FIDO beyond the browser

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FOSDEM - 3 Feb 2023

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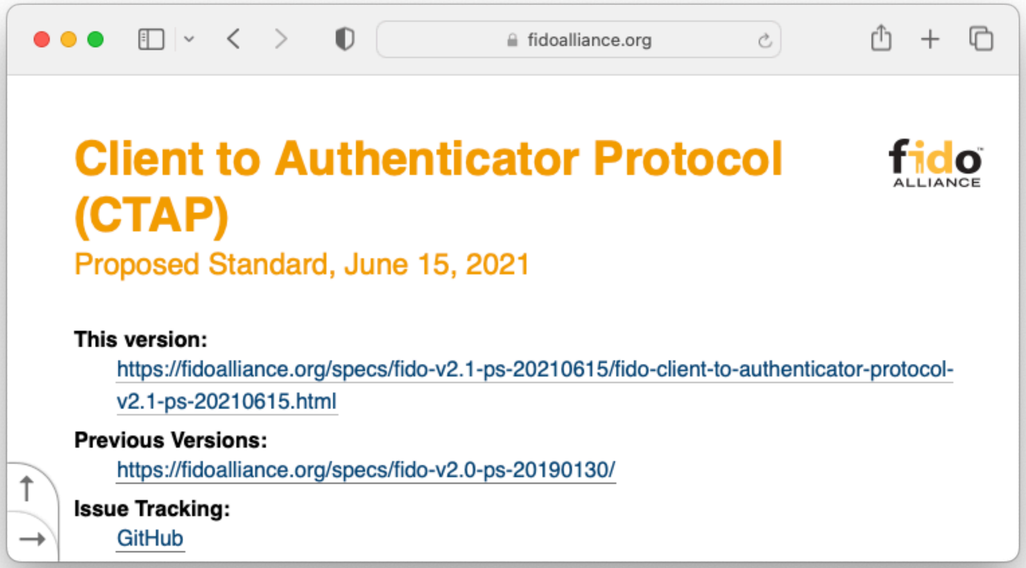
Overview

- What is FIDO?
- FIDO Security Keys
- Device attestation and the FIDO metadata service
- libfido2
- FIDO2 extensions
- Example use cases:
  - Authentication: pam-u2f, ssh
  - Signing: git commit signing
  - Encryption: LUKS2 disk encryption
  - Storage: SSH certificates

FIDO2

- Specifications:
  - CTAP - using a FIDO authenticator from a client (e.g. a browser)
  - Webauthn: API for using FIDO credentials in web applications



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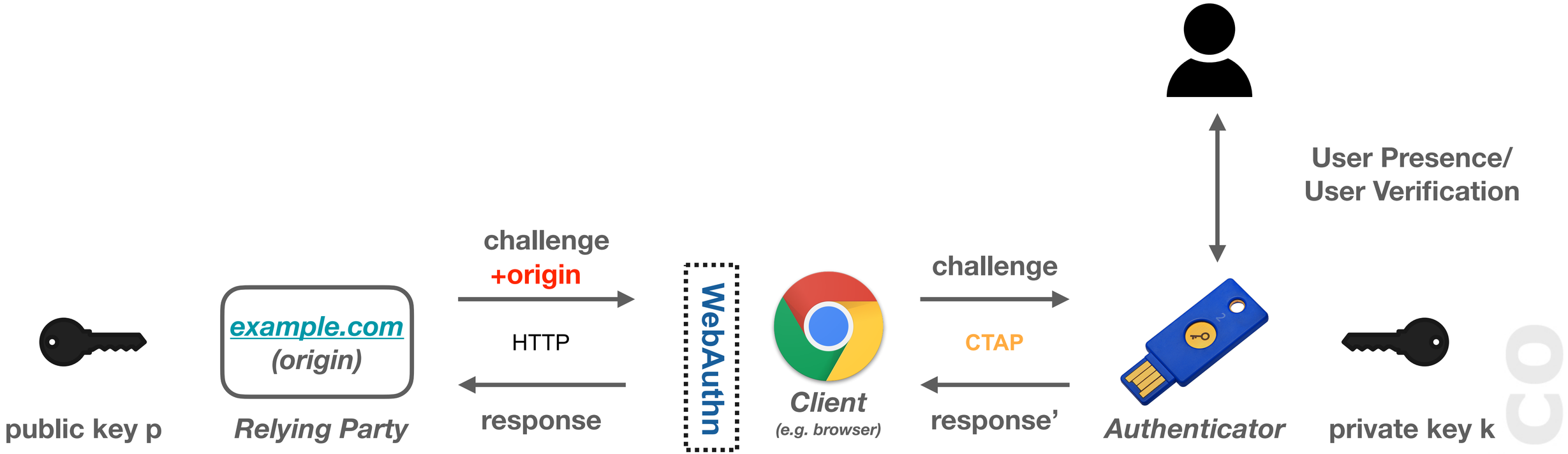
CTAP and Webauthn (simplified)



result = verify(p, response, challenge)
+origin

response = sign(k, challenge)
+origin

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FIDO Security Keys: roaming authenticators

CTAP: operations (simplified)

uID	credId	pub
jdoe	0xa1b2	0x41…

(RP user store)

RP

Client

Authenticator

credId	uID	rpID	priv
0xa1b2	jdoe	eg.com	0xf1…

(authR credential mapping)

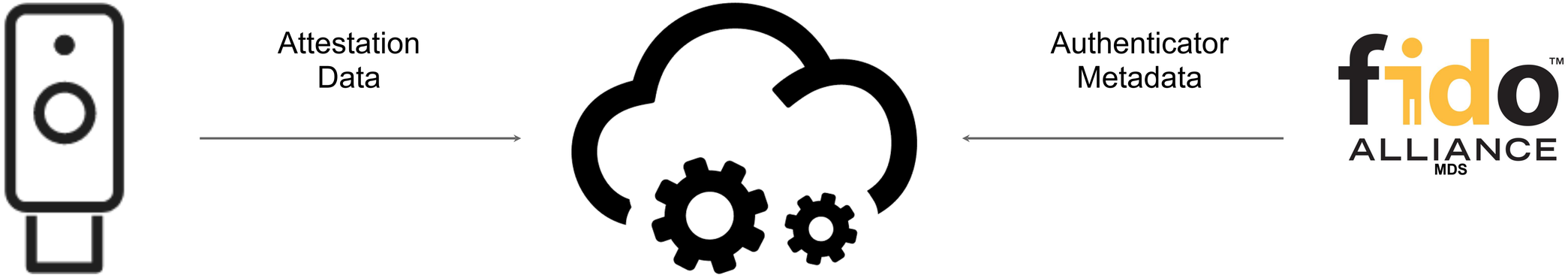
```
                                    makeCredential(rpId, uID, cData, …)
                                    (priv,pub) = genKeyPair()
                                    credId = genCredId(…)
                                    map {credId, uID, rpID} → priv
                                    signature = sign(…)
                                    { credId, pub, signature, … }
verify(resp,signature)
store[uID] = {credId, pub}

…

{credId, pub} = store[uID]
                                    getAssertion(credID, rpId, cData, …)
                                    priv = lookup {credID}
                                    signature = sign(priv, rpId, cData…)
                                    { signature, … }
verify(pub, resp, signature)
```

Attestation and Metadata

- Attestation provides verifiable evidence as to the authenticator’s origin
- Based on a hardware attestation key and certificate
- Use FIDO Alliance Metadata Service to determine provenance
- Implement Allow/Deny lists to filter Authenticators
- Typically used in high-assurance (enterprise) use cases



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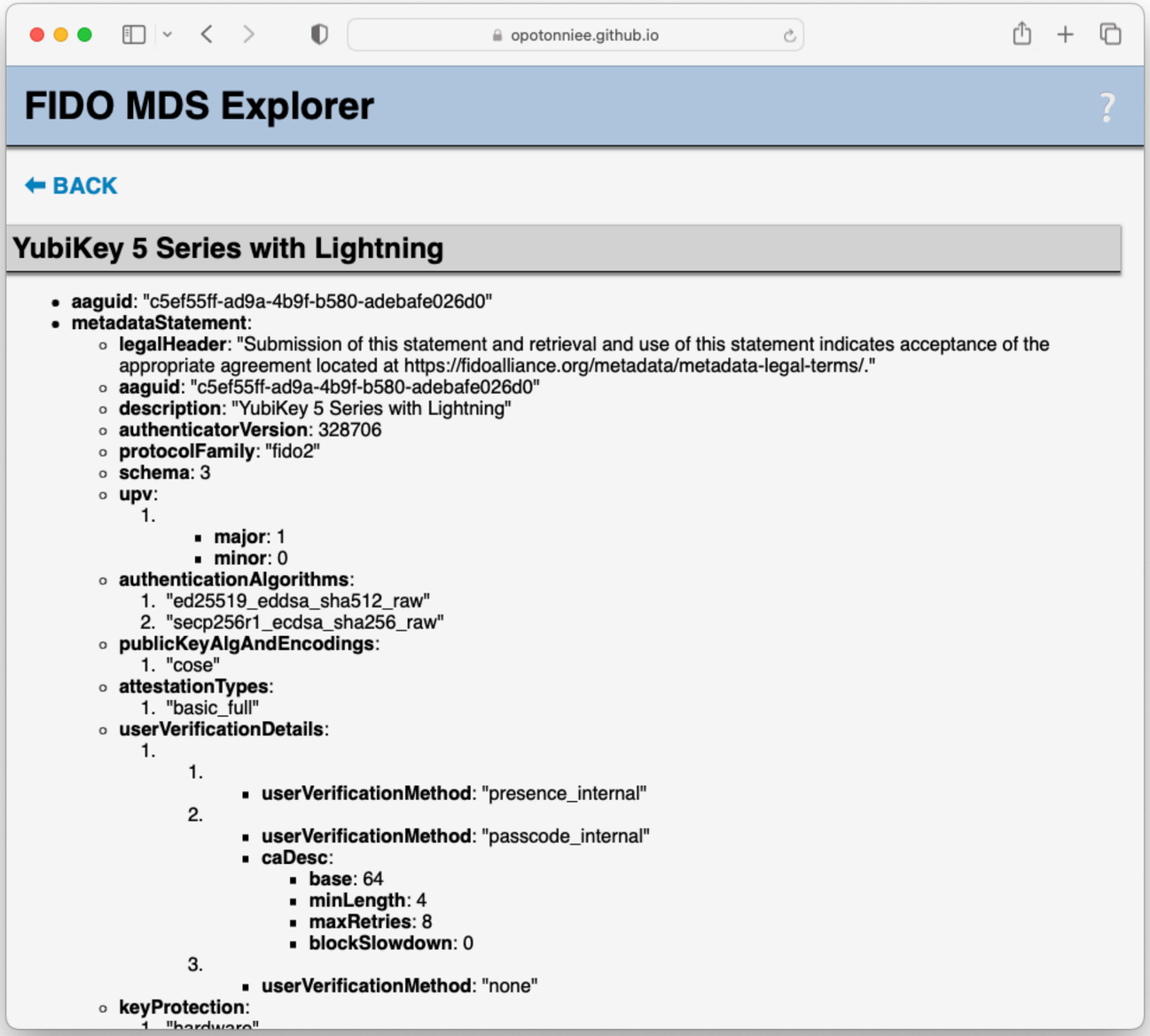
Metadata example

- `aaguid`
  (Authenticator unique ID)
- `keyProtection`
  `e.g. secure_element`
- `transports`
  `e.g. usb`
- `status`
  (certification level)



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FIDO Metadata Service

DEMO

- retrieve FIDO metadata JWT:

```
curl -Ls https://mds3.fidoalliance.org/ --output md.jwt
```

- extract certificate chain from JWT header (skipped):

```
[mds.pem, intermediates.pem]
```

- verify certificate chain:

```
openssl verify -CAfile cacerts.pem -untrusted intermediates.pem mds.pem
```

- verify JWT (using smallstep CLI):

```
cat md.jwt | step crypto jwt verify --key mds.pem --alg RS256 --subtle \
           | jq .payload > md.json
```

- parsing JSON (using jq):

```
cat md.json | jq -r '.entries[] | select(.aaguid) | .metadataStatement \
                                | [.aaguid,.description] | @tsv'
```

- example output:

```
ee882879-721c-4913-9775-3dfcce97072a YubiKey 5 Series
…
```


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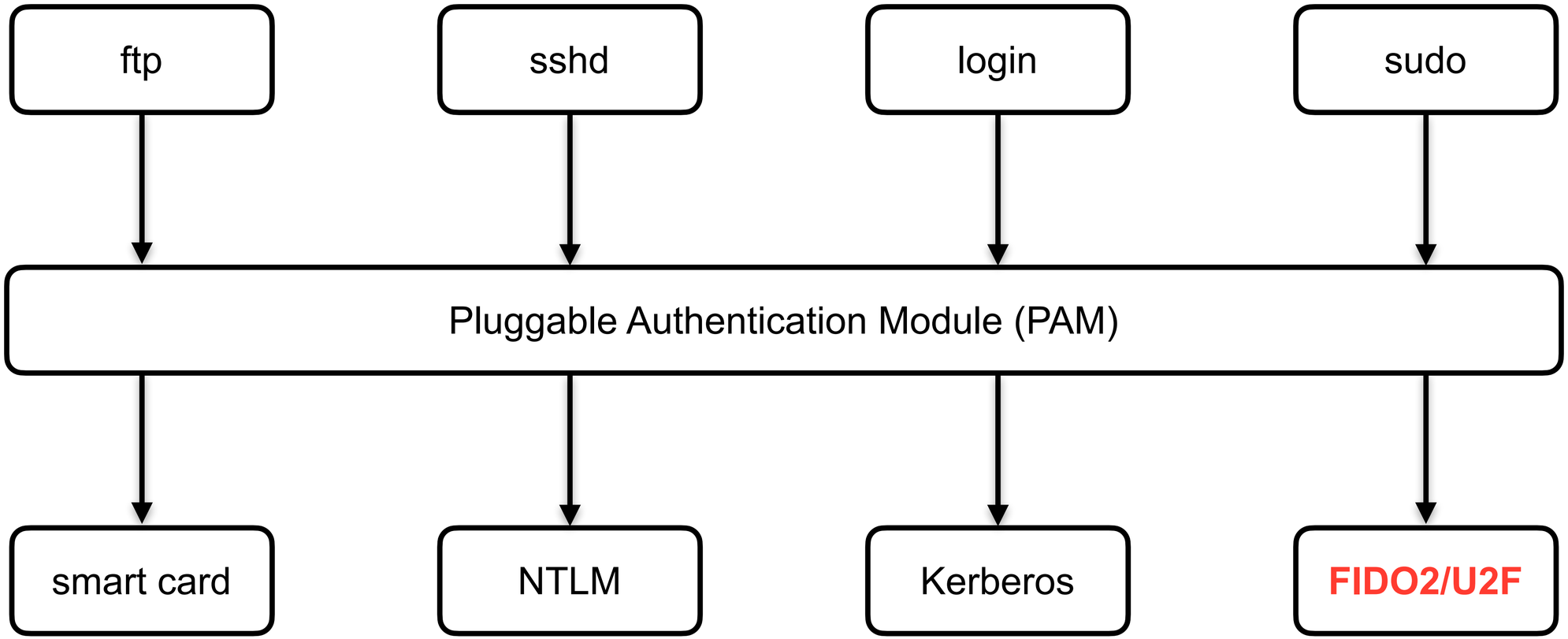
libfido2

- https://github.com/Yubico/libfido2
- Library and command-line tools
- Communicate with a FIDO device over USB or NFC
- Supports both FIDO U2F (CTAP 1) and FIDO2 (CTAP 2) protocols
- Works on Linux, macOS, Windows, OpenBSD, and FreeBSD
- Bindings for .NET, Go, Perl, Rust
- Also available:
  - https://github.com/Yubico/python-fido2

Example: pam-u2f



pam-u2f

- Pluggable Authentication Module (PAM) for U2F and FIDO2
- Require a FIDO credential on a security key
  when authenticating to a service
- Included in many distributions by default
- See also
  - Code: https://github.com/Yubico/pam-u2f
  - Docs: https://developers.yubico.com/pam-u2f/

example: require MFA for sudo

DEMO

- Install:
  ```
  apt install libpam-u2f
  ```
- Register a FIDO credential:
  ```
  pamu2fcfg > ~/.config/fido_keys
  ```
- Configure `/etc/pam.d/sudo`:
  ```
  @include common-auth
  auth required pam_u2f.so cue authfile=.config/fido_keys
  ```
- Test:
  ```
  $ sudo echo Ok
  [sudo] password for joost:
  Please touch the device.
  Ok
  $
  ```

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SSH keys backed by FIDO Security Keys

ID	RP ID	private_key
key_handle	“ssh:”	0xdeadbeef…

id_ecdsa

"sk-ecdsa-sha2-nistp256@openssh.com"
nistp256
Q
“ssh:” (rpID)
flags
key_handle (=credId)

id_ecdsa.pub

“sk-ecdsa-sha2-nistp256@openssh.com"
nistp256
Q
“ssh:” (rpID)

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SSH example: generating keys

DEMO

- Generate hardware backed ECDSA SSH key pair:

```
$ ssh-keygen -t ecdsa-sk -f ./id -N ""
Generating public/private ecdsa-sk key pair.
You may need to touch your authenticator to authorize key generation.
Enter PIN for authenticator: ********
You may need to touch your authenticator again to authorize key generation.
Your identification has been saved in ./id
Your public key has been saved in ./id.pub
The key fingerprint is:
SHA256:eGO0VlLwvP4rWPMdRYprfQ8F1tmnTQJWGq8WjV97pHk user@machine
The key's randomart image is:
...
```

- Idem, using ED25519:

```
$ ssh-keygen -t ed25519-sk -f ./id2 -N ""
```


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SSH example: authenticating to GitHub

DEMO

- Register your public key at GitHub:
  https://github.com/settings/keys

- Authenticate to a git repo over SSH:

```
$ git clone git@github.com:user/repo.git
Cloning into 'repo'...
Confirm user presence for key ED25519-SK SHA256:FpybChVXHU/…+8x0
User presence confirmed
...
Resolving deltas: 100% (6/6), done.
```


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SSH example: signing files

DEMO

- Generate hardware backed SSH key pair:
  `ssh-keygen -t ecdsa-sk -f ./id1 -N ""`
- Sign (in `file` namespace):
  `ssh-keygen -Y sign -n file -f ./id1 datafile`
  (generates signature in `datafile.sig`)
- Verify:

```
ssh-keygen -Y verify -n file -s datafile.sig \
           -f ./allowed_signers -I user1@example < datafile
```

- Trusted public keys in `allowed_signers`:

```
# user         key type                                pubkey
user1@example sk-ecdsa-sha2-nistp256@openssh.com AAAAInNr…3NoOg==
```


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Git example: commit signing

DEMO

- Generate hardware backed SSH key pair:
  ```
  ssh-keygen -t ecdsa-sk -f ~/.ssh/id1 -N ""
  ```
- Configure git:
  ```
  git config gpg.format ssh
  git config user.signingKey ~/.ssh/id1
  git config gpg.ssh.allowedSignersFile ~/.ssh/allowed_signers
  ```
- Sign a commit:
  ```
  git commit -S -m'initial import'
  ```
- Sign a tag:
  ```
  git tag -s v1.0 -m'signed v1.0 tag'
  ```
- Show and verify signatures:
  ```
  git log --oneline -show-signature
  ```


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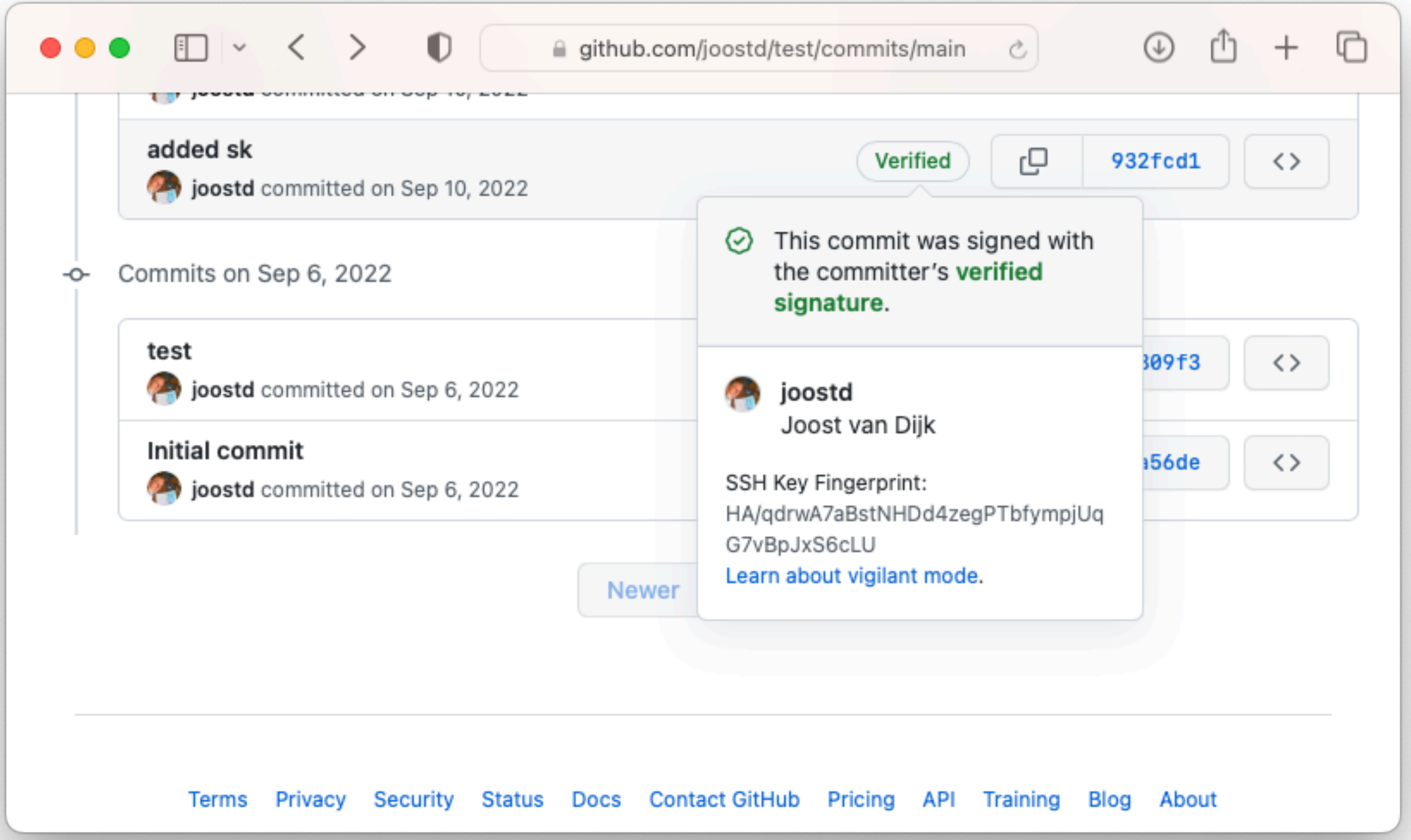
github.com/joostd/test/commits/main
added sk
joostd committed on Sep 10, 2022
Verified
932fcd1
Commits on Sep 6, 2022
test
joostd committed on Sep 6, 2022
Initial commit
joostd committed on Sep 6, 2022
This commit was signed with the committer's verified signature.
joostd
Joost van Dijk
SSH Key Fingerprint:
HA/qdrwA7aBstNHDd4zegPTbfympjUq
G7vBpJxS6cLU
Learn about vigilant mode.
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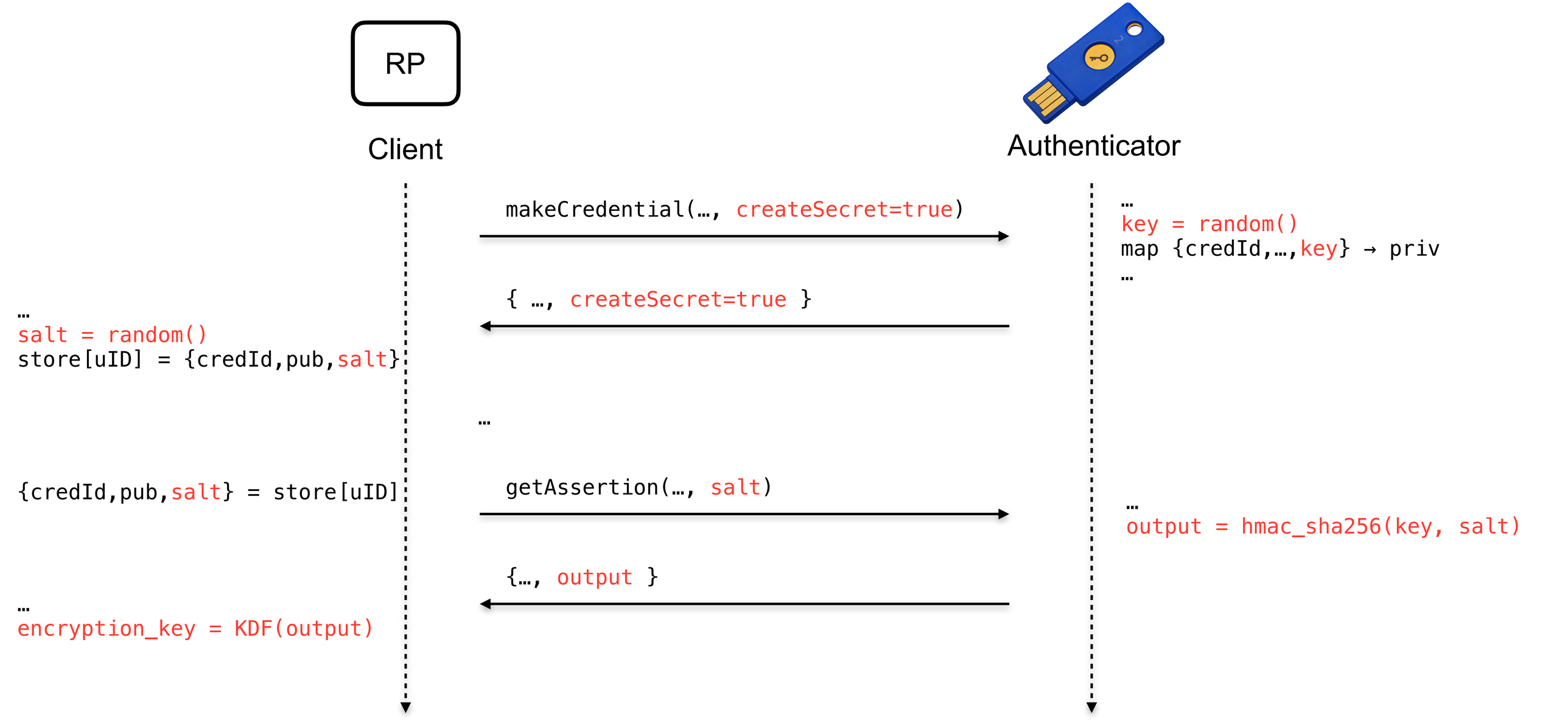
hmac-secret extension

- Goal: retrieve a symmetric secret from the authenticator
- On Windows: ensures you can sign-in to your device when it's off-line or in airplane mode
- Part of the secret is held by the client (the salt) and the other part of the secret is attached to the credential on the key.
- Combining the salt and the credential will produce the secret.
- Maintain different secrets on different systems.

CTAP: hmac-secret (simplified)



hmac-secret: example

DEMO

- Generate a resident (-r) FIDO credential with hmac-secret (-h):
```
cred -r -h -k ./pubkey -P myPIN /dev/hidraw1
```
- Generate some random salt:
```
cat /dev/urandom | head -c32 > ./salt
```
- Generate a secret key using our FIDO credential and our salt:
```
assert -p -h ./secret -s ./salt -P myPIN ./pubkey /dev/hidraw1
```
- Some data to encrypt:
```
echo some secret data > plaintext
```
- Encrypt our data (*safe to delete secret key and plaintext*)
```
openssl enc -aes256 -e -pass file:./secret \
            -in ./plaintext -out ./ciphertext
```
- Decrypt our data (*may need to regenerate secret key first*)
```
openssl enc -aes256 -d -pass file:./secret -in ./ciphertext
```

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hmac-secret application: LUKS

- LUKS (Linux Unified Key Setup) disk encryption
- systemd v248+ supports unlocking LUKS2 volumes using FIDO2 security keys
- derives the disk decryption key from a FIDO credential using the hmac-secret extension

- Enroll a FIDO2 authenticator to a LUKS2 encrypted volume:
  `systemd-cryptenroll –fido2-device=/dev/hidraw1 /dev/sda1`

largeBlobs extension

- store arbitrary data associated with credentials
- size ~1KB
- Requires a CTAP 2.1 security key
- Example use: store SSH certificates

example: store SSH certificates

DEMO

- store (-S) an SSH certificate as a largeBlob:
  `fido2-token -S -b -n ssh: ./id_ecdsa-cert.pub /dev/hidraw1`
- list (-L) largeBlobs:
  `fido2-token -L -b /dev/hidraw1`
- retrieve (-G) a largeBlob and save it to file:
  `fido2-token -G -b -n ssh: out.blob /dev/hidraw1`
- delete (-D) a largeBlob:
  `fido2-token -D -b -n ssh: /dev/hidraw1`

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Device attestation example: SSH commit

- Prove that the key that signed a file (or git commit, or …) was backed by a FIDO security key
- Produce an attestation statement when generating keys:

```
ssh-keygen -t "ed25519-sk" -f ./sk -N "" \
           -O write-attestation=attest.bin -O challenge=challengefile
```

- Extract attestation certificate, signature, and data from `attest.bin`
- Verify attestation certificate using FIDO MDS
- Verify attestation signature over data using attestation certificate
- Lookup AAGUID in FIDO MDS to find security key make and model

Conclusion

- FIDO2 comprises open standards CTAP and Webauthn
- FIDO2 security keys can be used as an alternative to traditional hardware security devices such as smart cards
  - More affordable
  - More user-friendly
  - More privacy-preserving
  - Primarily for authentication, but also for signing and encryption
  - Easy to integrate using Open Source software libraries

- Need help? Reach out!

Resources

- Developer Program: https://dev.yubi.co/
- CTAP 2.1 spec: https://fidoalliance.org/specs/fido-v2.1-ps-20210615/fido-client-to-authenticator-protocol-v2.1-ps-20210615.html
- FIDO dev forum: https://groups.google.com/a/fidoalliance.org/g/fido-dev
- libfido2: https://github.com/Yubico/libfido2
- FIDO Metadata:
  - https://fidoalliance.org/metadata/
  - https://opotonniee.github.io/fido-mds-explorer/
- SSH support for security keys:
  - https://github.com/openssh/openssh-portable/blob/master/PROTOCOL.u2f
- PAM u2f: https://github.com/Yubico/pam-u2f
- LUKS2 and cryptsetup: https://www.freedesktop.org/software/systemd/man/systemd-cryptenroll.html

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Questions?