CSE 484 : Computer Security and Privacy

Finish Cryptography; Start Web Security

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Admin

- Homework 2 due in a week (2/10)
- Final Project checkpoint #1 due in 2 weeks (2/17)

Final Project

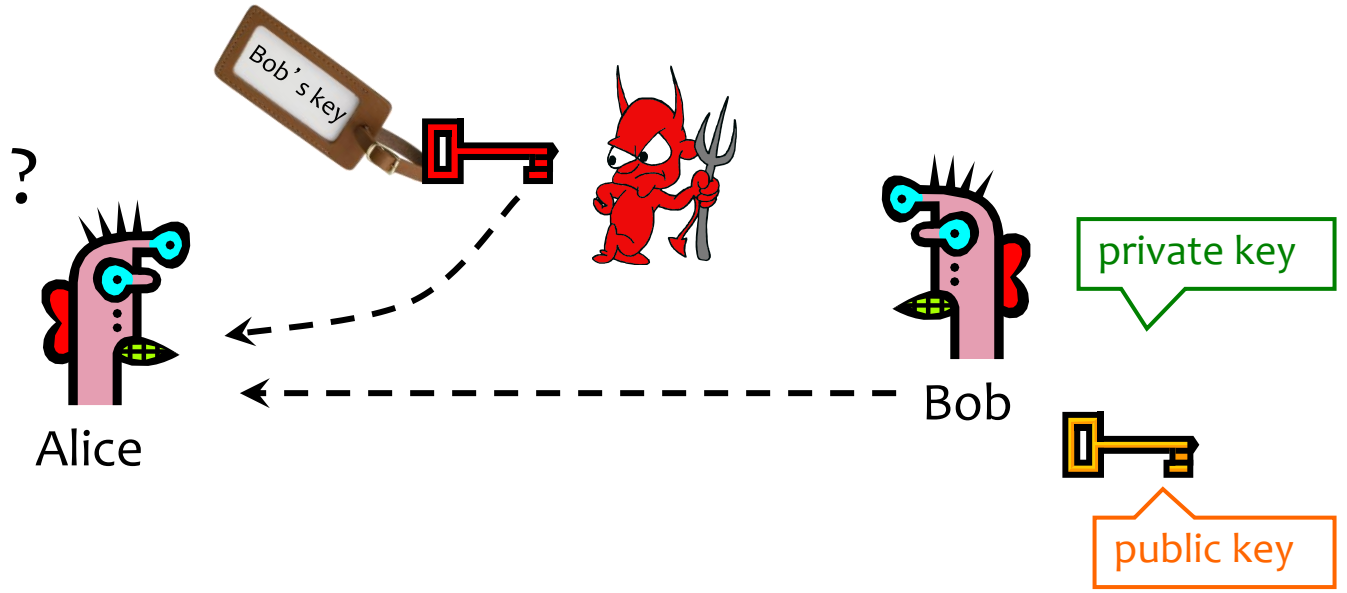
- Start making groups on Canvas
  - “Final Project Groups”
- Use the edstem forum to gather group members
- Goal is to have you find an interesting topic area and learn more!

https://courses.cs.washington.edu/courses/cse484/21wi/assignments/final_project.html

Want More Crypto?

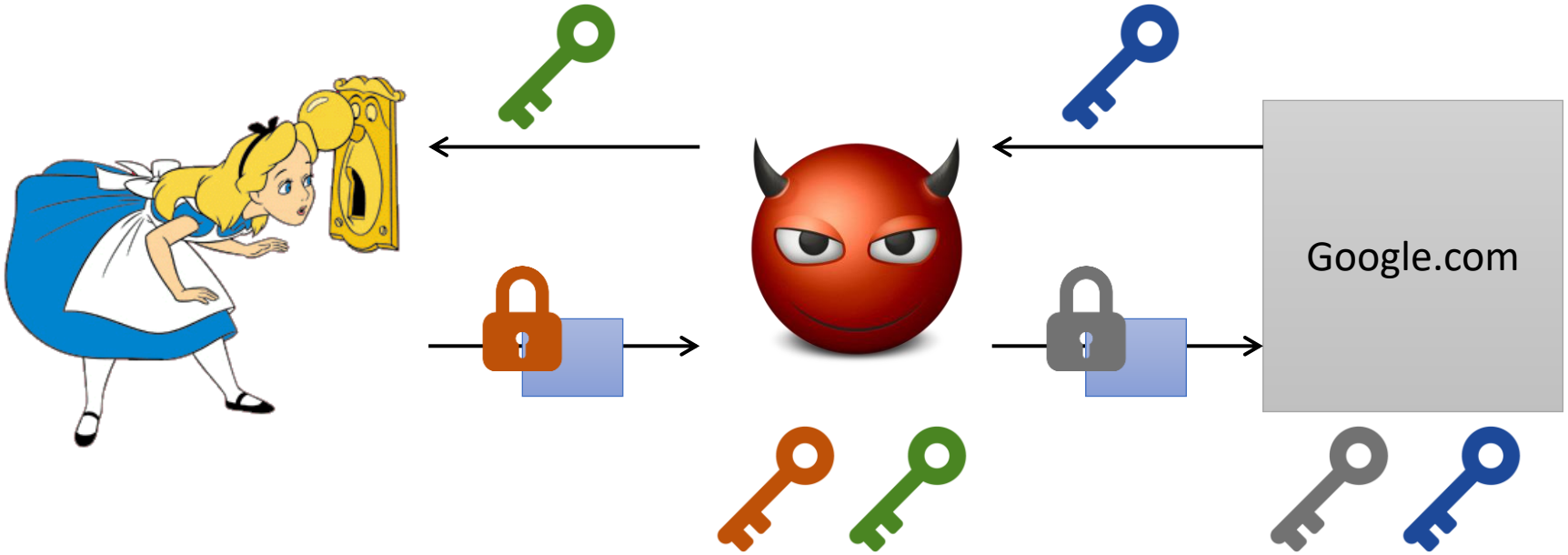
- Some suggestions:
  - CSE 490C (Rachel Lin): https://courses.cs.washington.edu/courses/cse490c/20au/
  - Stanford Coursera (Dan Boneh): https://www.coursera.org/learn/crypto

Authenticity of Public Keys



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

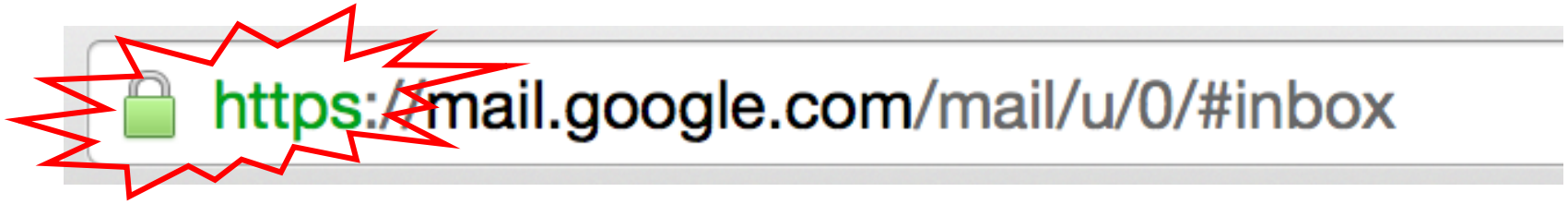
Threat: Person-in-the Middle



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}("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

You encounter this every day…

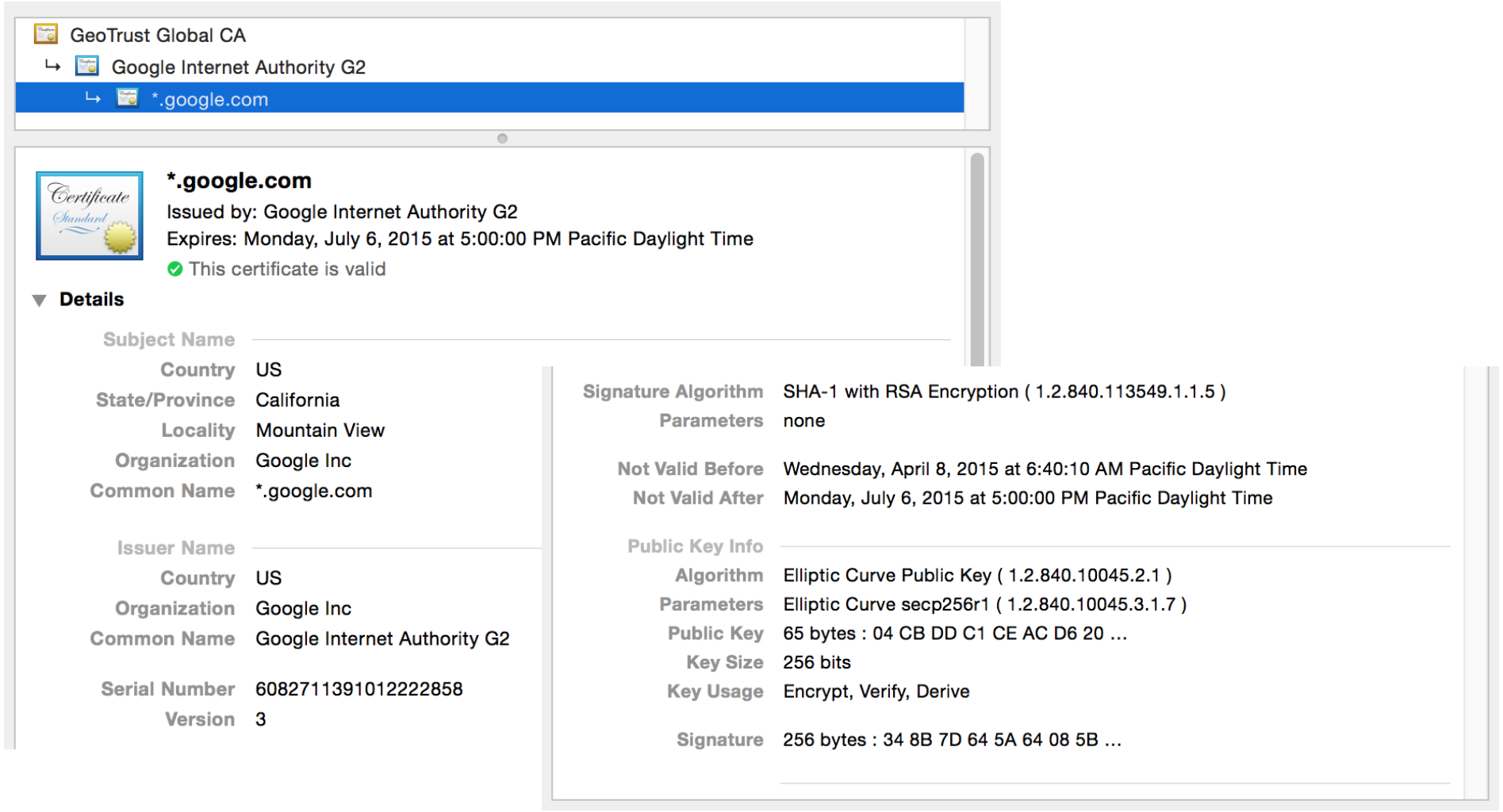


SSL/TLS: Encryption & authentication for connections

SSL/TLS High Level

- SSL/TLS consists of two protocols
  - Familiar pattern for key exchange protocols
- Handshake protocol
  - Use public-key cryptography to establish a shared secret key between the client and the server
- Record protocol
  - Use the secret symmetric key established in the handshake protocol to protect communication between the client and the server

Example of a Certificate



courses.cs.washington.edu/courses/cse484/21wi/

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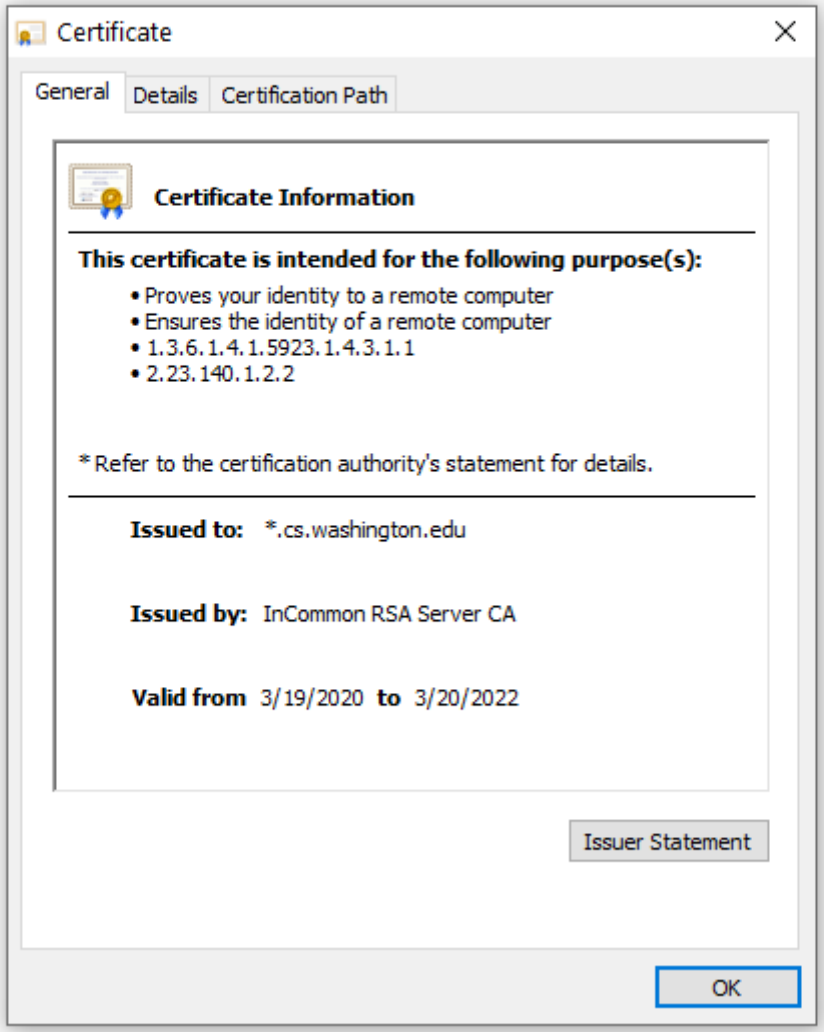

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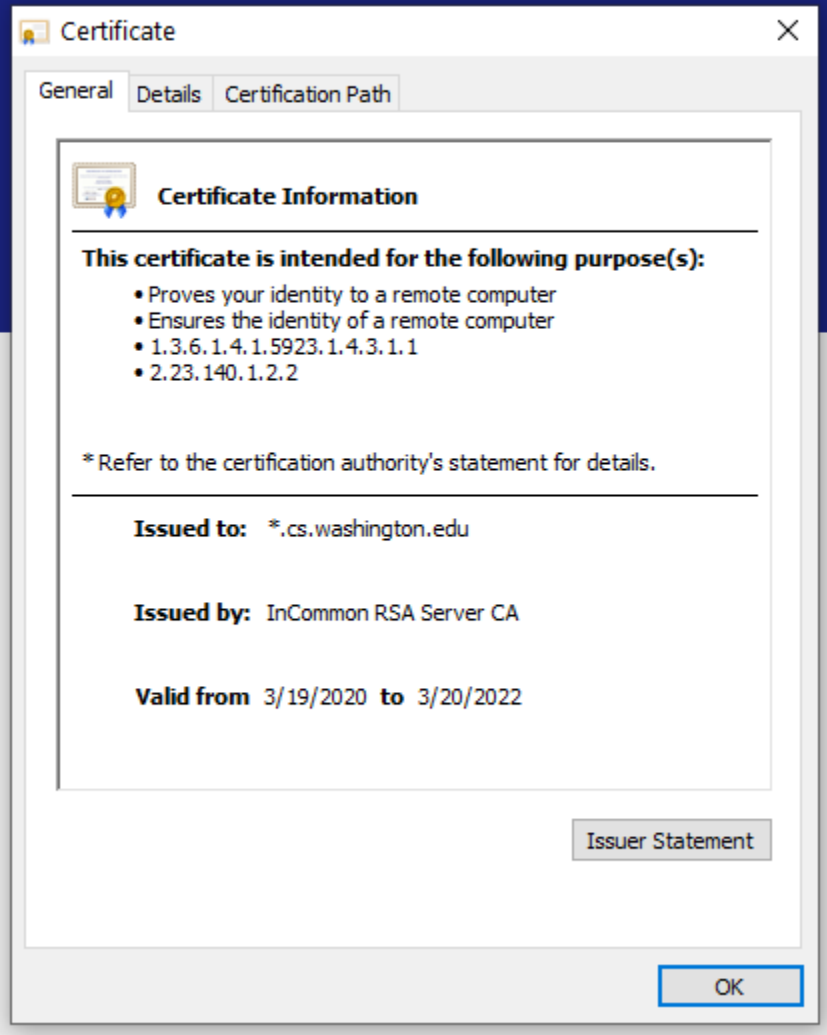
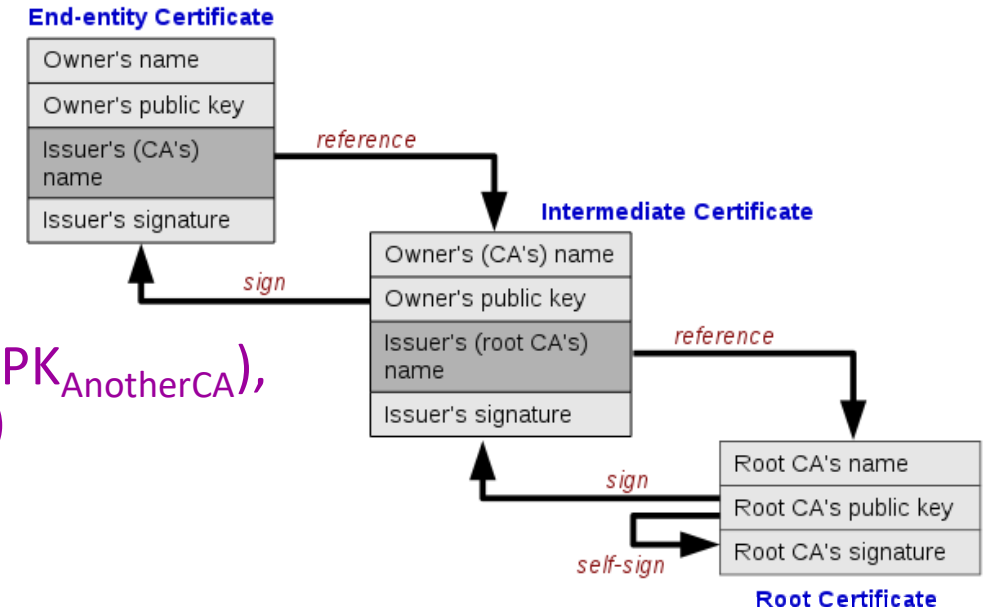


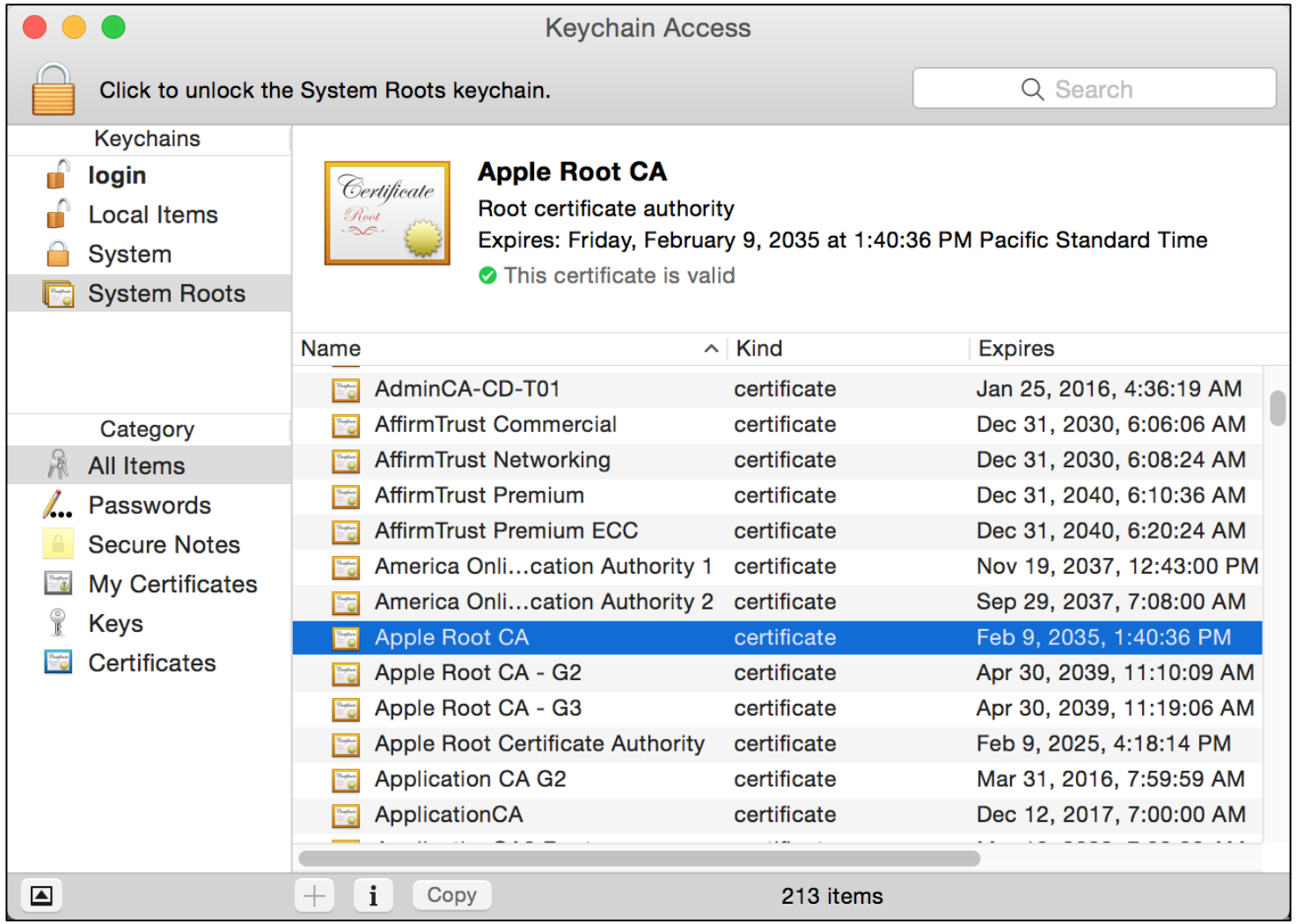
Hierarchical Approach

- 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
    - $sig_{Verisign}$("AnotherCA", $PK_{AnotherCA}$), $sig_{AnotherCA}$("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".

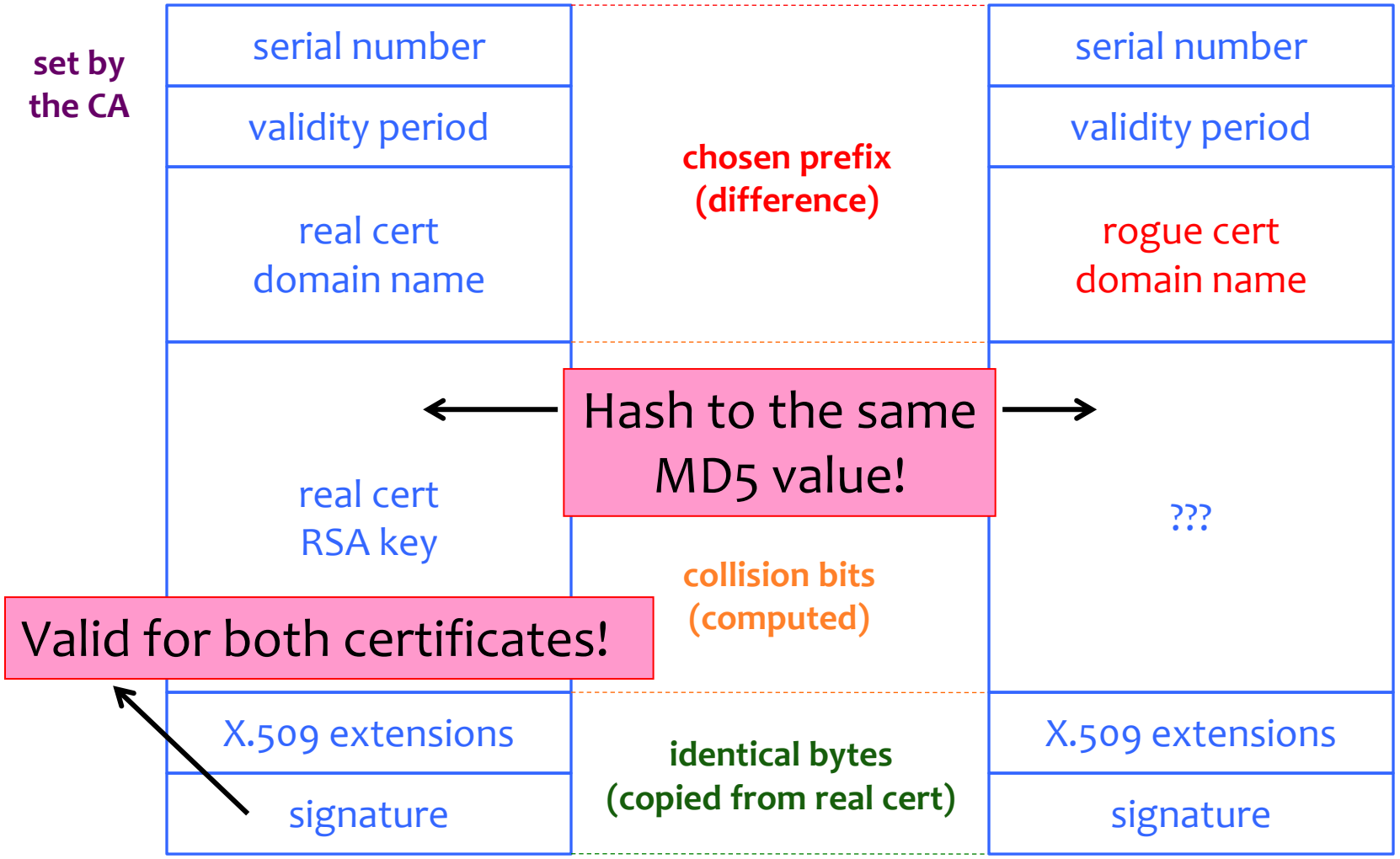
[Image from Wikipedia]

Many Challenges…

- Hash collisions
- 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?

[Sotirov et al. "Rogue Certificates"]

Colliding 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

More Rogue Certs

- In Jan 2013, a rogue *.google.com certificate was issued by an intermediate CA that gained its authority from the Turkish root CA TurkTrust
  - TurkTrust accidentally issued intermediate CA certs to customers who requested regular certificates
  - Ankara transit authority used its certificate to issue a fake *.google.com certificate in order to filter SSL traffic from its network
- This rogue *.google.com certificate was trusted by every browser in the world

Bad CAs

- DarkMatter (https://groups.google.com/g/mozilla.dev.security.policy/c/nnLVNfqgz7g/m/TseYqDzaDAAJ and https://bugzilla.mozilla.org/show_bug.cgi?id=1427262)
  - Security company wanted to get CA status
  - Questionable practices

- Symantec! (https://wiki.mozilla.org/CA:Symantec_Issues)
  - Major company, regular participant in standards
  - Poor practices, mismanagement 2013-2017
  - CA distrusted in Oct 2018

Certificate Revocation

- Revocation is very important
- Many valid reasons to revoke a certificate
  - Private key corresponding to the certified public key has been compromised
  - User stopped paying his certification fee to this CA and CA no longer wishes to certify him
  - CA's private key has been compromised!
- Expiration is a form of revocation, too
  - Many deployed systems don't bother with revocation
  - Re-issuance of certificates is a big revenue source for certificate authorities

Certificate Revocation Mechanisms

- Certificate revocation list (CRL)
  - CA periodically issues a signed list of revoked certificates
    - Credit card companies used to issue thick books of canceled credit card numbers
  - Can issue a "delta CRL" containing only updates
- Online revocation service
  - When a certificate is presented, recipient goes to a special online service to verify whether it is still valid
    - Like a merchant dialing up the credit card processor

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:

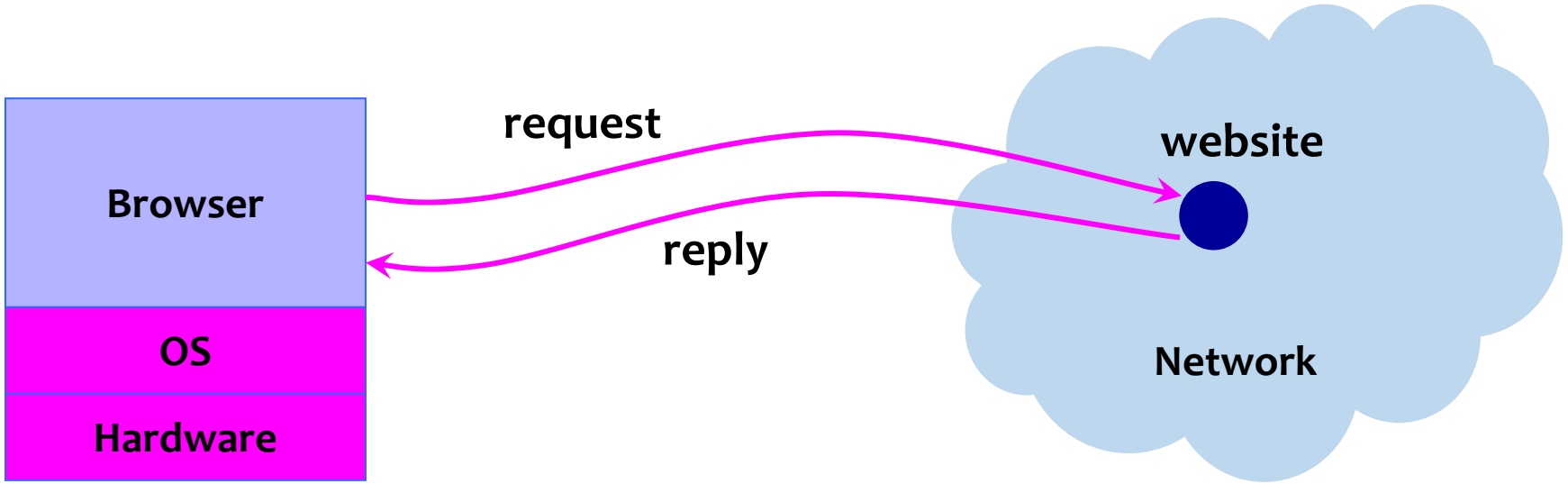
Certificate Pinning

- 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`"

Next Major Topic!

Web+Browser Security

Big Picture: Browser and Network



Where Does the Attacker Live?