Security: Network Attacks

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Network Attacks

- "man in the middle" attacks
- Attacker has access to network communication between browser and server.
- Passive attacks:
  - Eavesdrop on network traffic
- Active attacks:
  - Inject network packets
  - Modify packets
  - Reorder, replay packets
  - Block packets

Cryptography to the rescue

- Solution: use encryption to prevent eavesdropping and detect active attacks.
  - Old idea: Scramble the information before transmitting it, unscramble when received
- Traditional encryption:
  - Symmetric keys (same key on both ends)
  - Key distribution problem: how can we exchange keys without meeting in person?
- Public-key encryption solves the key distribution problem
  - Each principal (user, program, etc.) has two encryption keys, one public, one secret
  - Information encrypted with one can only be decrypted with the other.

    Encrypt with public key: Only principle can access

    Encrypt with secret key: Know that it comes from principle
- Public-key encryption is slower than symmetric encryption
  - Use public-key to exchange symmetric key

How to find the public key for a particular server?

Can't just ask it for its public key?

Don't know if the entity we're asking is really the server we want!

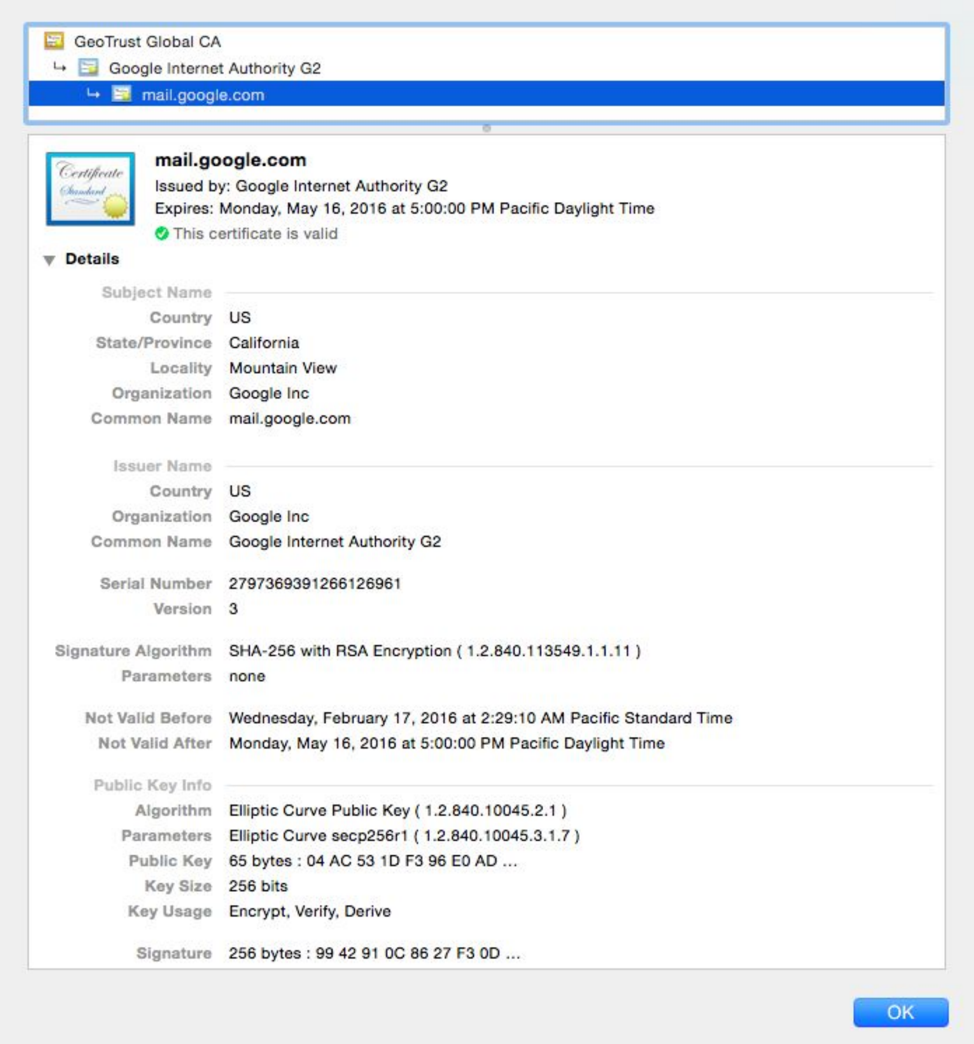
Certificate authority: well-known, trusted server that certifies public keys.

Certificate: a document encrypted with the secret key of a certificate authority

- Identifies a particular service along with its public key

Certificate authorities

- Certificate authorities establish selfs as well known services on Internet
    - Browsers hard-wired to accept certificates from dozens of authorities
- Internet services compute keys, gives the public key to a certificate authority along with proof of identity
- Certificate authority returns a certificate for that service.
- Service can pass along this certificate to browsers
    - Browser can validate the certificate came from the certification authority and see who the certification authority thinks the browser is talking to.
- Trust: Browser trusts to certification authority



GeoTrust Global CA
↳ Google Internet Authority G2
↳ mail.google.com

mail.google.com
Issued by: Google Internet Authority G2
Expires: Monday, May 16, 2016 at 5:00:00 PM Pacific Daylight Time
✓ This certificate is valid

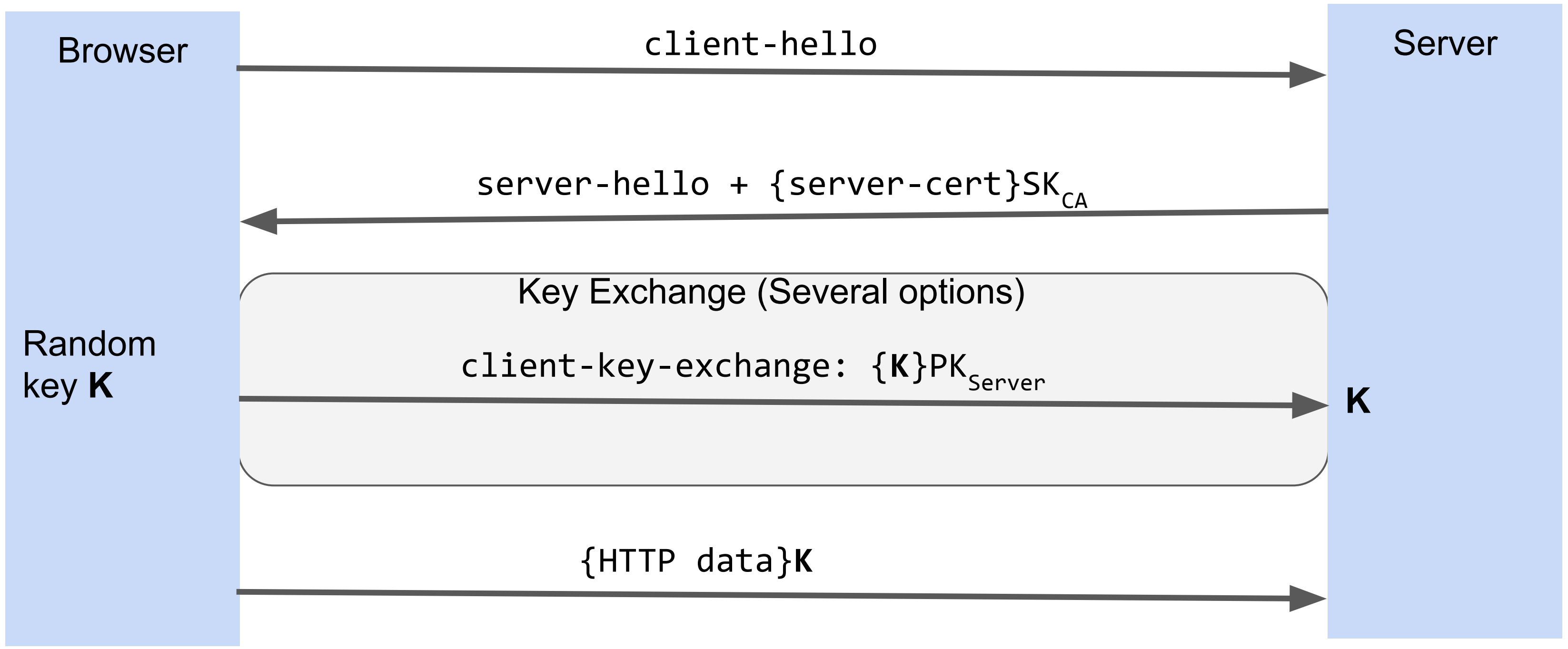
▼ **Details**

Subject Name	
Country	US
State/Province	California
Locality	Mountain View
Organization	Google Inc
Common Name	mail.google.com
Issuer Name	
Country	US
Organization	Google Inc
Common Name	Google Internet Authority G2
Serial Number	2797369391266126961
Version	3
Signature Algorithm	SHA-256 with RSA Encryption (1.2.840.113549.1.1.11)
Parameters	none
Not Valid Before	Wednesday, February 17, 2016 at 2:29:10 AM Pacific Standard Time
Not Valid After	Monday, May 16, 2016 at 5:00:00 PM Pacific Daylight Time
Public Key Info	
Algorithm	Elliptic Curve Public Key (1.2.840.10045.2.1)
Parameters	Elliptic Curve secp256r1 (1.2.840.10045.3.1.7)
Public Key	65 bytes : 04 AC 53 1D F3 96 E0 AD ...
Key Size	256 bits
Key Usage	Encrypt, Verify, Derive
Signature	256 bytes : 99 42 91 0C 86 27 F3 0D ...

Secure Sockets Layer (SSL) & Transport Layer Security (TLS) - **HTTPS**

- Protocol used for secure communication between browsers and servers
- Browser uses certificate to verify server's identity.
- Only one way: SSL/TLS does not allow the server to verify browser identity.
- Uses certificates and public-key encryption to pass a secret session-specific key from browser to server

Secure Sockets Layer (SSL) & Transport Layer Security (TLS) Overview



Browser

Server

`client-hello`

`server-hello + {server-cert}SK`$_{CA}$

Key Exchange (Several options)

Random key **K**

`client-key-exchange: {`**K**`}PK`$_{Server}$

K

`{HTTP data}`**K**

Excuses for not using HTTPS for all Web traffic?

- Expensive: slows down Web servers
- Breaks web page caching
- Today around 37% of most popular websites use HTTPS
    - Percentage going up

Problem: SSL stripping

- Common use pattern: user browses site with HTTP, upgrades to HTTPS for checkout.
- Active network attacker interposes on communication
- When server returns pages with HTTPS links, attacker changes them to HTTP.
- When browser follows those links, attacker intercepts requests, creates its own HTTPS connection to server, and forwards requests via that.
- As a result, the attacker sees all client packets (e.g., passwords).
- Browser provides feedback to user about whether HTTPS is in use, but most users won't notice the difference.

Problem: Mixed content

- Main page loaded with HTTPS, but some internal content loaded via HTTP (e.g. `<script src="http://.../script.js">`).
  - Network attacker can modify content to attack page.

- Some browsers help to notify users:
  - IE7: displays dialog for user, doesn't show SSL lock.
  - Firefox: displays lock icon with "!"
  - Chrome: did show warning, now just shows same as HTTP

- Common developer error: over-specified URLs:

  ```
  <script src="http://www.site.com/library.js">
  ```

  Instead, don't specify explicit protocols (or even site):

  ```
  <script src="/library.js">
  ```

Problem: "Just in time" HTTPS

- Login page displayed with HTTP
    - Form posted with HTTPS.
    - Appears secure but it isn't:
        - Active attack corrupts login page (send password someplace else during form post)
        - SSL stripping during form post: nothing indicates that the actual connection didn't use SSL
- Solution: before server returns HTML for login page, check for HTTPS; if page fetched via HTTP, redirect to the HTTPS version

Problem: Bad certificate

- If a certificate is bad/unknown, browser issues warning dialog:
  - Most users can't understand, so they just click OK.
  - Some browsers warn repeatedly, but users will still just click through.
  - This enables various network attacks.