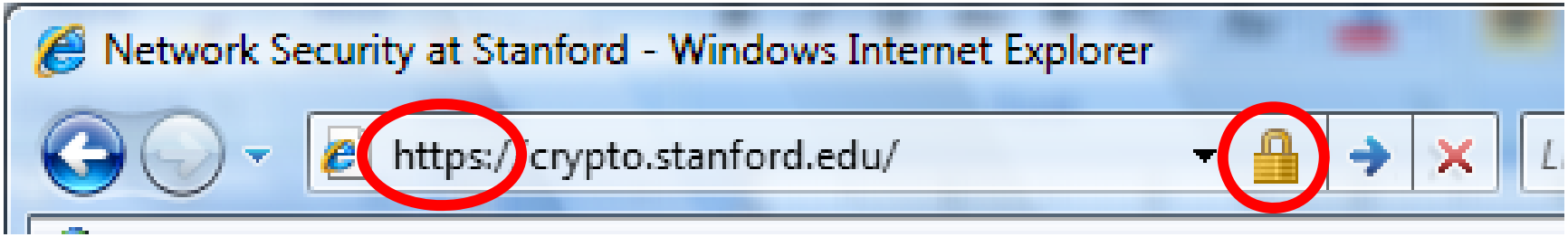


HTTPS and the Lock Icon

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

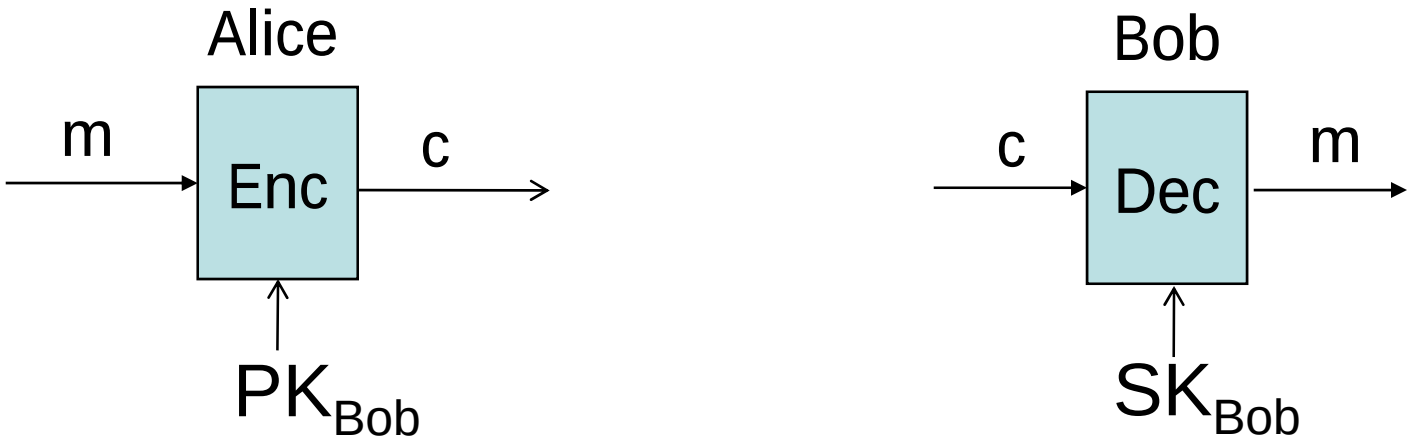
  Active attacker: eavesdrops, injects, blocks, and modifies packets

Examples:

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

SSL/TLS overview

Public-key encryption:

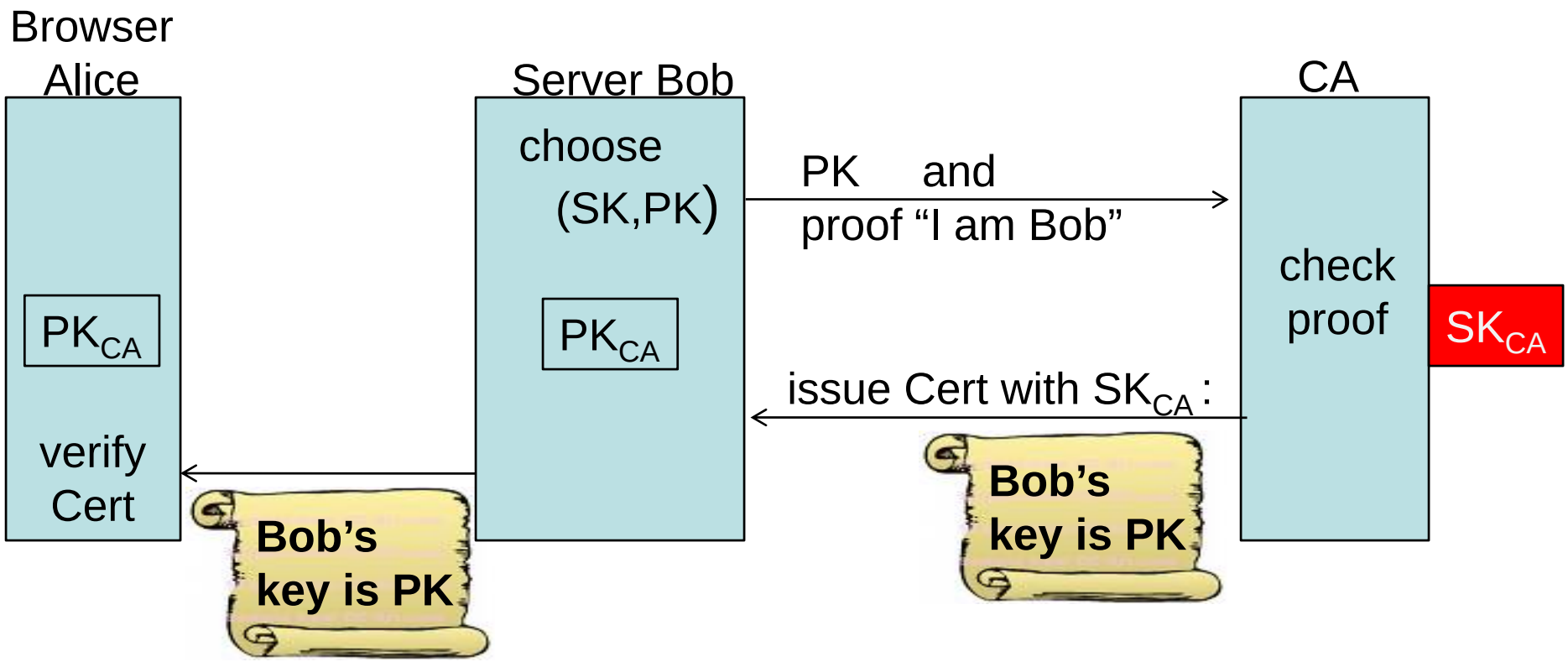


Bob generates (SK_{Bob} , PK_{Bob})

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

Certificates

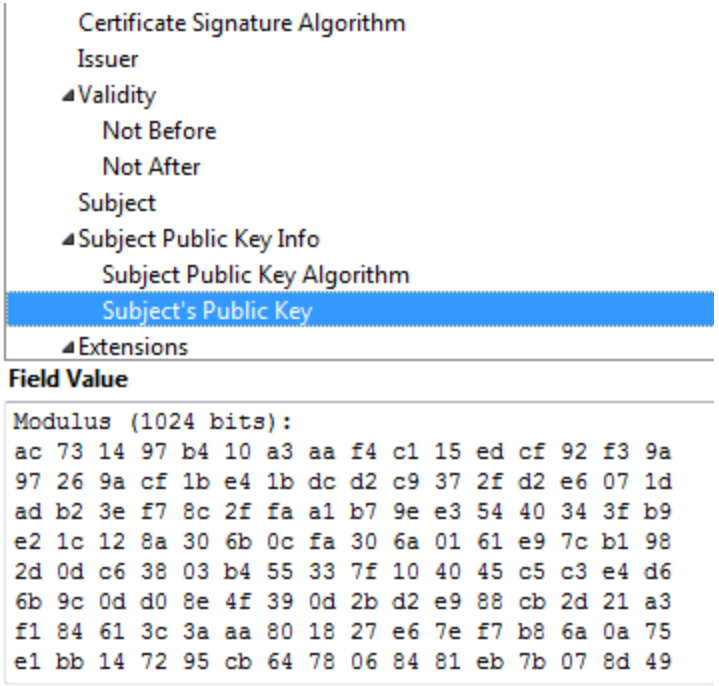
How does Alice (browser) obtain PK_{Bob} ?

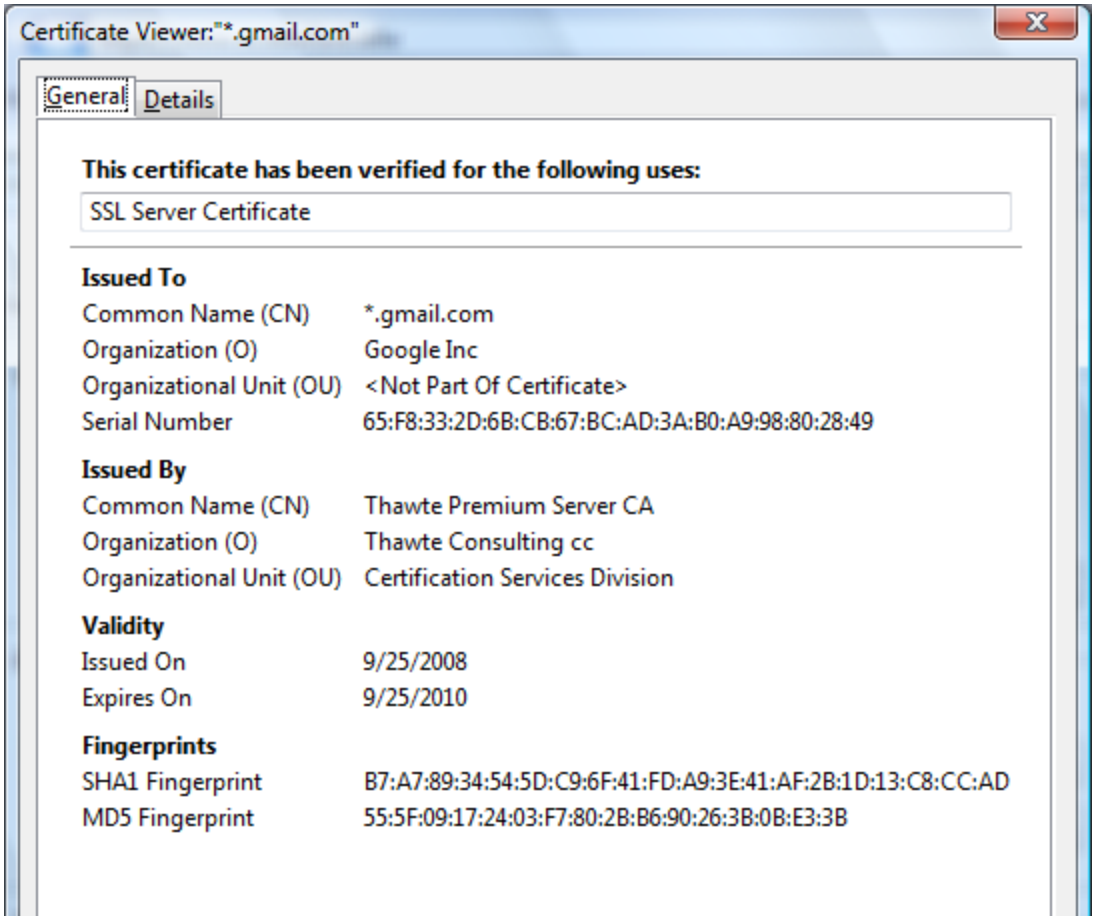


Bob uses Cert for an extended period (e.g. one year)

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

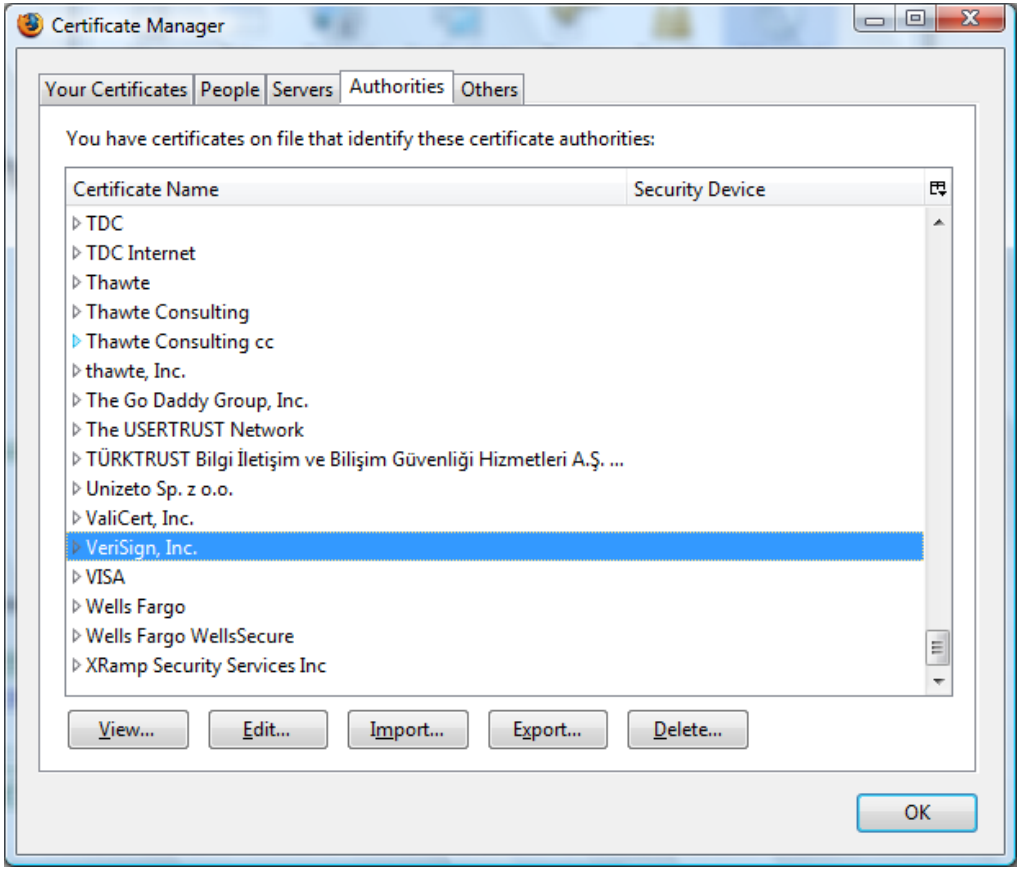
matching rules:

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

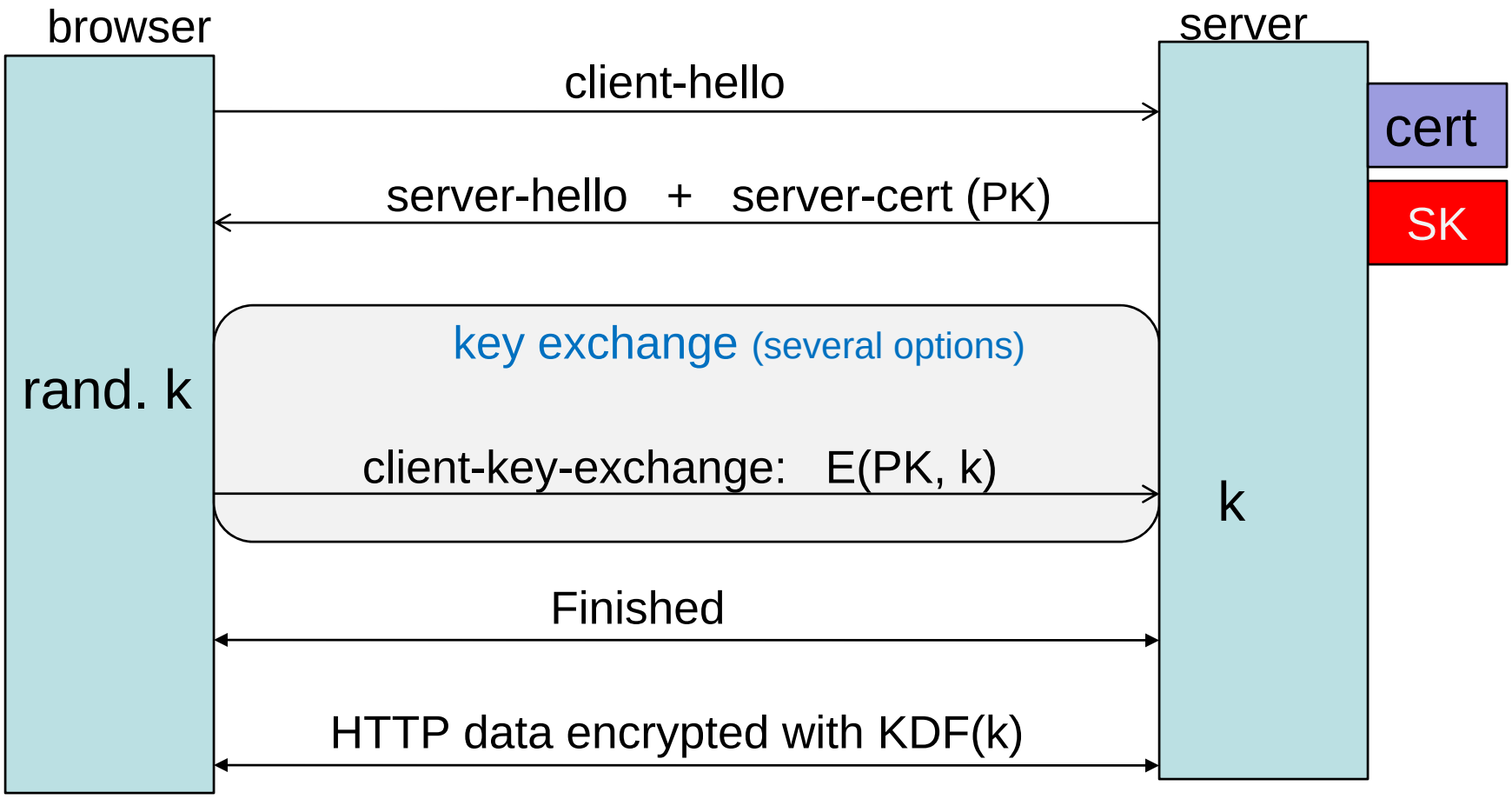
FF3: "*" matches anything

Certificate Authorities

Browsers accept certificates from a large number of CAs



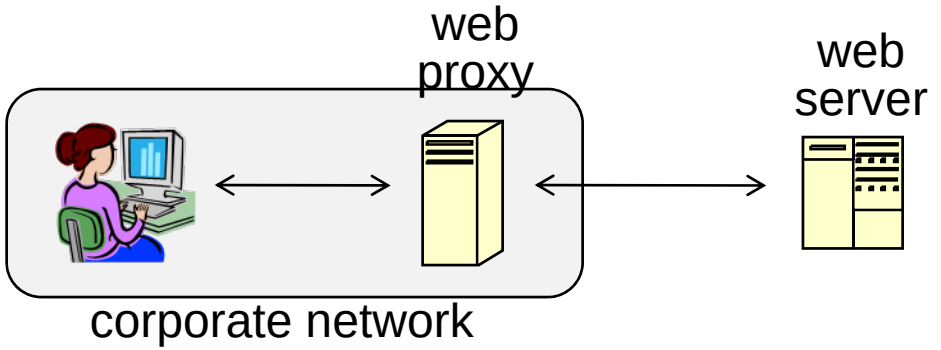
Brief overview of SSL/TLS



Most common: server authentication only

Integrating SSL/TLS with HTTP ⇒ HTTPS

Two complications



- **Web proxies**

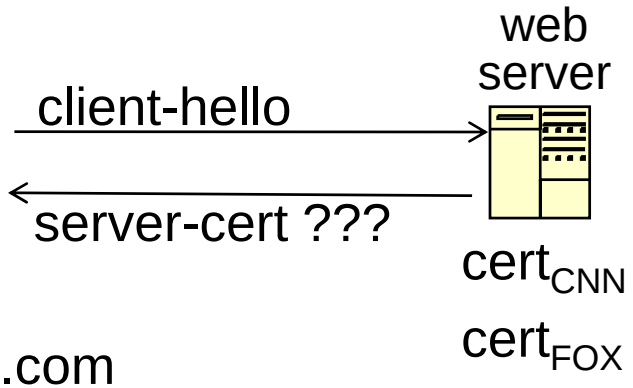
  solution: browser sends

  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

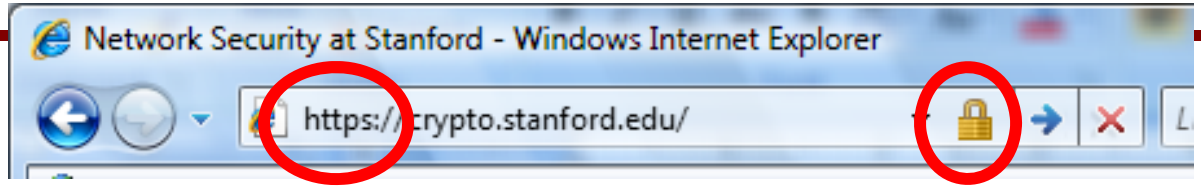
  implemented in FF2 and IE7 (vista)

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**

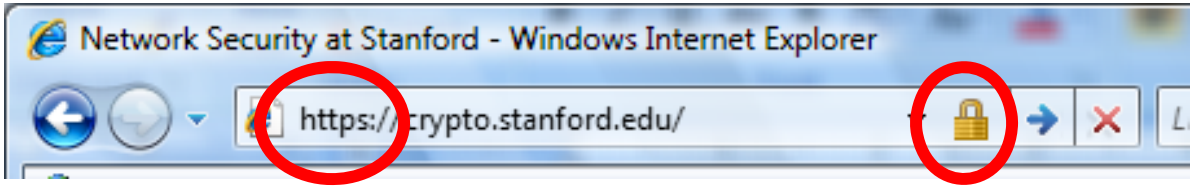
In reality:

- 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



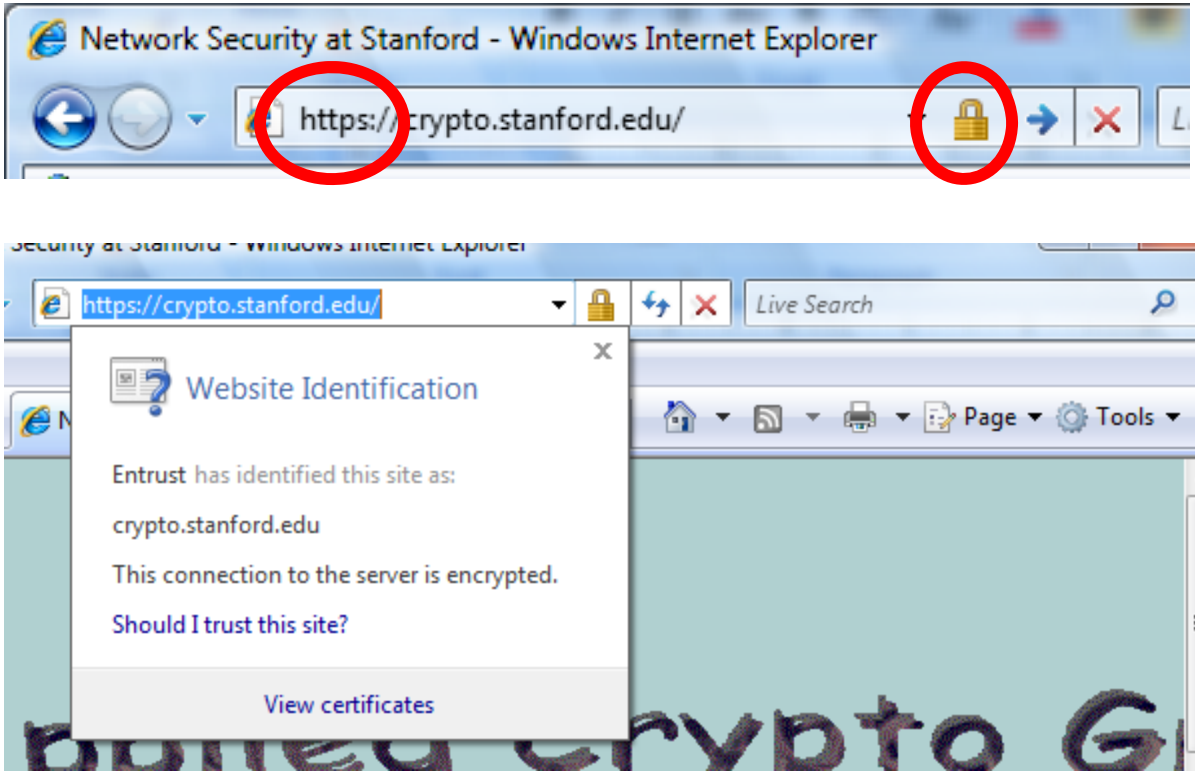
- **All elements on the page fetched using HTTPS**

  (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

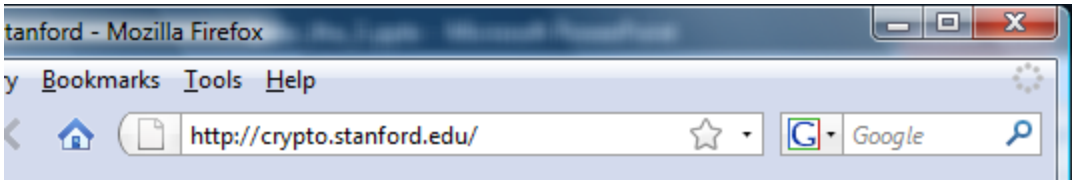
The lock UI: help users authenticate site

IE7:

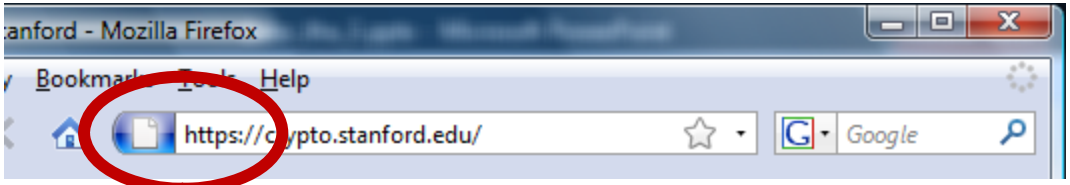


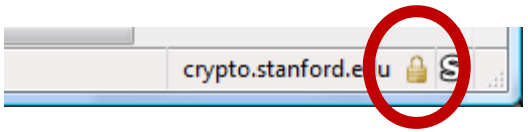
The lock UI: help users authenticate site

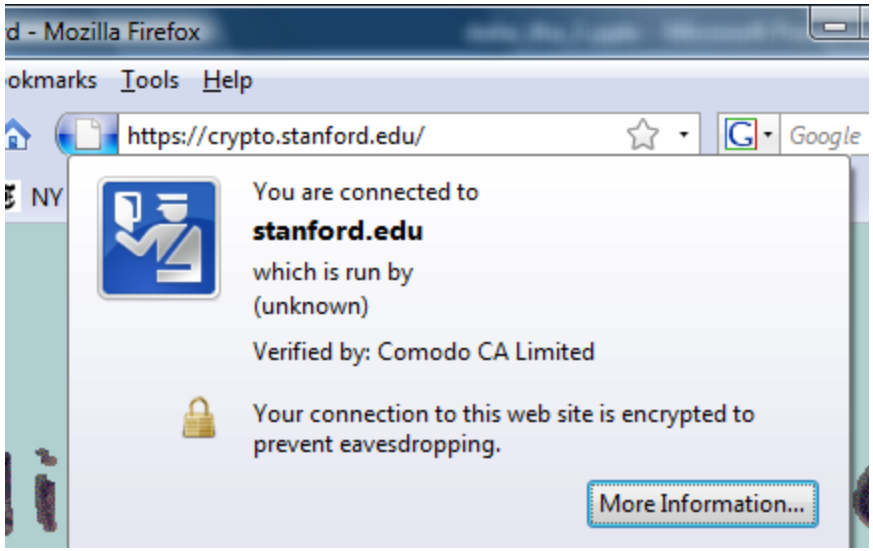
Firefox 3: (no SSL)



(SSL)

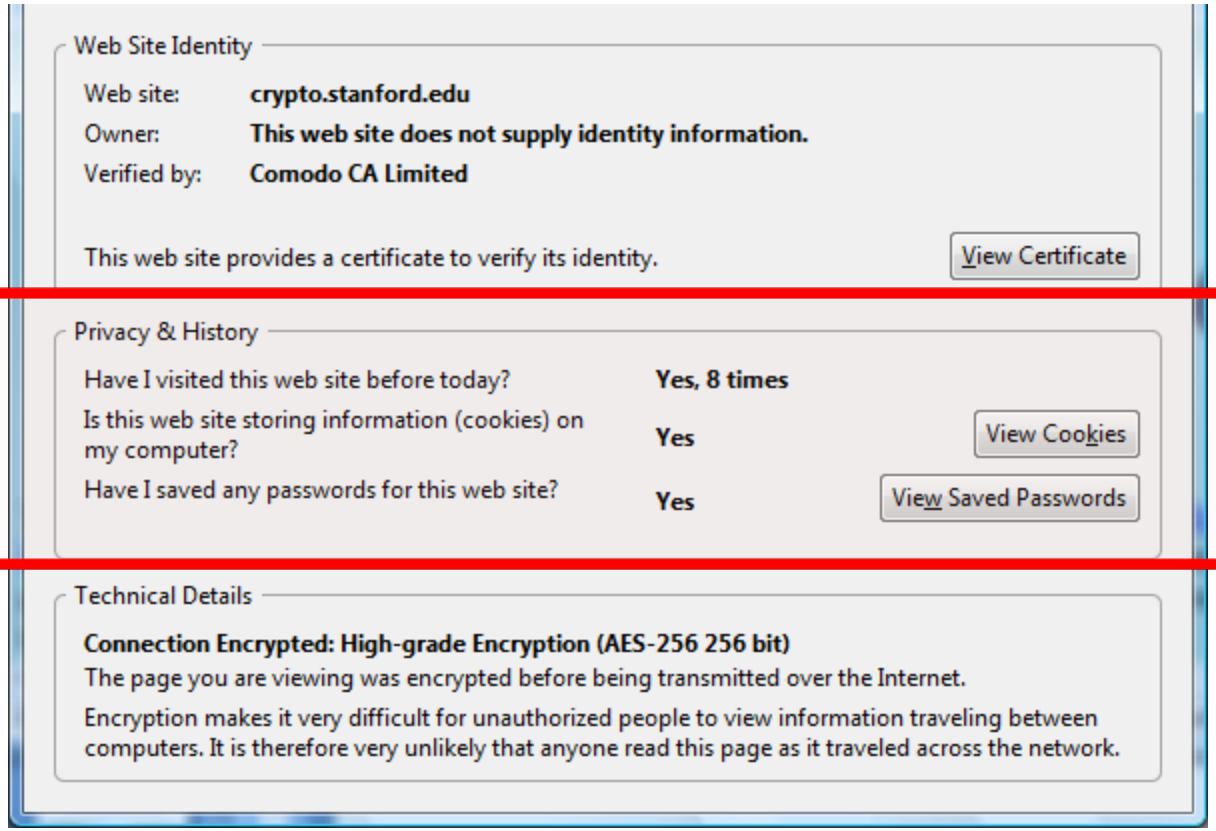






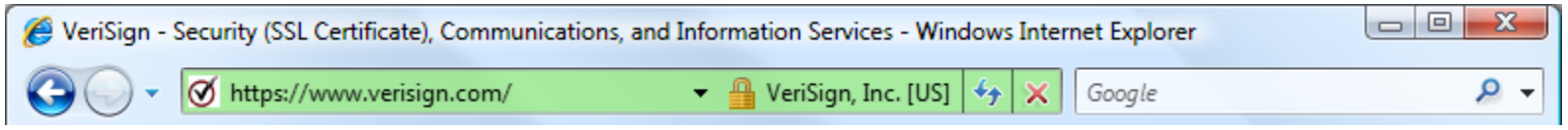
The lock UI: help users authenticate site

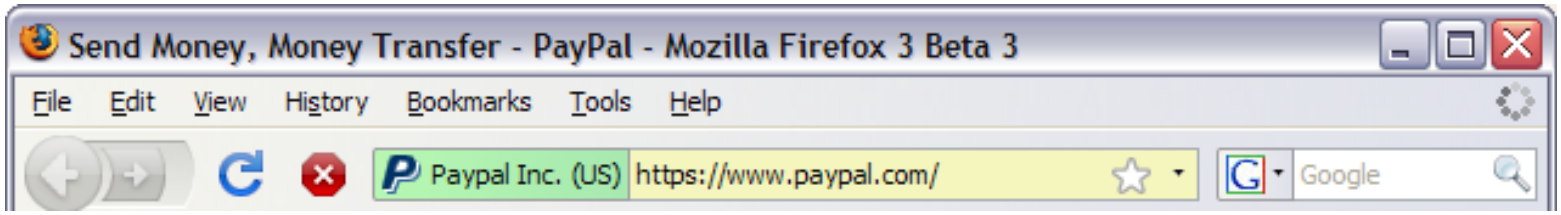
Firefox 3: clicking on bottom lock icon gives



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

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

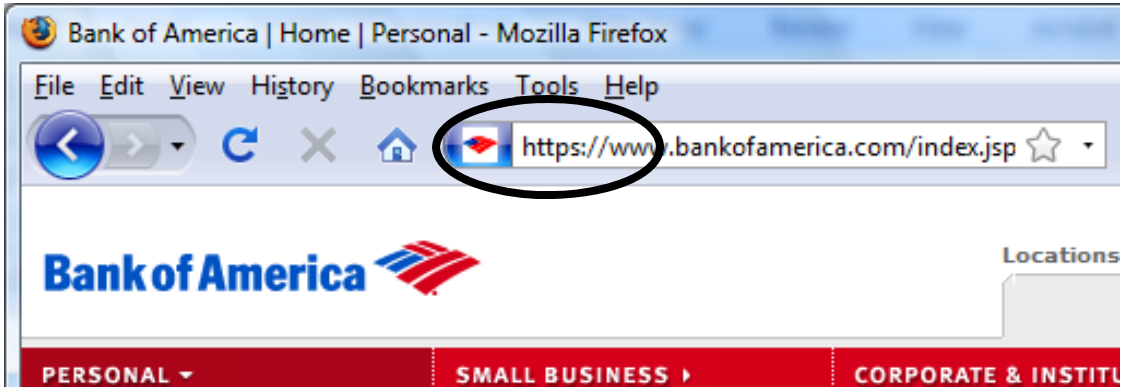
View source:

```
<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

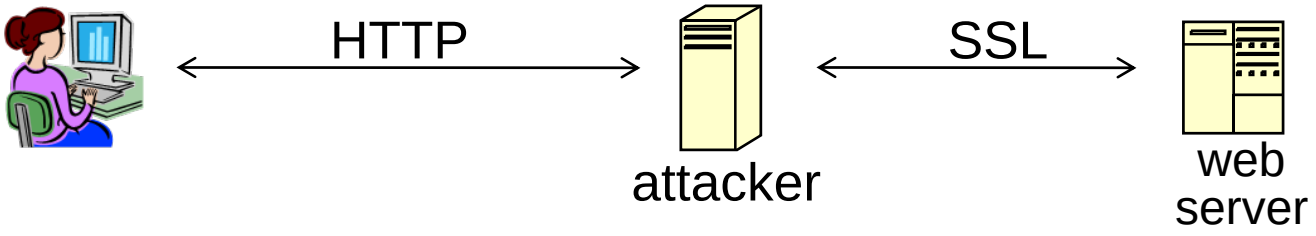
1. **Upgrade from HTTP to HTTPS**
2. **Semantic attacks on certs**
3. **Invalid certs**
4. **Mixed content**
   - HTTP and HTTPS on the same page
5. **Origin contamination**
   - Weak HTTPS page contaminates stronger HTTPS page

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 “=”

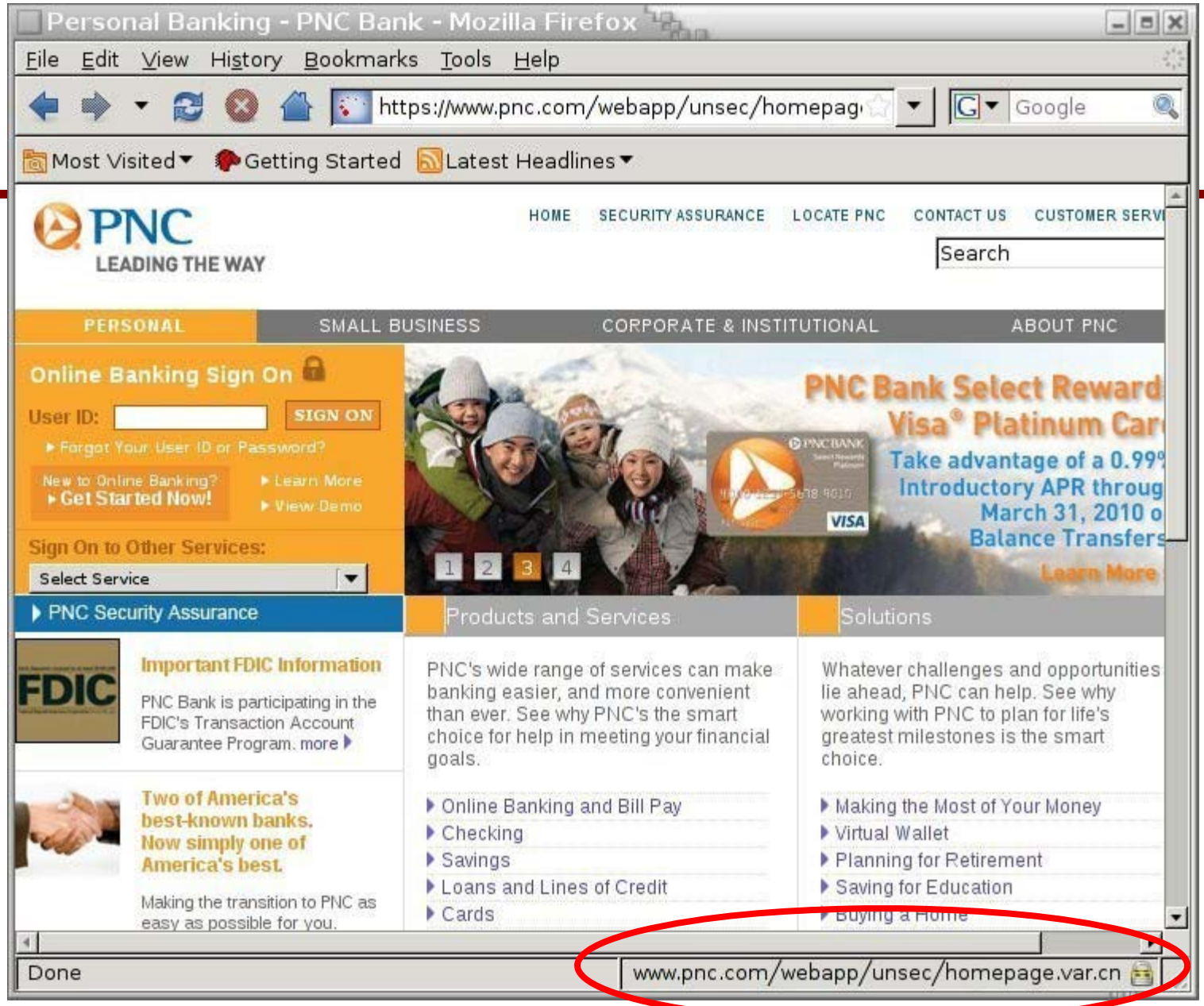
Attack: buy domain cert for *.badguy.cn

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
CUSTOMER SERV
Search
PERSONAL
SMALL BUSINESS
CORPORATE & INSTITUTIONAL
ABOUT PNC
Online Banking Sign On
User ID:
SIGN ON
Forgot Your User ID or Password?
New to Online Banking?
Get Started Now!
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PNC Bank is participating in the FDIC's Transaction Account Guarantee Program. more
PNC's wide range of services can make banking easier, and more convenient than ever. See why PNC's the smart choice for help in meeting your financial goals.
Online Banking and Bill Pay
Checking
Savings
Loans and Lines of Credit
Cards
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.
Making the Most of Your Money
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

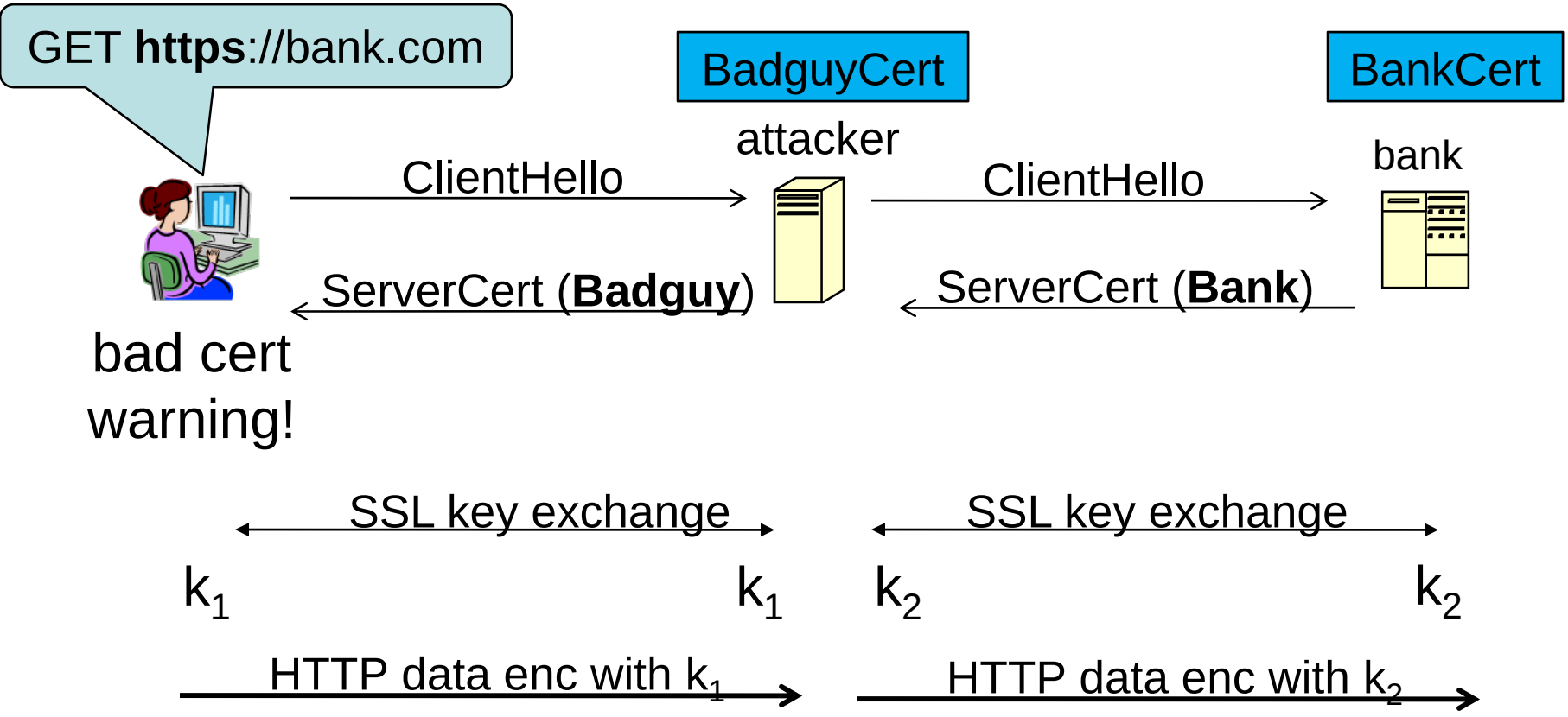
Users often ignore warning:

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

Accepting invalid cert enables man-in-middle attacks

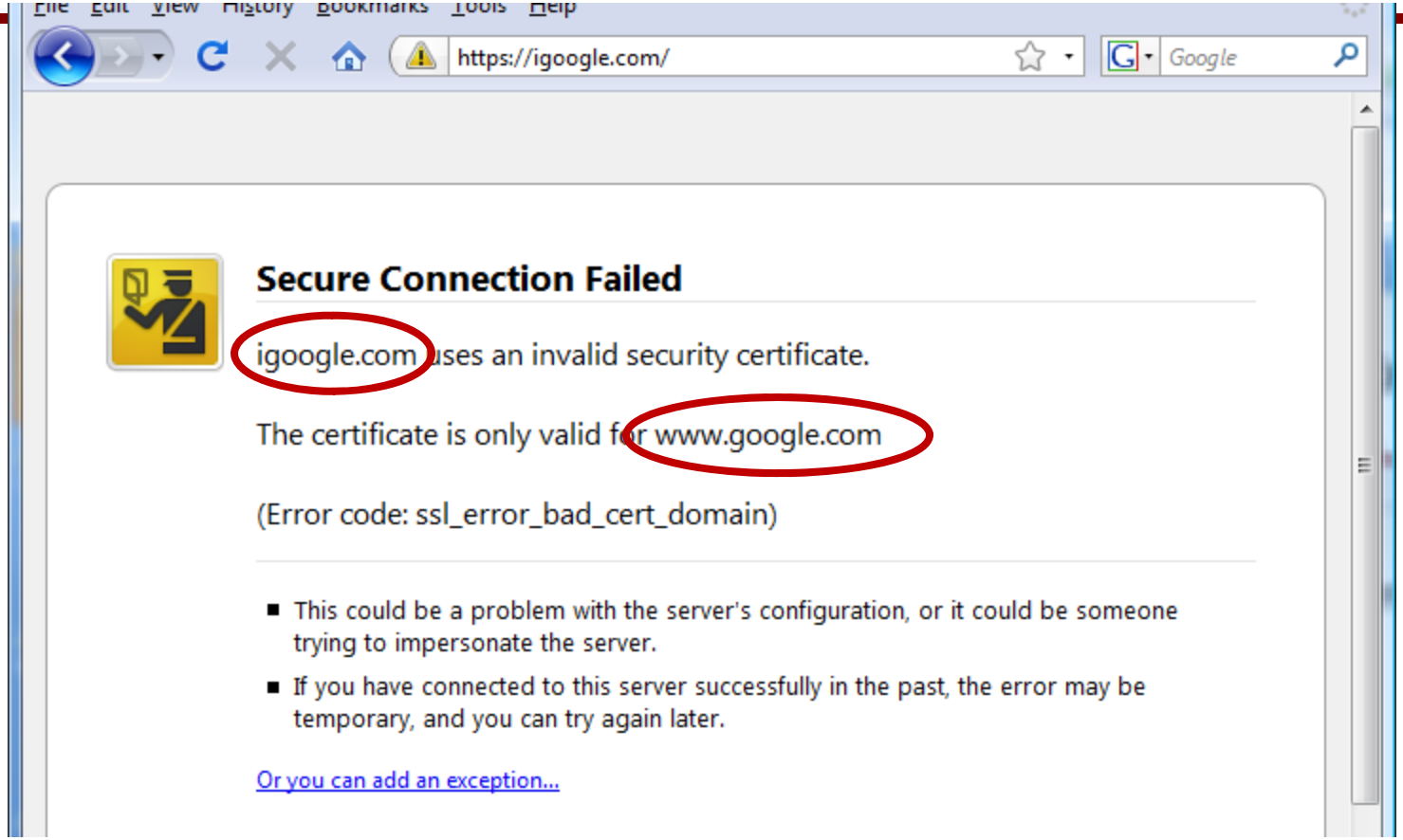
(see http://crypto.stanford.edu/ssl-mitm)

Man in the middle attack using invalid certs



Attacker proxies data between user and bank.
Sees all traffic and can modify data at will.

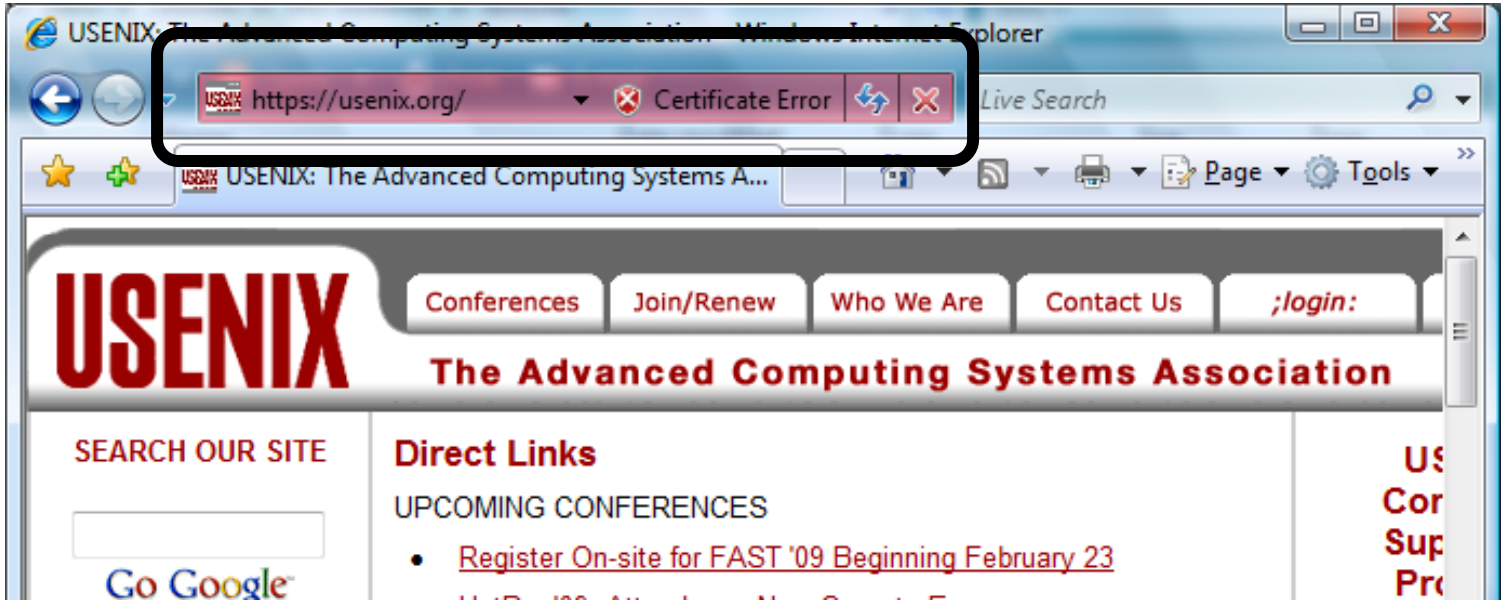
Firefox: Invalid cert dialog



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



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)

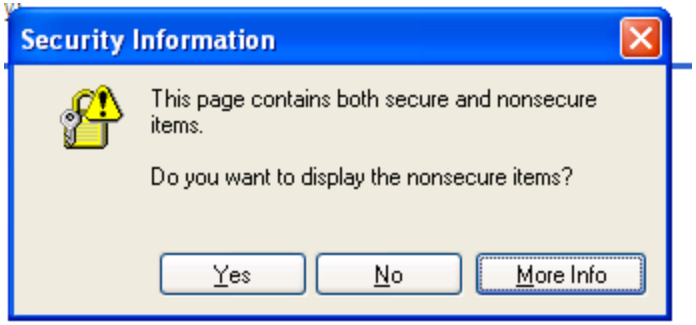
Both browsers:

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

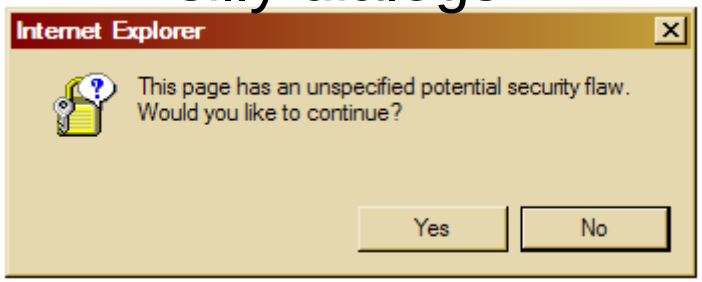
Safari: does not attempt to detect mixed content

Mixed Content: HTTP and HTTPS

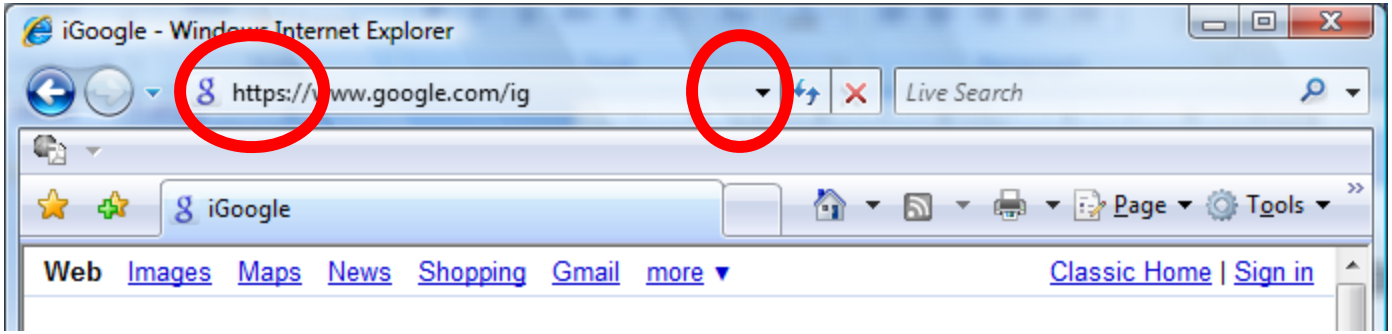
IE7:



silly dialogs

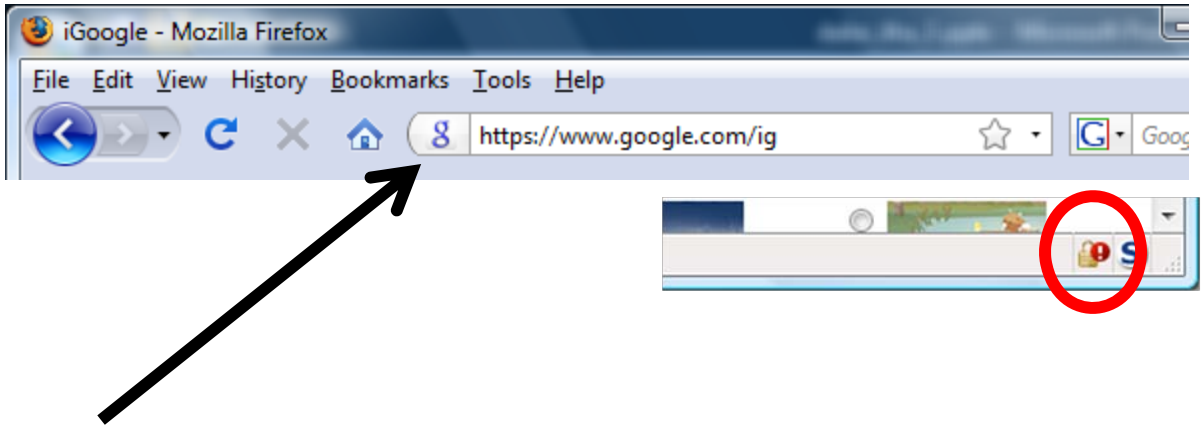


No SSL lock in address bar:

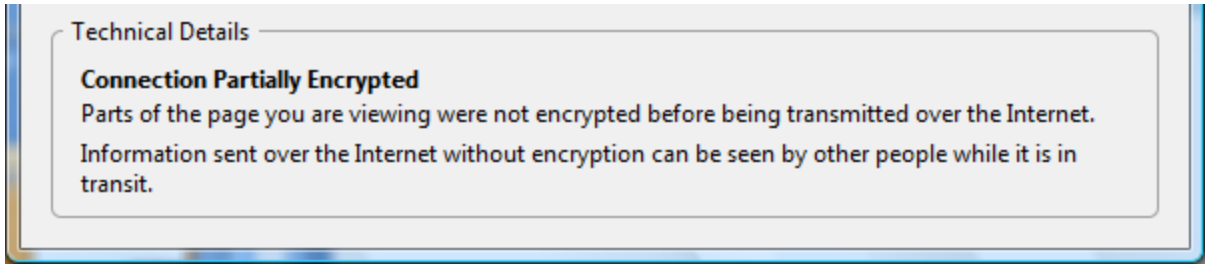


Mixed Content: HTTP and HTTPS

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>
```

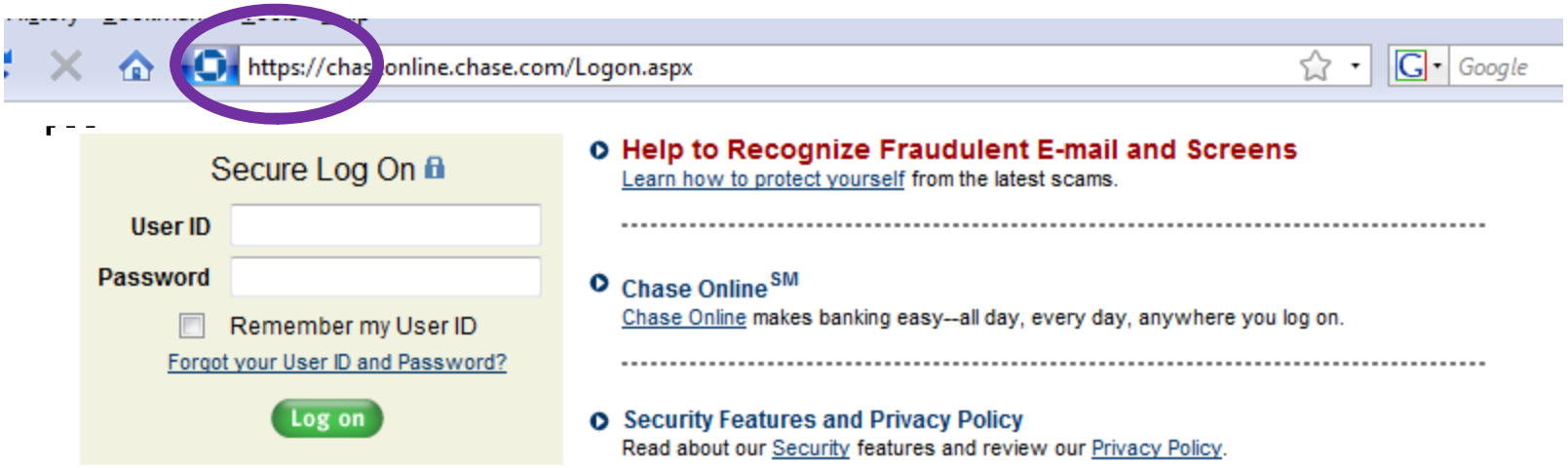
Active network attacker can now hijack session

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

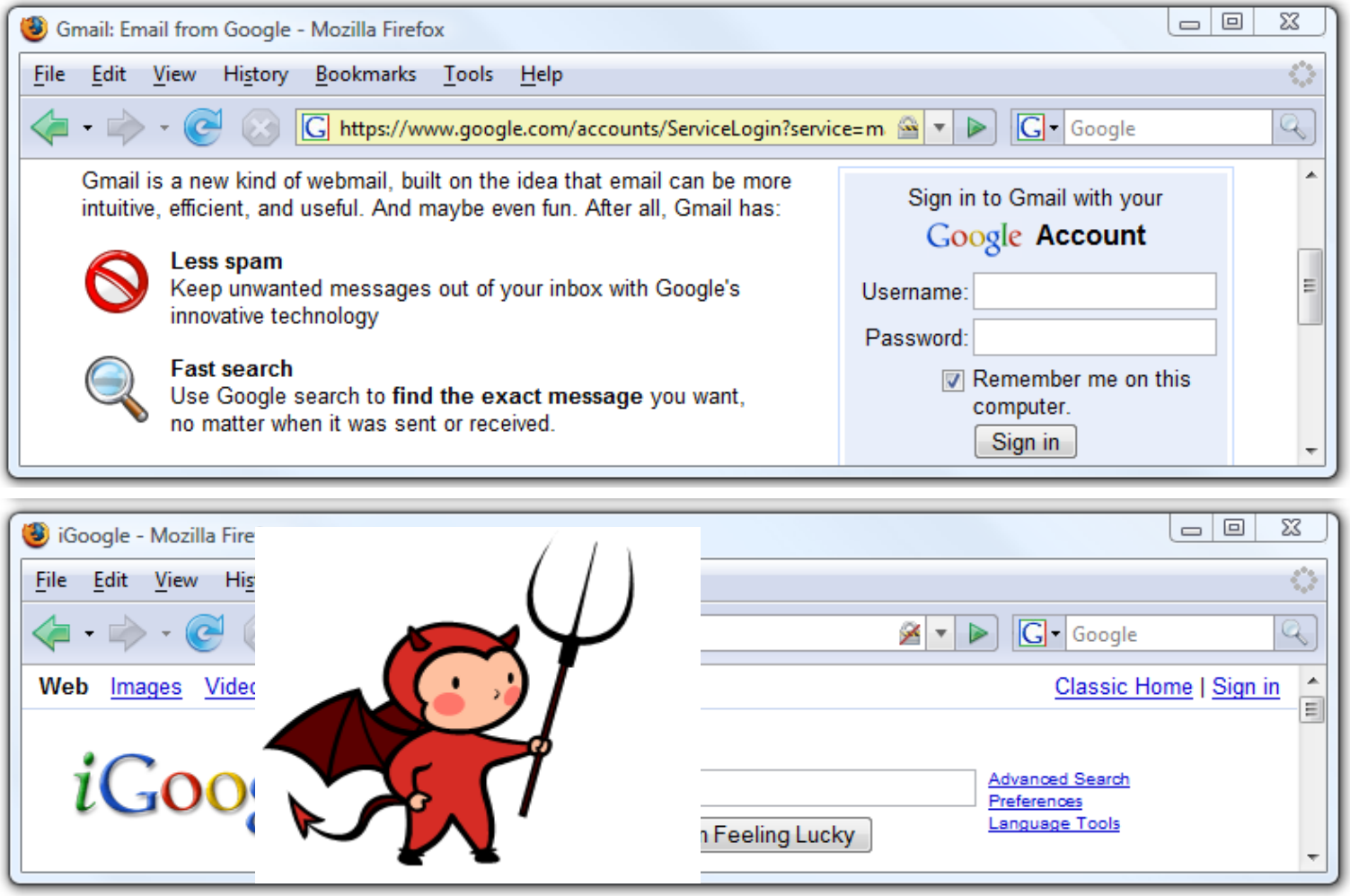


var so = new SWFObject("http://mfasa.chase.com/auth/device.swf", ...

network attacker can modify SWF file and hijack session

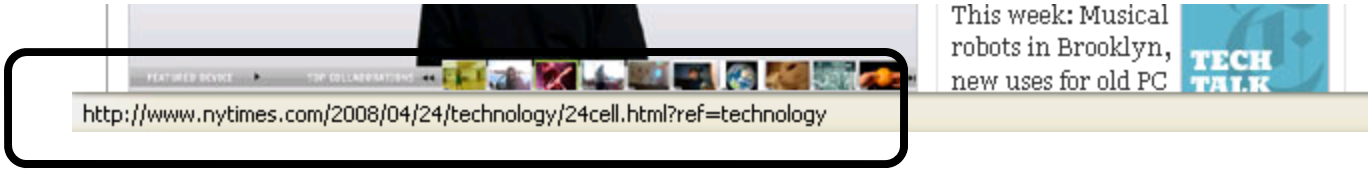
(the site has been fixed)

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