Security Evaluation of Multi-Factor Authentication in Comparison with the Web Authentication API

WINGS | Tim Brust | 05. November 2019

Motivation

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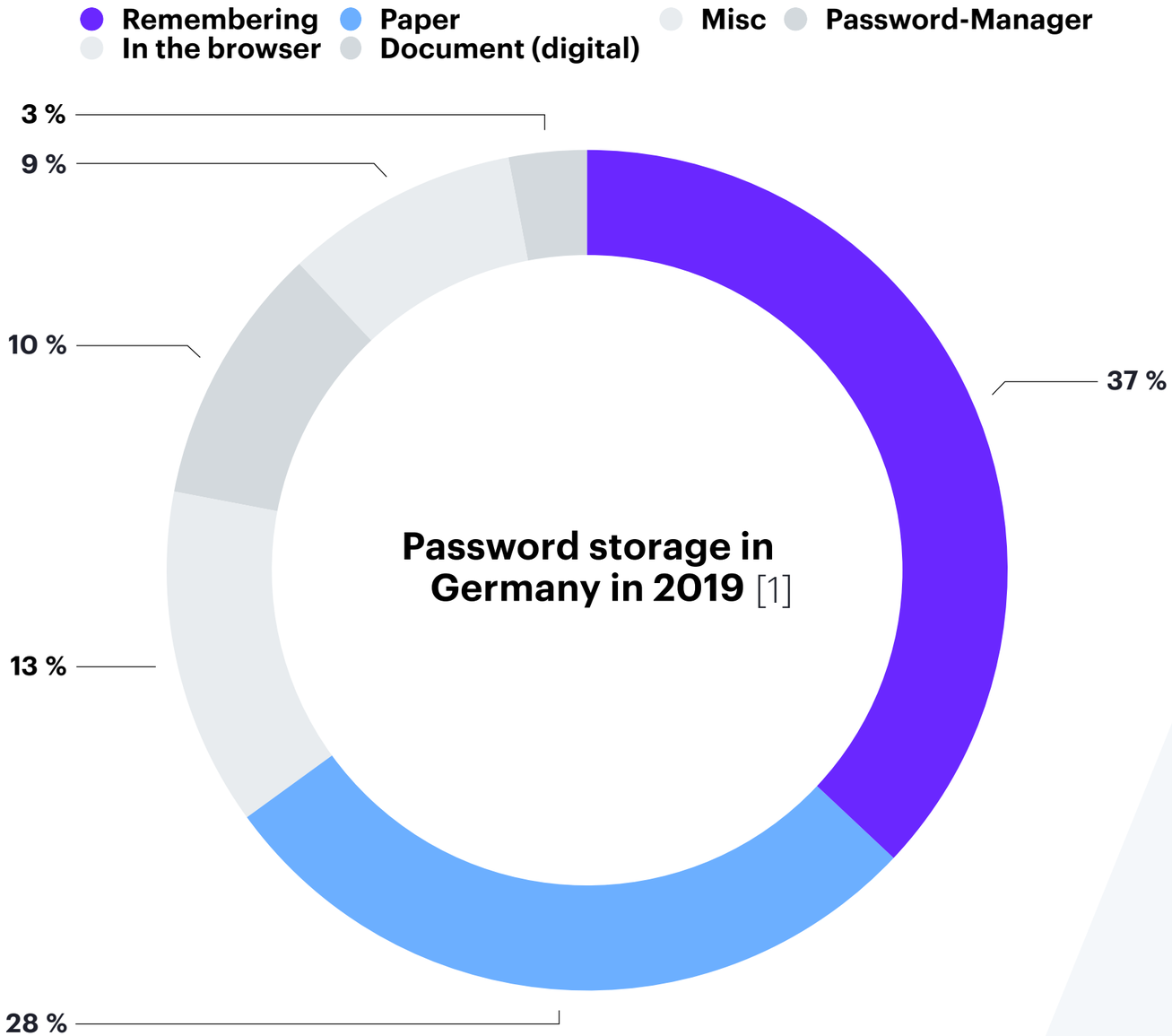
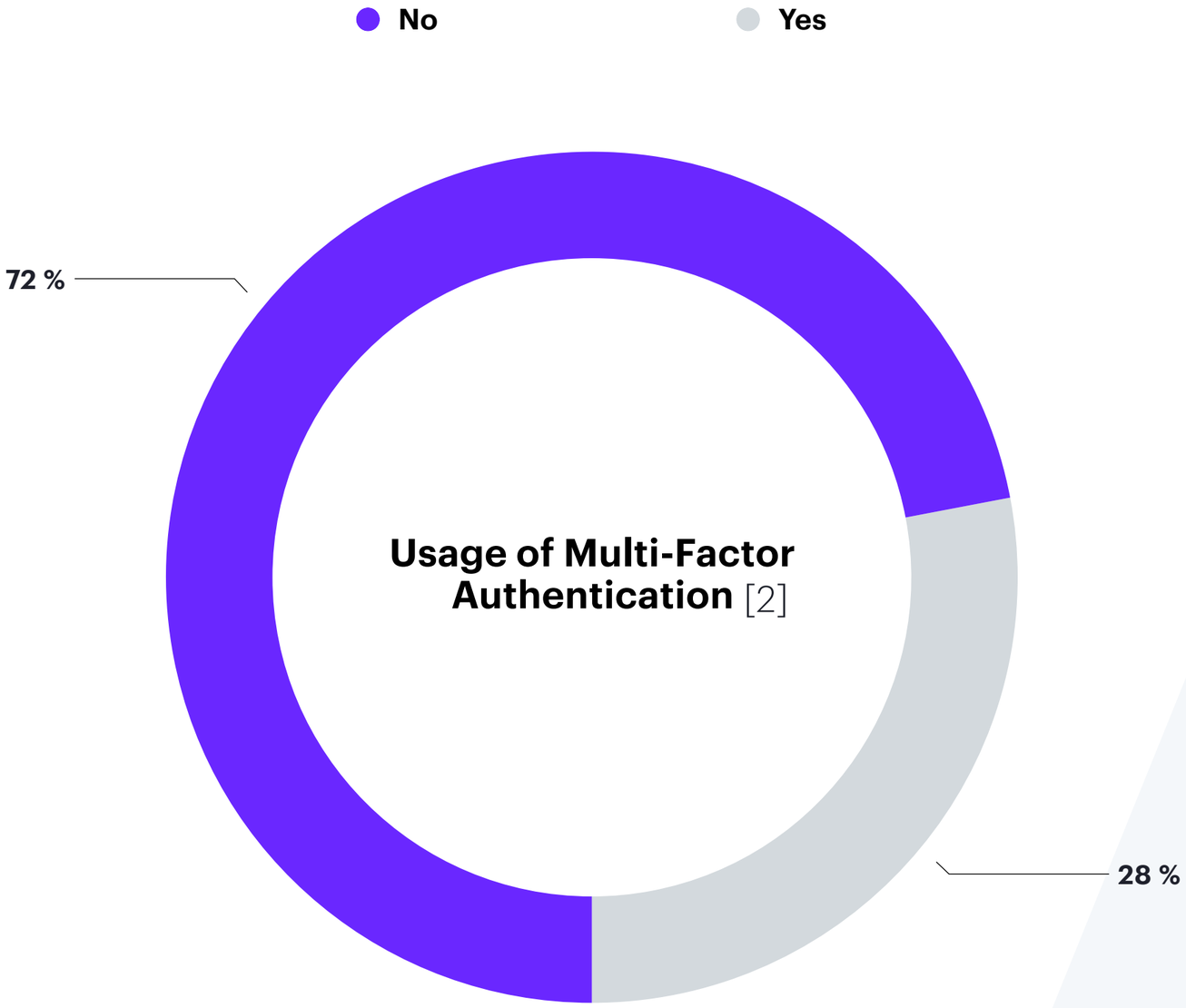
Password storage in Germany in 2019



Over 65% do not use password manager!

Usage of Multi-Factor Authentication in the US in 2017



Over 70% do <u>not</u> use multi-factor authentication!

Amount of Breached Credentials in One Year

1 900 000 000 [3]

One-Factor Authentication

2

Methods of Authentication

Knowledge

- Secret only the user knows
- Examples
  - Password, PINs
  - Security question

Possession

- A possession only the user has (access to)
- Hard- or Software
- Examples
  - Chipcard
  - (Security-) key
  - App

Biometrics

- Physical trait
- Examples
  - Face, Iris, Ear
  - Fingerprint, ...

Further methods

- Location-based
- Time-based
- Behavior-based
- Social authentication

Security Aspects

Threats Independent of the Authentication Method

Initialization

> Malware on infected devices can intercept, eavesdrop, and forward secrets

> Security cameras (IoT), a colleague looking of the should or webcams can gain access to the information, too

Transmission

> Eavesdropping on the communication (i.e. HTTP traffic)

> Manipulation of the ports (e.g. USB port) or sensors

Knowledge

> The human brain has difficulties remembering a strong, unique password for every account
> Re-usage of the same password for different/multiple accounts
> Usage of easy to guess passwords, or passwords that are associated with the user
> Saving/storing passwords in a unsecured manner

> Security questions can decrease the security when answered honestly
> Forced password change does not increase the security

> Unknown if the service provider, e.g., hashes, salts or peppers the passwords
> Often one password hash is enough for further attacks

Possession

> Danger of theft, loss, damage, or oblivion
> Usable by other persons upon theft or loss
> Wireless communication might be eavesdropped on
> Replacement is more expensive than knowledge

Biometrics

> Traits can change over time
> (Temporary) unavailability due to injuries
> Problems of the “intra-user variance”
> Data privacy and security concerns of the user
> Traits are copyable; but not replaceable

Multi-Factor Authentication

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Einmalpasswörter

- Event-based (HOTP) and time-based (TOTP), both are standardized in the RFCs
- Based on “Message Authentication Codes”
- Usage of a shared secret
- Generation on the client side (e.g. via Apps) or on the server
  - Transmission of the password via e-mail or SMS

- Proprietary solutions from RSA and Yubico exist, too

Sicherheitsschlüssel

- Can be realized in both hardware and software
- RSA SecurID is a well known example
  - Generates 60s OTP, too

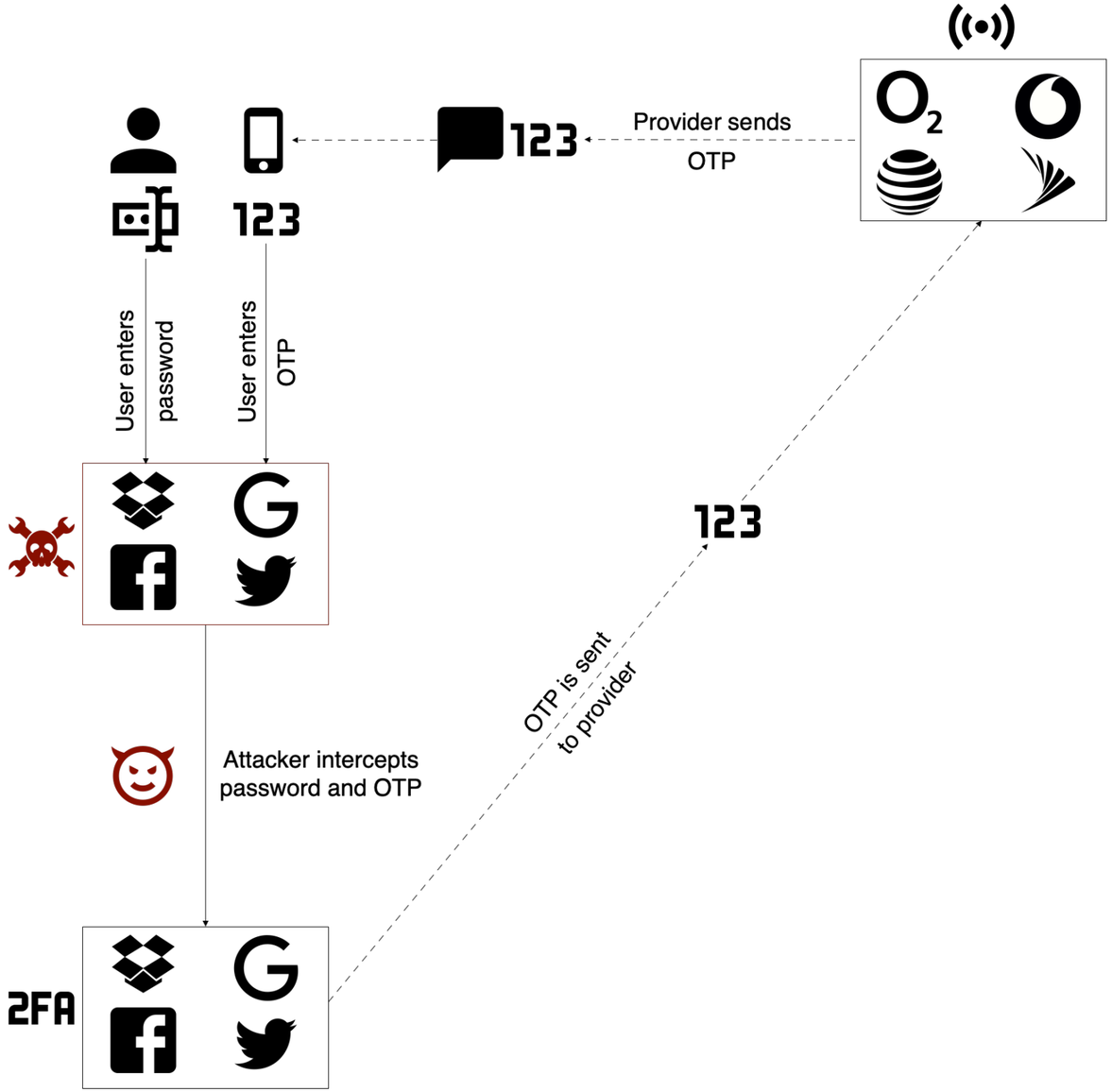
- Universal Second Factor (U2F) as an open standard
  - No specification by, e.g. the W3C; experimental API
  - Security keys can communicate via USB, BLE, or NFC
  - Usage of public-key authentication and the challenge-response protocol

Security Aspects

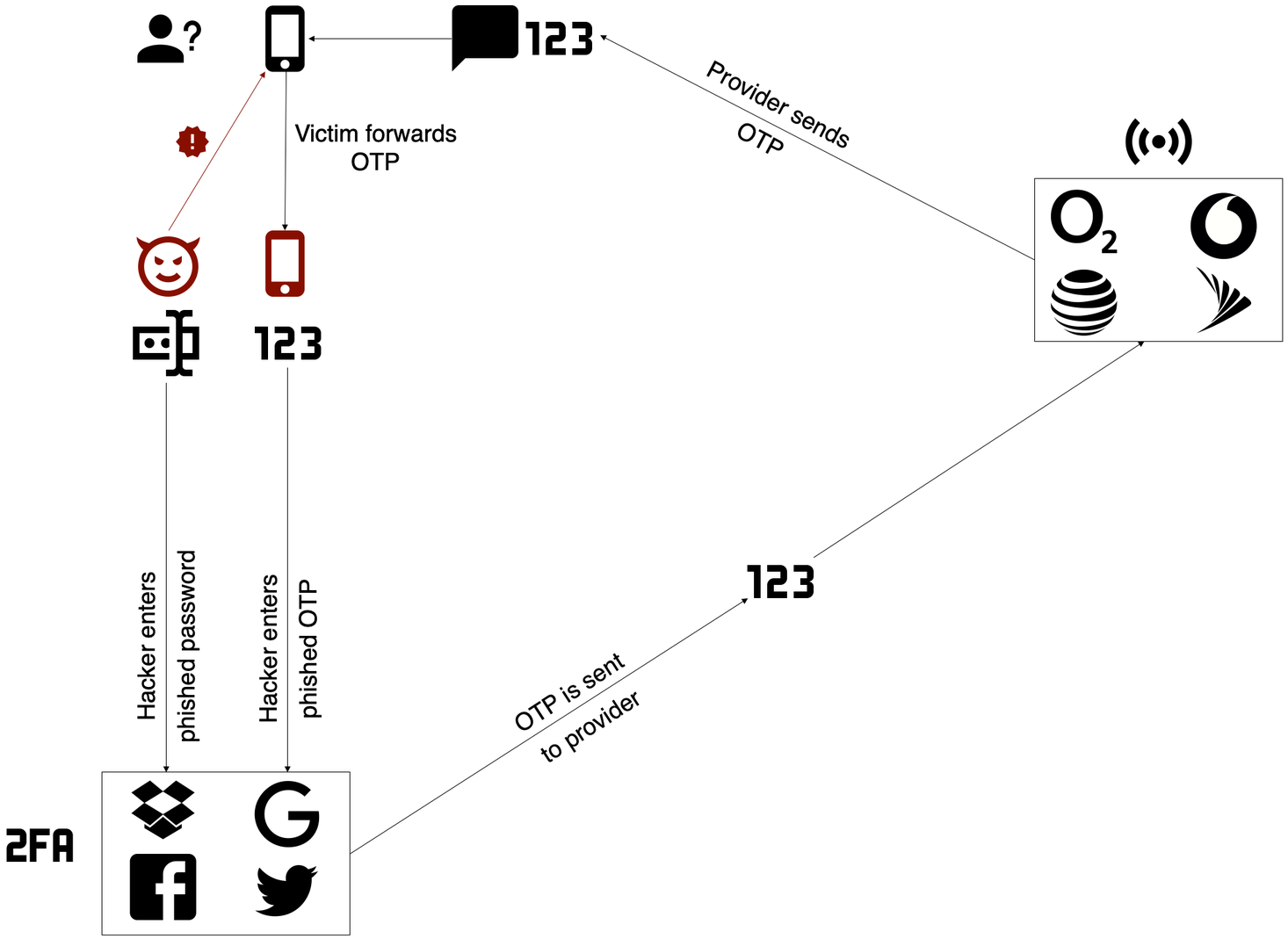
One-Time Passwords

- Used algorithm are secure
- Collisions of MD5 and SHA-1 do not expose a threat
- Exploitation of faulty configurations
  - Chosen alphabet is too small
  - Missing invalidation of the passwords
  - No restriction of authentication can enable brute-force attacks
  - Problems with time synchronization
  - Look ahead window can increase the attack surface
- Lack of requiring the second factor when disabling it

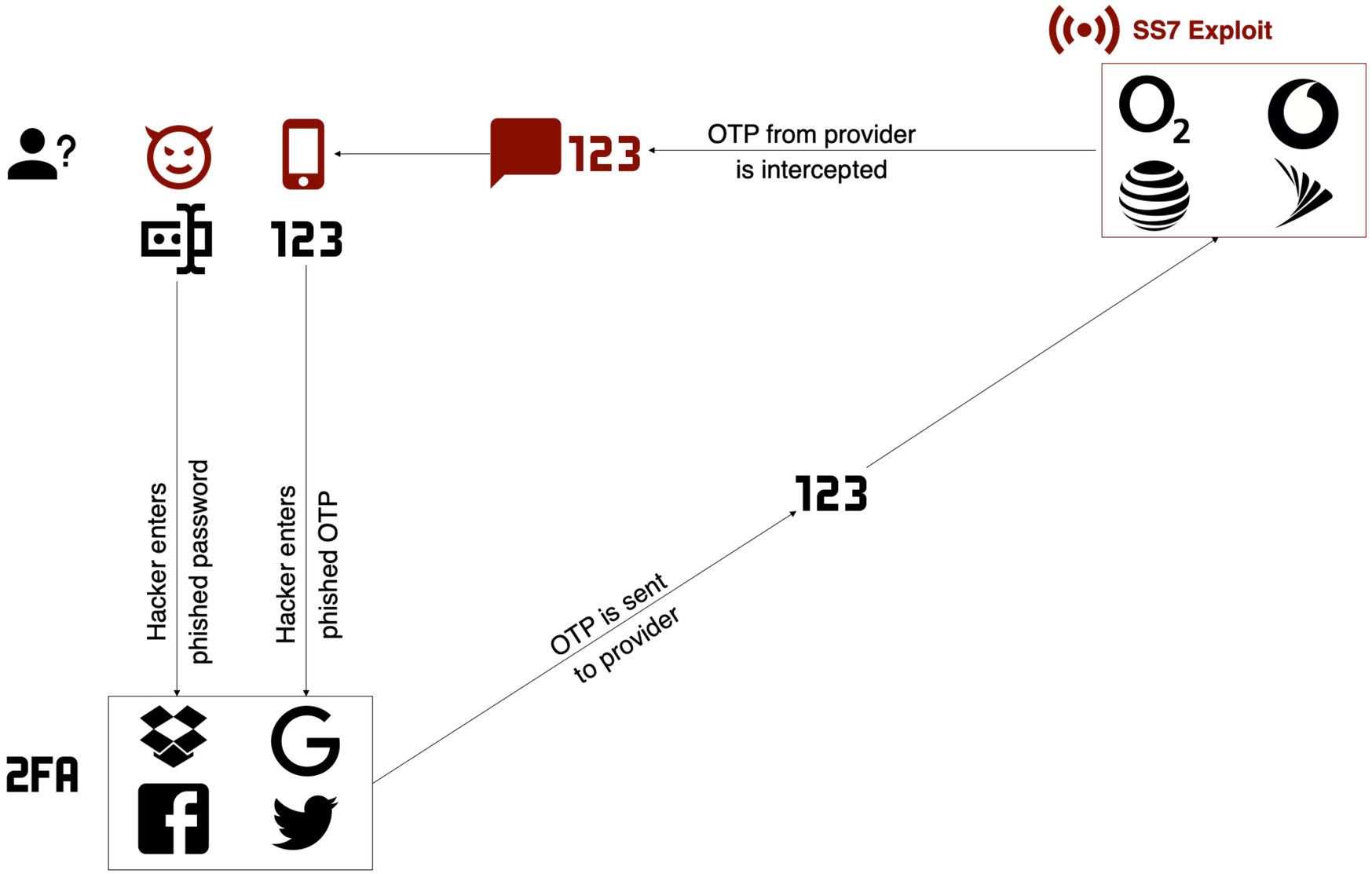
Successful Phishing Attack With 2FA enabled



Verification Code Forwarding Attack



SS7 Attack


SS7 Exploit
123
OTP from provider
is intercepted
123
Hacker enters
phished password
Hacker enters
phished OTP
123
OTP is sent
to provider
2FA

Security Keys

> Threats of authentication by possession apply, too
> RSA Hack in 2011 resulted in the replacement of 40 million tokens because the private key was stolen
> Often no possibility to upgrade the firmware on the security keys

> Vulnerability to side-channel attacks
> Physical attacks against the chips

> Central metadata service of the U2F protocol is a lucrative target

Web Authentication API

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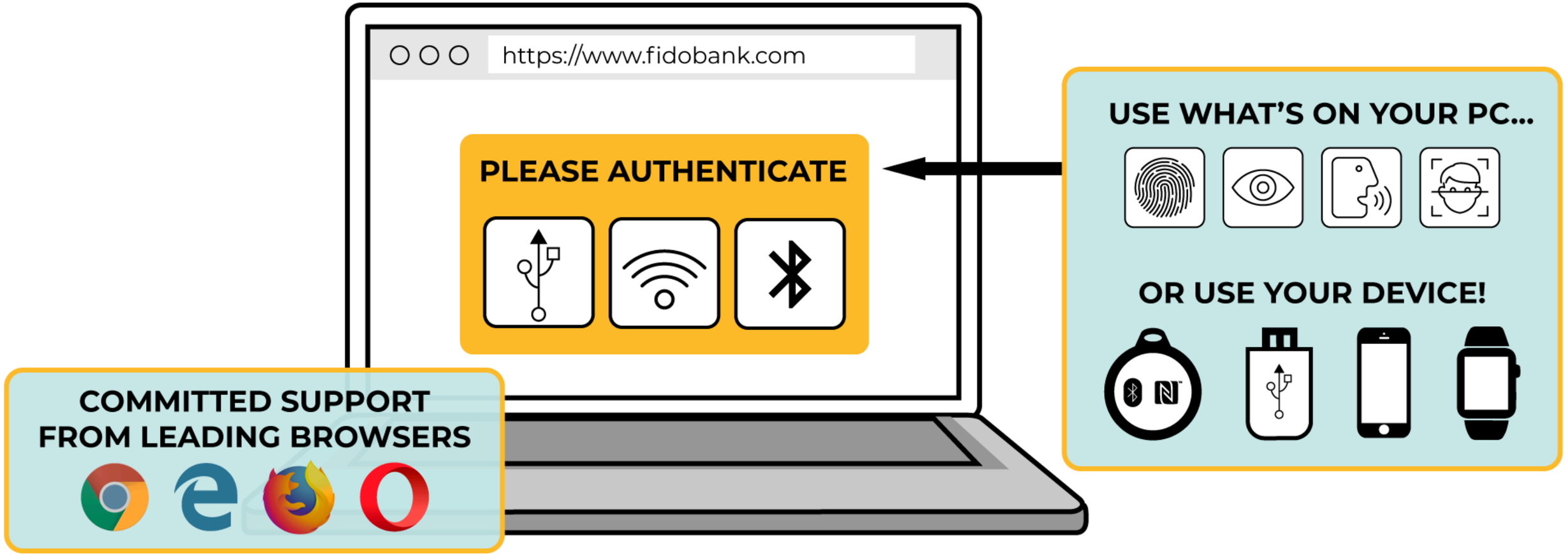
“An API for accessing Public Key Credentials [...]” [4]

“[...] enabling the creation and use of strong, [...] public key-based credentials by web applications, for the purpose of strongly authenticating users.” [4]

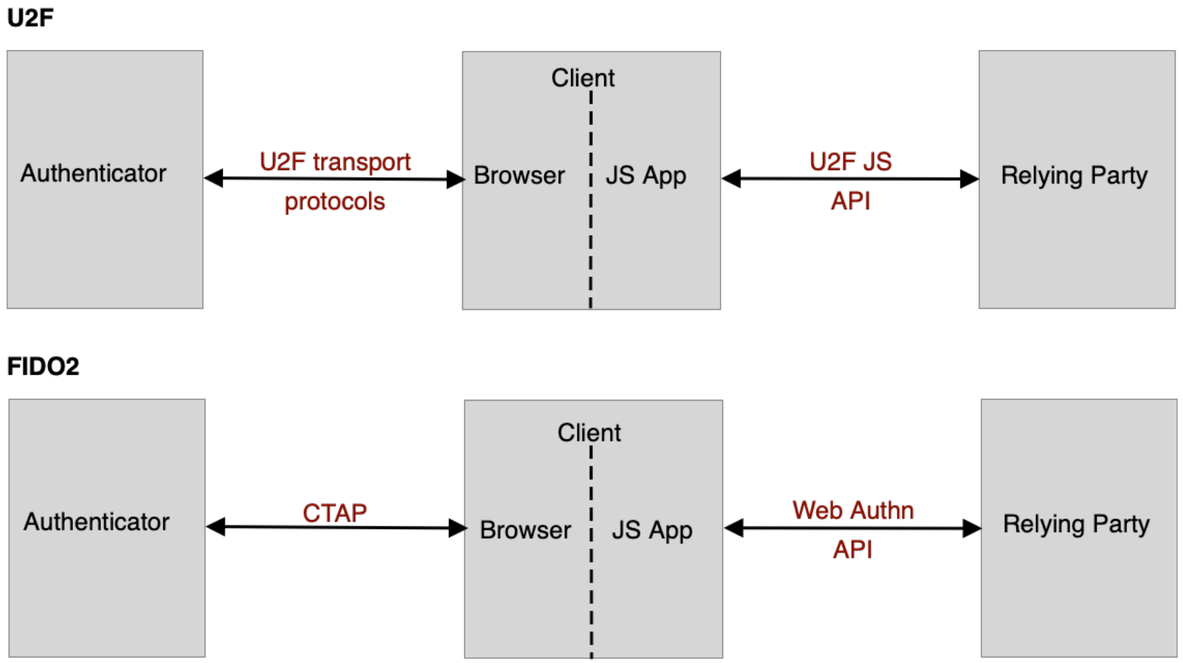
Web Authentication API



Source: https://www.w3.org/2018/04/pressrelease-webauthn-fido2.html.en; last accessed on 11/03/2019

Web Authentication API

- Allows **passwordless** registration, login und multi-factor authentication
- Based on Public-Key Authentication
- Part of FIDO2 (CTAP & Web Authentication API); specified as a standard by the W3C
- Backwards compatible to U2F



fido™ ALLIANCE

- Fast IDentity Online (FIDO)
- Founded in 2013
- Members (et al.)
  - PayPal, Google, Microsoft, Mastercard, VISA, Samsung, BSI
- Specifications of UAF, U2F, CTAP, and the first drat of the Web Authentication API as FIDO 2.0

Web Authentication API

> Authenticator can either be internal (built-in) or external (via USB, Bluetooth, or NFC)
> Supported by Chrome, Edge, Firefox, Safari, Chrome & Firefox für Android

> No support of the API by the Internet Explorer; problematic for the enterprise sector
> Many Android web browsers do not support the API
> No support of iOS Safari, only third-party app “Brave Browser” supports the API

Security Aspects

Security Aspects and Usability

- **No known successful attacks**
- Formally verified
- Security problems are only on a protocol level
  - Missing requirement of a secure random number generator
  - Support of RSASSA PKCS#1 v1.5 (=> Bleichenbacher's attack)
  - No point compression on the elliptic curve required
  - "Weak" choice of elliptic curves (Barreto-Naehring) with reduced amount of bits for security
- No possibility to backup or export the key material
  - Each account should be associated with at least two different authenticators

Comparison to Other MFA solutions

- Evolution of the U2F protocol, authentication by possession threats apply, too
  - Due to the specification by the W3C the browser support is increases
- In comparison to, e.g., TOTP some browsers and operating systems are missing support and interoperability
- WebAuthn is resistant against phishing, many other MFA solutions are not
- WebAuthn has no backup functionality
- No solution provides a protection for, e.g., session hijacking

Conclusion

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Conclusion

Generally

> Sensitization of the users about the dangers
> Increase awareness for a secure handling of credentials

Existing MFA solutions

> MFA can increase the security, but is often not resistant against phishing
> SMS traffic can be eavesdropped
> Problems with password still remain

Web Authentication API

> Can replace passwords with public-key authentication
> Allows registration, login, and MFA with the help of public-key authentication
> Currently not supported enough, especially in mobile operating systems and web browsers
> Few websites have implemented the API

Sources

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2. Olabode Anise and Kyle Lady. State of the Auth: Experiences and Perceptions of Multi-Factor Authentication. Nov. 7, 2019: URL: https://duo.com/blog/state-of-the-auth-experiences-and-perceptions-of-multi-factor-authentication (last accessed on 11/03/2019).
3. Kurt Thomas et al. “Protecting accounts from credential stuffing with password breach alerting.” In: 28th USENIX Security Symposium. USENIX Security ’19. Santa Clara, CA, USA: USENIX Association, Aug. 2019, pp. 1556–1571. ISBN: 978-1-939133-06-9.
4. Dirk Balfanz et al. Web Authentication: An API for accessing Public Key Credentials Level 1. Mar. 4, 2019. URL: https://www.w3.org/TR/2019/REC-webauthn-1-20190304 (last accessed on 11/03/2019).