# 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?

The main disadvantage of the symmetric key encryption is that all parties involved have to exchange the key used to encrypt the data before they can decrypt it.

- Public-key encryption helps with 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

A public key is made freely available to anyone who might want to send you a message. The second private key is kept a secret so that you can only know.

- 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

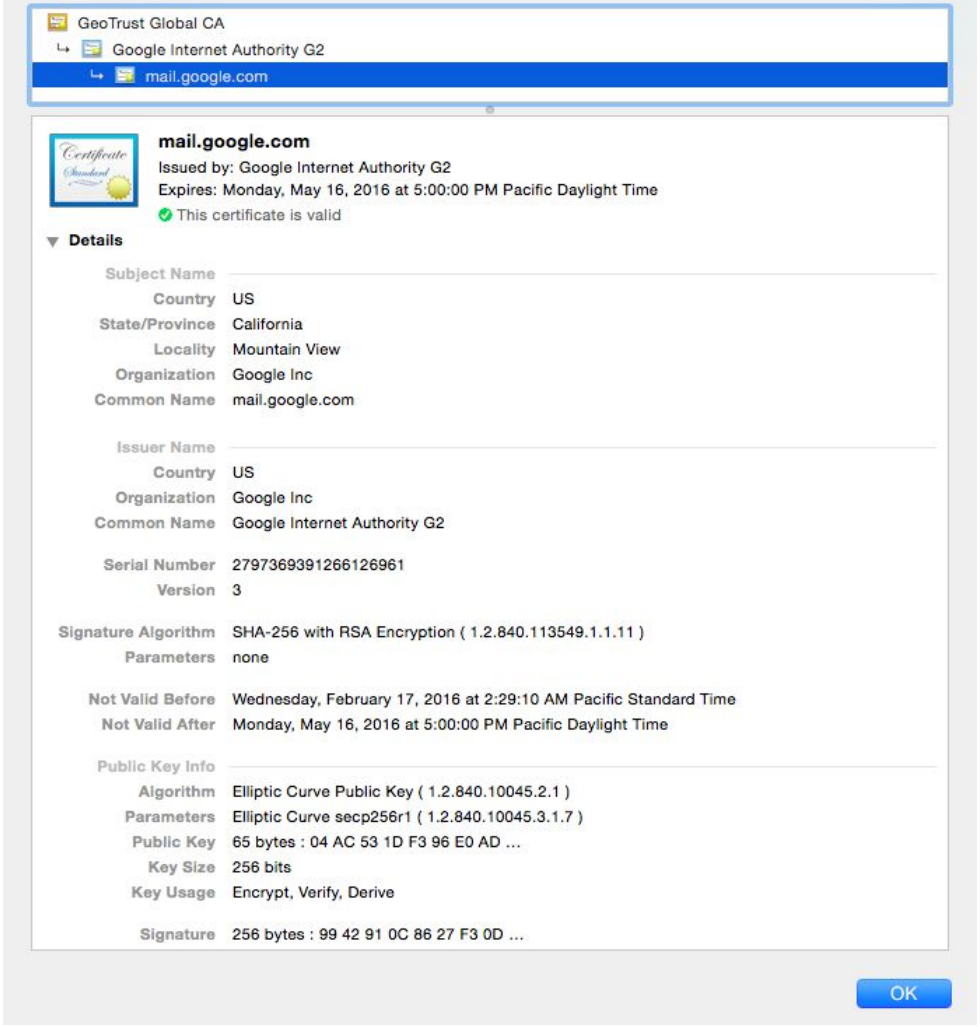
# Certificate authorities

When a server and a client require a secure encrypted communication, they send a query over the network to the other party, which sends back a copy of the certificate. The other party's public key can be extracted from the certificate. A certificate can also be used to uniquely identify the holder.

- 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

internet service --key--> certificate authorities
certificate authorities --certificate--> service
service --certificate--> browser

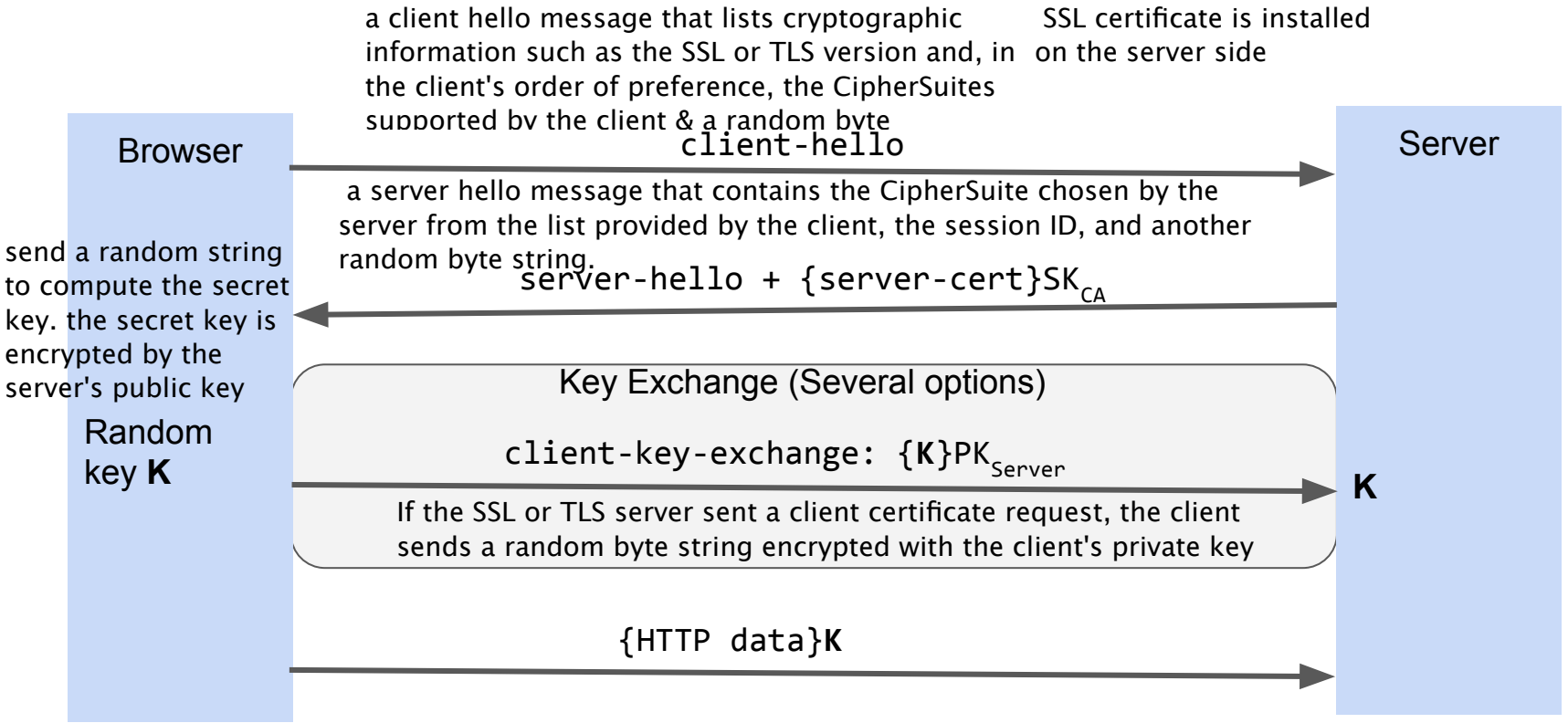
- Certificate authority returns a certificate for that service
- Service can pass along this certificate to browsers
  - Browser can validate the certificate came from the certification authority and see who the certification authority thinks the browser is talking to.
- Trust: Browser trusts to certification 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 ...
OK

## 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



# Excuses for not using HTTPS for all Web traffic?

- Expensive: slows down web servers - more cycles per connection
  - Can now offload to networking hardware
- Breaks in-the-middle web page caching
- Today around 75% of most popular websites use HTTPS
  - Percentage going up quickly

# 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.