Securing the SSL/TLS channel against man-in-the-middle attacks: Future technologies - HTTP Strict Transport Security and Pinning of Certs

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Tobias Gondrom

- 12 years information security experience (Global Head of Security, CISO, CTO)
- 10 years application development experience
- Information Security & Risk Management, Research and Advisory, Managing Director, Thames Stanley Ltd.
- Author of Standards on Digital Signatures and Secure Archiving
- Chair of IETF Web Security Working Group http://datatracker.ietf.org/wg/websec/charter/ Member of the IETF Security Directorate
- London OWASP chapter board member, OWASP Global Industry Committee www.owasp.org

Defending against MITMA

- Past Attacks/Breaches
- Insufficient Transport Layer Protection
- Possible Solutions
  - HSTS - Secure Channels: Strict Transport Security
  - Cert Pinning
- When

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CA breaches March 15th 2011: Comodo breach

- Nine fake certificates for seven domains were issued: mail.google.com, login.live.com, www.google.com, login.yahoo.com (three certificates), login.skype.com, addons.mozilla.org, and global trustee
- Hacked several times afterwards

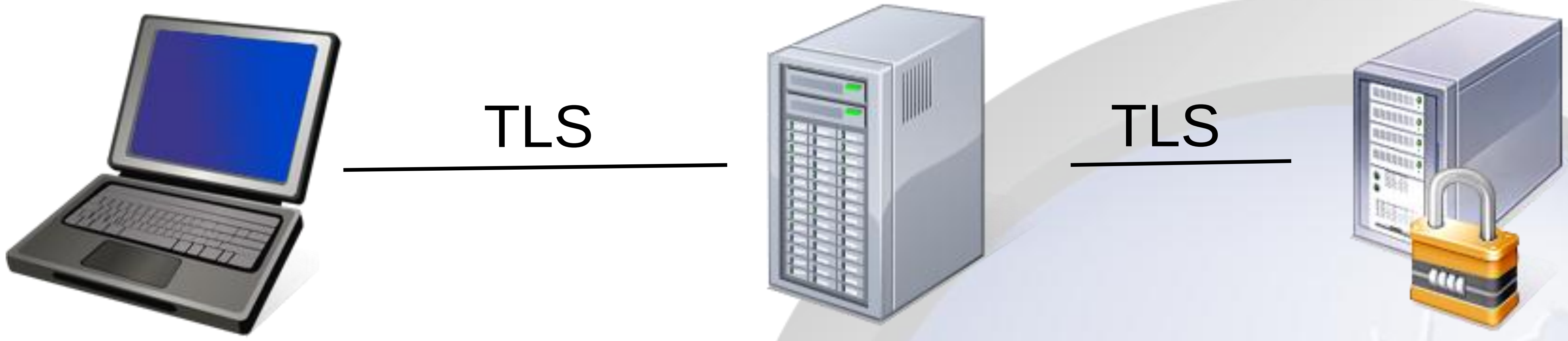
CA breaches
June (?) 2011: DigiNotar breach

- Discovered on June 19th
- July 10, 2011: wildcard cert issued for Google, subsequently used by unknown persons in Iran to conduct a man-in-the-middle attack against Google services
- August 28, 2011, certificate problems were observed on multiple Internet service providers in Iran
- Tor Project has published extensive updates on the scope of the attack, including a list of 531 fraudulent certificates issued by DigiNotar

CA breaches
June (?) 2011: DigiNotar breach

- All browser vendors remove trust of DigiNotar swiftly, e.g. August 30, 2011: Mozilla removed DigiNotar certificates from their list of trusted CAs (via patches etc.)
- September 20, 2011 – DigiNotar filed for bankruptcy
- Remark: Google Chrome users were protected from this attack because Chrome was able to detect the fraudulent certificate due to pinning.
- Statements have appeared that the DigiNotar attacker is the same person who attacked Comodo earlier
- The attacker claims to be an individual Iranian who has chosen to help the government monitor individuals' communications. Additionally, he claims to have compromised four additional as-yet-unspecified certificate authorities.

MITMA - TLS attack



Attacker replaced Server cert with own compromised cert and could read all communication (incl. passwords) in the clear

The situation

- Browsers trust CA certificates for all domains equally (any trusted CA can sign for any identity, true or fake, e.g. google.com, paypal.com, …)
- hundreds of CAs
- From 46 countries/jurisdictions
- If a single one is broken, all TLS/SSL domains are prone to attacks

From EFF: SSL Observatory

- 1,482 CA Certificates trustable by Windows or Firefox
- 1,167 distinct issuer strings
- 651 organizations, but ownerships & jurisdictions overlap
- (If a CA can sign for one domain, it can sign for any domain.)

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OWASP Top 10 – Insufficient Transport Layer Protection

A1: Injection

A2: Cross-Site Scripting (XSS)

A3: Broken Authentication and Session Management

A4: Insecure Direct Object References

A5: Cross Site Request Forgery (CSRF)

A6: Security Misconfiguration

A7: Failure to Restrict URL Access

A8: Insecure Cryptographic Storage

A9: Insufficient Transport Layer Protection

A10: Unvalidated Redirects and Forwards

What’s the problem

- Some are not using / not mandating TLS/SSL
- Relies on trust relationships (trust on first use / trusted source)
- Weak channel protection
- Authentication & leakage of credentials

=> Today, Web Applications try to fix this on the Application level with little support of the underlying infrastructure

A9 – Insufficient Transport Layer Protection

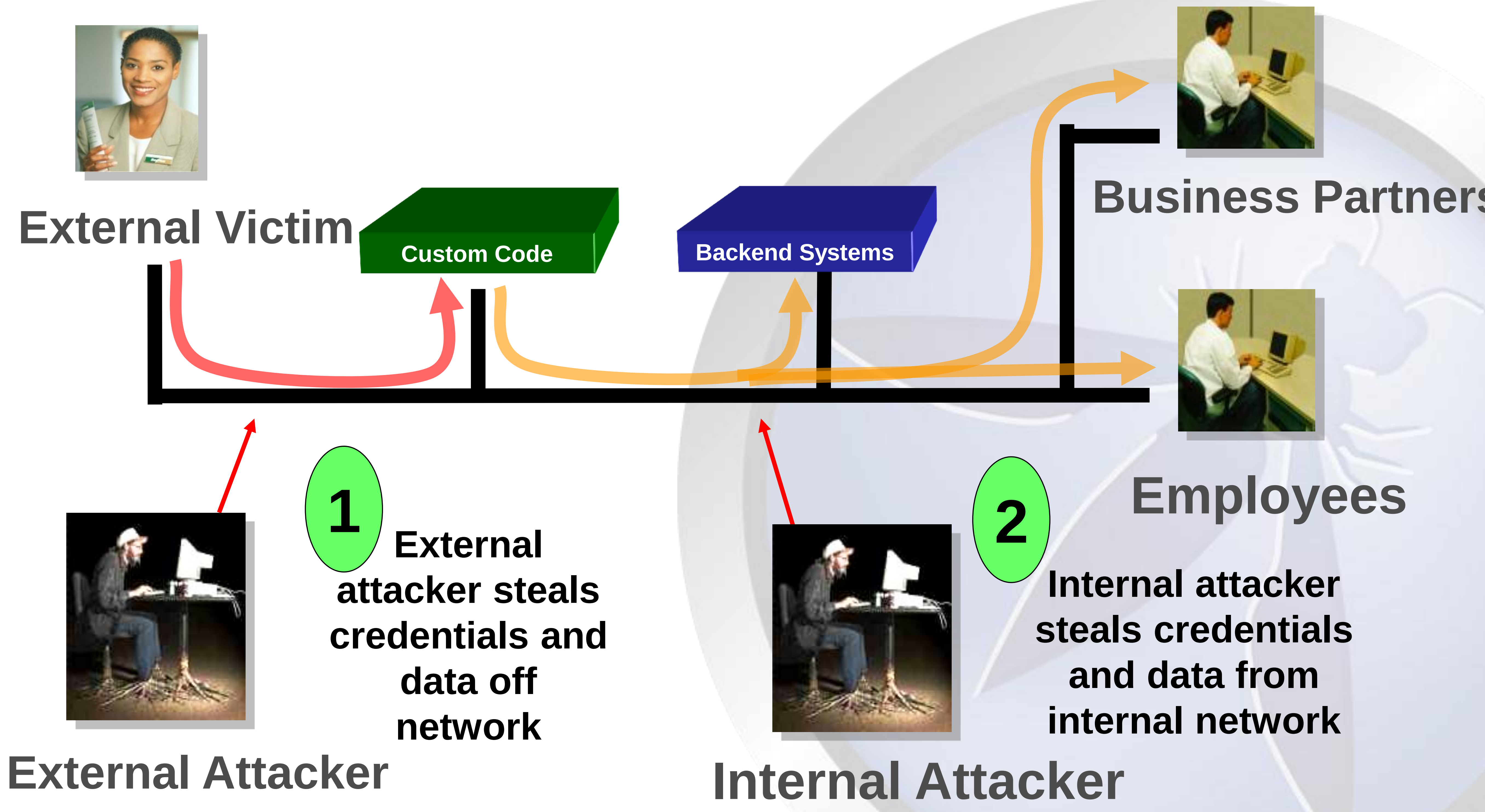
Transmitting sensitive data insecurely

- Failure to identify all sensitive data
- Failure to identify all the places that this sensitive data is sent
  - On the web, to backend databases, to business partners, internal communications
- Failure to properly protect this data in every location

Typical Impact

- Attackers access or modify confidential or private information
  - e.g, credit cards, health care records, financial data (yours or your customers)
- Attackers extract secrets to use in additional attacks
- Company embarrassment, customer dissatisfaction, and loss of trust
- Expense of cleaning up the incident
- Business gets sued and/or fined

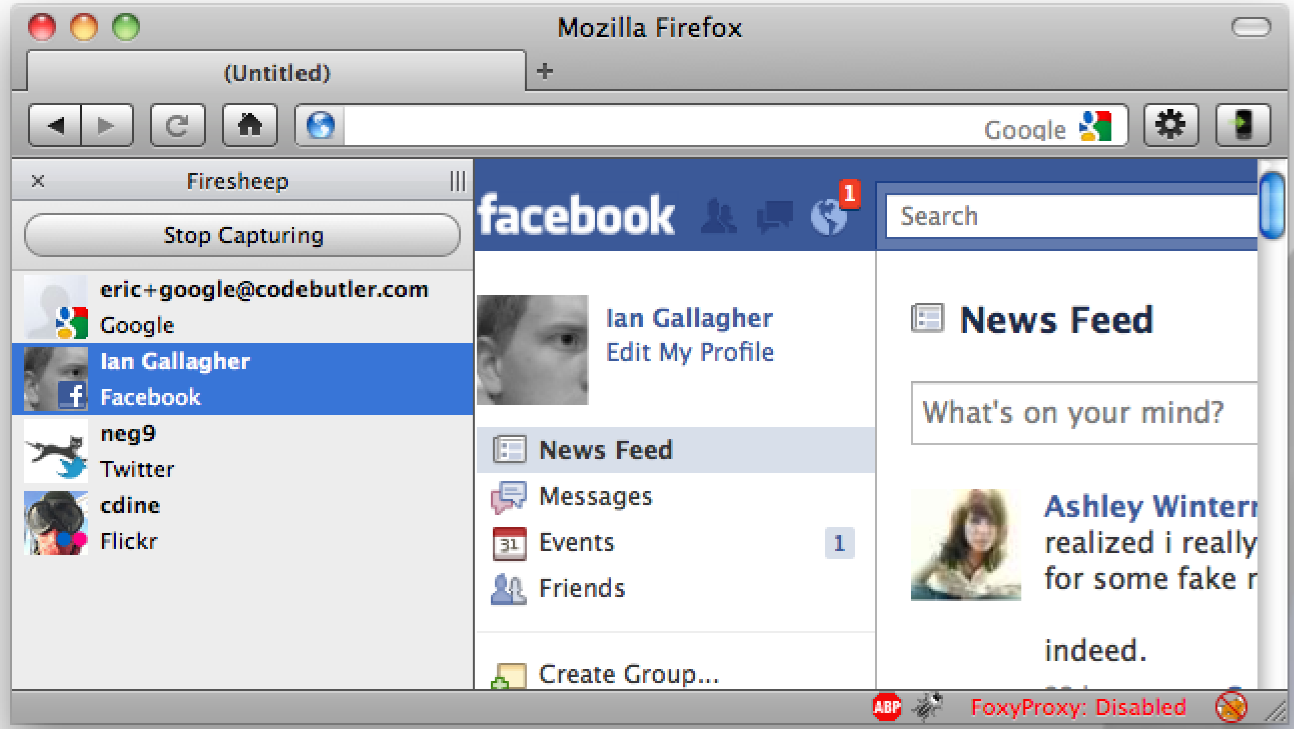
Insufficient Transport Layer Protection



1 External attacker steals credentials and data off network

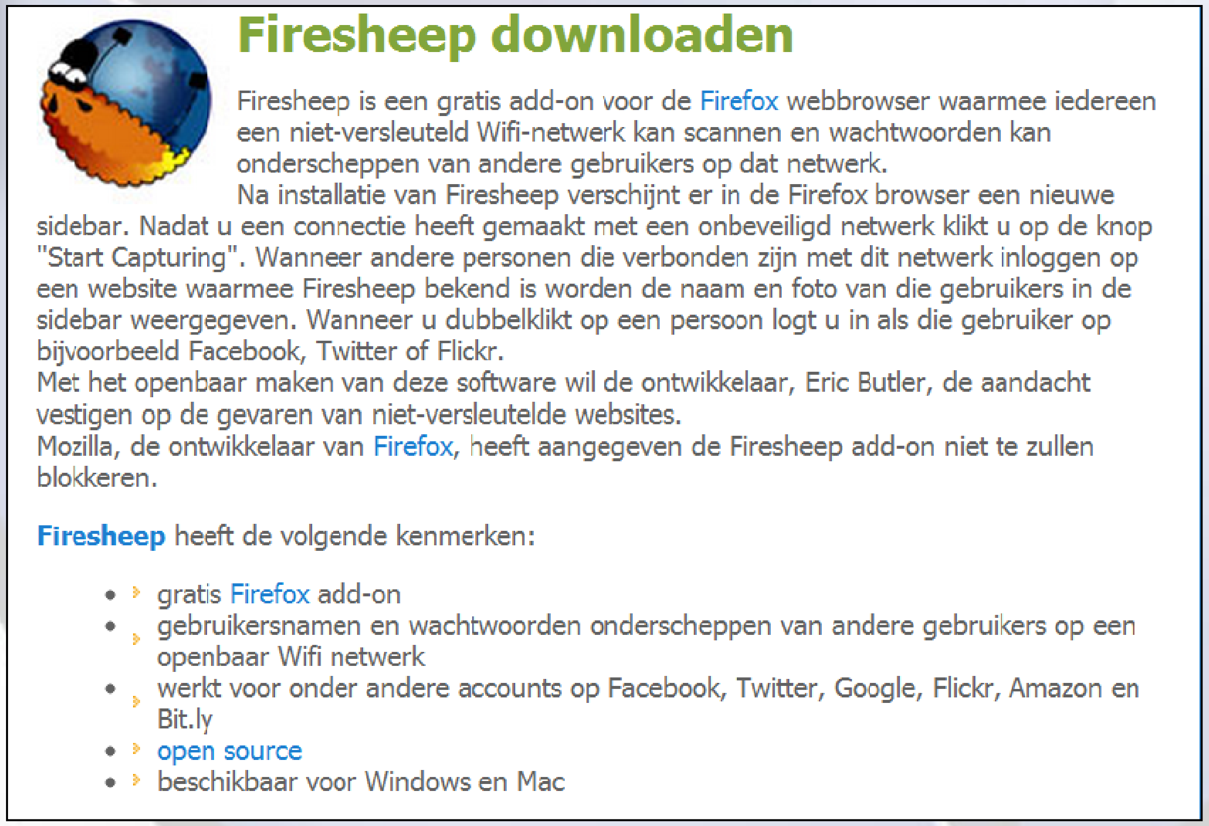
2 Internal attacker steals credentials and data from internal network

Still not using SSL?



Now: Redirect to https before login.

How about you?

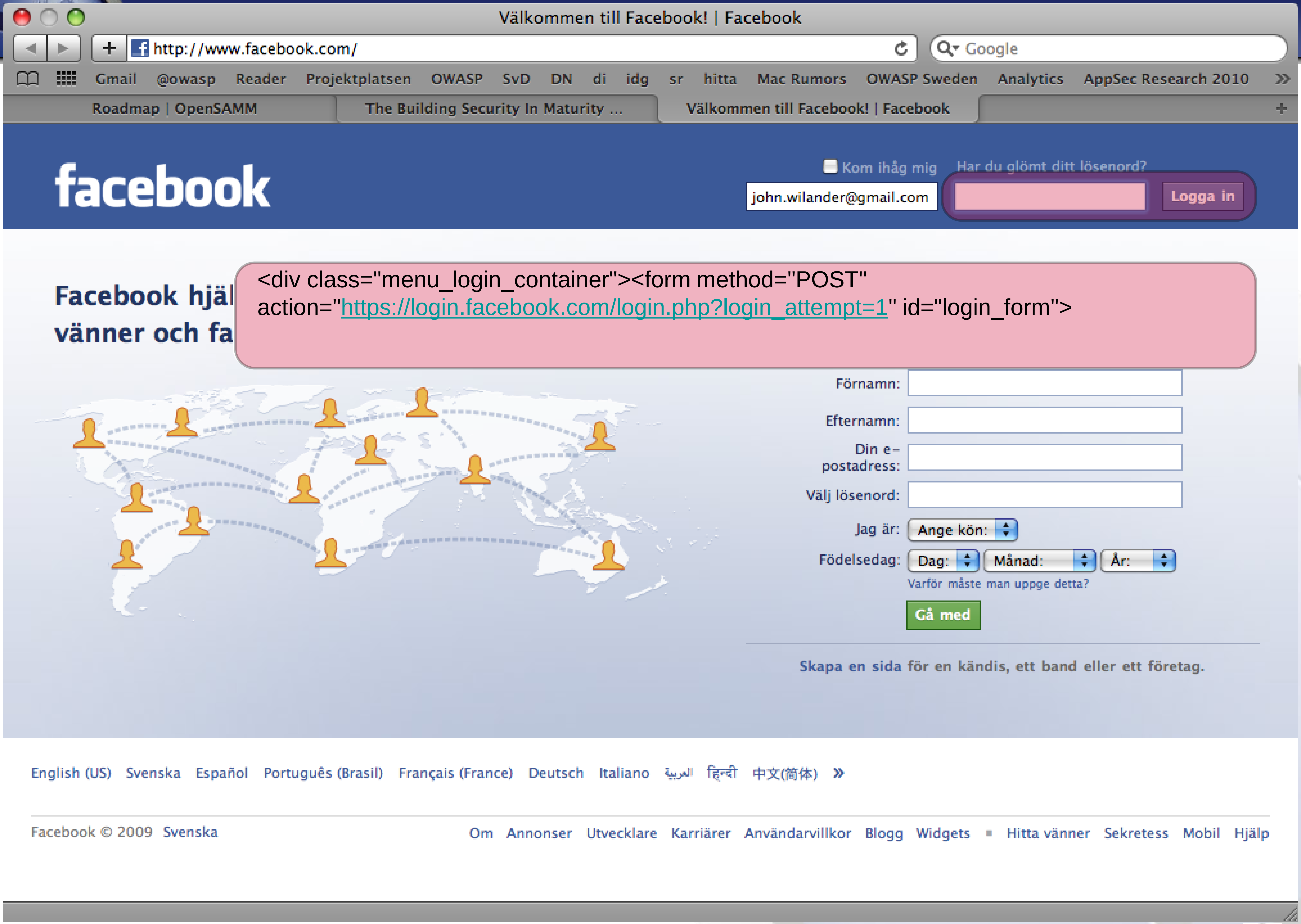


Firesheep downloaden

Firesheep is een gratis add-on voor de Firefox webbrowser waarmee iedereen een niet-versleuteld Wifi-netwerk kan scannen en wachtwoorden kan onderscheppen van andere gebruikers op dat netwerk.
Na installatie van Firesheep verschijnt er in de Firefox browser een nieuwe sidebar. Nadat u een connectie heeft gemaakt met een onbeveiligd netwerk klikt u op de knop "Start Capturing". Wanneer andere personen die verbonden zijn met dit netwerk inloggen op een website waarmee Firesheep bekend is worden de naam en foto van die gebruikers in de sidebar weergegeven. Wanneer u dubbelklikt op een persoon logt u in als die gebruiker op bijvoorbeeld Facebook, Twitter of Flickr.
Met het openbaar maken van deze software wil de ontwikkelaar, Eric Butler, de aandacht vestigen op de gevaren van niet-versleutelde websites.
Mozilla, de ontwikkelaar van Firefox, heeft aangegeven de Firesheep add-on niet te zullen blokkeren.

Firesheep heeft de volgende kenmerken:

- gratis Firefox add-on
- gebruikersnamen en wachtwoorden onderscheppen van andere gebruikers op een openbaar Wifi netwerk
- werkt voor onder andere accounts op Facebook, Twitter, Google, Flickr, Amazon en Bit.ly
- open source
- beschikbaar voor Windows en Mac



Välkommen till Facebook! | Facebook

http://www.facebook.com/

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Roadmap | OpenSAMM — The Building Security In Maturity ... — Välkommen till Facebook! | Facebook

facebook

Kom ihåg mig — Har du glömt ditt lösenord?

john.wilander@gmail.com — Logga in

```
<div class="menu_login_container"><form method="POST"
action="https://login.facebook.com/login.php?login_attempt=1" id="login_form">
```

Facebook hjäl
vänner och fa

Förnamn:	
Efternamn:	
Din e-postadress:	
Välj lösenord:	
Jag är:	Ange kön:
Födelsedag:	Dag: Månad: År:

Varför måste man uppge detta?

Gå med

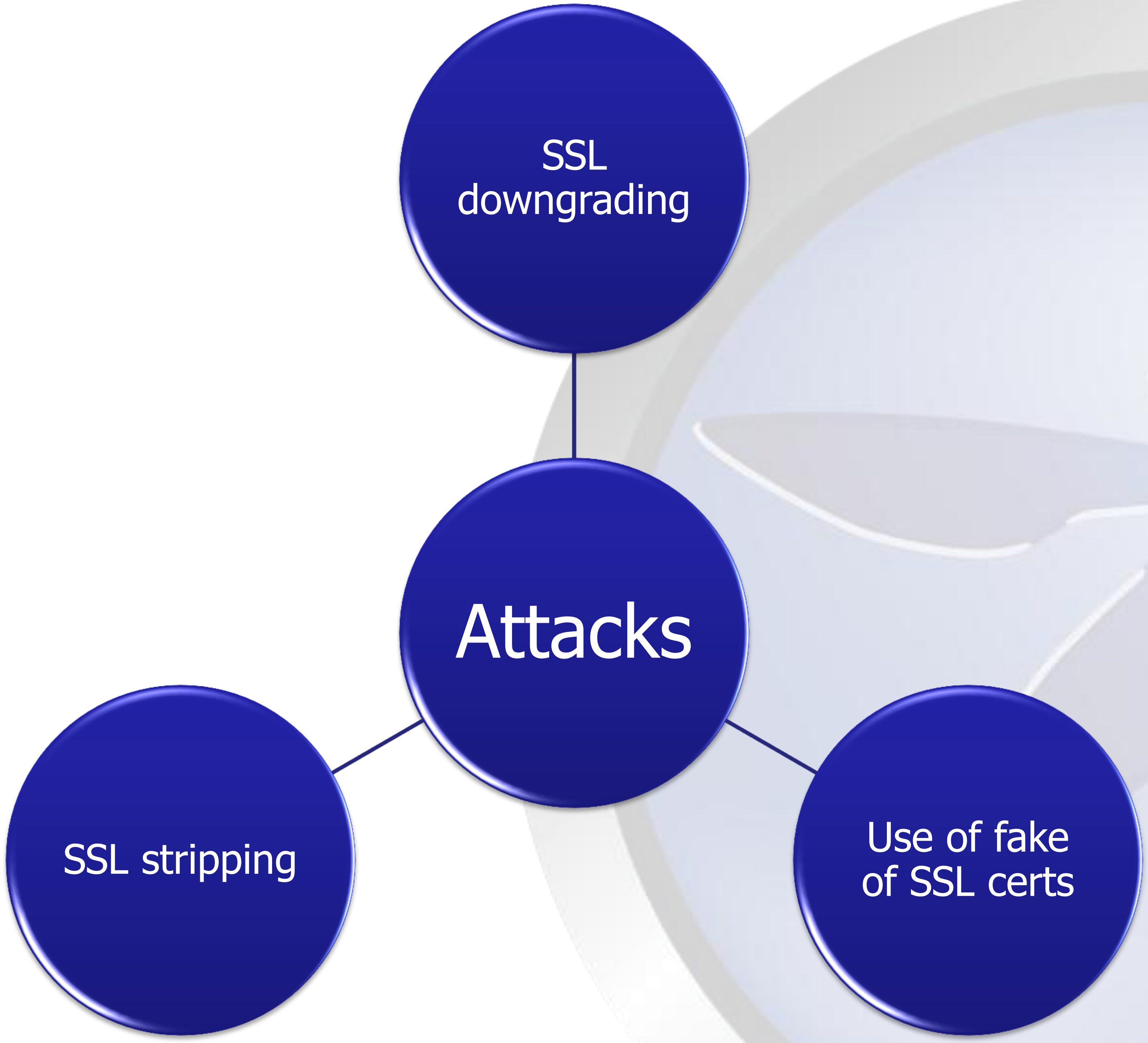
Skapa en sida för en kändis, ett band eller ett företag.

English (US) Svenska Español Português (Brasil) Français (France) Deutsch Italiano العربية हिन्दी 中文(简体) »

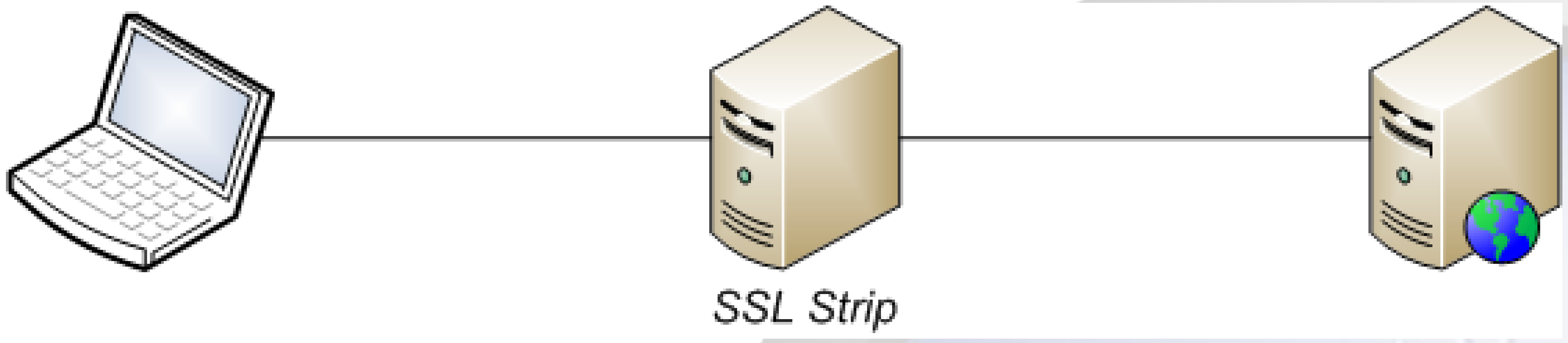
Facebook © 2009 Svenska

Om Annonser Utvecklare Karriärer Användarvillkor Blogg Widgets · Hitta vänner Sekretess Mobil Hjälp

Common attack vectors



Moxie's SSL Strip



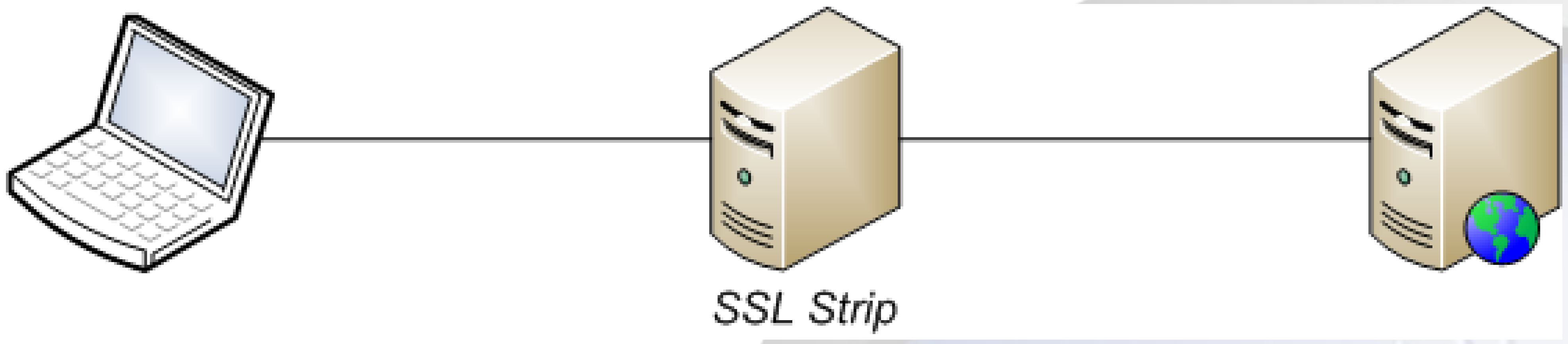
Terminates SSL

Changes https to http

Normal https to the server

Acts as client

Moxie's SSL Strip



Secure cookie?

Encoding, gzip?

Cached content?

Sessions?

Strip the secure attribute off all cookies.

Strip all encodings in the request.

Strip all if-modified-since in the request.

Redriect to same page, set-cookie expired

A9 – Avoiding Insufficient Transport Layer Protection

Use the mechanisms correctly

- Use TLS on **all** connections with sensitive data
- Use standard strong algorithms (disable old SSL algorithms)
- Manage keys/certificates properly
- Verify SSL certificates before using them
- Use proven mechanisms when sufficient
  - E.g., SSL vs. XML-Encryption

See: http://www.owasp.org/index.php/Transport_Layer_Protection_Cheat_Sheet for more details

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Who – Introducing the Players

- OWASP
  - Top Ten
  - Browser Security Day at OWASP Summit
- IETF
  - Web Security WG
- Browser Vendors
- Secure Web-sites of critical information and payment systems (e.g. paypal, google, ebay, …)
- Security Researchers and Plug-in developers for browsers

What’s been done / what’s coming

- Secure Channel:
  - HSTS Strict Transport Security
  - Cert Pinning
  - TLS cert pinning in DNSSEC
- Other methods:
  - Moxie’s Convergence (browser plug-in)

HSTS - Secure Channels: Strict Transport Security

- Server declares **"I only talk TLS"**
  - Example:
    HTTP(S) Response Header:
    `Strict-Transport-Security: max-age=15768000; includeSubDomains`
- Header can be cached and also prevents leakage via subdomain-content through non-TLS links in content
- Weakness: "Trust on first use"
  - Possible pre-loaded HSTS in browsers
- Already first deployments

Cert Pinning (1)

draft-ietf-websec-key-pinning-01

- Server identities tend to be long-lived, but clients have to re-establish the server's identity on every TLS session.
- How could Google/Chrome be resilient to DigiNotar attack?
  - Google built-in in Chrome "preloaded" fingerprints for the known public keys in the certificate chains of Google properties. Thereby exposed the false *.google.com certificate DigiNotar signed.

Cert Pinning (2)

But….

…..preloading does not scale, so we need something dynamic:

=> Could use an HTTP header

i.e. transmit the SHA1 or SHA256 hash of the Subject Public Key Info structure of the X.509 certificate. (You could pin to end entity, intermediary, root. Select your degree of precision.)

Cert Pinning - Syntax

Header add Public-Key-Pins `"max-age=10000; pin-sha1=\"ObT42aoSpAqWdY9WfRfL7i0HsVk=\"; pin-sha1=\"hvfkN/qlp/zhXR3cuerq6jd2Z7g=\""`

Cert Pinning - parameters

- List at least 2 certs: 1 live pin (a hash of an SPKI in the current cert chain) and at least one backup pin (a hash of an SPKI not in the current cert chain).
- Clients remember the most recently seen set of pins for max-age seconds after it was most recently seen.
- Clients drop TLS connections if not using the listed certs.

Cert Pinning – possible problems

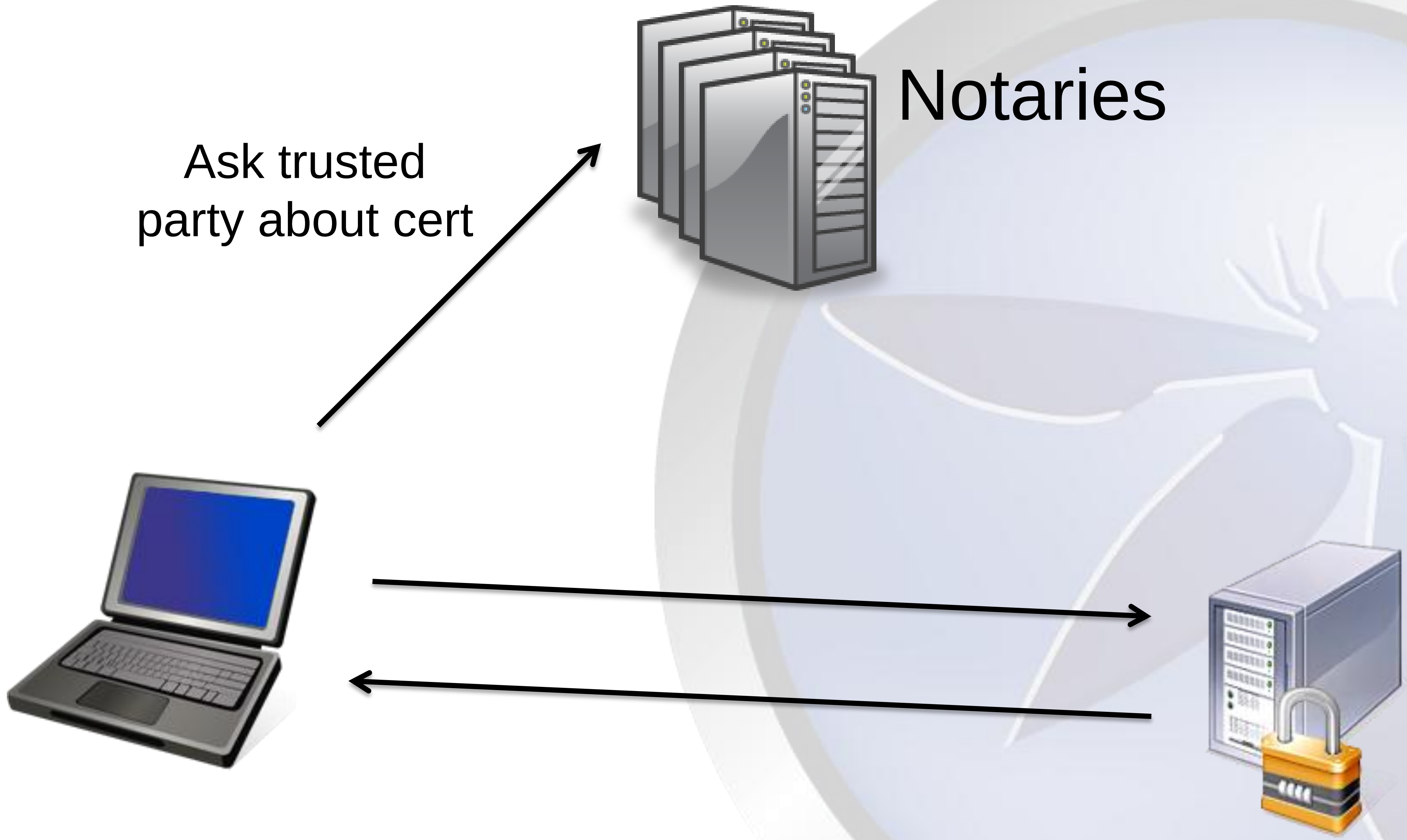
Possible Problems:

- Bootstrap – “trust on first use”
  - Pre-loaded browser
- Servers might accidently "brick" themselves (pin for a long time to an SPKI which is later lost, for example) – reason why backup cert is mandatory
- Attackers with ISP capabilities / man-in-the-middle access may try to “brick” domains for users even when outside of their reach (imagine: Iranian travelling abroad and no longer able to access Google, etc.)
  - Recovery / cache flush mechanisms

Other Methods: Secure Channels: DNSSEC for TLS

- DNSSEC can be used to declare supported protocols for domains
- DNSSEC can be used to declare server certificate for domain
- Advantage: Advantage of trusted signed source
- Disadvantage: long time to deploy

Other Methods: Moxie's Convergence – plug-in



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When - Timeframes

- HSTS Strict Transport Security – now
- Cert Pinning Q1 2013
- TLS in DNSSEC – 201?

Join the discussion

Ideas / feedback / participation welcome

IETF Websec:
http://tools.ietf.org/wg/websec/charters

Or drop me an email:
tobias.gondrom@gondrom.org

???

Questions?

Thank you