CSE 484 / CSE M 584: Computer Security and Privacy

Web Security
[Certificates and Overview]

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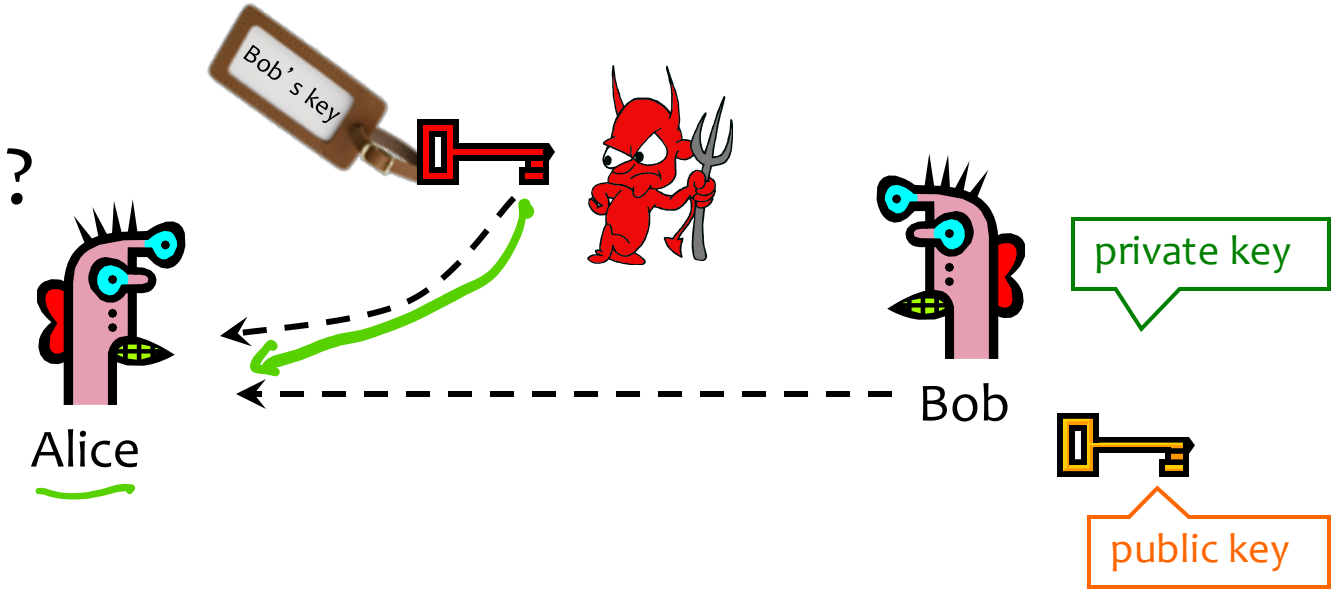
Admin

- Today:
  - Transition to web security
- Lab 1 due on Friday
  - See FAQs on discussion board

Cryptography Summary

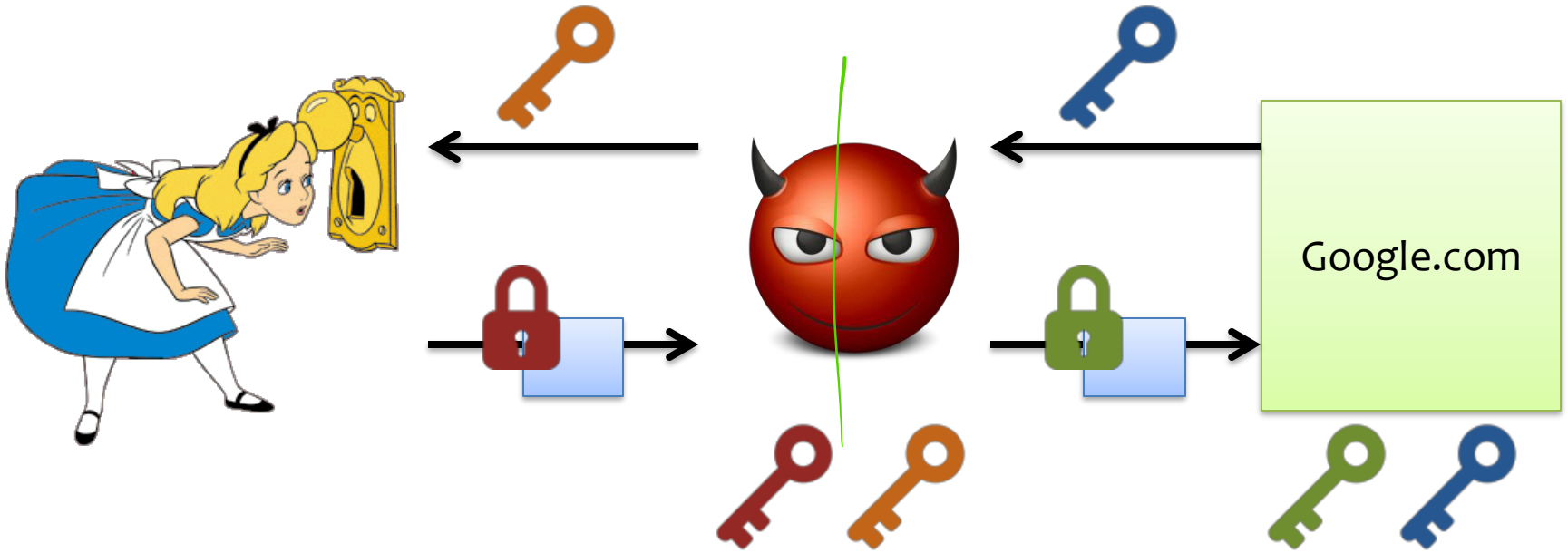
- Goal: Privacy
  - Symmetric keys:
    - One-time pad, Stream ciphers
    - Block ciphers (e.g., DES, AES) → modes: EBC, CBC, CTR
  - Public key crypto (e.g., Diffie-Hellman, RSA)
- Goal: Integrity
  - MACs, often using hash functions (e.g, SHA-256)
- Goal: Privacy and Integrity
  - Encrypt-then-MAC → not encrypt AND MAC
- Goal: Authenticity (and Integrity)
  - Digital signatures (e.g., RSA, DSS)

Authenticity of Public Keys



Problem: How does Alice know that the public key she received is really Bob's public key?

Threat: Person-in-the Middle

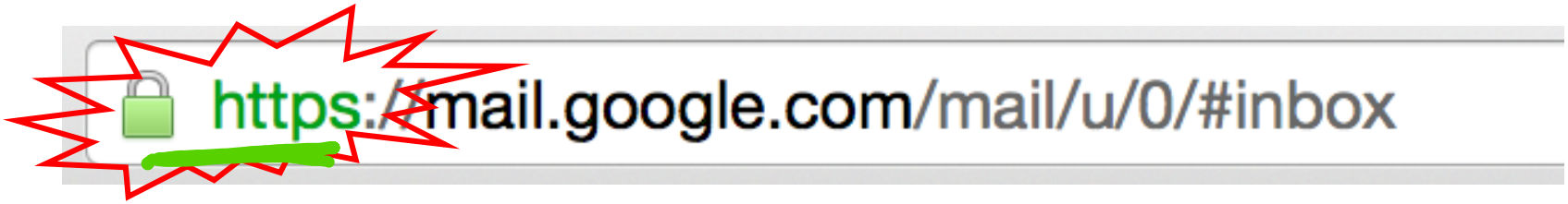


Distribution of Public Keys

- Public announcement or public directory
  - Risks: forgery and tampering
- Public-key certificate
  - Signed statement specifying the key and identity
    - $sig_{CA}(\text{“Bob”}, PK_B)$
- Common approach: certificate authority (CA)
  - Single agency responsible for certifying public keys
  - After generating a private/public key pair, user proves his identity and knowledge of the private key to obtain CA's certificate for the public key (offline)
  - Every computer is pre-configured with CA's public key

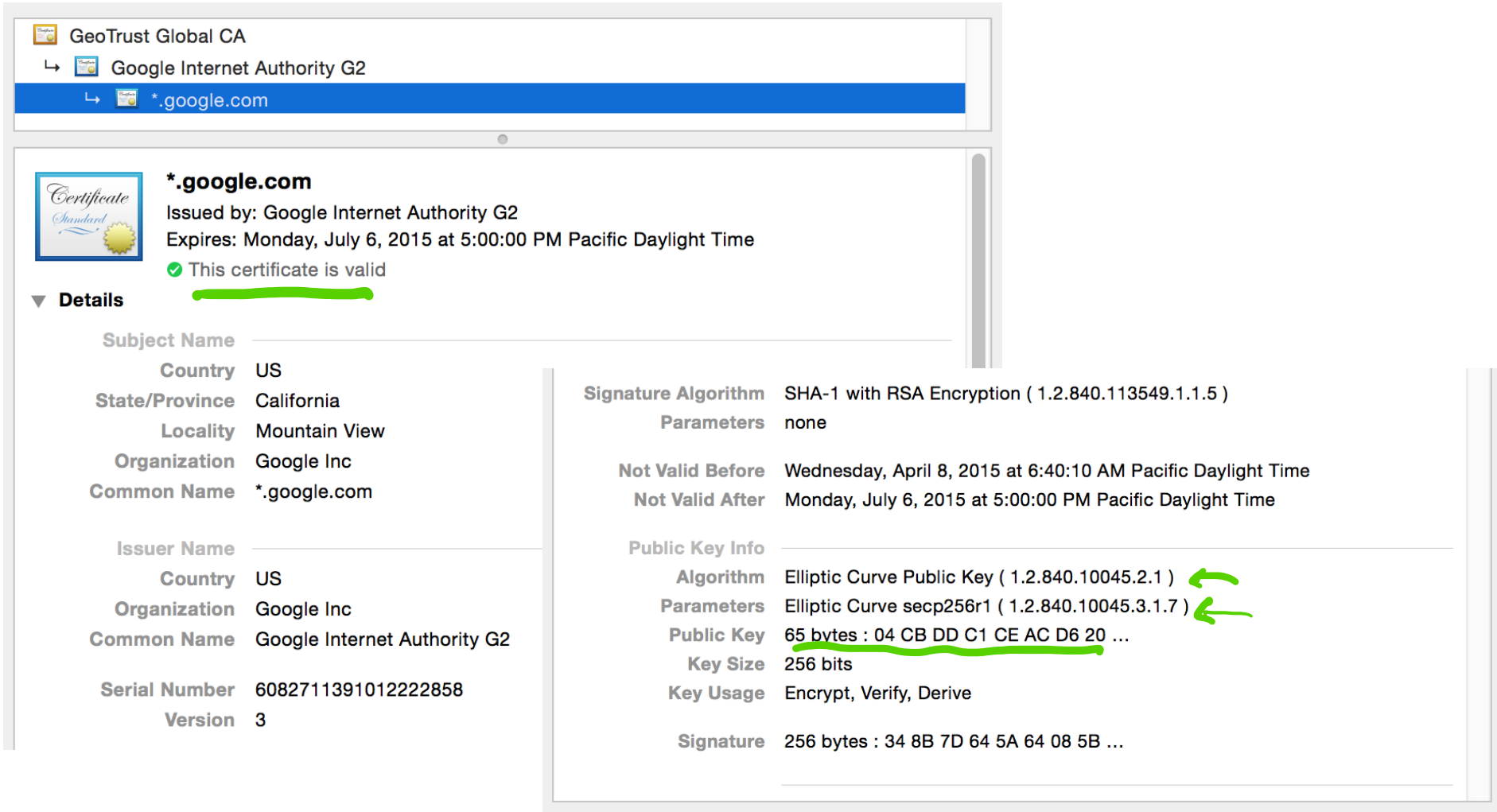
verisign

You encounter this every day…



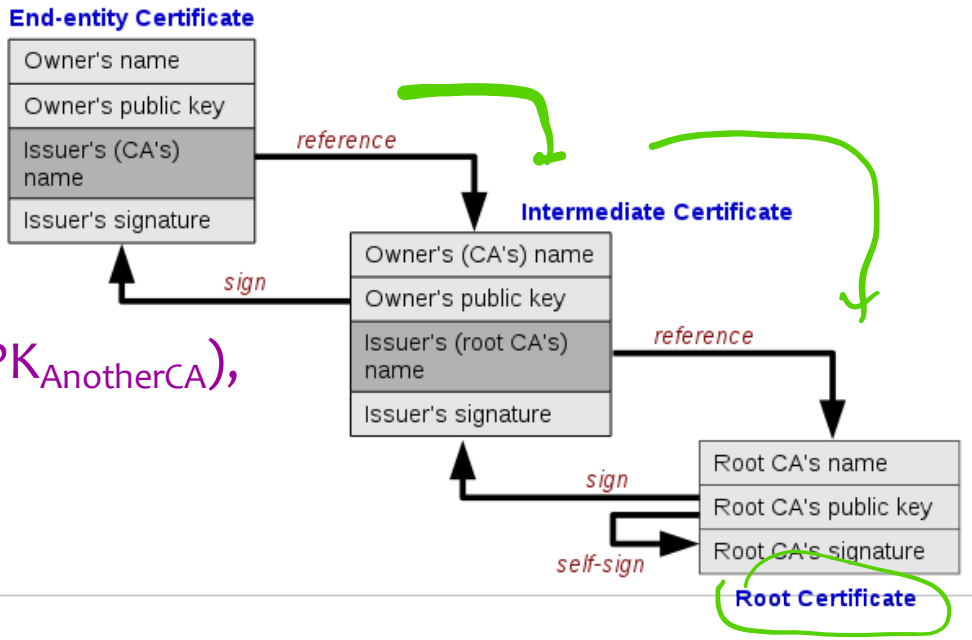
SSL/TLS: Encryption & authentication for connections

Example of a Certificate



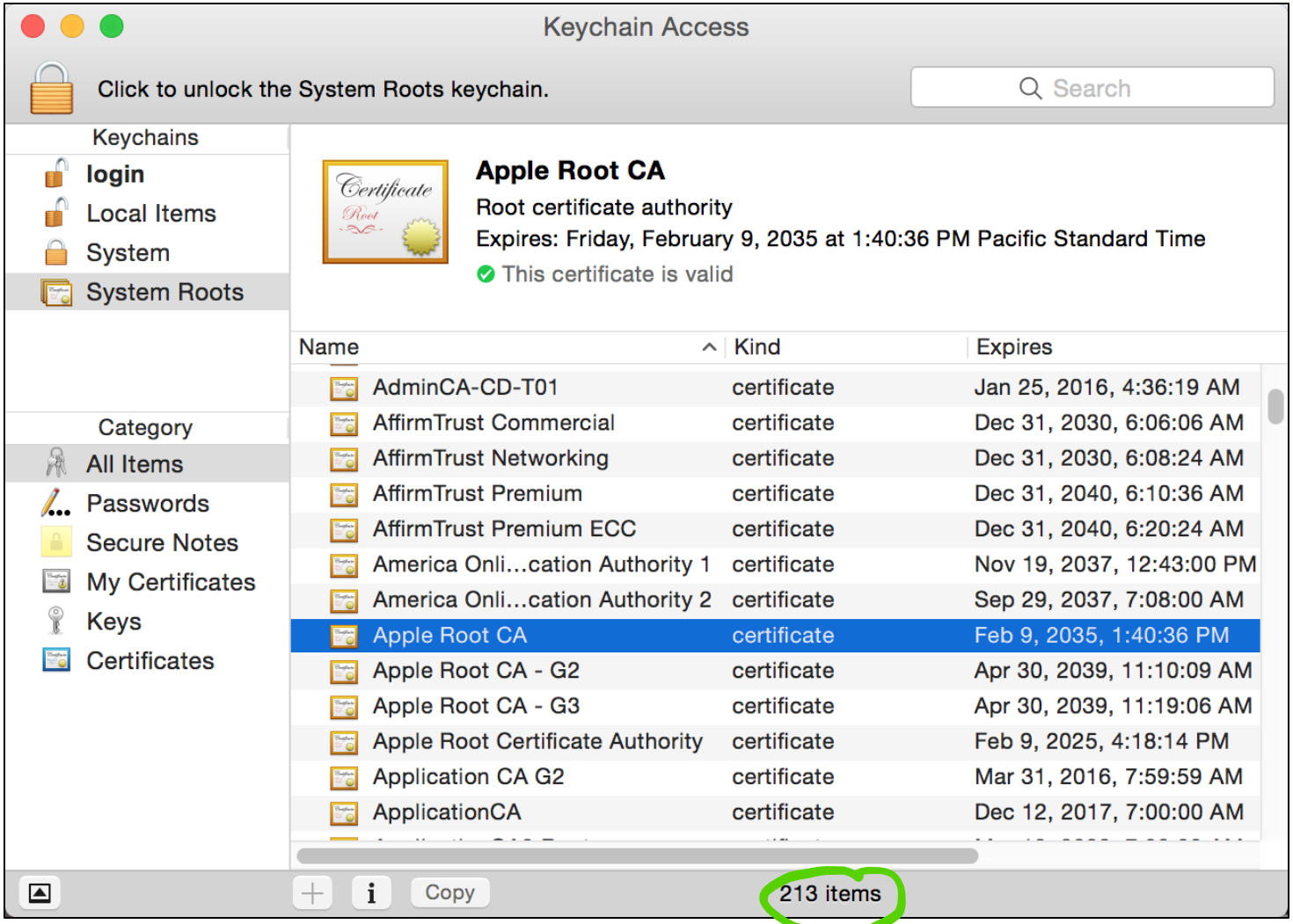
Hierarchical Approach

- Single CA certifying every public key is impractical
- Instead, use a trusted root authority (e.g., Verisign)
  - Everybody must know the root's public key
  - Instead of single cert, use a certificate chain
    - $sig_{Verisign}(\text{“AnotherCA”}, PK_{AnotherCA})$, $sig_{AnotherCA}(\text{“Alice”}, PK_A)$



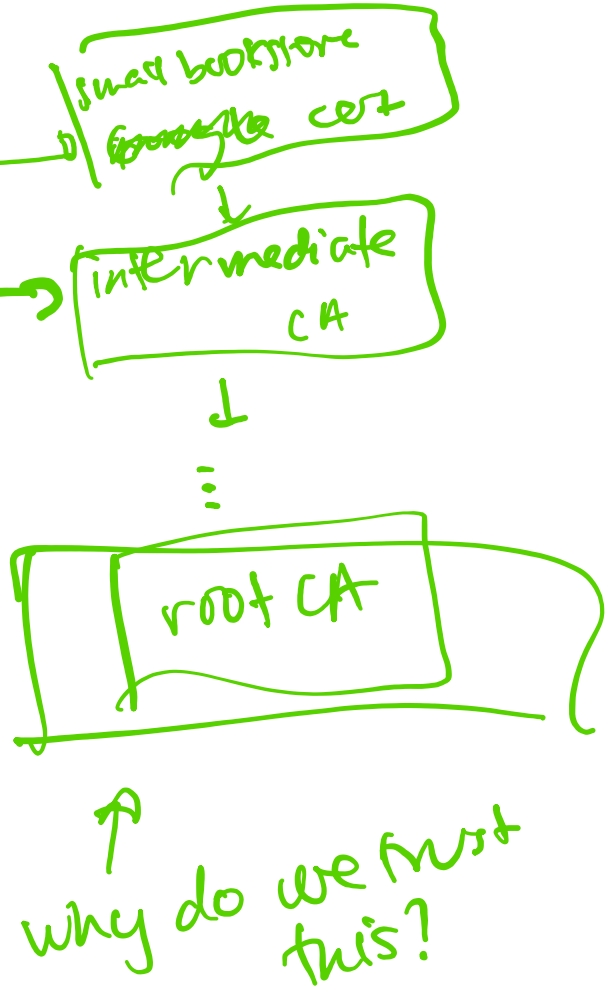
  - What happens if root authority is ever compromised?

Trusted(?) Certificate Authorities



Turtles All The Way Down…

The saying holds that the world is supported by a chain of increasingly large turtles. Beneath each turtle is yet another: it is "turtles all the way down".



[Image from Wikipedia]

Many Challenges…

- Hash collisions ← md5 ← explicitly forge a cert
- Weak security at CAs ←
  - Allows attackers to issue rogue certificates
- Users don't notice when attacks happen
  - We'll talk more about this later in the course
- How do you revoke certificates?

Attacking CAs

DigiNotar Hacked by Black.Spook and Iranian Hackers Posted by Mikko @ 09:05 GMT | Comments

DigiNotar is a Dutch Certificate Authority. They sell SSL certificates.

Somehow, somebody managed to get a rogue SSL certificate from them on **July 10th, 2011**. This certificate was issued for domain name **.google.com**.

What can you do with such a certificate? Well, you can impersonate Google — assuming you can first reroute Internet traffic for google.com to you. This is something that can be done by a government or by a rogue ISP. Such a reroute would only affect users within that country or under that ISP.

Security of DigiNotar servers:

- All core certificate servers controlled by a single admin password (Prod@dm1n)
- Software on public-facing servers out of date, unpatched
- No anti-virus (could have detected attack)

Consequences

- Attacker needs to first divert users to an attacker-controlled site instead of Google, Yahoo, Skype, but then…
  - For example, use DNS to poison the mapping of mail.yahoo.com to an IP address
- … "authenticate" as the real site
- … decrypt all data sent by users
  - Email, phone conversations, Web browsing

Attempt to Fix CA Problems:

Certificate Transparency

- **Problem:** browsers will think nothing is wrong with a rogue certificate until revoked
- **Goal:** make it impossible for a CA to issue a bad certificate for a domain *without the owner of that domain knowing*
  - (Then what?)
- **Approach:** auditable certificate logs

www.certificate-transparency.org

Attempt to Fix CA Problems:

Certificate Pinning

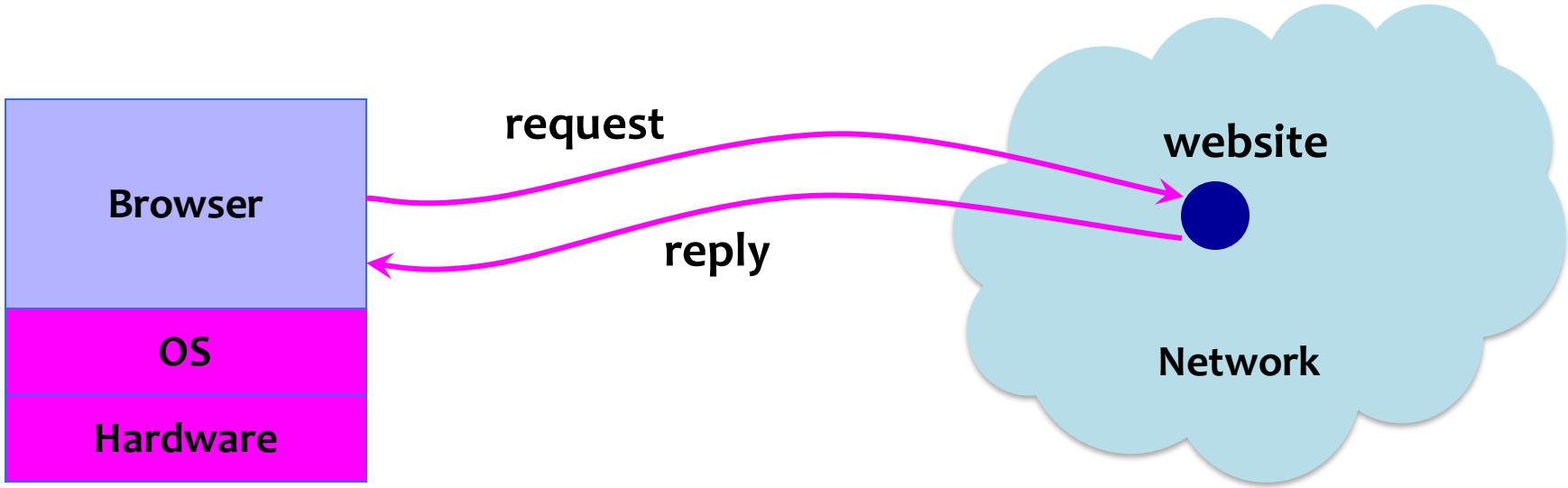
Assumes attack are rare

- Trust on first access: tells browser how to act on subsequent connections
- HPKP – HTTP Public Key Pinning
  - Use these keys!
  - HTTP response header field "`Public-Key-Pins`"
- HSTS – HTTP Strict Transport Security
  - Only access server via HTTPS
  - HTTP response header field "`Strict-Transport-Security`"

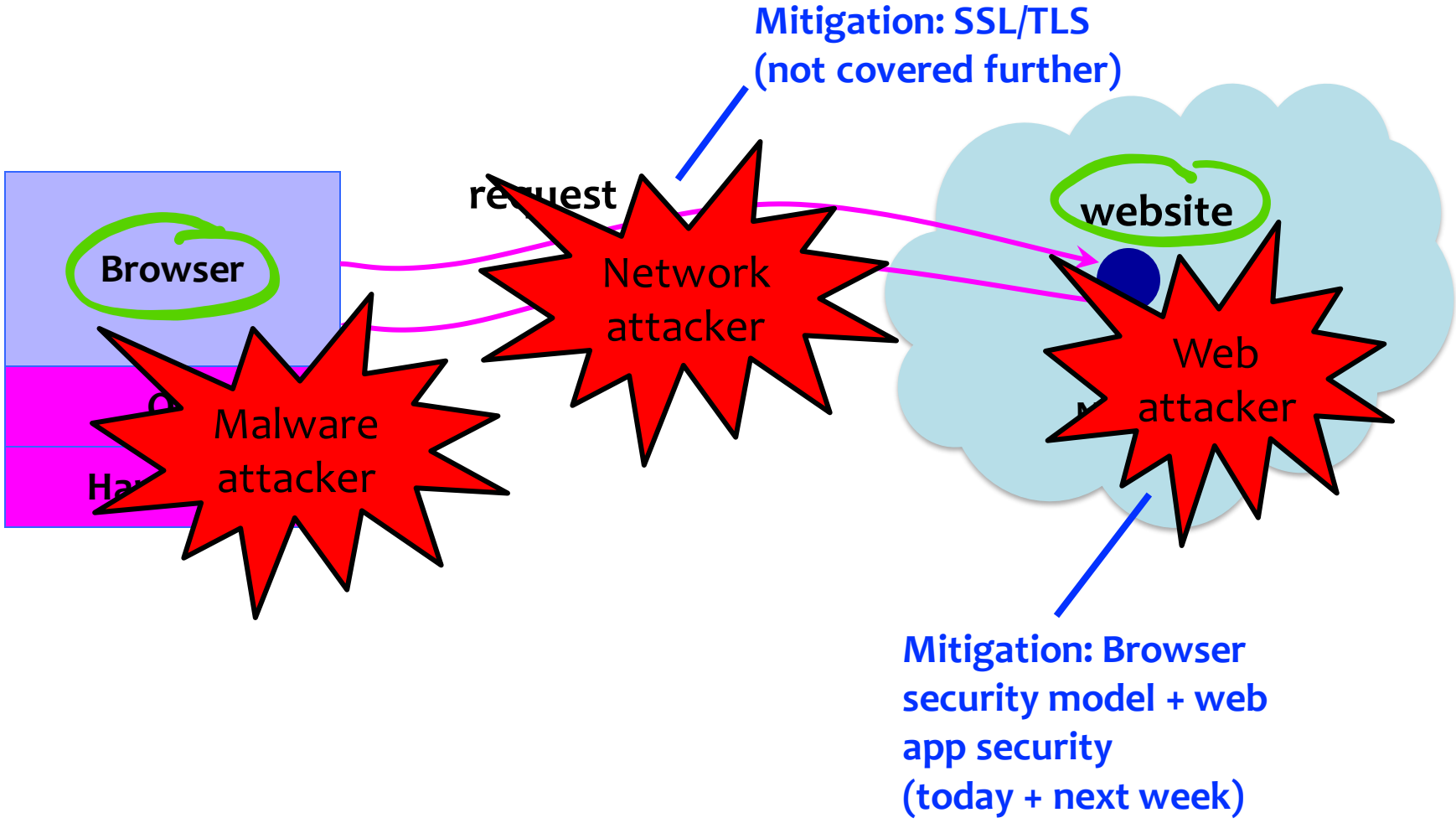
Let's Encrypt (EFF)

Web+Browser Security

Big Picture: Browser and Network



Where Does the Attacker Live?



Web Attacker

- Controls a malicious website (**attacker.com**)
  - Can even obtain SSL/TLS certificate for site
- User visits attacker.com – why?
  - Phishing email, enticing content, search results, placed by an ad network, blind luck …
- Attacker has no other access to user machine!
- Variation: good site **honest.com**, but:
  - An iframe with malicious content included
  - Website has been compromised