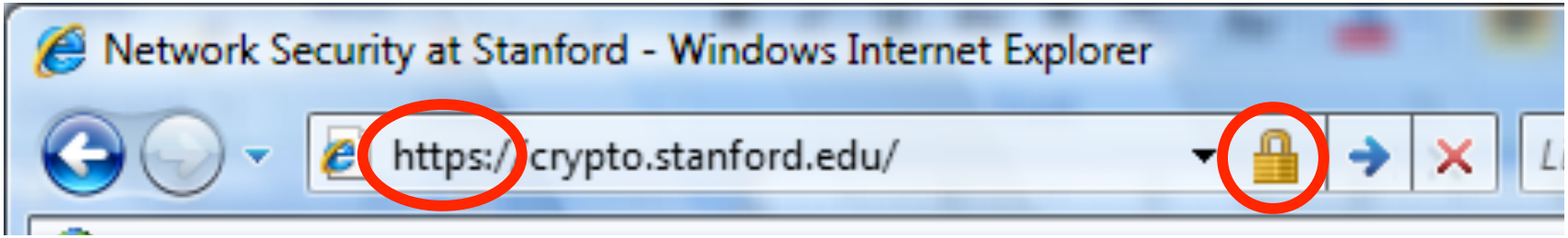


HTTPS and the Lock Icon

Dan Boneh

Goals for this lecture

- **Brief overview of HTTPS:**
  - How the SSL/TLS protocol works (very briefly)
  - How to use HTTPS
- **Integrating HTTPS into the browser**
  - Lots of user interface problems to watch for

Threat Model: Network Attacker

Network Attacker:

- Controls network infrastructure: Routers, DNS

  Passive attacker: only eavesdrops on net traffic

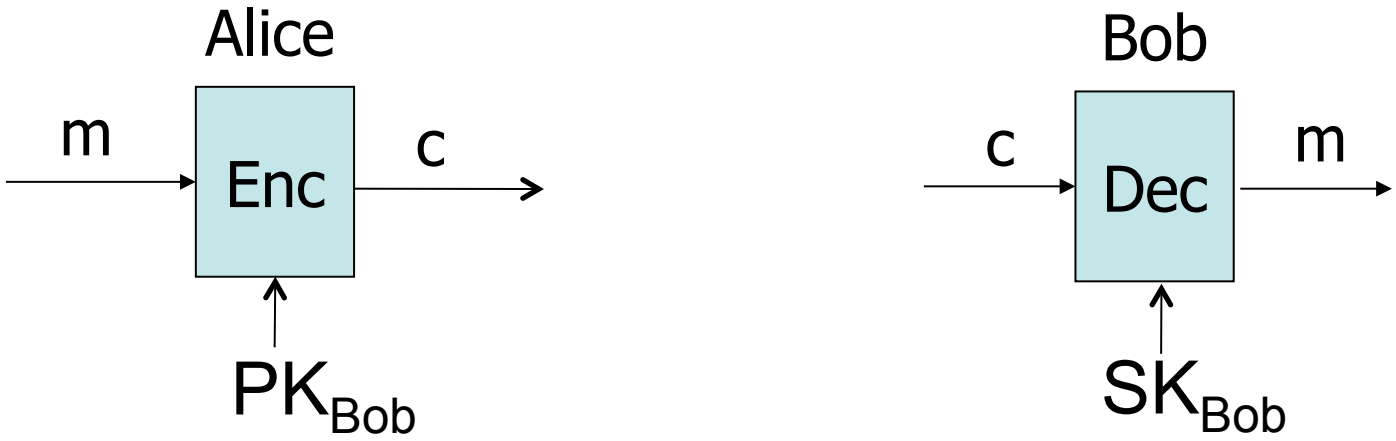
  Active attacker: eavesdrops, injects, blocks, and modifies packets

Examples:

- Wireless network at Internet Café
- Internet access at hotels (untrusted ISP)

SSL/TLS overview

Public-key encryption:

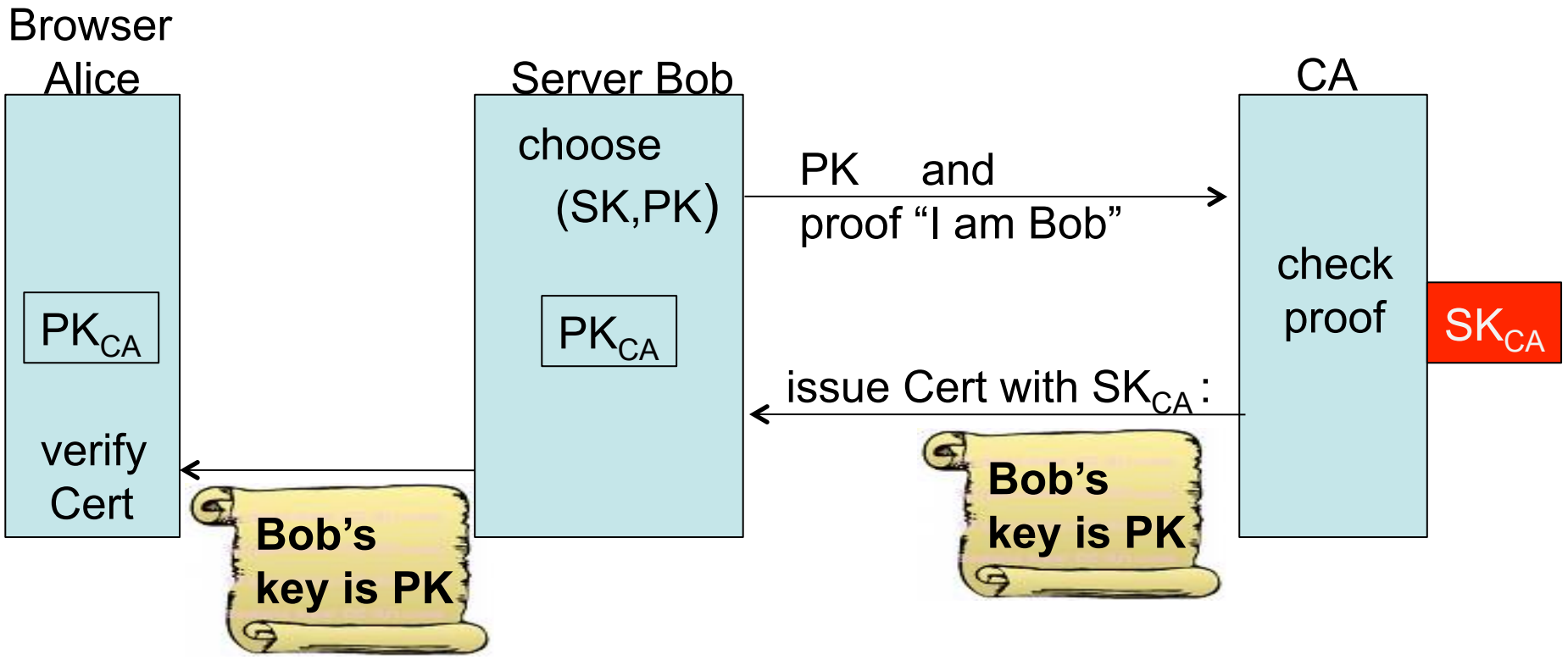


Bob generates (SK_{Bob} , PK_{Bob})

Alice: using PK_{Bob} encrypts messages and only Bob can decrypt

Certificates

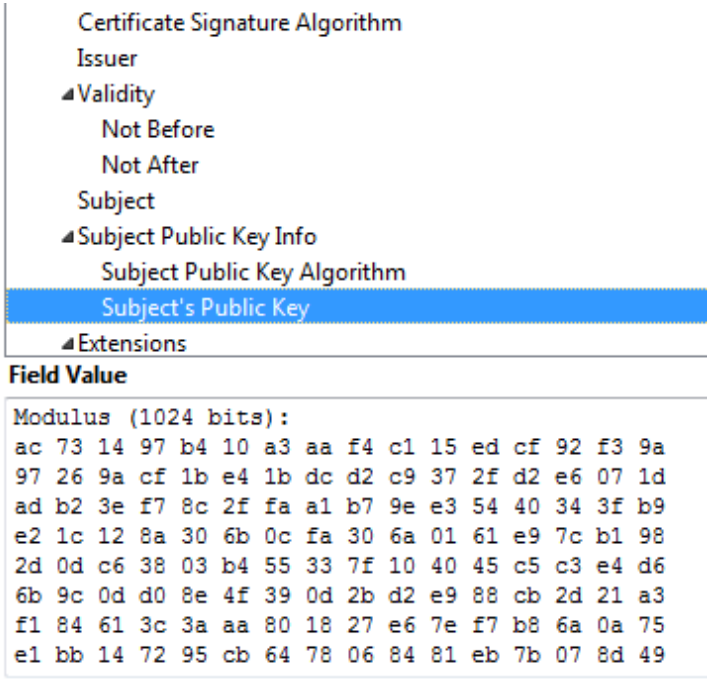
How does Alice (browser) obtain PK_{Bob} ?

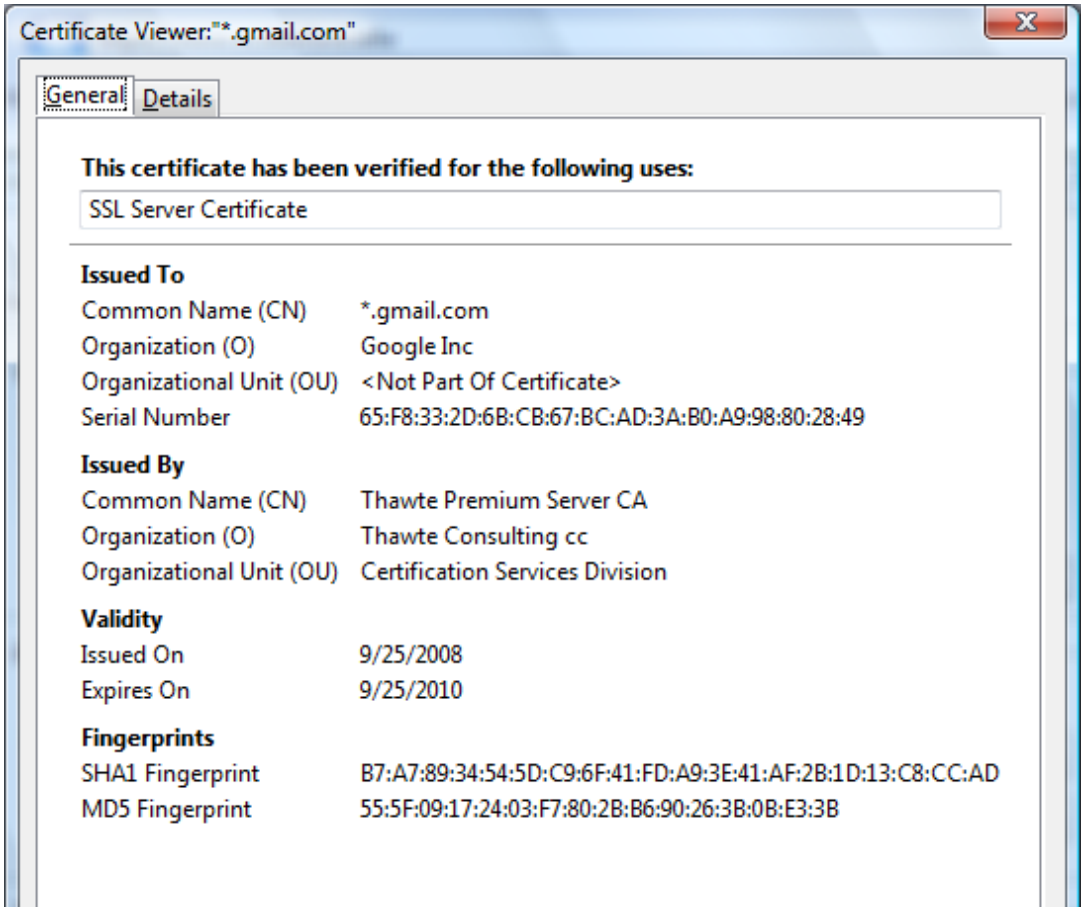


Bob uses Cert for an extended period (e.g. one year)

Certificates: example

Important fields:





Certificates on the web

Subject's CommonName can be:

- An explicit name, e.g. cs.stanford.edu , or
- A name with a wildcard character, e.g.
  .stanford.edu or cs.stanford.edu

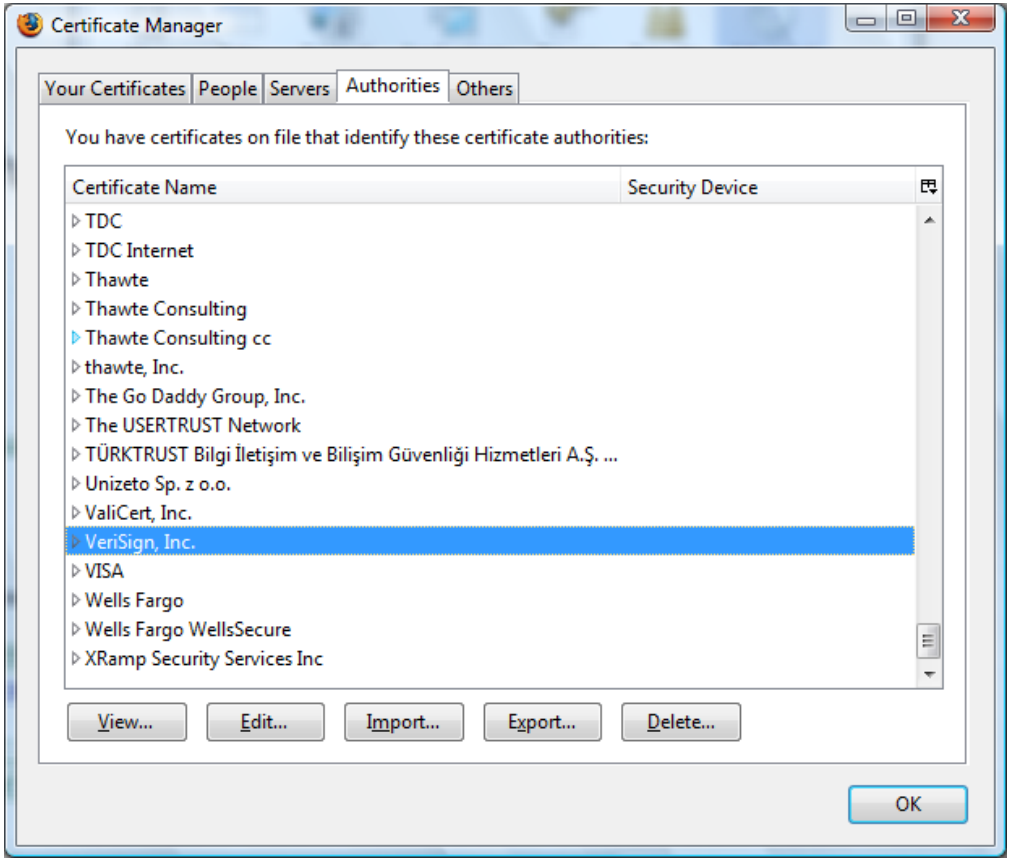
matching rules:

IE7: "*" must occur in leftmost component, does not match "."
example: ***.a.com** matches **x.a.com** but not **y.x.a.com**

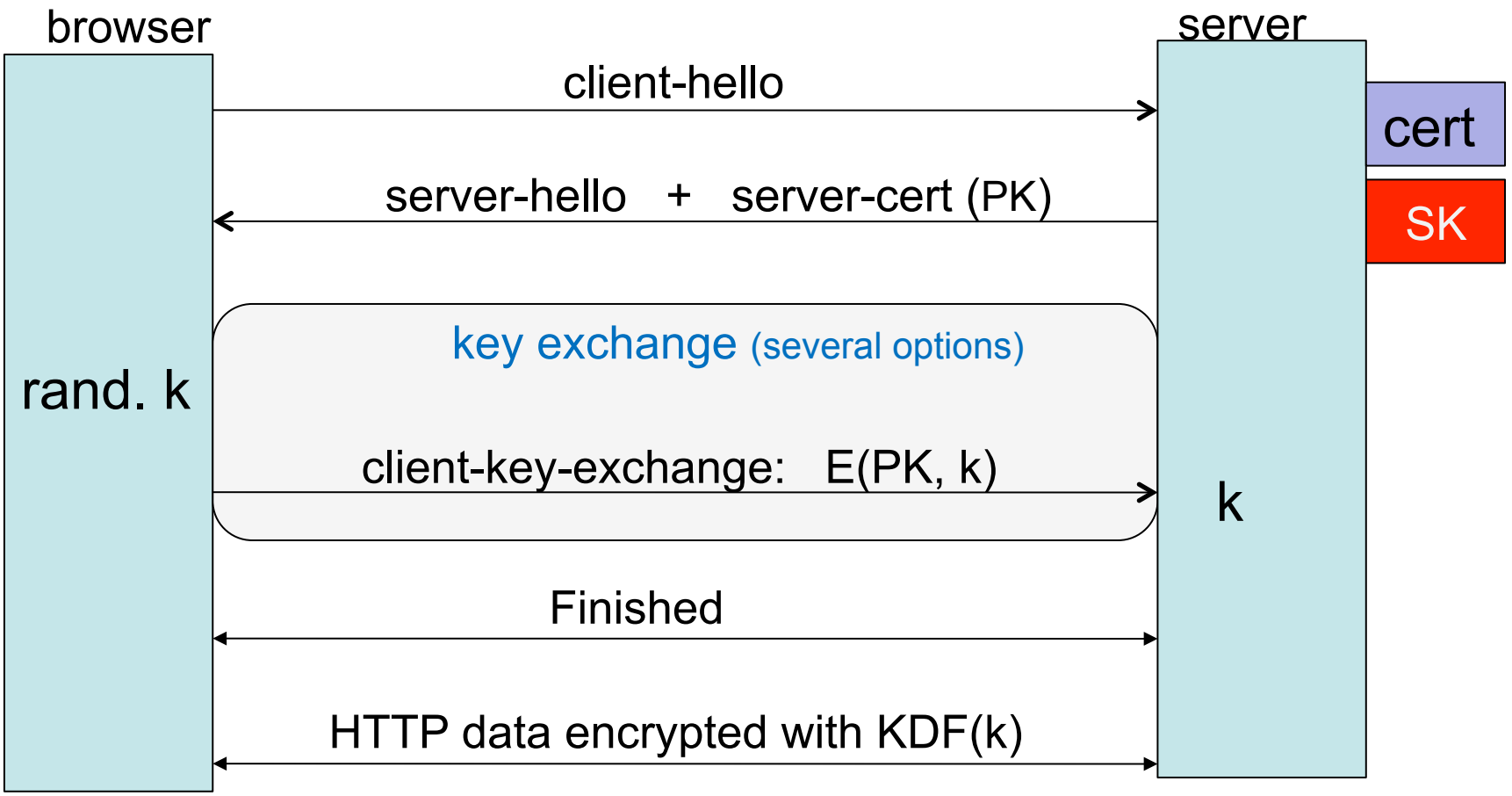
FF3: "*" matches anything

Certificate Authorities

Browsers accept certificates from a large number of CAs



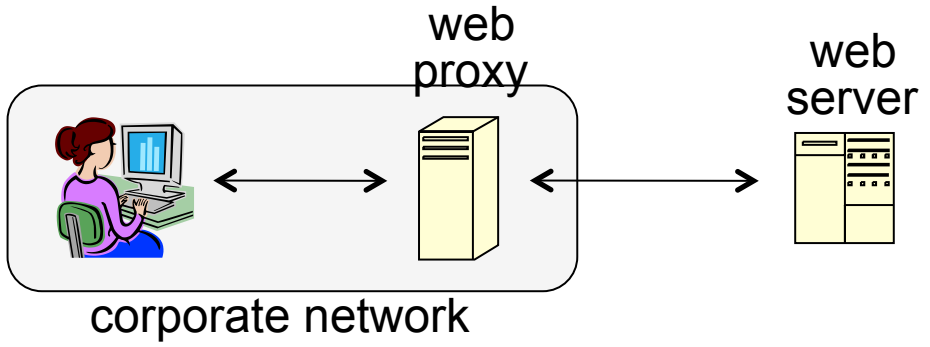
Brief overview of SSL/TLS



Most common: server authentication only

Integrating SSL/TLS with HTTP ⇒ HTTPS

Two complications



- **Web proxies**

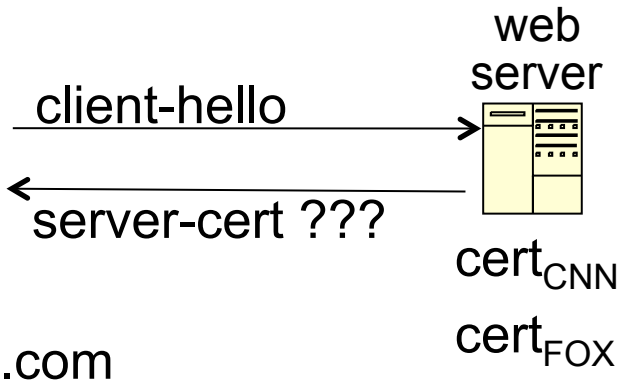
  solution: browser sends

  CONNECT domain-name

  before client-hello (dropped by proxy)

- **Virtual hosting:**

  two sites hosted at same IP address.



  solution in TLS 1.1 (RFC 4366)

  client_hello_extension: server_name=cnn.com

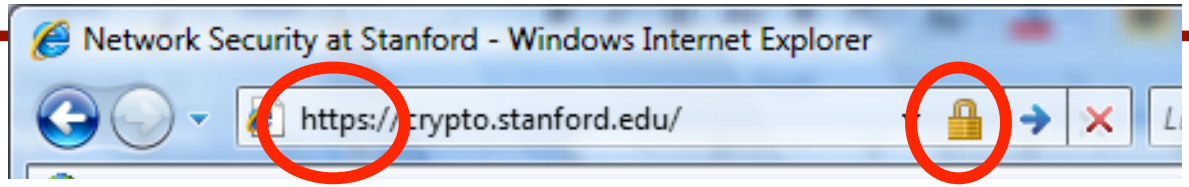
  implemented in FF2 and IE7 (vista)

Why is HTTPS not used for all web traffic?

- **Slows down web servers**
- **Breaks Internet caching**
  - ISPs cannot cache HTTPS traffic
  - Results in increased traffic at web site
- **Incompatible with virtual hosting** (older browsers)

HTTPS in the Browser

The lock icon: SSL indicator



Intended goal:

- Provide user with identity of page origin
- Indicate to user that page contents were not viewed or modified by a **network attacker**

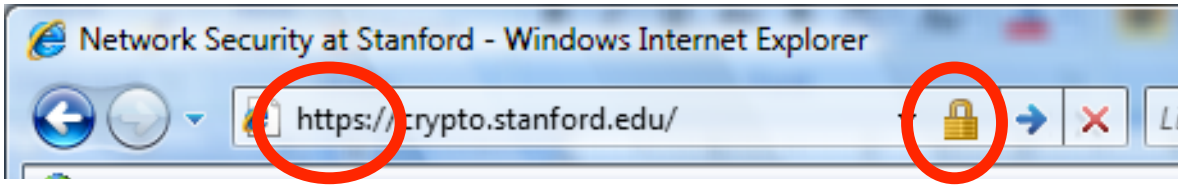
In reality:

- Origin ID is not always helpful

  example: Stanford HR is hosted at BenefitsCenter.com

- Many other problems (next few slides)

When is the (basic) lock icon displayed



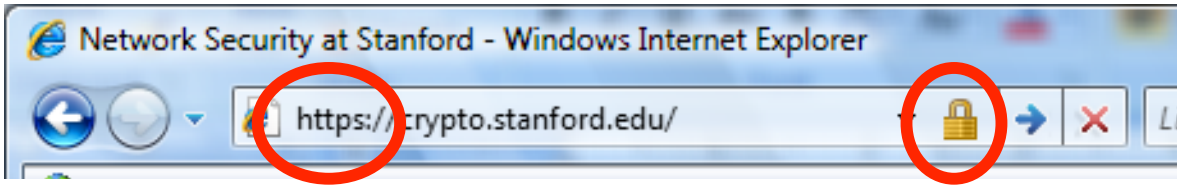
- **All elements on the page fetched using HTTPS**

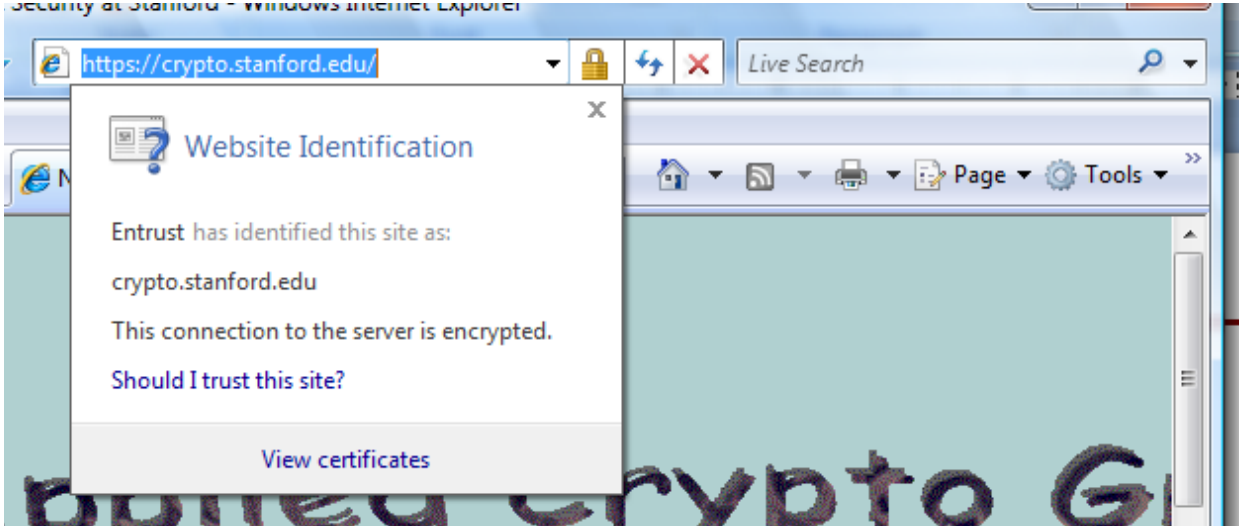
  (with some exceptions)

- **For all elements:**
  - HTTPS cert issued by a CA trusted by browser
  - HTTPS cert is valid (e.g. not expired)
  - CommonName in cert matches domain in URL

The lock UI: help users authenticate site

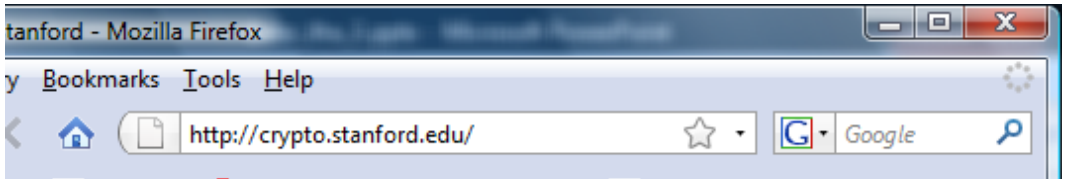
IE7:



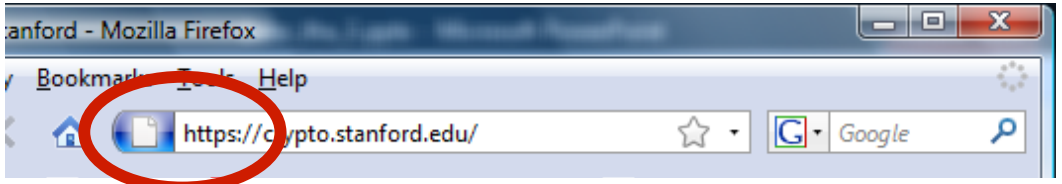


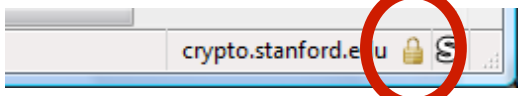
The lock UI: help users authenticate site

Firefox 3: (no SSL)



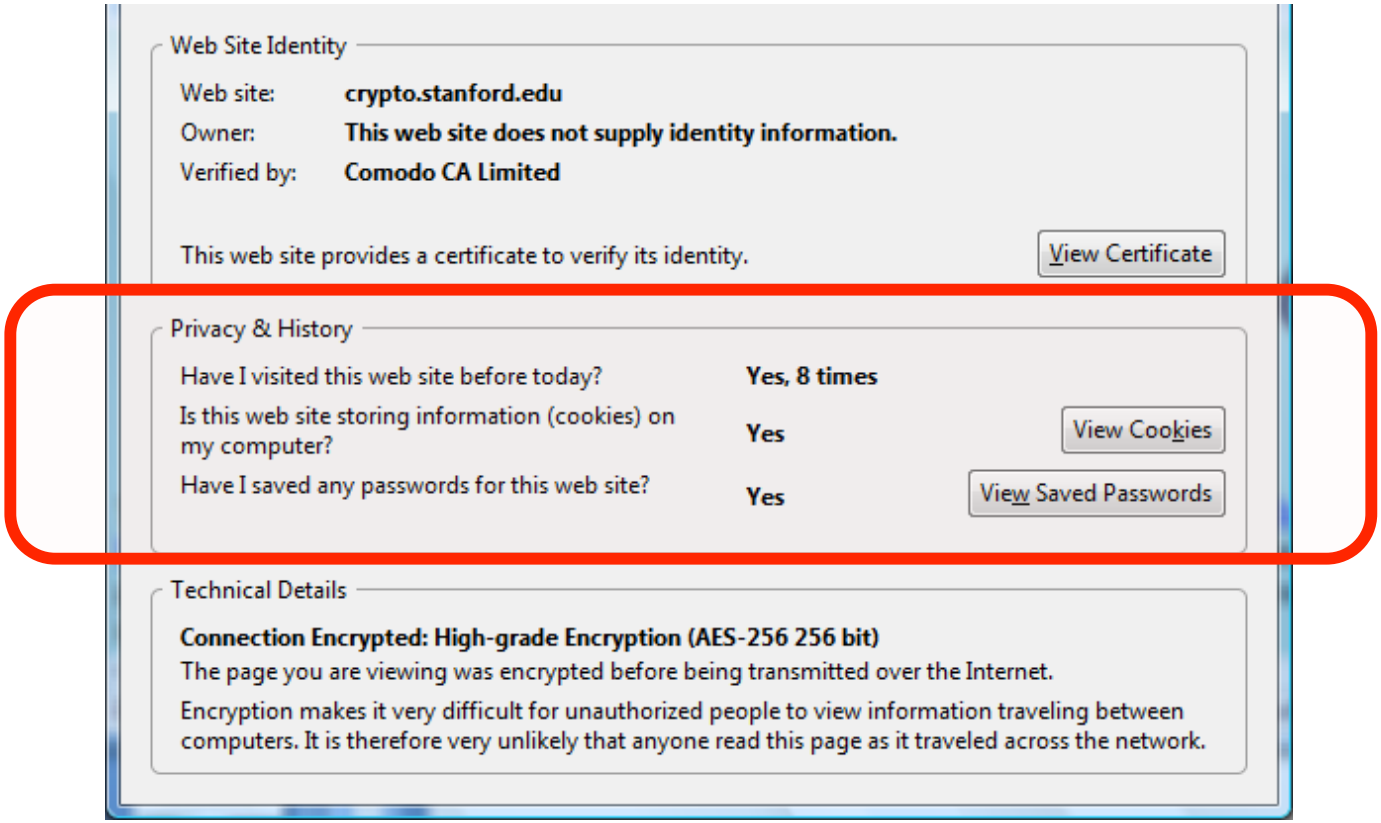
(SSL)





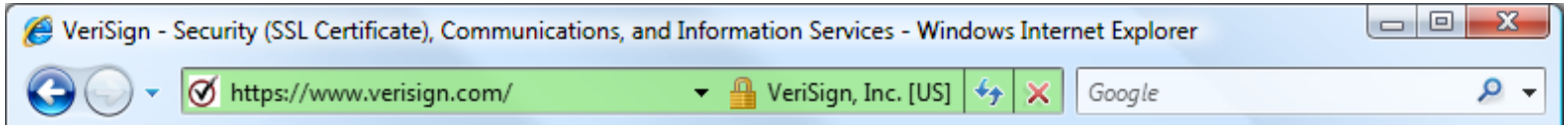
The lock UI: help users authenticate site

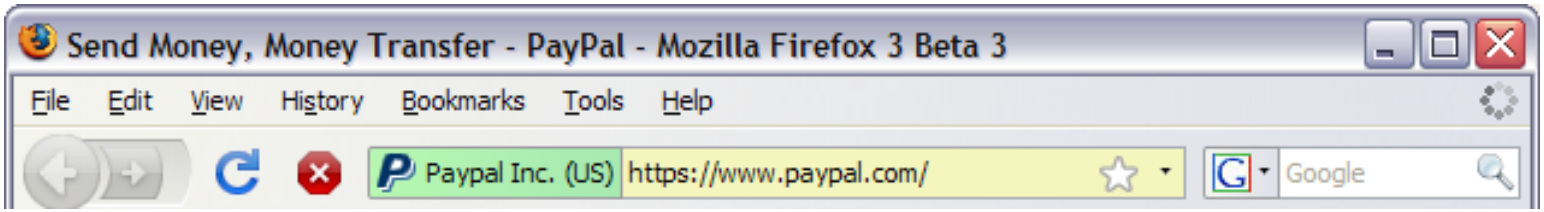
Firefox 3: clicking on bottom lock icon gives



The lock UI: Extended Validation (EV) Certs

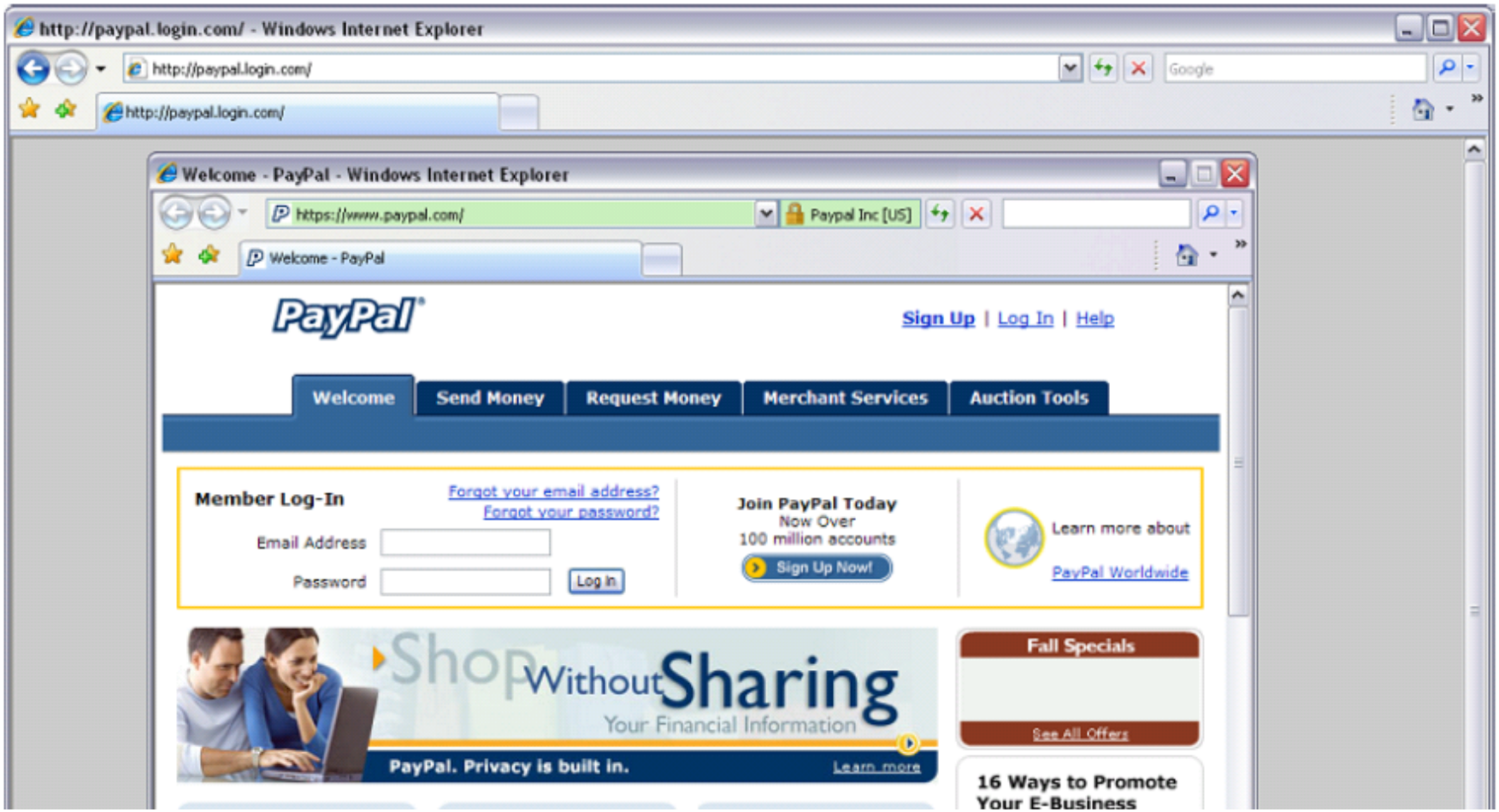
- **Harder to obtain than regular certs**
  - requires human lawyer at CA to approve cert request
- **Designed for banks and large e-commerce sites**





- **Helps block "semantic attacks":** www.bankofthe**vv**est.com

A general UI attack: picture-in-picture



Trained users are more likely to fall victim to this [JSTB'07]

HTTPS and login pages: incorrect version

Users often land on login page over HTTP:

- Type site's HTTP URL into address bar, or
- Google links to the HTTP page

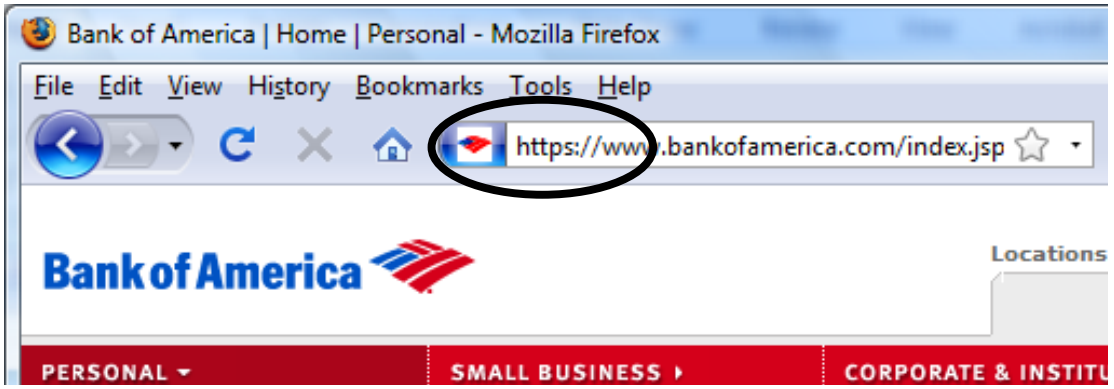
View source:

```
<form method="post"
      action="https://onlineservices.wachovia.com/..."
```

HTTPS and login pages: guidelines

General guideline:

- Response to **http**://login.site.com
  should be Redirect: **https**://login.site.com



Problems with HTTPS and the Lock Icon

Problems with HTTPS and the Lock Icon

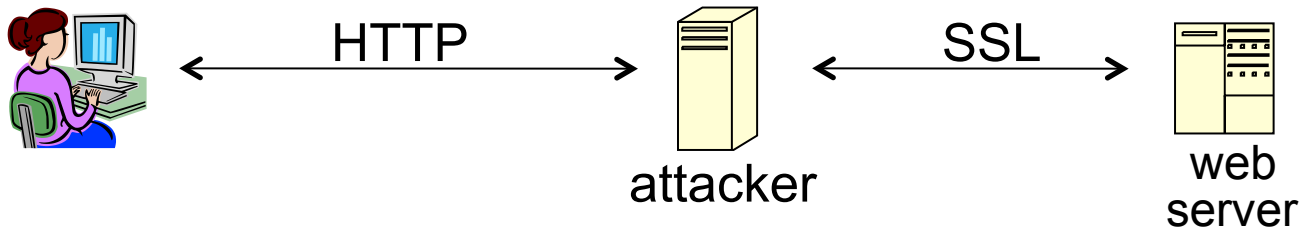
1. **Upgrade from HTTP to HTTPS**
2. **Semantic attacks on certs**
3. **Invalid certs**
4. **Mixed content**
   - HTTP and HTTPS on the same page
5. **Origin contamination**
   - Weak HTTPS page contaminates stronger HTTPS page

1. HTTP → HTTPS upgrade

Common use pattern:

- browse site over HTTP; move to HTTPS for checkout
- connect to bank over HTTP; move to HTTPS for login

Easy attack: prevent the upgrade (ssl_strip) [Moxie'08]



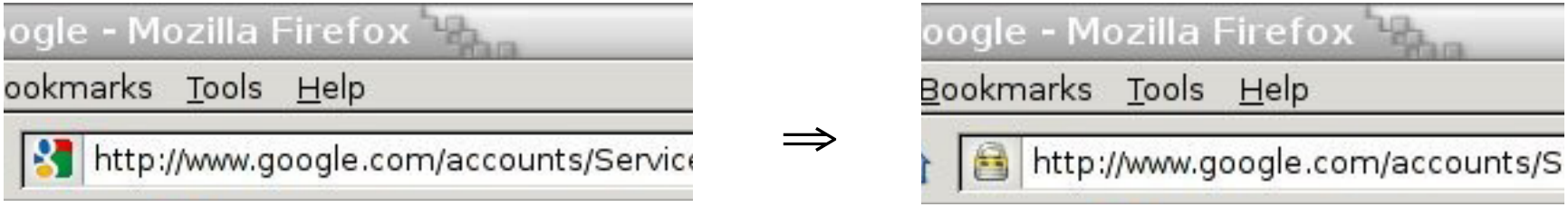
<a href=**https**://…> ⇒ <a href=**http**://…>

Location: **https**://... ⇒ Location: **http**://... (redirect)

<form action=**https**://… > ⇒ <form action=**http**://…>

Tricks and Details

Tricks: drop-in a clever fav icon



Details:

- Erase existing session and force user to login:

  ssl_strip injects “Set-cookie” headers to delete existing session cookies in browser.

Number of users who detected HTTP downgrade: 0

2. Semantic attacks on certs

International domains: xyz.cn

- Rendered using international character set
- Observation: chinese character set contains chars that look like “/” and “?” and “.” and “=”

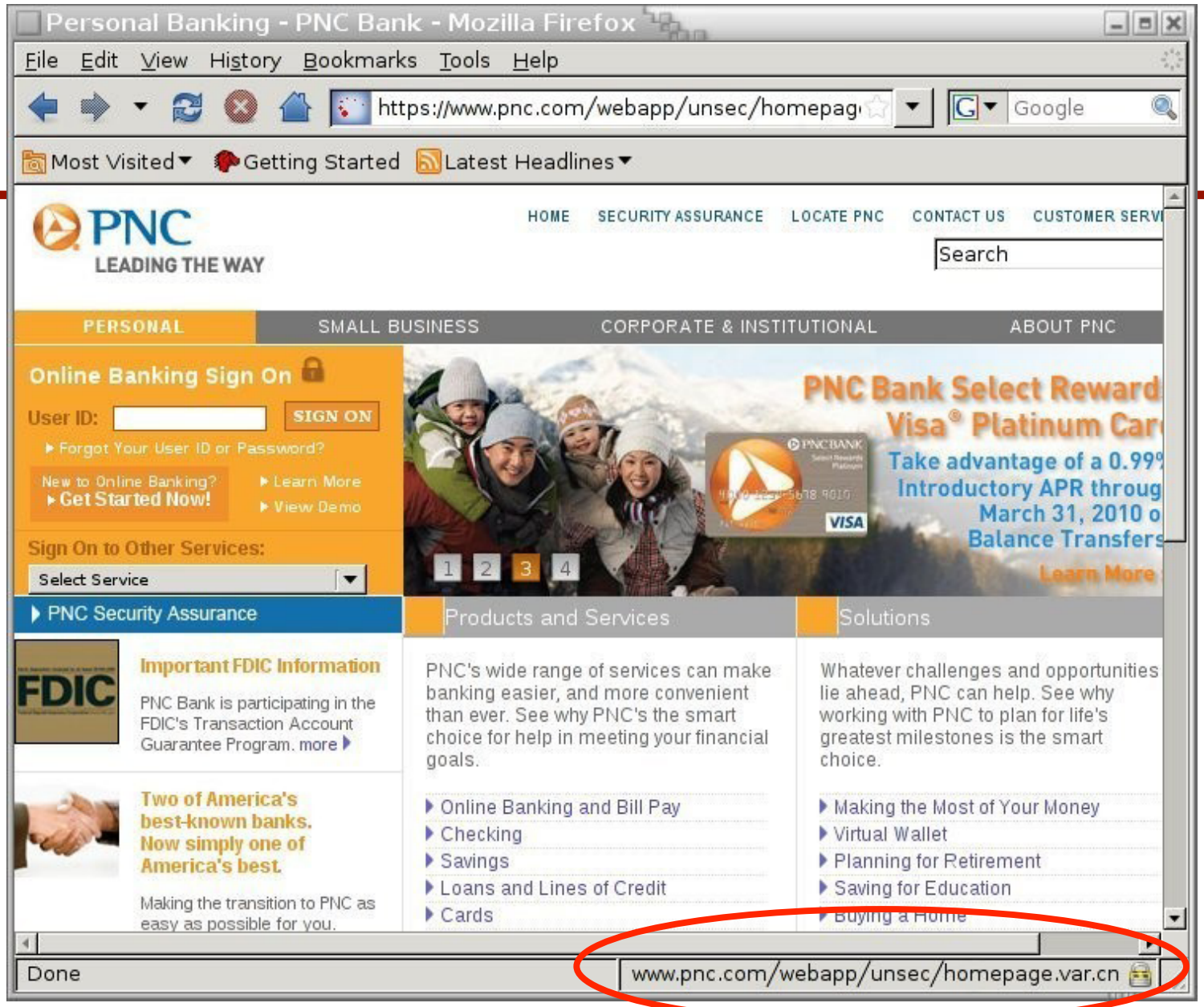
Attack: buy domain cert for *.badguy.cn

setup domain called:

www.bank.com/accounts/login.php?q=me**.baguy.cn**

note: single cert *.badguy.cn works for all sites

Extended validation (EV) certs may help defeat this


Personal Banking - PNC Bank - Mozilla Firefox
File Edit View History Bookmarks Tools Help
https://www.pnc.com/webapp/unsec/homepag
Google
Most Visited
Getting Started
Latest Headlines
PNC
LEADING THE WAY
HOME
SECURITY ASSURANCE
LOCATE PNC
CONTACT US
Search
PERSONAL
SMALL BUSINESS
CORPORATE & INSTITUTIONAL
ABOUT PNC
Online Banking Sign On
User ID:
SIGN ON
Forgot Your User ID or Password?
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Whatever challenges and opportunities lie ahead, PNC can help. See why working with PNC to plan for life's greatest milestones is the smart choice.
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Virtual Wallet
Planning for Retirement
Saving for Education
Buying a Home
Two of America's best-known banks. Now simply one of America's best.
Making the transition to PNC as easy as possible for you.
Done
www.pnc.com/webapp/unsec/homepage.var.cn

[Moxie'08]

3. Invalid certs

Examples of invalid certificates:

- expired: current-date > date-in-cert
- CommonName in cert does not match domain in URL
- unknown CA (e.g. self signed certs)
  - Small sites may not want to pay for cert

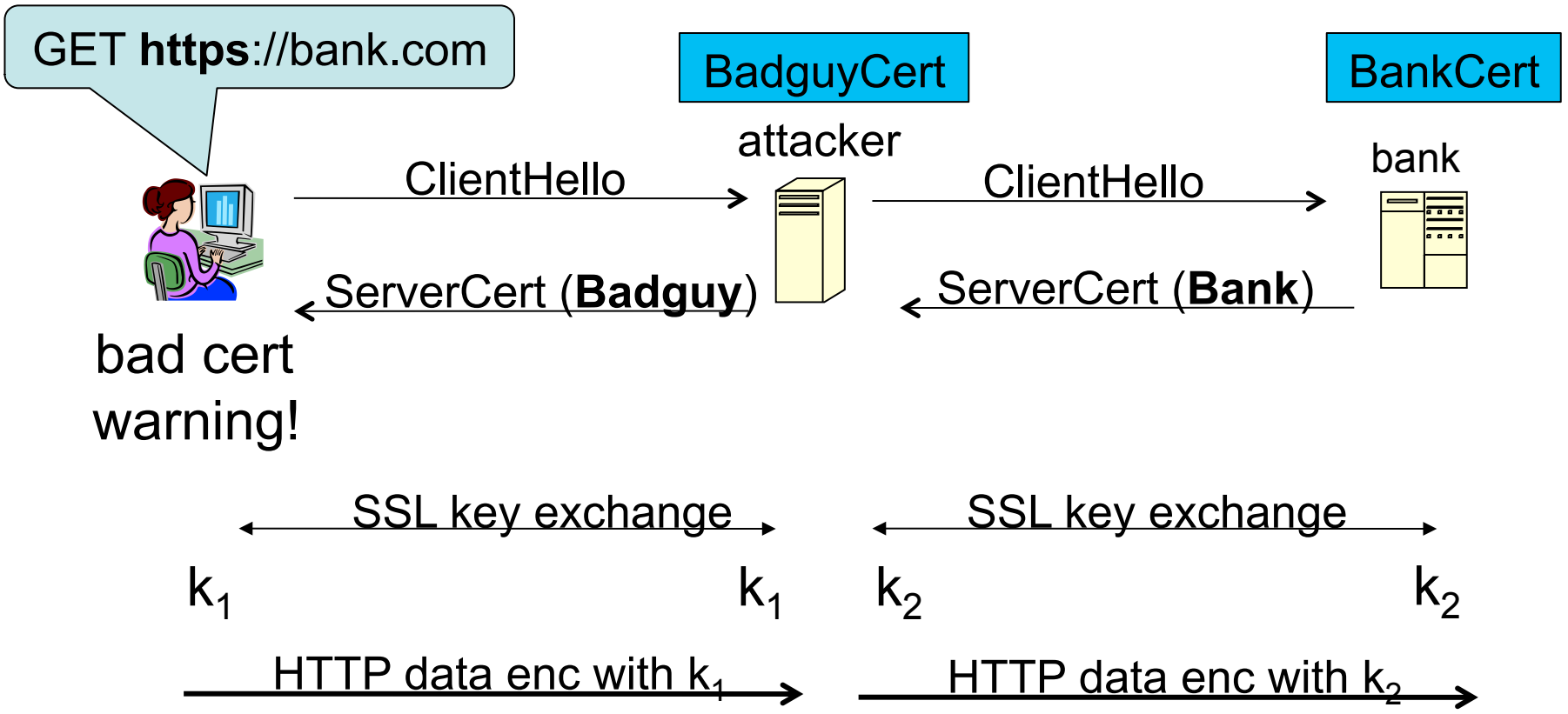
Users often ignore warning:

Is it a misconfiguration or an attack? User can't tell.

Accepting invalid cert enables man-in-middle attacks

(see http://crypto.stanford.edu/ssl-mitm)

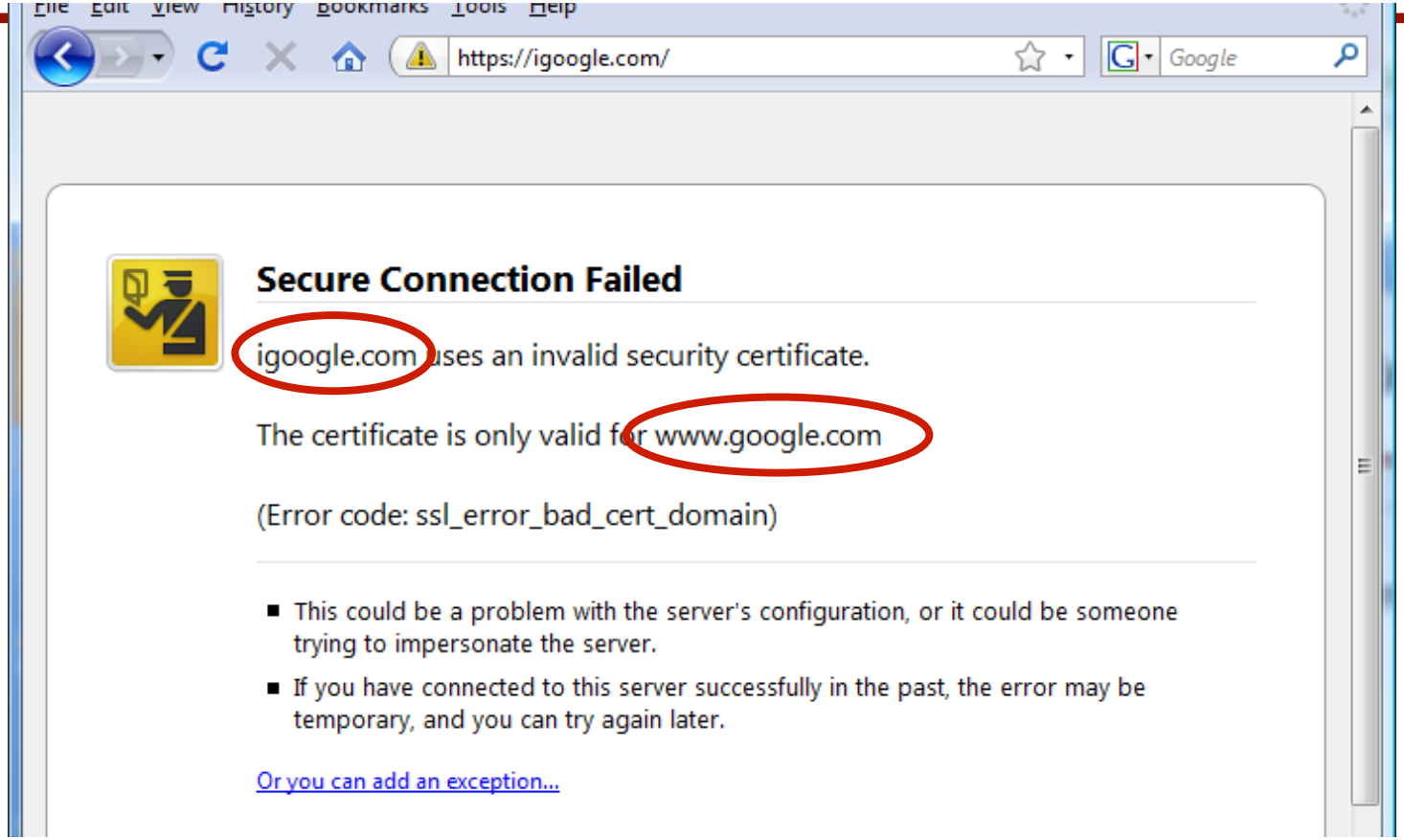
Man in the middle attack using invalid certs



Attacker proxies data between user and bank.

Sees all traffic and can modify data at will.

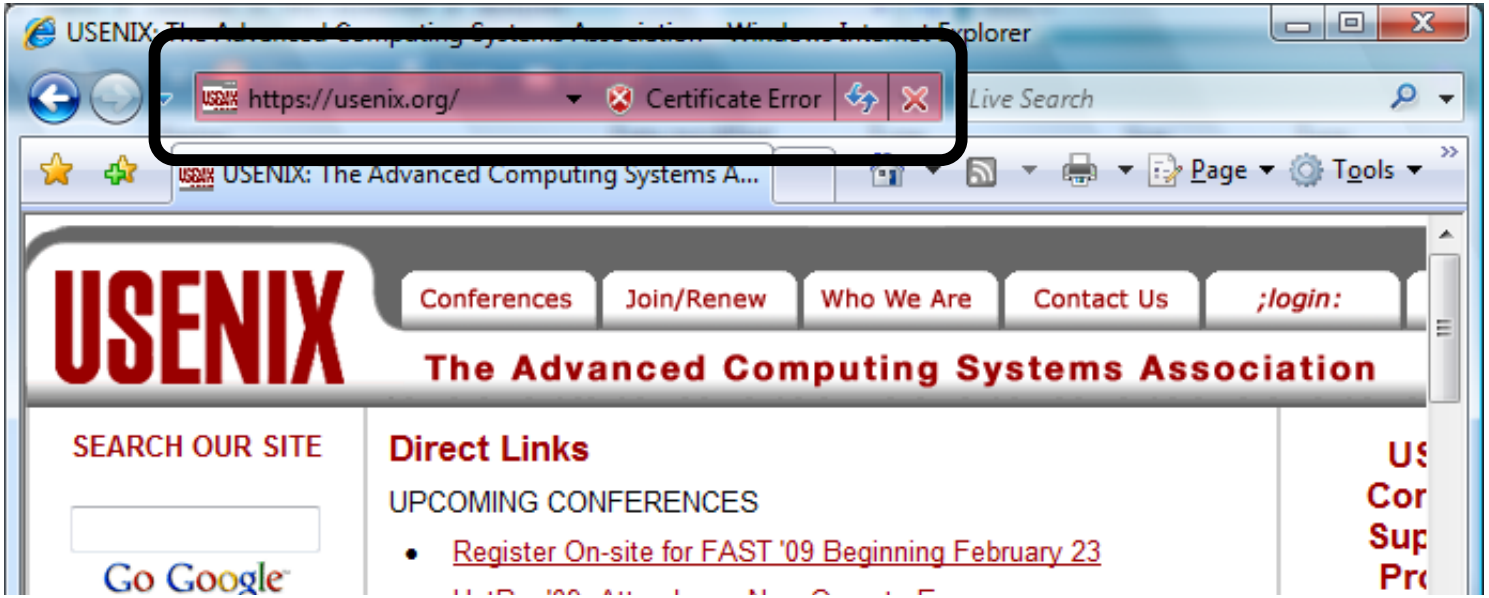
Firefox: Invalid cert dialog



Firefox 3.0: <u>Four clicks</u> to get firefox to accept cert

- page is displayed with full HTTPS indicators

IE: invalid cert URL bar



Commercial Tools to Forge Certs

PacketForensis: SSL MiTM for law enforcement

Scenario [SS'10]: (browsers on windows trust 264 root CAs)

- User in country X wishes to access web site in country Y
- Country X compels its local CA to issue cert for web site

➔ country X can eavesdrop on all traffic to web site
(no cert warning in user's browser)

SS'10 solution: browser extension that rejects certs where issuing country ≠ web-site country

4. Mixed Content: HTTP and HTTPS

Page loads over HTTPS, but contains content over HTTP

(e.g. <script src="http://.../script.js>)

IE7: displays mixed-content dialog and no SSL lock

Firefox 3.0: displays `!' over lock icon (no dialog by default)

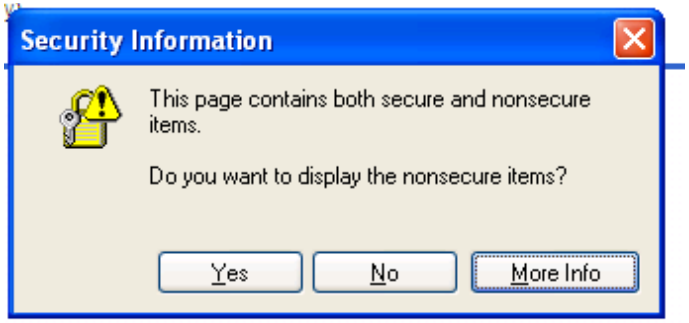
Both browsers:

- Flash swf file over HTTP does not trigger warning !!
- note: Flash can script the embedding page

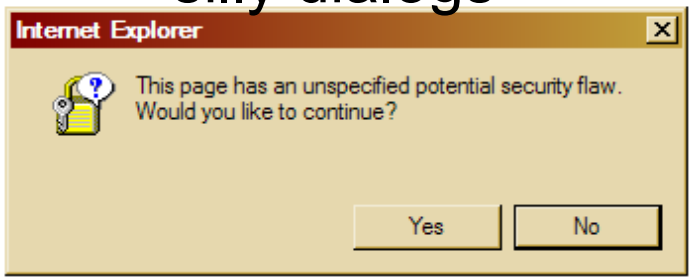
Safari: does not attempt to detect mixed content

Mixed Content: HTTP and HTTPS

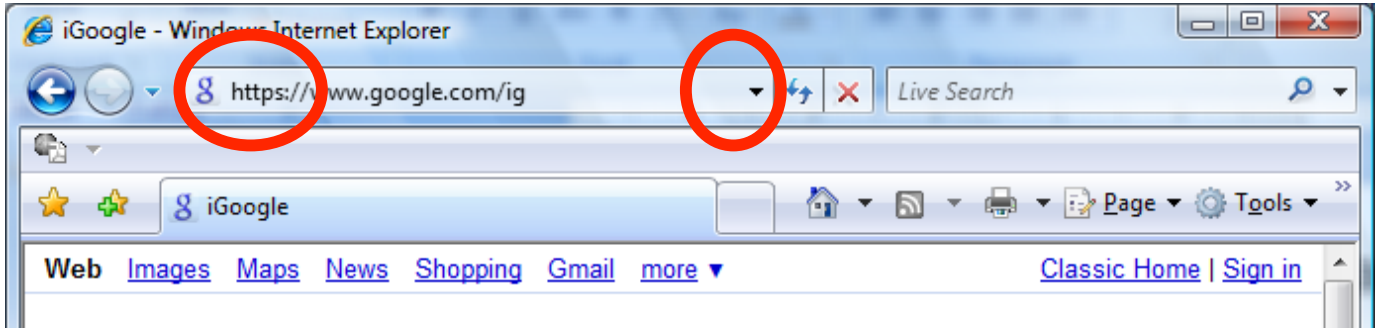
IE7:



silly dialogs

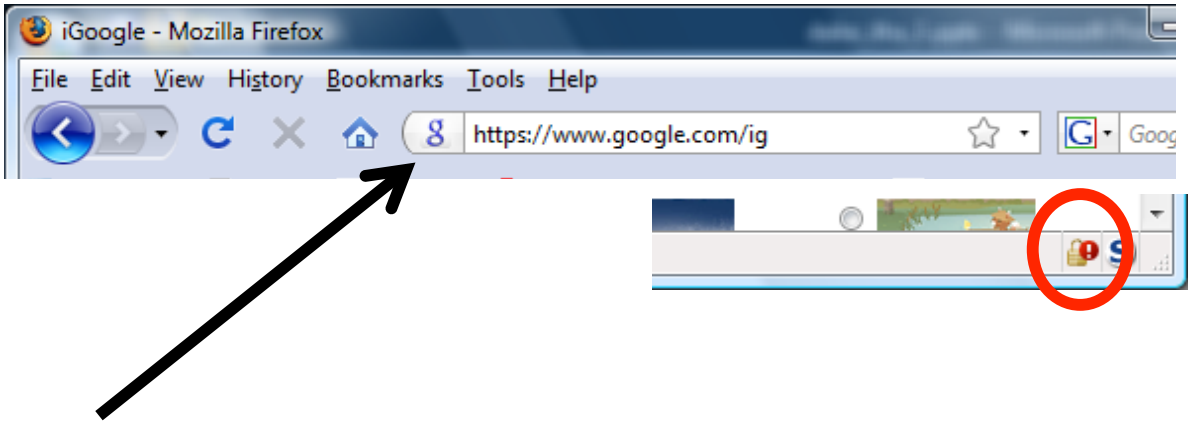


No SSL lock in address bar:

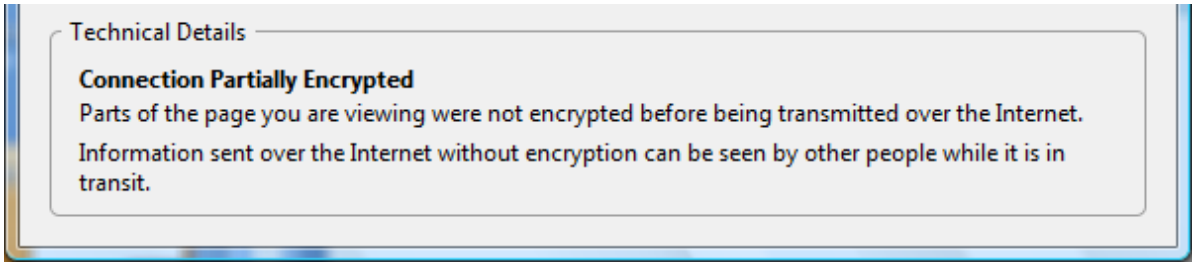


Mixed Content: HTTP and HTTPS

Firefox 3.0:



- No SSL indicator in address bar
- Clicking on bottom lock gives:



Mixed content and network attacks

banks: after login all content served over HTTPS

Developer error: somewhere on bank site write

```
<embed  src=http://www.site.com/flash.swf>
```

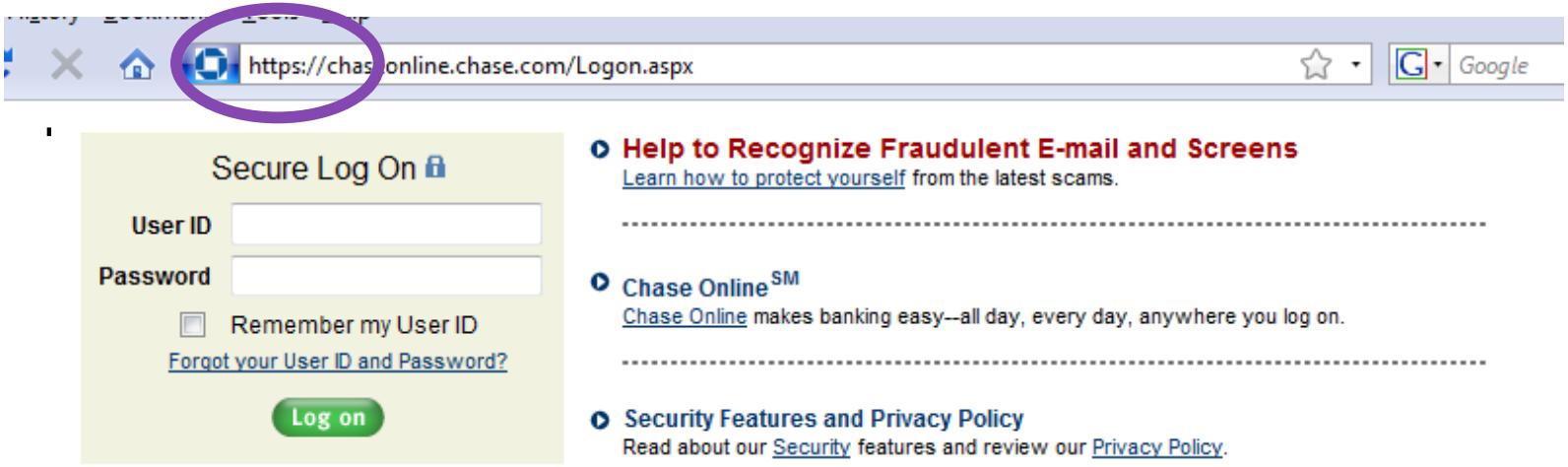
Active network attacker can now hijack session

Better way to include content:

```
<embed  src=//www.site.com/flash.swf>
```

served over the same protocol as embedding page

An Example From an Online Bank

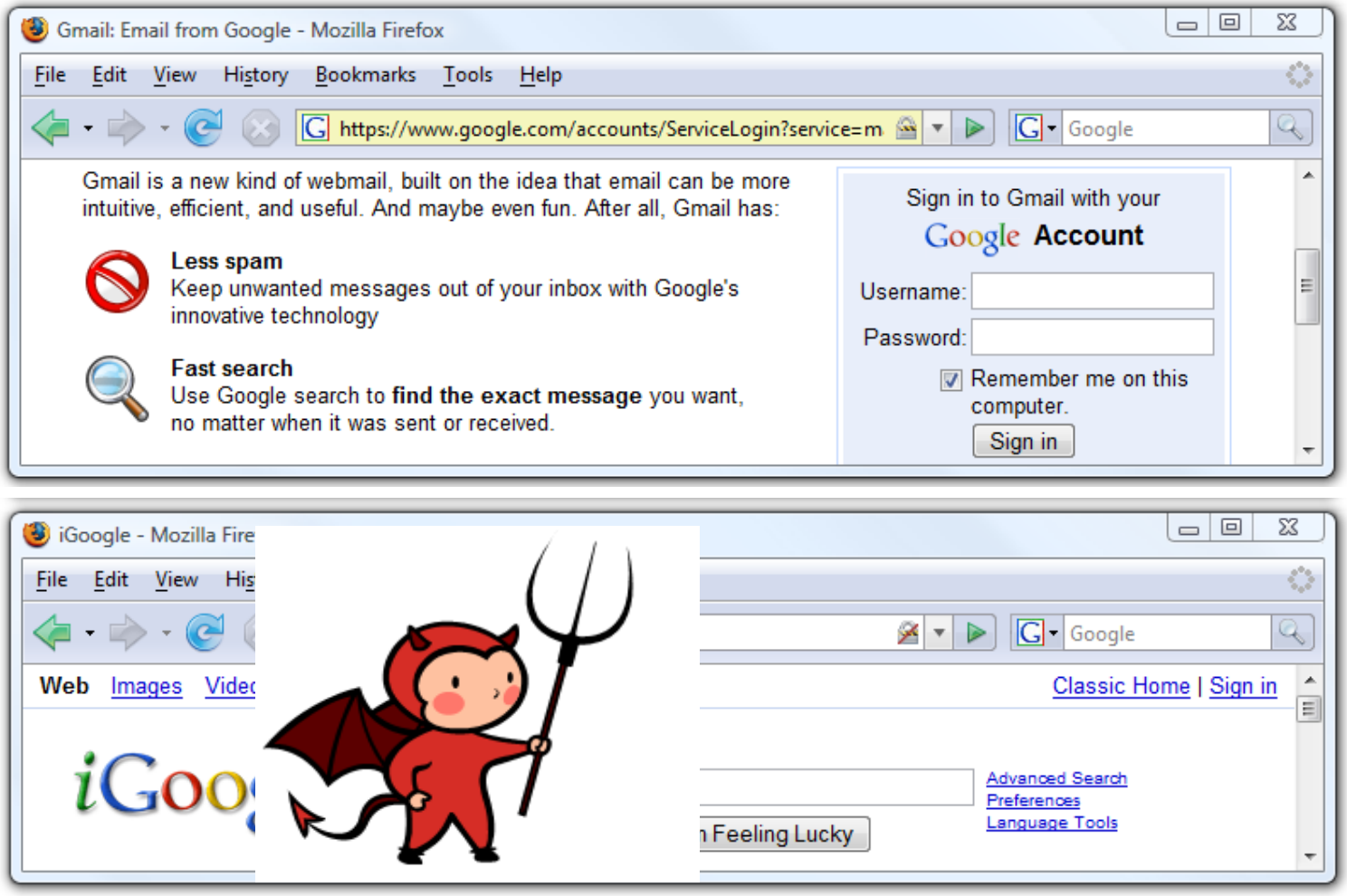


var so = new SWFObject("**http**://mfasa.chase.com/auth/device.swf", ...

network attacker can modify SWF file and hijack session

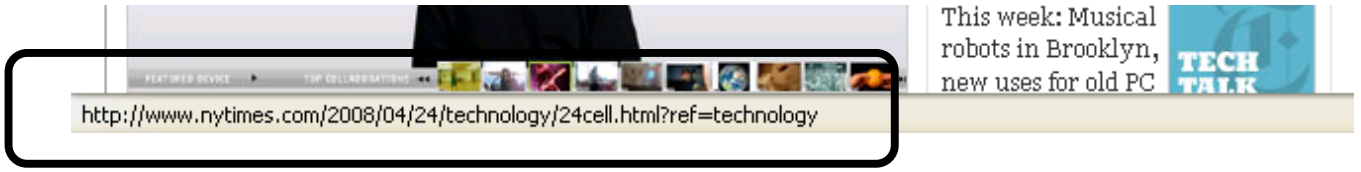
(the site has been fixed)

5. Origin Contamination: an example



safeLock: removes lock from top page after loading bottom page

Final note: the status Bar



Trivially spoofable

```
<a href="http://www.paypal.com/"
        onclick="this.href = 'http://www.evil.com/';">
    PayPal</a>
```

THE END