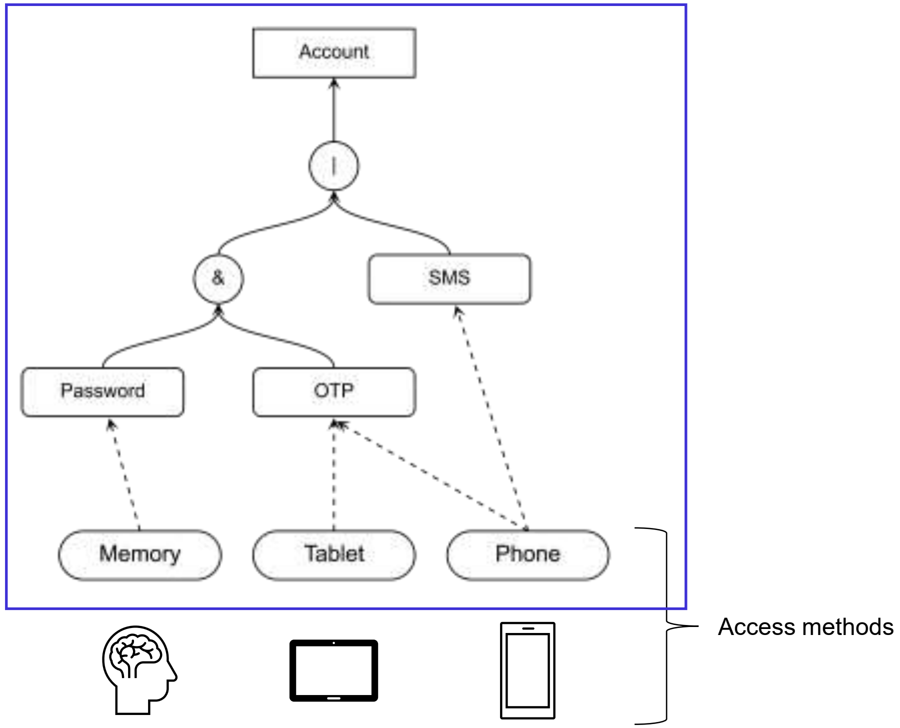


[4] Hammann, Sven, et al. "User account access graphs." *Proceedings of the 2019 ACM SIGSAC Conference on Computer and Communications Security*. 2019.
[5] Pöhn, Daniela, et al. "A framework for analyzing authentication risks in account networks." *Computers & Security 135* (2023): 103515. 2023.
[6] Grassi, et al. "Digital Identity Guidelines: Authentication and Lifecycle Management". https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-63b.pdf. 2020.
[7] European Comission. "eIDAS Levels of Assurance". https://ec.europa.eu/digital-building-blocks/wikis/display/DIGITAL/eIDAS+Levels+of+Assurance. 2023.

Account Access Graphs II

Accessibility scores

- Lower bound number of access methods required to access the account
- Evaluation:
  - Derive boolean term and simplify
  - Scores $s_i = \frac{1}{n_i}$ $(n_i = \text{number of occurrences})$
  - & = minimum
  - | = sum



- Example:

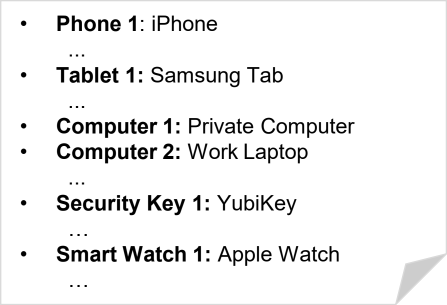
```
(Memory ∧ (Tablet ∨ Phone)) ∨ Phone
(Memory ∧ Tablet) ∨ (Memory ∧ Phone) ∨ Phone
(Memory ∧ Tablet) ∨ Phone
```

$$s_{acc} = \min(1,1) + 1 = 2$$

Online Survey

- Study participants acquired through Prolific*

- Questionnaire tasks:
  1. Create an enumerated list of devices



- **Phone 1**: iPhone
  …
- **Tablet 1:** Samsung Tab
  …
- **Computer 1:** Private Computer
- **Computer 2:** Work Laptop
  …
- **Security Key 1:** YubiKey
  …
- **Smart Watch 1:** Apple Watch
  …

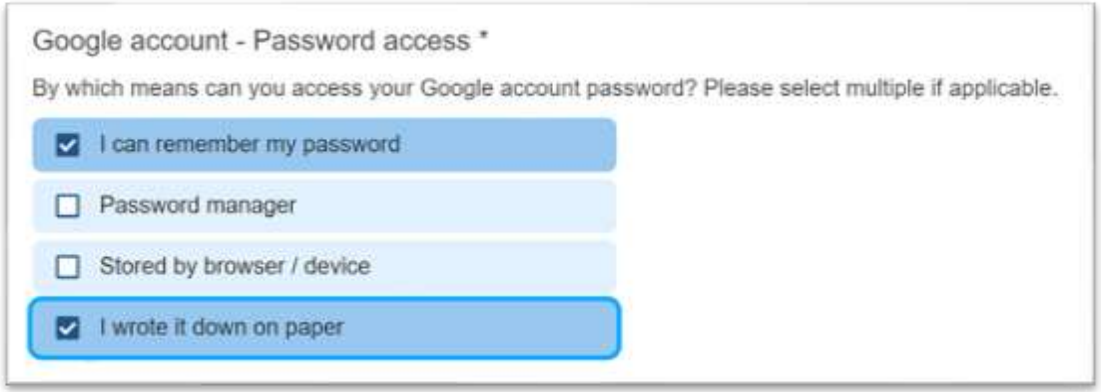
  2. Questions on Apple / Google account configurations and access methods

Category		Apple	Google
Gender	male	45	48
	female	46	46
Age range	11-20	5	3
	21-30	44	37
	31-40	23	30
	41-50	13	14
	51-60	5	9
	61-70	2	1
Country of residence	USA	44	47
	Germany	47	47
Total		91	94

Demographics of survey participants

* https://prolific.com (last accessed 2024-02-08)

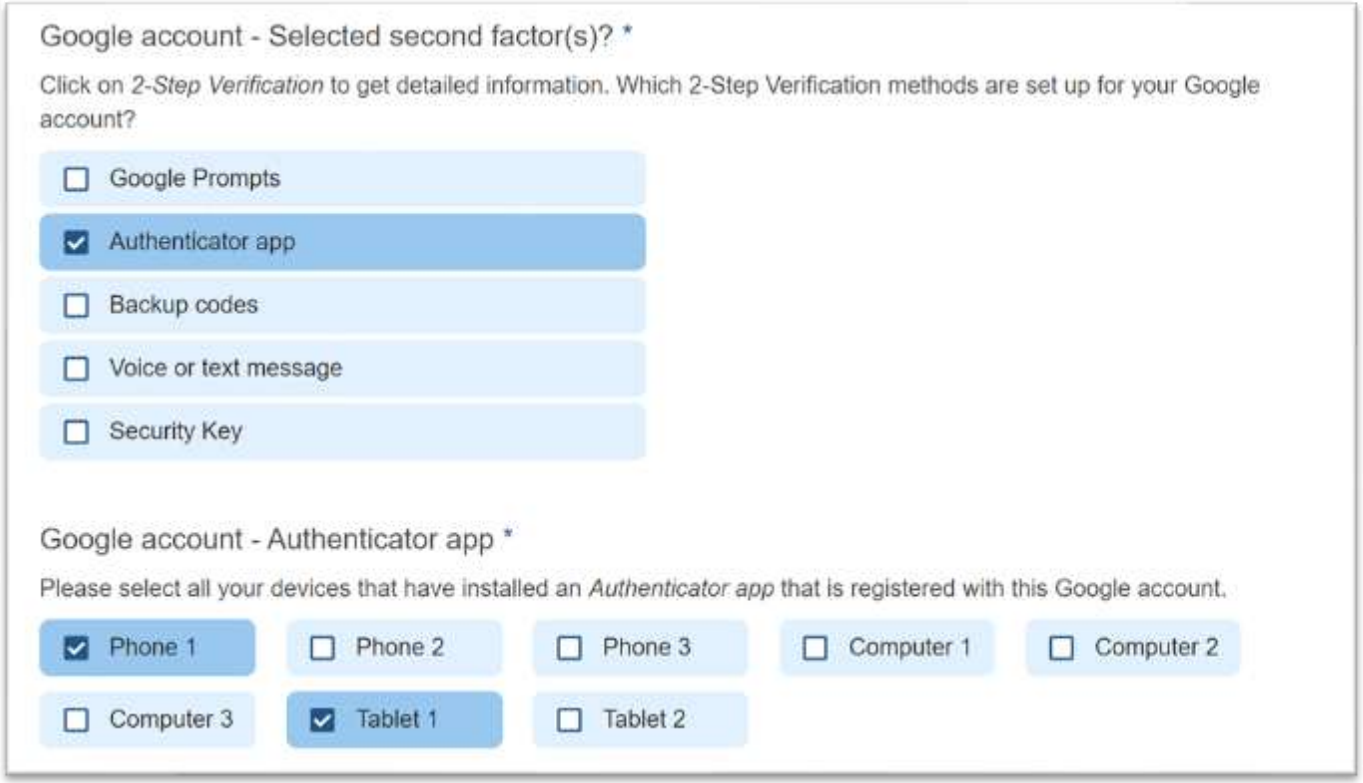
Survey Question Examples



Google account - Password access *

By which means can you access your Google account password? Please select multiple if applicable.

- ☑ I can remember my password
- □ Password manager
- □ Stored by browser / device
- ☑ I wrote it down on paper



Google account - Selected second factor(s)? *

Click on *2-Step Verification* to get detailed information. Which 2-Step Verification methods are set up for your Google account?

- □ Google Prompts
- ☑ Authenticator app
- □ Backup codes
- □ Voice or text message
- □ Security Key

Google account - Authenticator app *

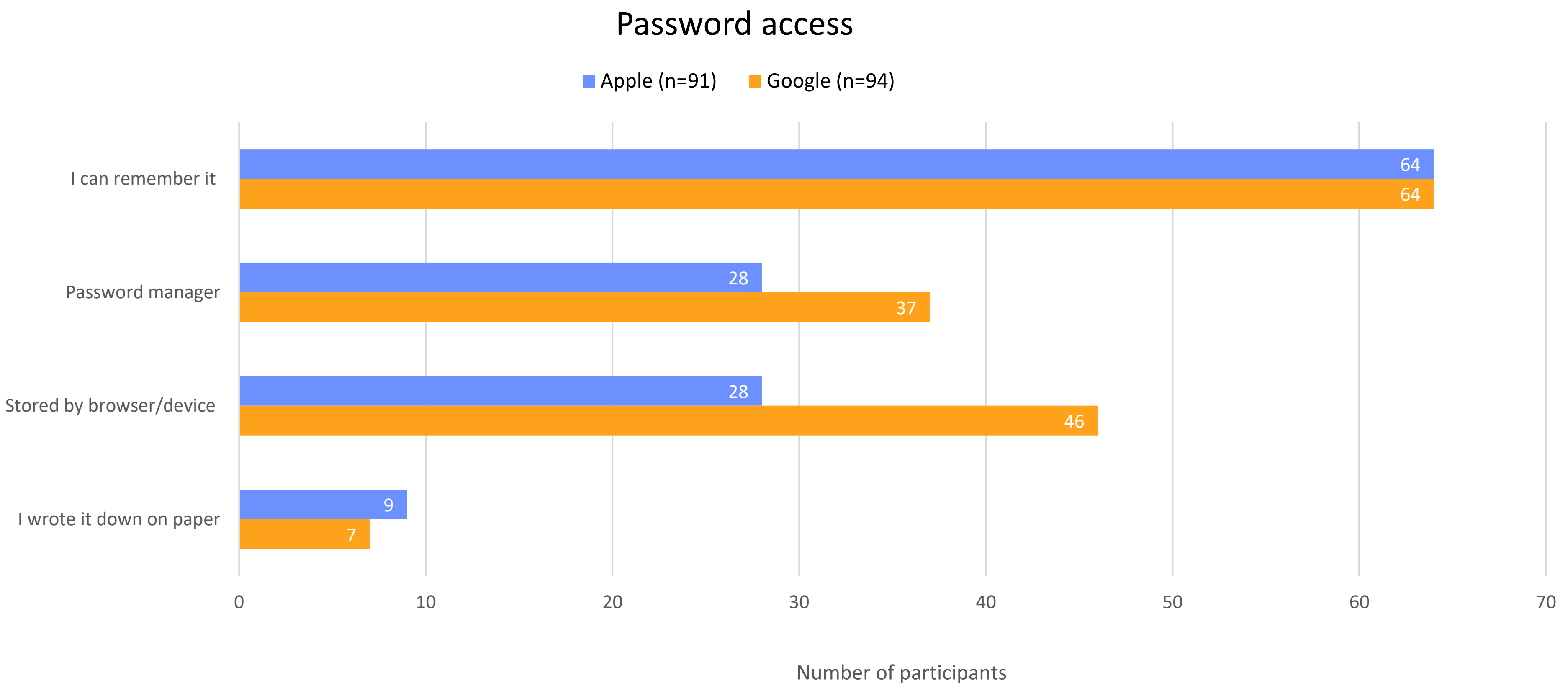
Please select all your devices that have installed an *Authenticator app* that is registered with this Google account.

☑ Phone 1 □ Phone 2 □ Phone 3 □ Computer 1 □ Computer 2

□ Computer 3 ☑ Tablet 1 □ Tablet 2

Results I

RQ1 How do the users access their passwords?



Results II

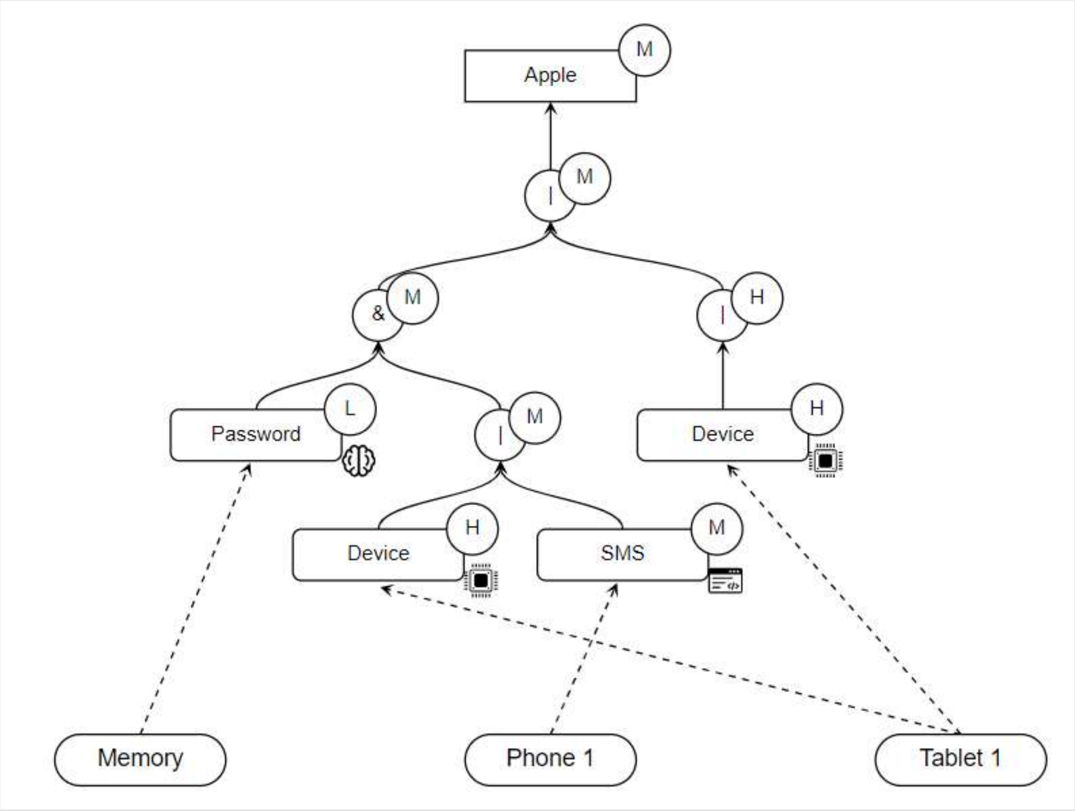
RQ2 Which MFA and recovery methods did the users enable?

- Apple
  - Linking to devices: ~96%
    → used for both MFA and recovery unless explicitly disabled
  - Text message enabled: ~97%
  - Recovery key enabled: ~19%

- Google:
  - 68% of the Google accounts had at least one MFA method enabled
  - Previous findings:
    - In 2015, less than 7% of Google users had MFA enabled[8]
    - In 2018, around 10% of Gmail accounts set up MFA[9]
    - Auto enrolment of MFA in Google accounts since 2021[10]

[8] Petsas, Thanasis, et al. "Two-factor authentication: is the world ready? Quantifying 2FA adoption." *Proceedings of the eighth European workshop on system security*. 2015.
[9] Milka, Grzergor. "Anatomy of account takeover." *Enigma 2018* (Enigma 2018). 2018.
[10] Risher, M. “A simpler and safer future - without passwords”. https://blog.google/technology/safety-security/a-simpler-and-saferfuture-without-passwords/. 2021.

AAG Example



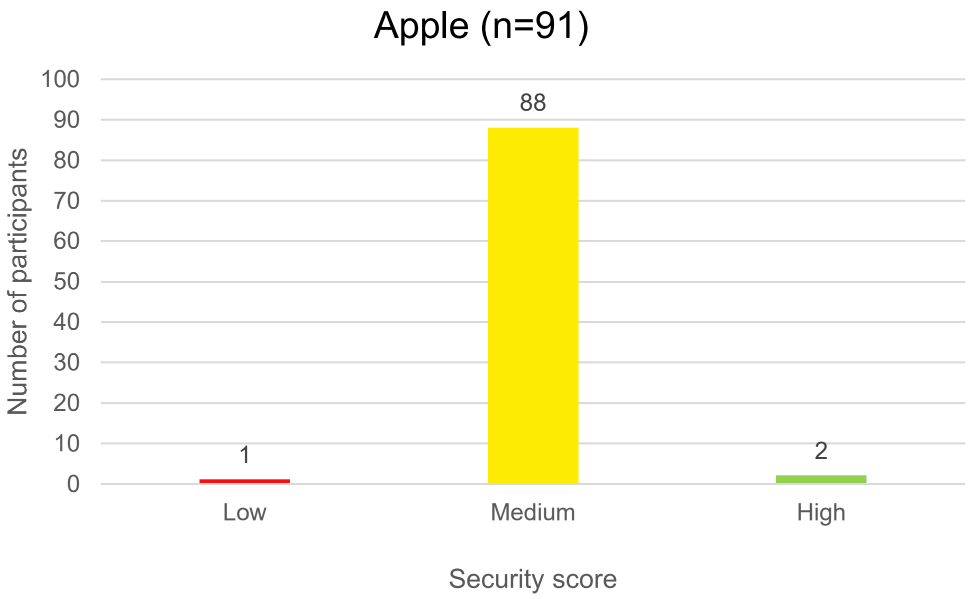
Apple P2

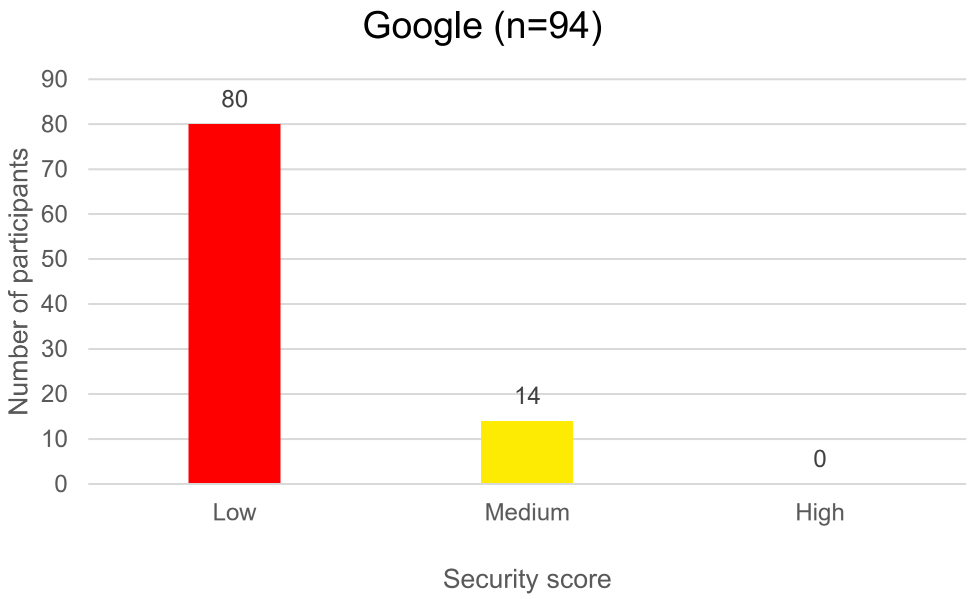
- Security score: Medium
- Accessibility score: 2

Results III

RQ3 How secure are the account setups?

Security scores

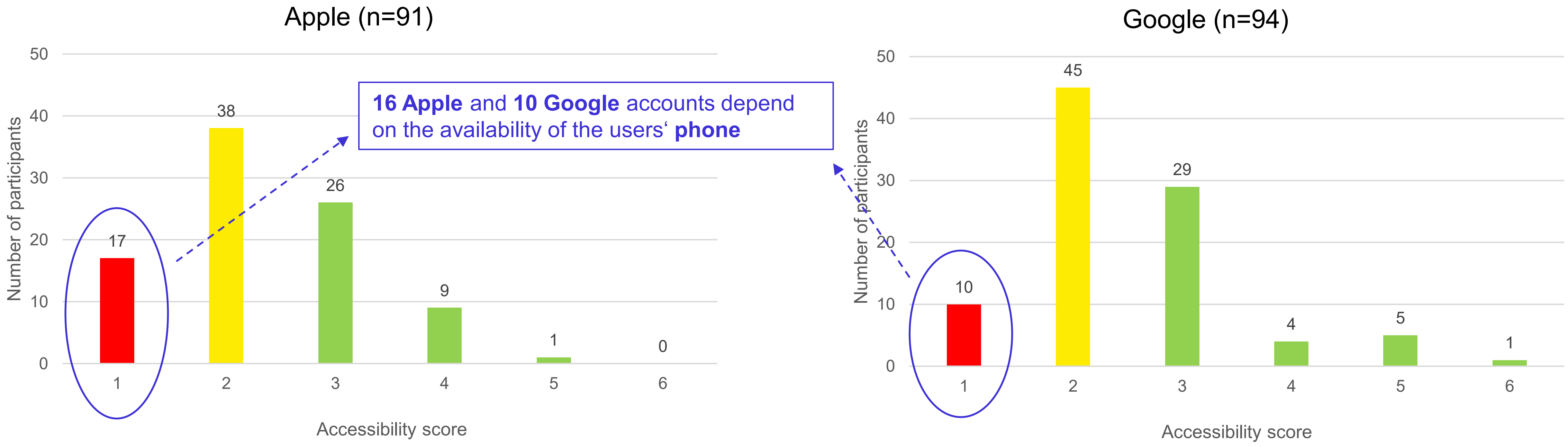




Results IV

RQ4 How many access methods do the user accounts depend on?

Accessibility scores



16 Apple and **10 Google** accounts depend on the availability of the users' **phone**

Conclusion

Summary:

- Majority of Apple accounts had a higher security score compared to Google accounts
- Several Apple and Google test participants could lose account access when only losing their phone
- Study data and tools available on GitHub: https://github.com/Digital-Security-Lab

Future work:

- Follow-up studies with more online services, e.g. lab studies (currently done in a Master's thesis project)
- Derive concepts for service providers to improve security and accessibility
- Consider risk-based authentication in AAG models

Thank you!
Any questions?

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Also on in RG

References

[1] Taneski, Viktor, Marjan Heričko, and Boštjan Brumen. "Systematic overview of password security problems." *Acta Polytechnica Hungarica 16.3* (2019): 143-165. 2019.

[2] Das, Sanchari, Bingxing Wang, and L. Jean Camp. "MFA is a Waste of Time! Understanding Negative Connotation Towards MFA Applications via User Generated Content." *arXiv e-prints* (2019): arXiv-1908. 2019.

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[7] European Comission. “eIDAS Levels of Assurance”. https://ec.europa.eu/digital-building-blocks/wikis/display/DIGITAL/eIDAS+Levels+of+Assurance. 2023.

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