ECE458/ECE750T27: Computer Security

Cryptography: Linking Keys and Identities

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Last lecture:

- Symmetric vs Asymmetric Cryptography
- Diffie-Hellman key exchange (Symmetric key exchange)
- Public/Private key cryptography
  - Knapsack cryptosystem (Asymmetric key generation)

- These can create a shared secret key but….
  - Diffie-Hellman – key use only proves that communication partner same as when key was generated
  - Public/private – key use proves nothing about authentication

Encryption properties we want:

1. The communication between you and the other party is **confidential** and has **not been changed (integrity)**
   - No one can read what you sent
   - No one can change what you sent
2. **Knowing who** you are communicating with (authenticity)
   - You are talking to who you think you are talking to and not someone else

LINKING KEYS AND IDENTITIES

We still have a problem:

Public/Private still assumes that we know which key goes with which person/entity.

Linking keys to identities is one of the founding problems in Usable Security and Privacy.

Even now we have no good answer.

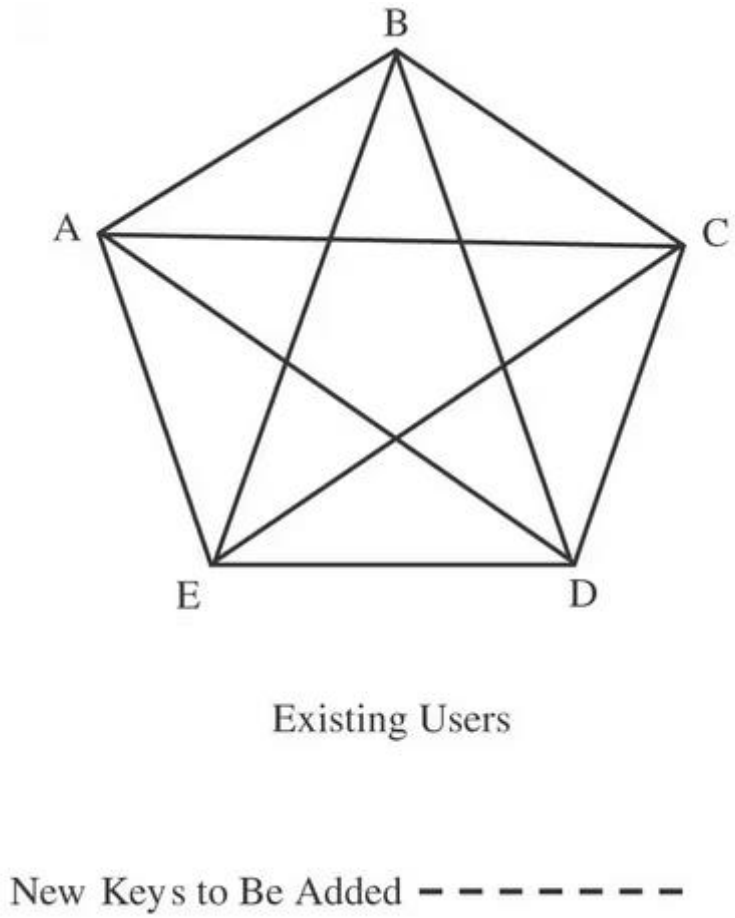
How do we solve the identity problem?

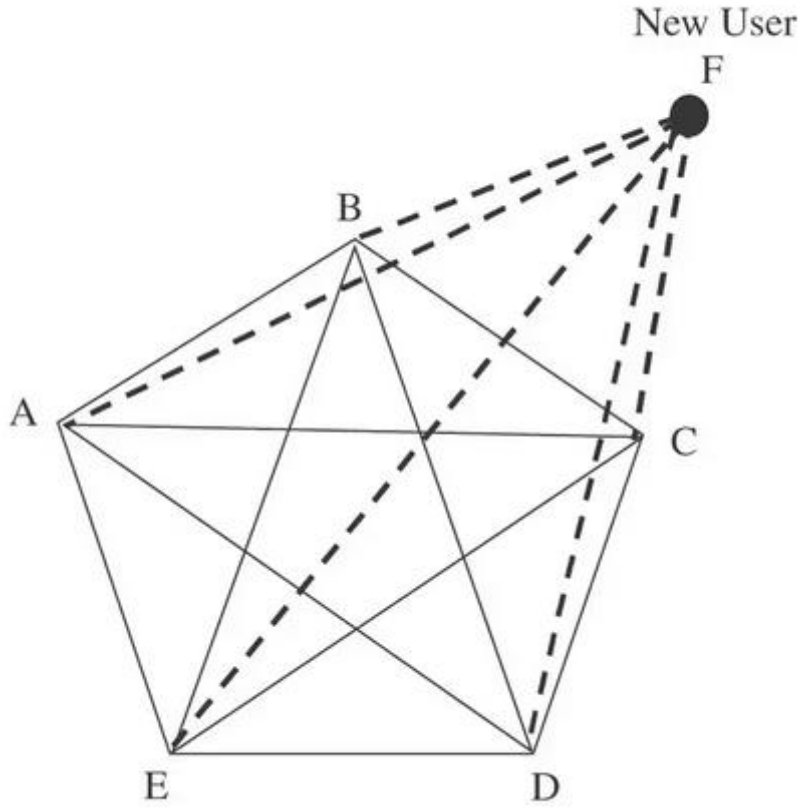
Idea: Have the humans do the linking of identity to cryptographic keys.

Approach scales poorly

An n user system requires n*(n-1)/2 keys

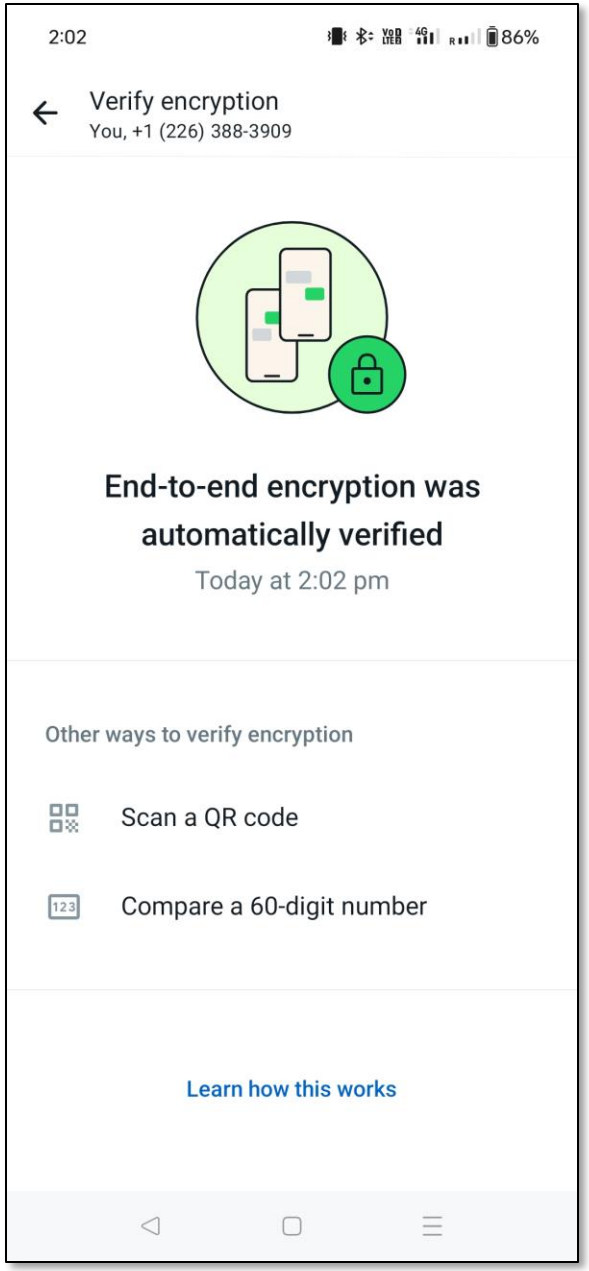
Expecting people to verify that many keys, as well as store and not loose them is unreasonable



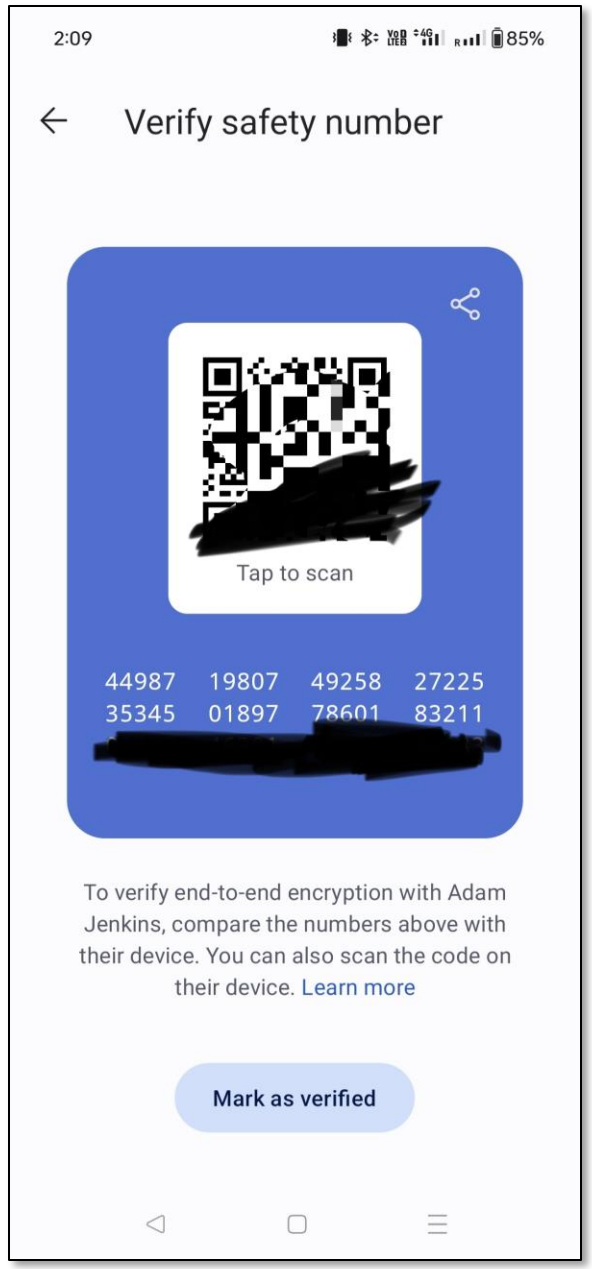


User comparing of keys is still used for verification today by common apps like WhatsApp and Signal.

WhatsApp



Signal



We could post the public key somewhere highly public and verifiable it came from us.

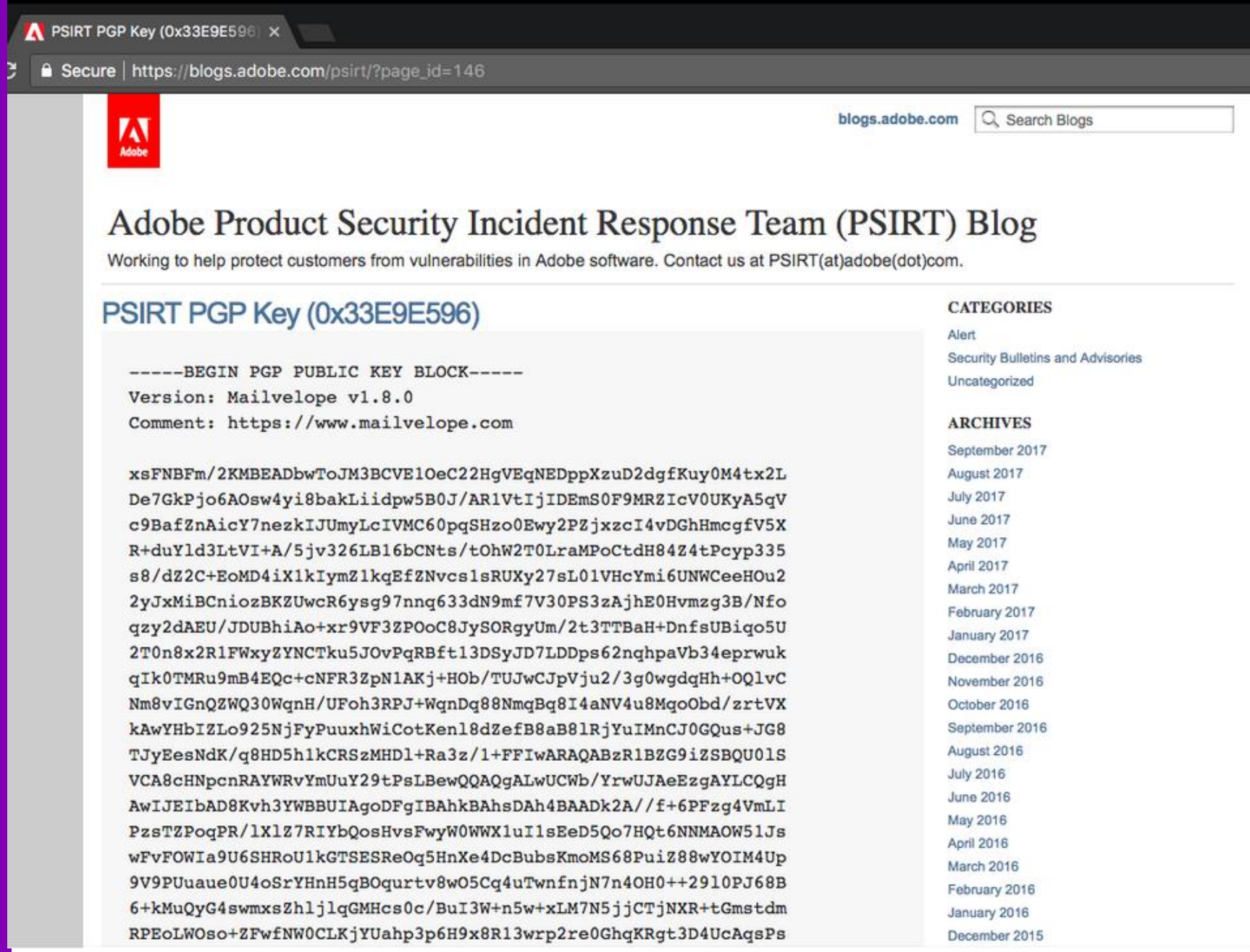


Photo credit: Juho Nurminen @jupenur

Other people can then compare the keys on their computers to the highly visible copy.

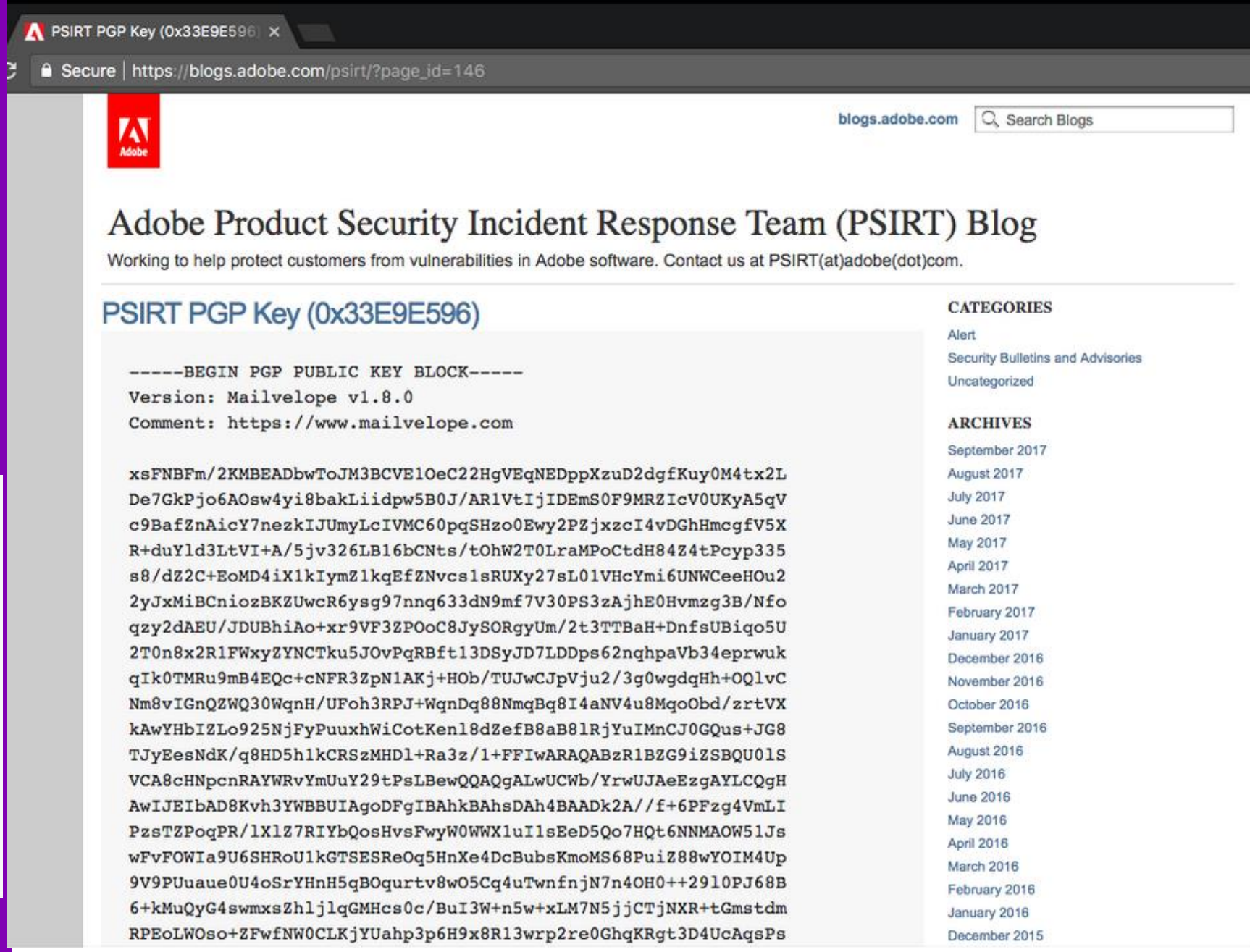


Photo credit: Juho Nurminen
@jupenur

Though we must be careful to post ONLY the public key…

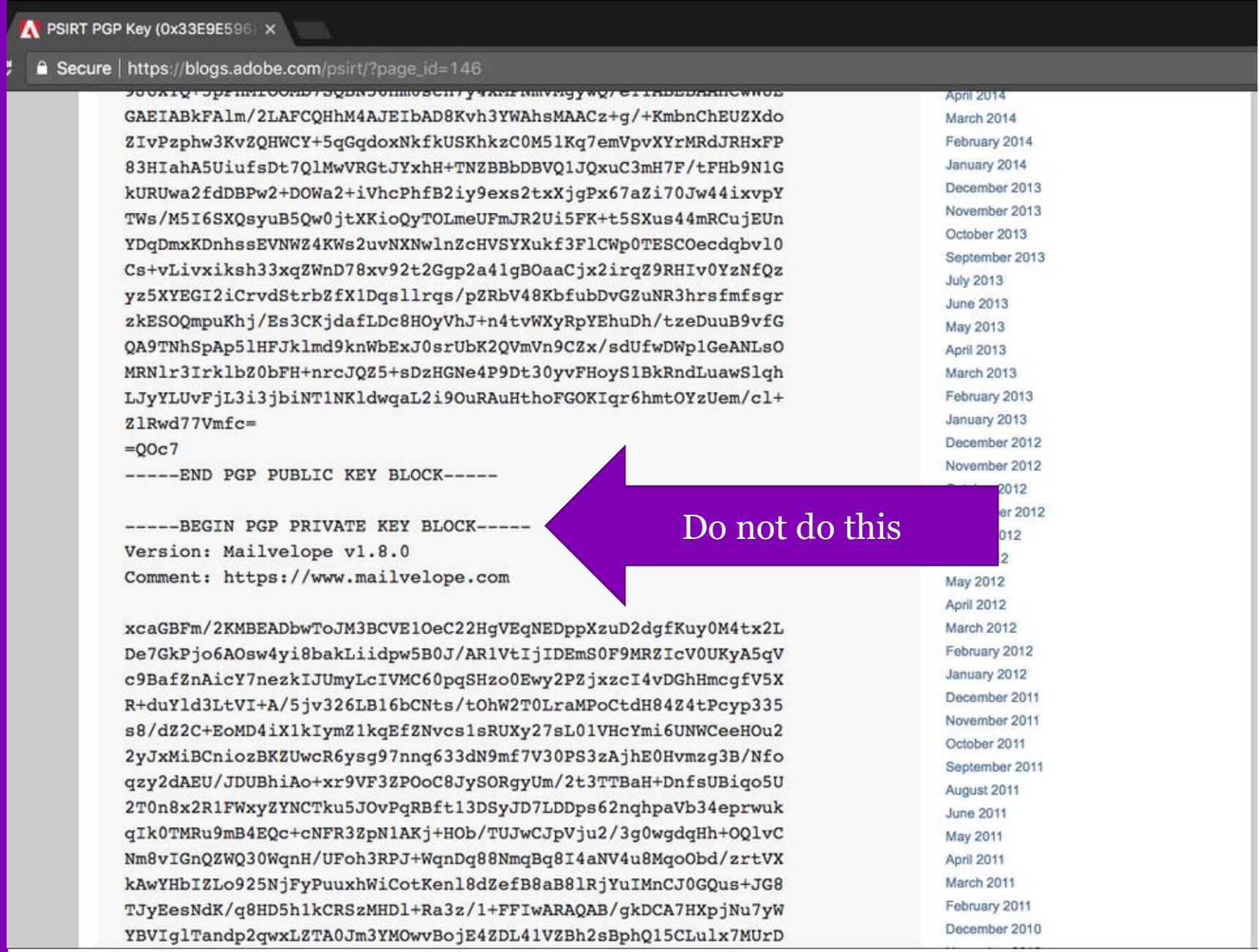


Photo credit: Juho Nurminen @jupenur

Nice idea, but it does not scale.

Also a chicken-and-egg problem. How do we find a place guaranteed to be from us without using cryptography?

Idea 2: Crowdsourcing!
We could slowly build a web of verifications like:

Alice verified Bob's key
Bob verified Charlie's key
so
Alice can trust Charlie's key

Web of trust

- Alice hand verifies that Bob's public key really does belong to Bob
- Then Alice "signs" the key by encrypting it with her private key.
- Now anyone that has hand verified Alice's key, can also trust Bob's key (if they trust Alice to do verifications).
- Key signing parties 

My public key

-----BEGIN PGP PUBLIC KEY BLOCK-----
Version: GnuPG v2

mQENBFHMcgABCAC9WrYDO6K2L3VHyi4eHN6suHLqMpJ+SO+IUTuLEVnUzIoXAUXH
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bFBpsUuBGaYZTSS05x1RdXHqpEbgap8dtuHhVvJw9QYDQBJr0K4aKyG9qqMD8cta
Pl/FAdyAqwH8Nw9efqAK+RQxSVUaue9BYEnbIRpsDK6MkP3YMFmu5ki5AQ0EUcxy
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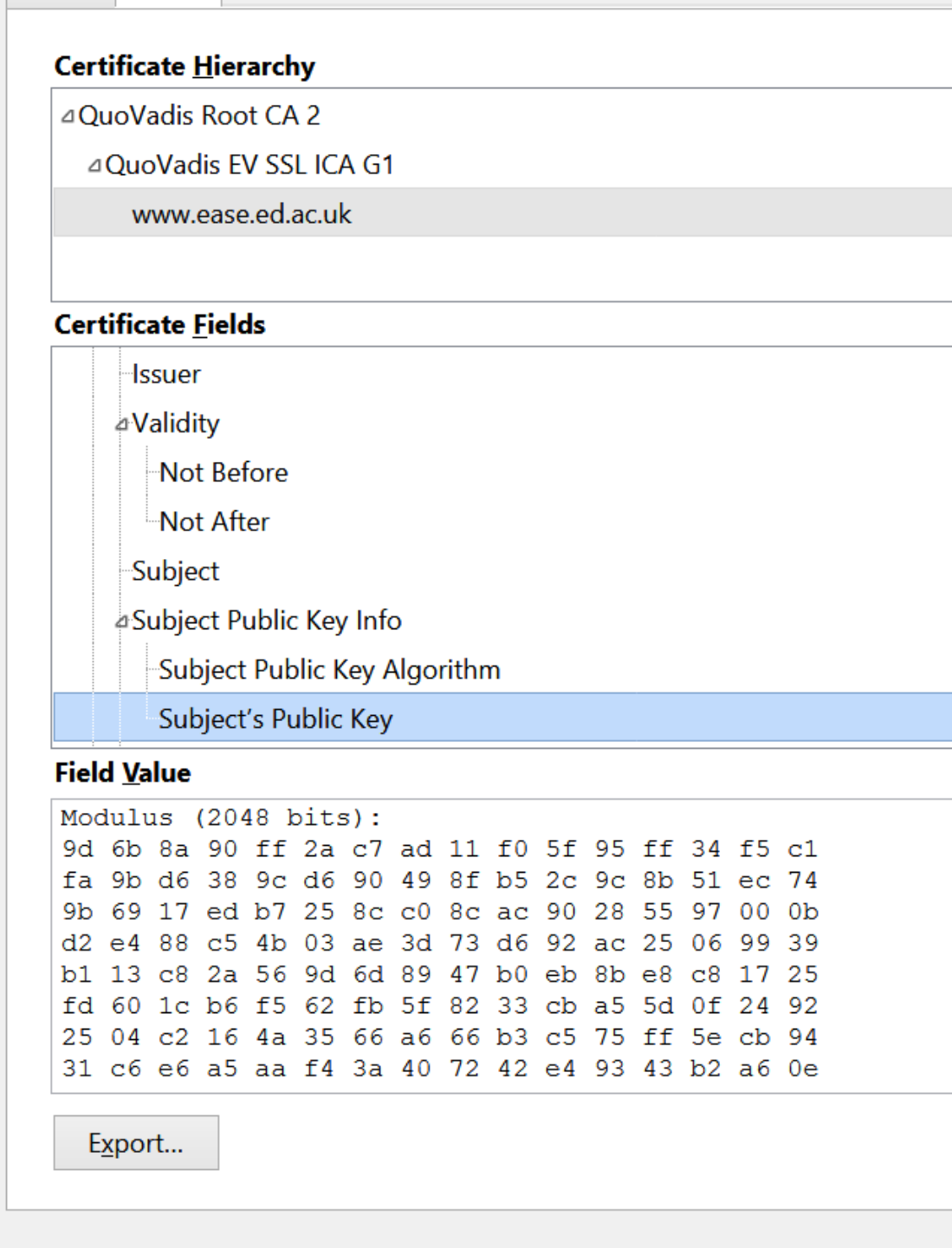
YKG3gbV9iyczAS31gbogVLAZqNSWhp8vVIEE28Fyf/Ed
=x5FK
-----END PGP PUBLIC KEY BLOCK-----

Wonderful idea in theory. But verifying those long keys is hard… also I don’t trust most people to do a thorough job of it….

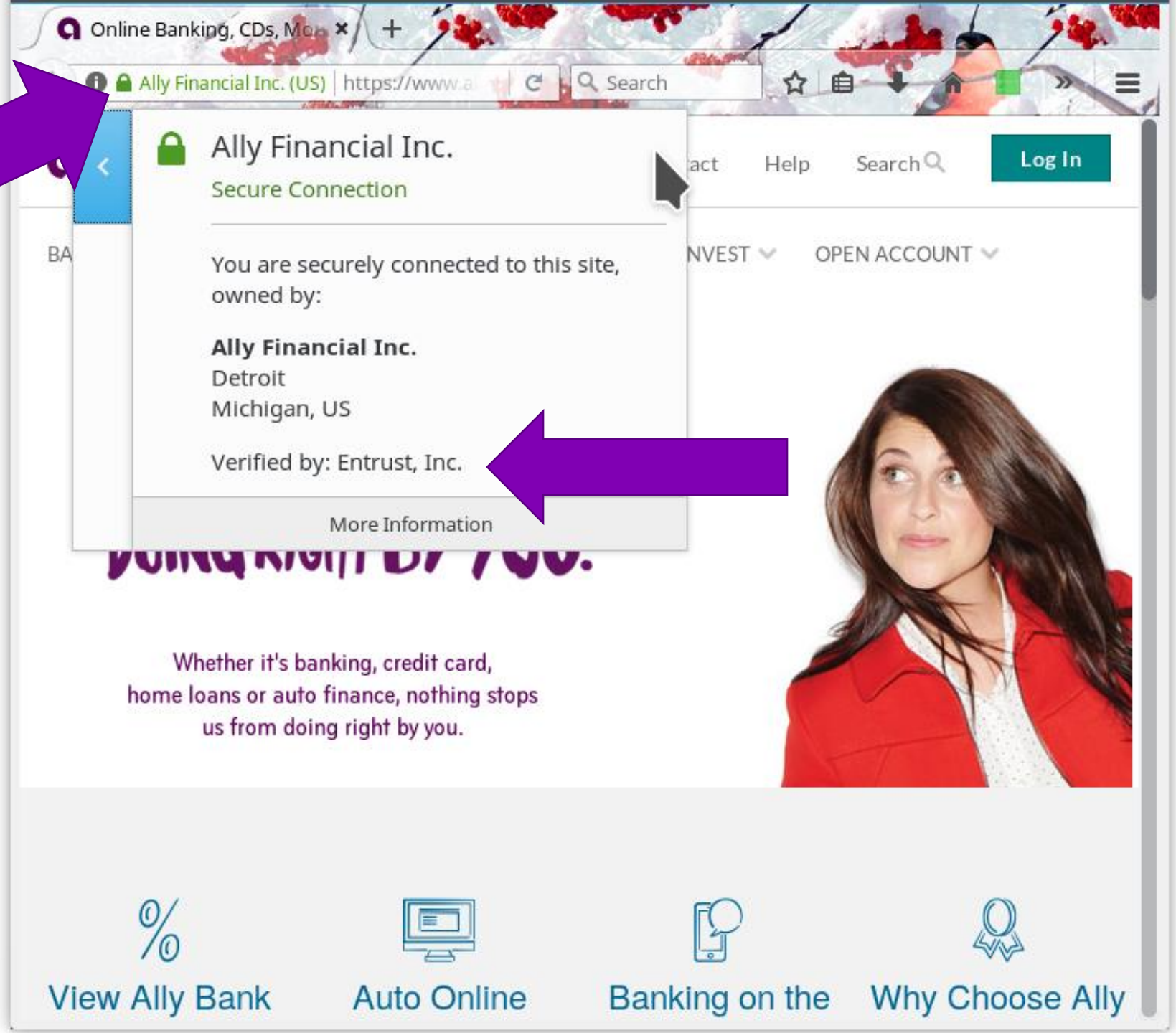
Idea 3: What if a couple of trusted groups did the verifications. Then they could have high standards and everyone could just trust them.

Certificate Authorities

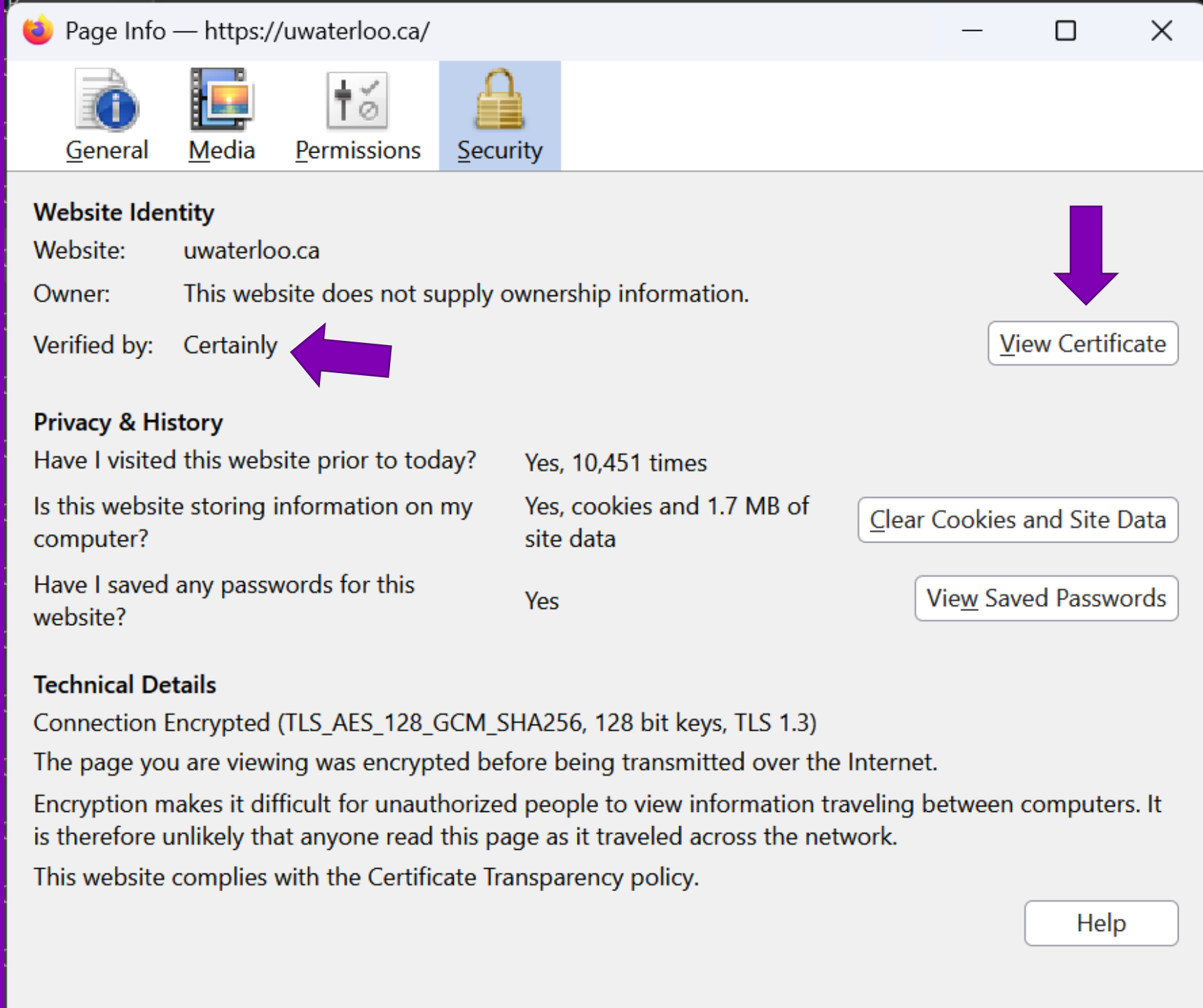
- A certificate authority verifies some properties of a person/organization and issues a “certificate” signed by their private key.
- Certificates can be quite detailed about what has been verified, and what they have been verified to do.

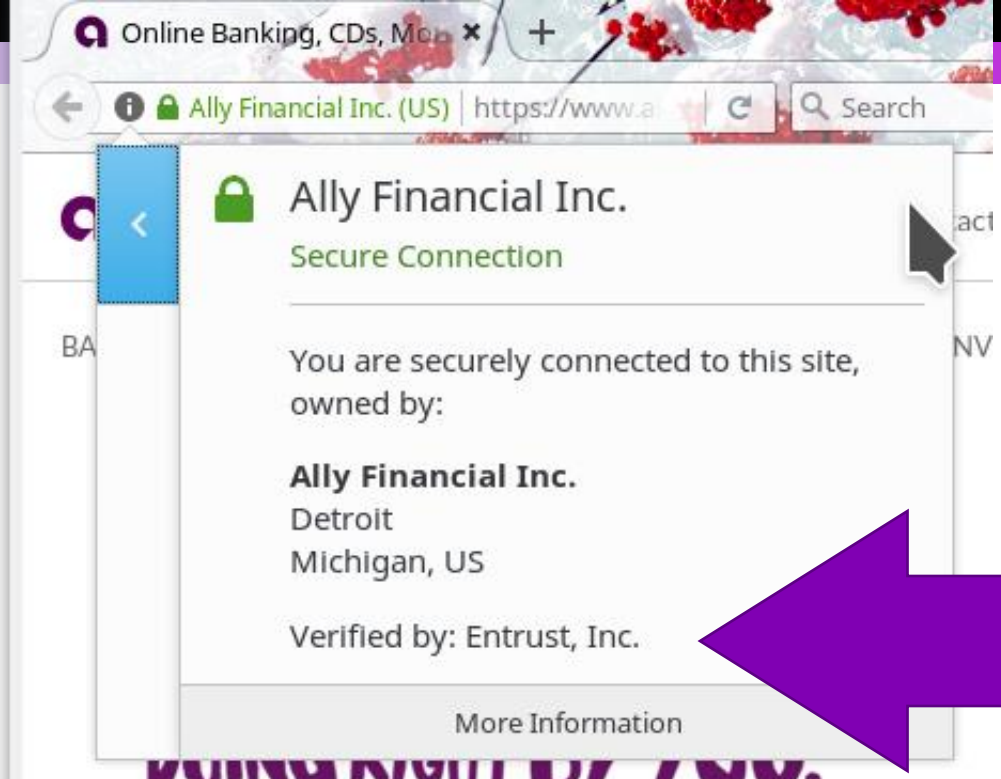


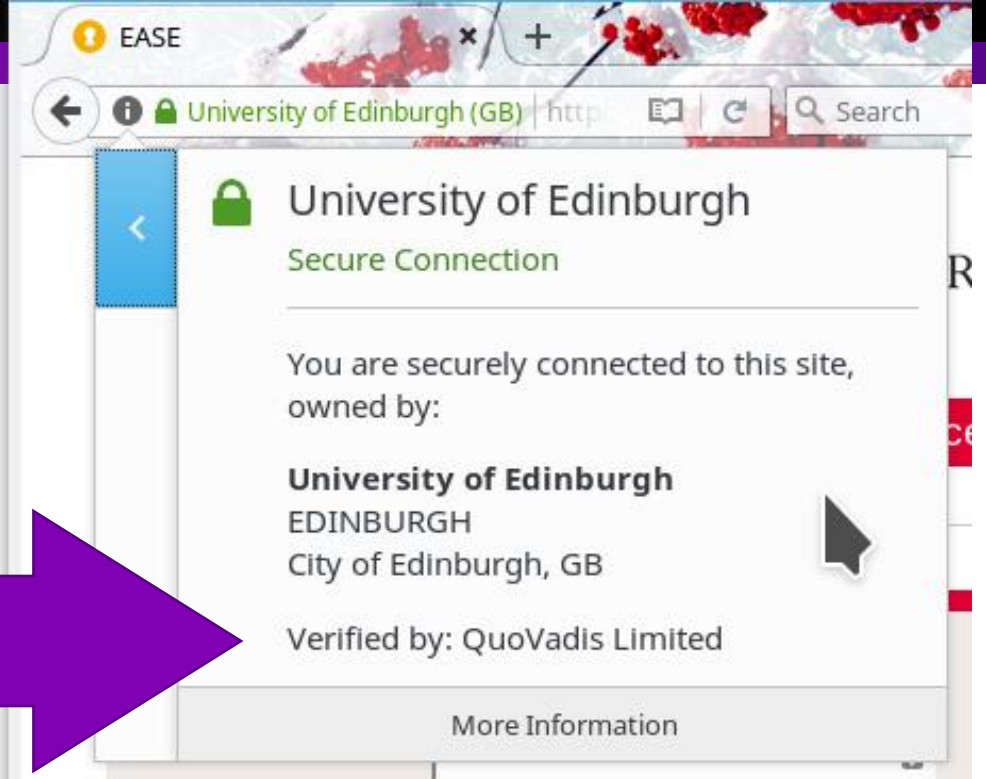
Certificate Authorities are used by browsers to verify identity



You can see lots of details about any encrypted connection.



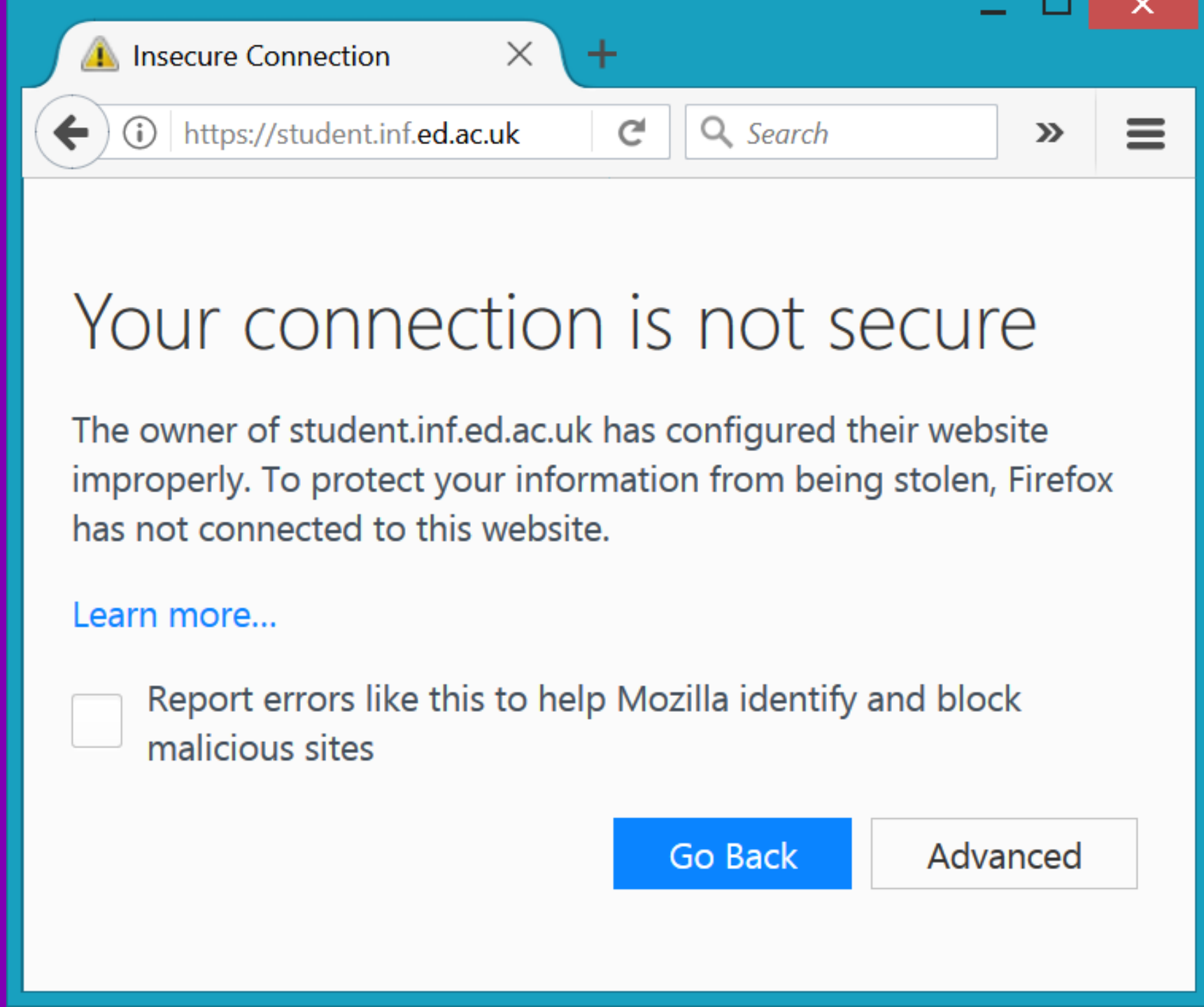




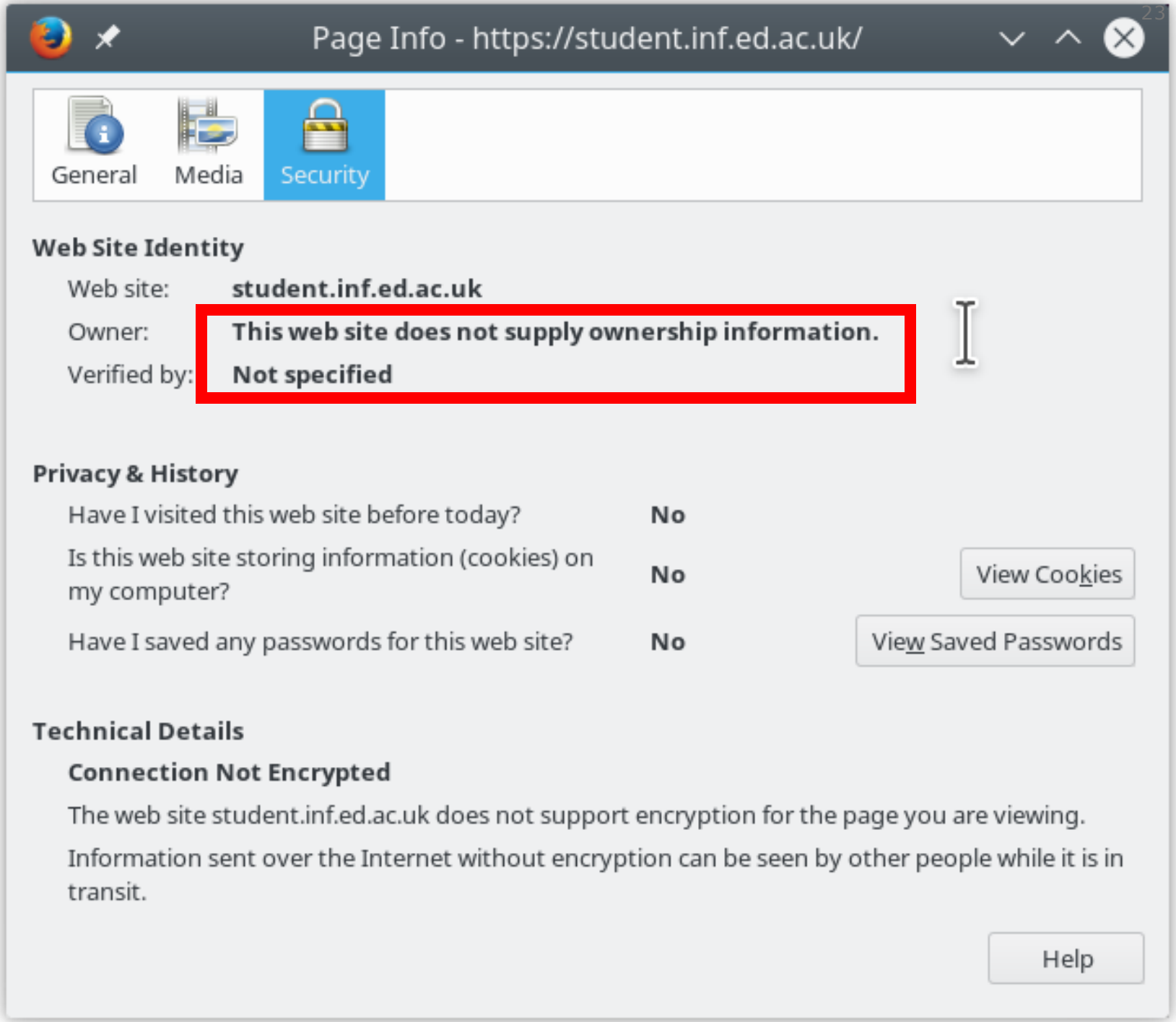
But now don't we just have the same problem again?

How does the browser know which Certificate Authorities to trust?

Clearly some Certificate Authorities are trusted and some are not.

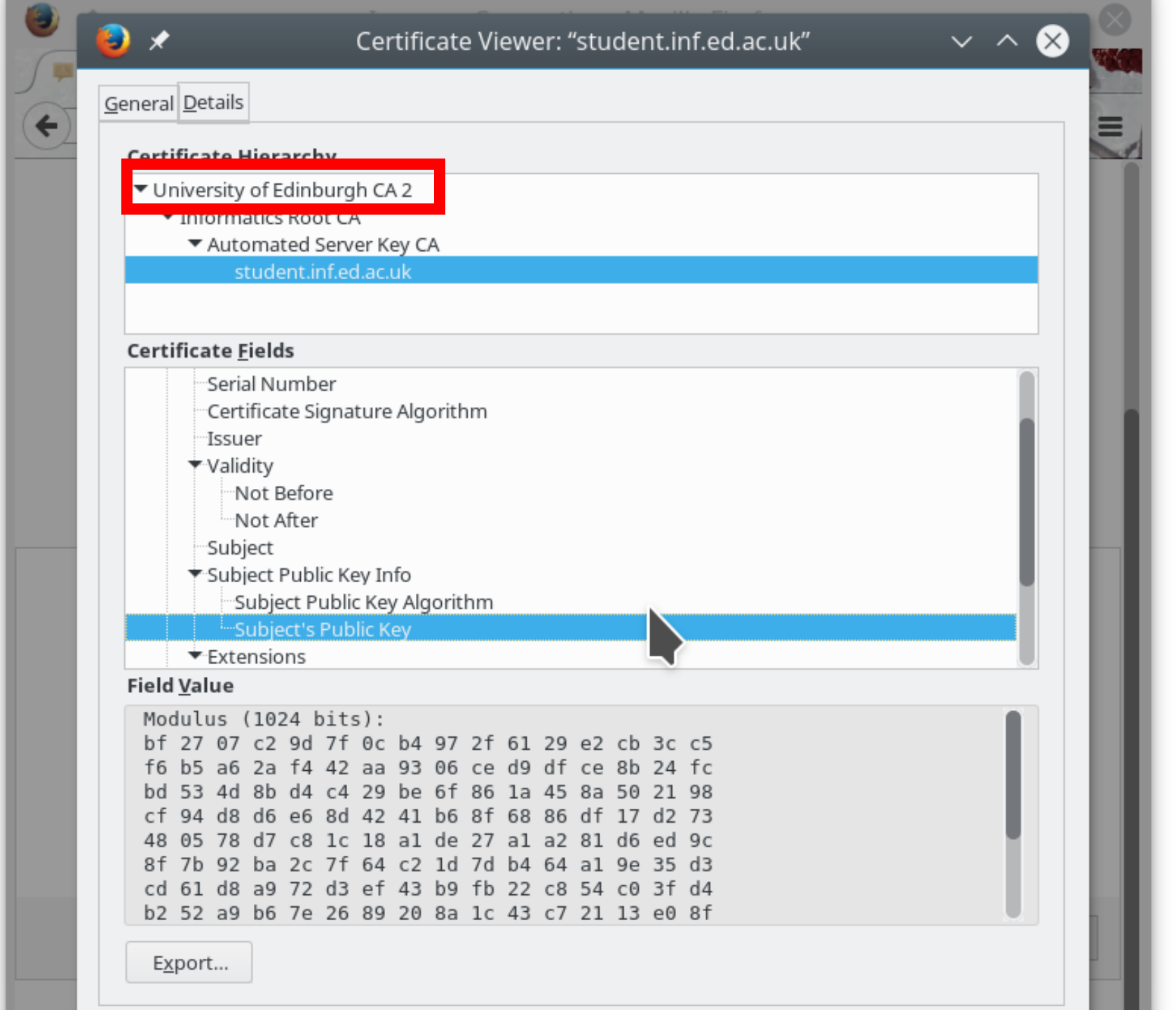


Errors like this one mean that a certificate exists but it is not signed by any organization this browser trusts.



This site is “self signed” which means that the University created its own Certificate Authority and used it to sign all the sites keys.

Why?
It costs money to get a signed certificate.



Your operating system and your browser both maintain lists of Certificate Authorities that they trust.

These lists differ between operating systems, browsers, and organizations.

Each organization makes its own trust decisions about Certificate Authorities

INFOWORLD TECH WATCH

By Fahmida Y. Rashid, Senior Writer, InfoWorld | MAR 24, 2017

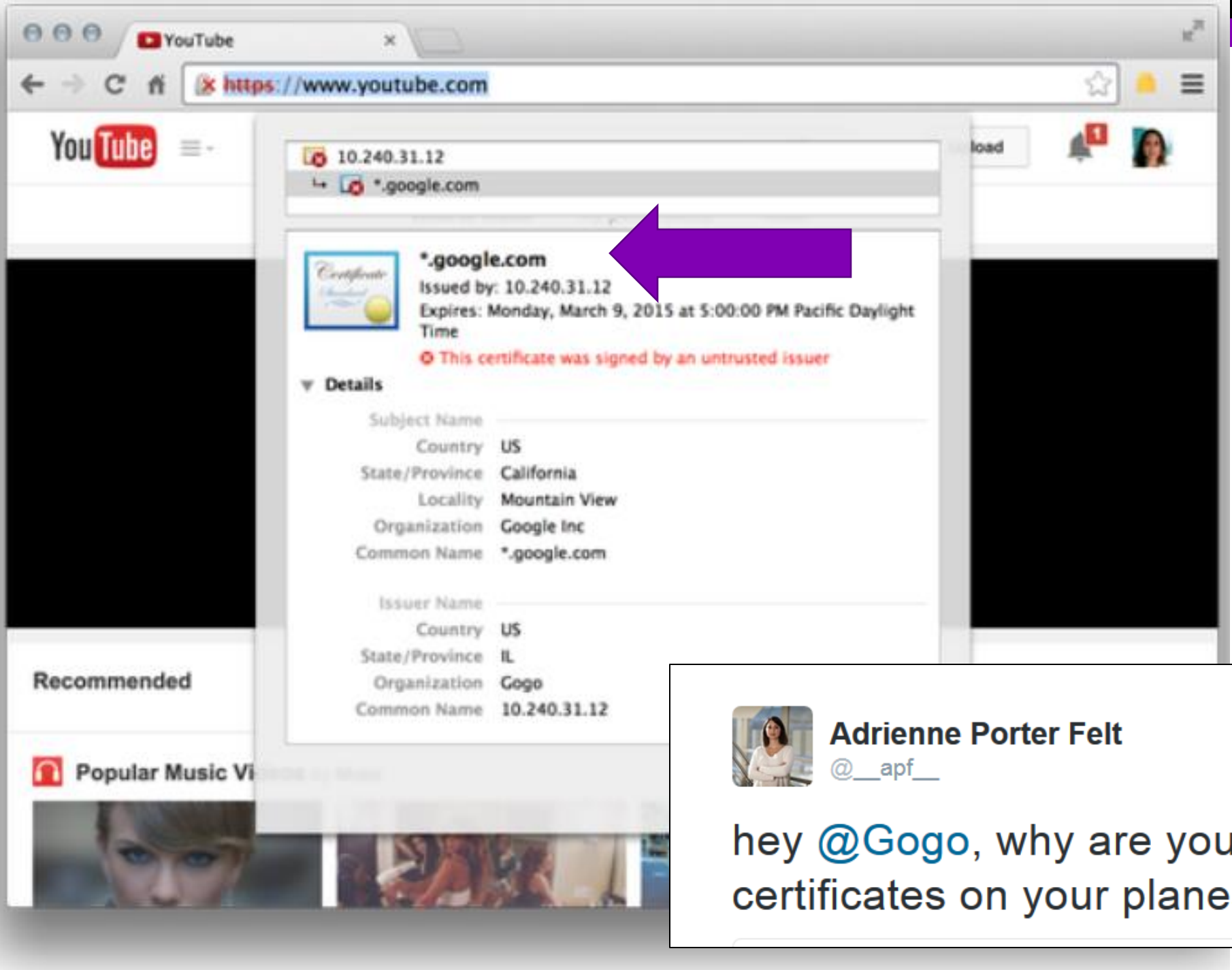
Google to Symantec: We don't trust you anymore

Admins need to consider whether they still want to use Symantec after its repeated mistakes with issuing TLS certificates

geralt via pixabay

Security teams, network administrators, and operations teams have busy days ahead. Google's Chrome development team is fed up with Symantec as a certificate authority and has announced plans to no longer trust current Symantec certificates.

In the past 18 months, Google has tangled repeatedly with Symantec over the way it issues transport layer security (TLS) certificates, with Symantec promising to do better. The latest incident—an investigation into 127 mis-issued certificates—ballooned into "at least 30,000, issued over a period spanning several years," Ravi Sleevi, a software engineer on the Google

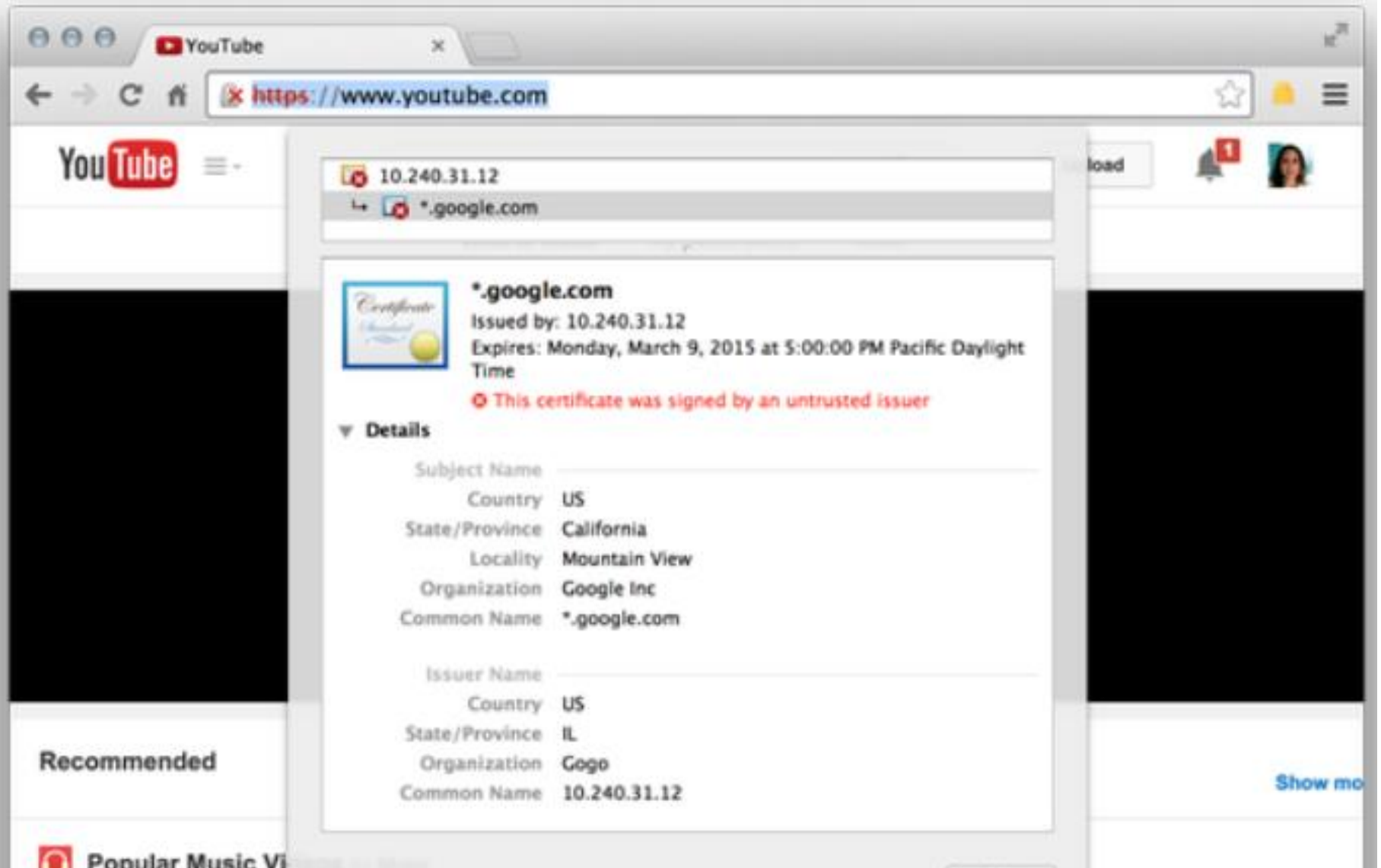


Adrienne Porter Felt
@__apf__

Following

hey @Gogo, why are you issuing *.google.com certificates on your planes?

Think-pair-share

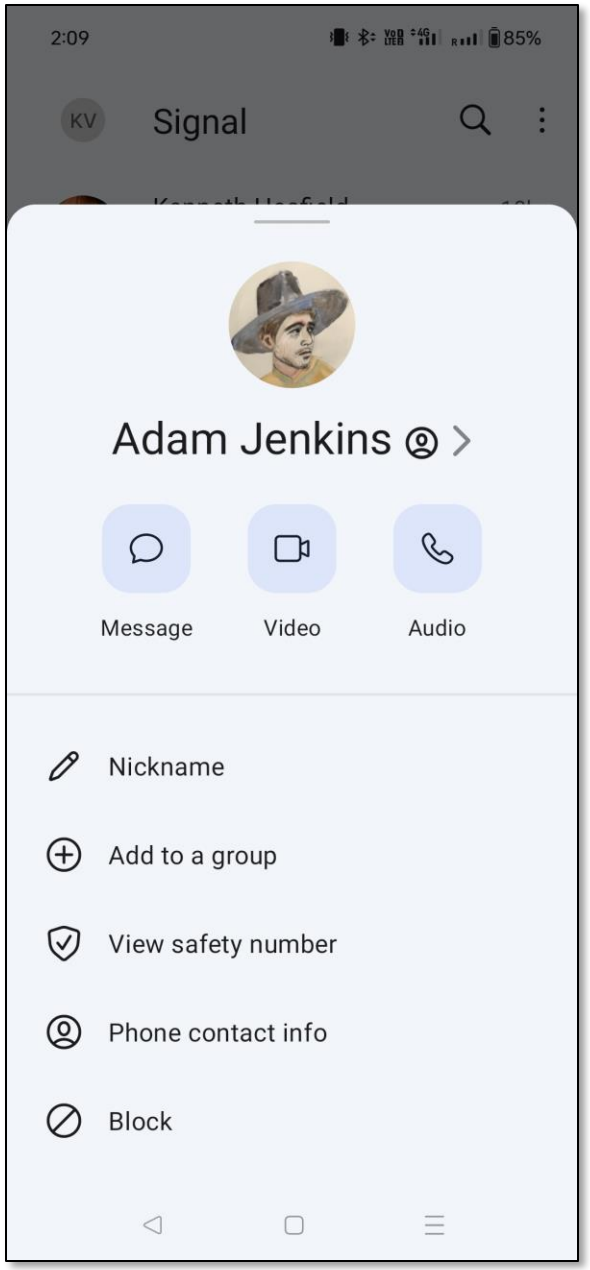


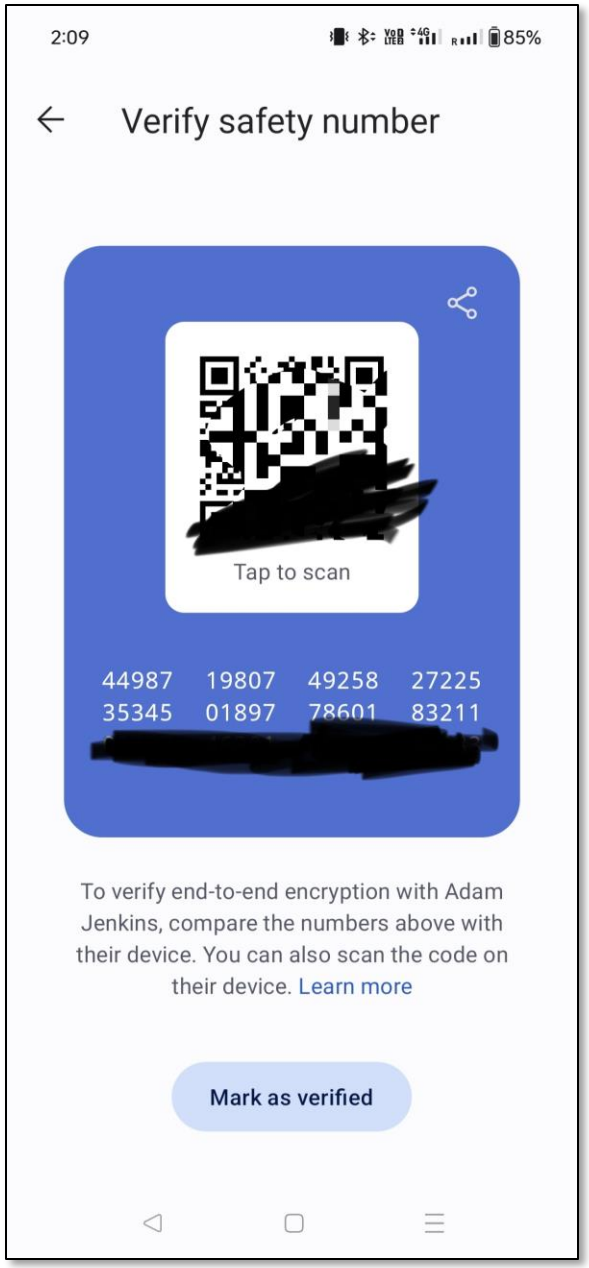
- A Firefox user would (theoretically) have seen no error in this case.
- How was Gogo able to successfully load a Google page with no errors on some browsers?

END-TO-END MESSAGING

Signal

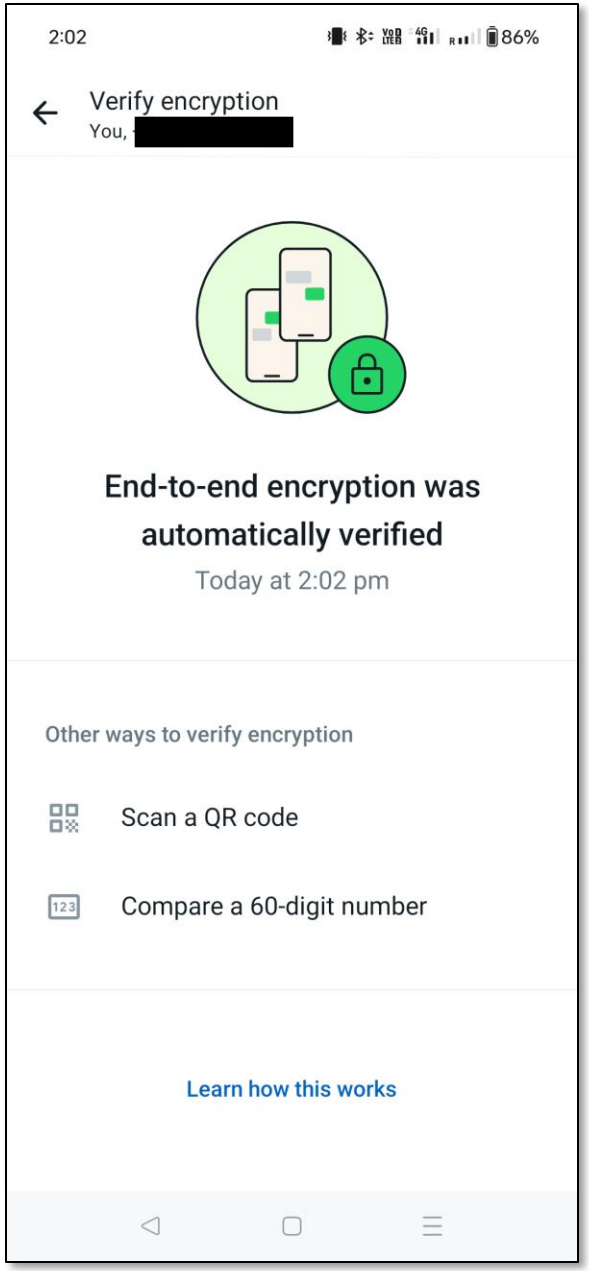
- End to end encrypted
- The “ends” are the apps on both sides





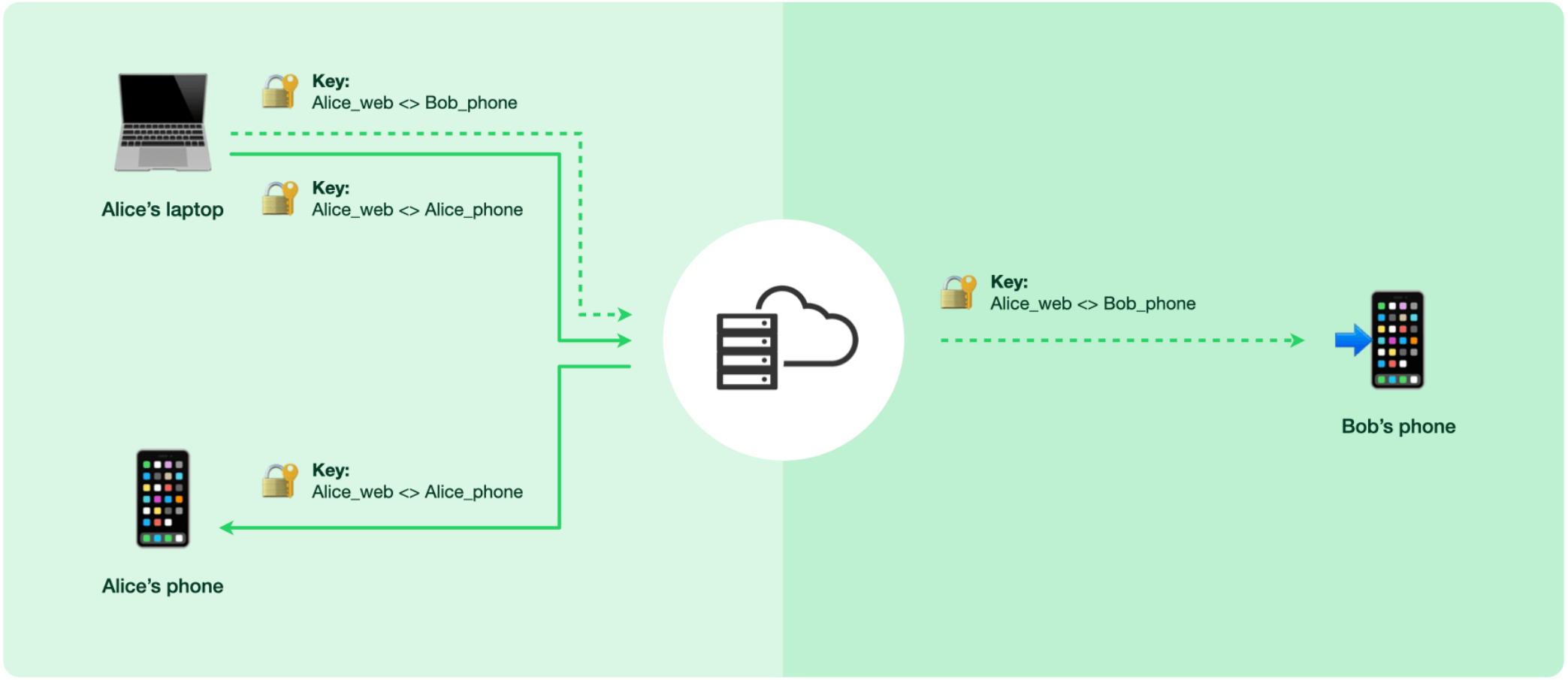
WhatsApp

- All messages, including group chats, are end-to-end encrypted
- The “ends” are the WhatsApp app on both devices
- Keys are managed by WhatsApp itself and shared with the devices as needed



WhatsApp: syncing chats

Life of a message



https://engineering.fb.com/2021/07/14/security/whatsapp-multi-device/

FIDO: PASSWORDLESS AUTHENTICATION

PassKeys

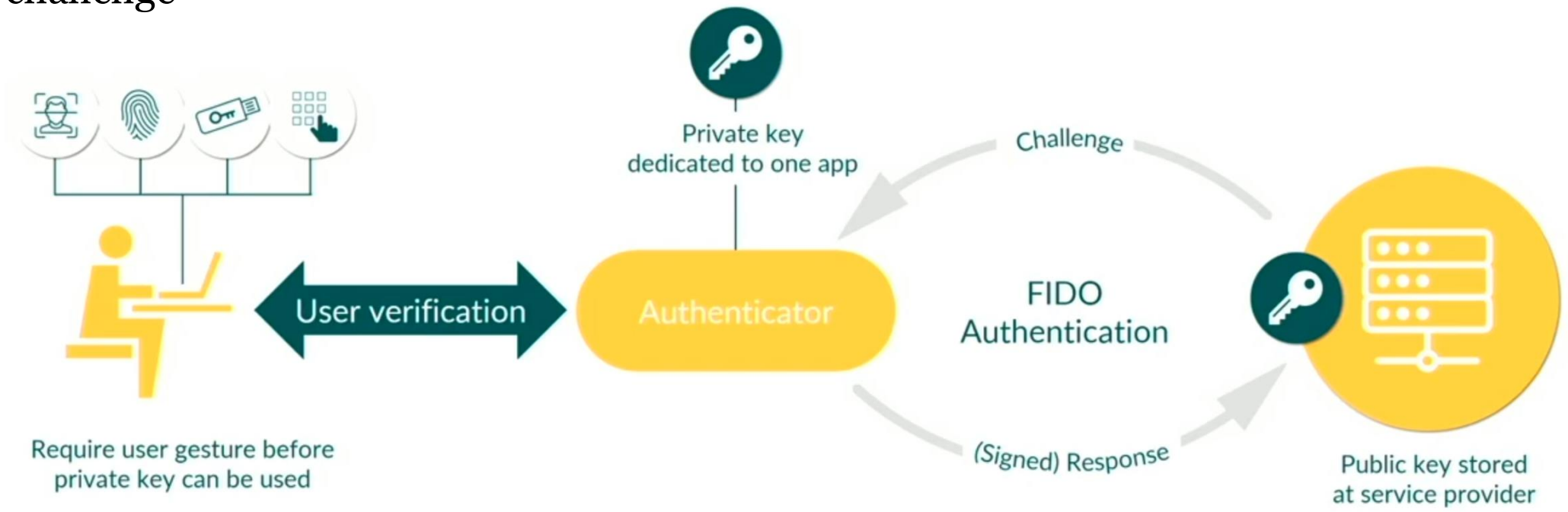
Idea:
Use public/private keys instead of passwords.

PassKeys: Registration

- A user is setting up a new account/relationship with a website
  - Device (phones, laptops, etc.) generates and stores a private/public key pair
  - Sends the public key to the website which stores it
  - Similar to a password, account authentication is now tied to the key not to the user identity

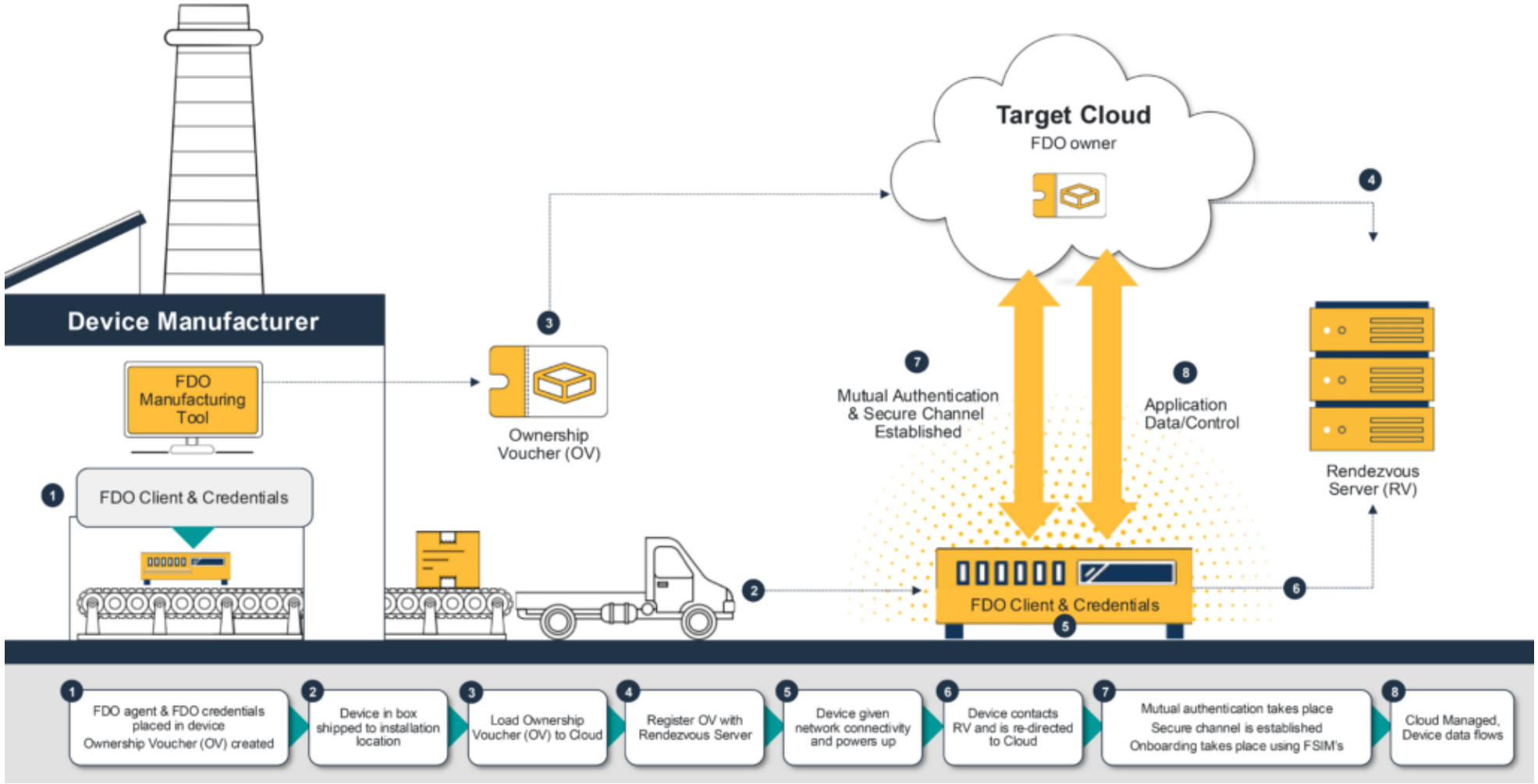
PassKeys: Authentication

- On login/authentication request
  - Server sends a challenge
  - Device verifies the user (e.g. fingerprint) and uses private key to sign the challenge
- Signature may also include facts about the device
- Website then uses their copy of the public key to verify the signature



David Turner, Authenticate Virtual Summit: Demystifying Passkey Implementations https://www.youtube.com/watch?v=Qiy_s-WpURc

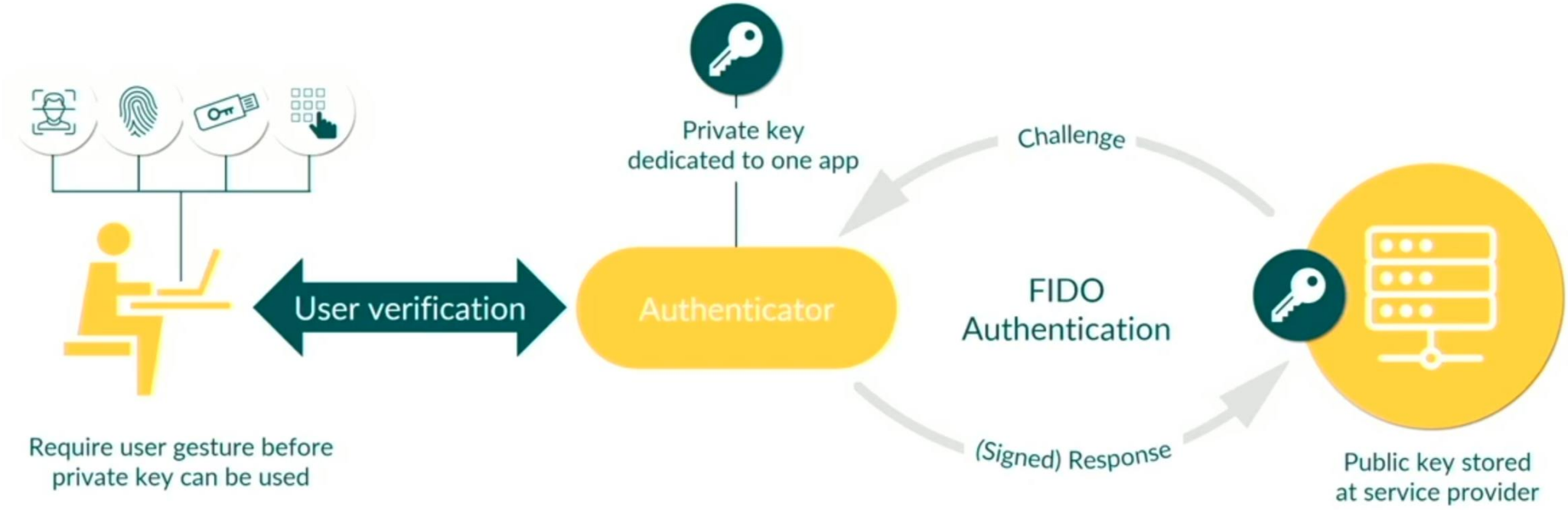
Hardware matters: device need to be trusted



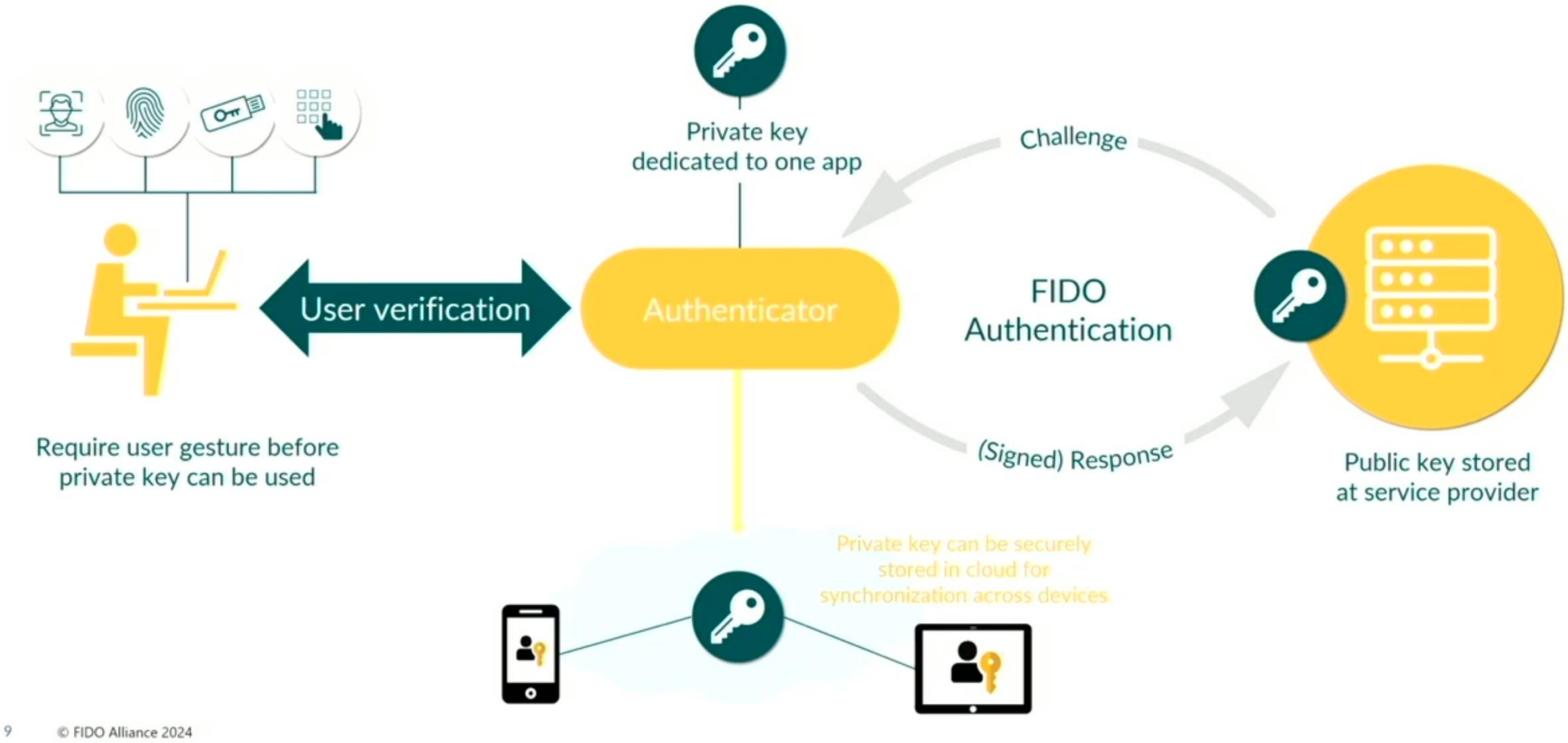
https://fidoalliance.org/device-onboarding-overview/

Think-pair-share

- What happens if the website gets hacked and they loose all the public keys?
- What type of capabilities/access would an attacker need to compromise this system?



What about multiple devices: key syncing



David Turner, Authenticate Virtual Summit: Demystifying Passkey Implementations https://www.youtube.com/watch?v=Qiy_s-WpURc

QUESTIONS